

(43) International Publication Date
21 January 2016 (21.01.2016)(51) International Patent Classification:
G02B 6/44 (2006.01)(21) International Application Number:
PCT/IB2015/055123(22) International Filing Date:
7 July 2015 (07.07.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
201410338572.0 16 July 2014 (16.07.2014) CN(71) Applicant: **TYCO ELECTRONICS (SHANGHAI) CO., LTD** [CN/CN]; F/G Section, 1/F, Building 15, 999 Yinglun Road, Pilot Free Trade Zone, Shanghai (CN).(71) Applicant (for MG only): **TYCO ELECTRONICS UK LTD** [GB/GB]; Faraday Road, Dorcan, Swindon, Wiltshire SN3 5HH (GB).(72) Inventors: **WANG, Junfeng**; c/o Tyco Electronics (Shanghai) Co. Ltd., F/G Section, 1/F, Building 15, 999 Yinglun Road, Pilot Free Trade Zone Shanghai (CN). **WANG, Xingze**; c/o Tyco Electronics (Shanghai) Co. Ltd., F/G Section, 1/F, Building 15, 999 Yinglun Road, Pilot Free Trade Zone Shanghai (CN). **XU, Liangliang**; c/o Tyco Electronics (Shanghai) Co. Ltd., F/G Section, 1/F, Building 15, 999 Yinglun Road, Pilot Free Trade Zone Shanghai (CN). **YANG, Lizhang**; c/o Tyco Electronics

(Shanghai) Co. Ltd., F/G Section, 1/F, Building 15, 999 Yinglun Road, Pilot Free Trade Zone Shanghai (CN).

(74) Agent: **FASSIO, Valeria**; Murgitroyd & Company, Piazza Borromeo 12, I-20123 Milan (IT).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, 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) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (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).

Published:

— with international search report (Art. 21(3))

(54) Title: CONNECTION DEVICE FOR OPTICAL AND ELECTRIC HYBRID CABLE

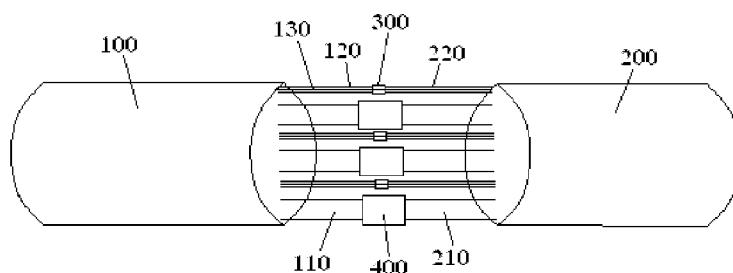


Fig. 1

(57) Abstract: A connection device for connecting a first optical and electric hybrid cable and a second optical and electric hybrid cable is disclosed. The first optical and electric hybrid cable has a first power cable and a first fiber tube for receiving a fiber therein, and the second optical and electric hybrid cable has a second power cable and a second fiber tube for receiving the fiber therein. The connection device comprises a fiber tube connector for coupling the first fiber tube with the second fiber tube, and a power cable connector for electrically connecting the first power cable and the second power cable. The fiber is inserted into the first fiber tube and the second fiber tube after the first fiber tube and the second fiber tube have been coupled together. An optical connection of two optical and electric hybrid cables is achieved in a convenient and quick manner only using the fiber tube connector, instead of using a fiber connection box having fiber connector, fiber adapter, fiber-arranging tray, fiber-coiling tray, shrinkable tube, etc., therefore, the disclosed connection device is very simple in structure.



WO 2016/009305 A1

CONNECTION DEVICE FOR OPTICAL AND ELECTRIC HYBRID CABLE

CROSS-REFERENCE TO RELATED APPLICATION

5

This application claims the benefit of Chinese Patent Application No. 201410338572.0 filed on July 16, 2014 in the State Intellectual Property Office of China, the whole disclosure of which is incorporated herein by reference.

10 BACKGROUND OF THE INVENTION

Field of the Invention

15 The present disclosure relates to a connection device for connecting a first optical and electric hybrid cable and a second optical and electric hybrid cable.

Description of the Related Art

20 In some situations for special applications, there exists a need for an optical and electric hybrid cable, that is, a cable having both power cable and fiber. For the connection of such optical and electric hybrid cables, the applicant of the present application has proposed a technical solution previously, in which the electrical connection of the power cables contained in two optical and electric hybrid cables is achieved by means of a conventional crimping method, and the optical splicing of the fibers contained in two optical
25 and electric hybrid cables is achieved by means of a fiber optic splicing box. It is complicated to splice the fibers of two optical and electric hybrid cables, in particular, an end of each fiber of the optical and electric hybrid cables is firstly connected to a fiber optic connector, and then two fiber optic connectors with fibers are coupled with each other via a fiber adapter, thus the optical splicing of the fibers in two optical and electric hybrid cables
30 is achieved. Another technical solution is proposed prior to the above technical solution set forth by the applicant of the present application, in which the optical splicing of the fibers in two optical and electric hybrid cables is achieved by means of butt fusion. However, such butt fusion process encounters disadvantages such as process complexity and high cost, since fiber-arranging tray, fiber-coiling tray, shrinkable tube, etc. are required.

35 In the technical solutions described above, it is necessary to adopt a special fiber optic splicing box to achieve the optical splicing of the fibers in two optical and electric hybrid cables, causing complicated structure, difficult operation, and high cost.

SUMMARY OF THE INVENTION

The purpose of the present disclosure is intended to solve at least one aspect of the above issues and faults in the prior art.

5 One object of the present disclosure is to provide a connection device for connecting a first optical and electric hybrid cable and a second optical and electric hybrid cable with a simple structure.

According to an aspect of the present disclosure, there is provided a connection device for connecting a first optical and electric hybrid cable and a second optical and electric hybrid cable. The first optical and electric hybrid cable has a first power cable and a first fiber tube for receiving a fiber therein, and the second optical and electric hybrid cable has a second power cable and a second fiber tube for receiving the fiber therein. The connection device comprises a fiber tube connector for coupling the first fiber tube with the second fiber tube, and a power cable connector for electrically connecting the first power cable and the second power cable, wherein the fiber is inserted into the first fiber tube and the second fiber tube after the first fiber tube and the second fiber tube have been coupled together.

According to an exemplary embodiment of the present invention, the first optical and electric hybrid cable and the second optical and electric hybrid cable comprise one or more power cables respectively; and the connection device comprises one or more power cable connectors for electrically connecting the power cables of the first optical and electric hybrid cable and the second optical and electric hybrid cable respectively.

According to another exemplary embodiment of the present invention, the first optical and electric hybrid cable and the second optical and electric hybrid cable comprise one or more fiber tubes respectively; and the connection device comprises one or more fiber tube connectors for coupling the fiber tubes of the first optical and electric hybrid cable and the second optical and electric hybrid cable respectively.

According to another exemplary embodiment of the present invention, all power cables in the first optical and electric hybrid cable or the second optical and electric hybrid cable are wrapped in a metal shielding layer, and insulation filling materials are filled into the gap between the metal shielding layer and the power cables; and the fiber tubes of the first optical and electric hybrid cable or the second optical and electric hybrid cable are embedded in the insulation filling materials.

According to another exemplary embodiment of the present invention, the first optical and electric hybrid cable and the second optical and electric hybrid cable comprise three power cables and three fiber tubes, respectively; the connection device comprises three power cable connectors and three fiber tube connectors; and the three power cables of the first optical and electric hybrid cable or the second optical and electric hybrid cable are intertwined with each other, and tangential to each other with peripheries thereof.

According to another exemplary embodiment of the present invention, the fiber tube connector comprises: a tubular body having a first insertion port and a second insertion port opposite to the first insertion port; a first resilient barb member provided on the inner wall of the first insertion port; and a second resilient barb member provided on the inner wall of the second insertion port. The first fiber tube and the second fiber tube are inserted into the tubular body through the first insertion port and the second insertion port, respectively; the first resilient barb member is configured to allow the first fiber tube to be inserted towards inside of the tubular body, and prevent the first fiber tube from being pulled out towards outside of the tubular body; and the second resilient barb member is configured to allow the second fiber tube to be inserted towards inside of the tubular body, and prevent the second fiber tube from being pulled out towards outside of the tubular body.

According to another exemplary embodiment of the present invention, the fiber tube connector further comprises: a first resilient seal ring accommodated in the inner wall of the first insertion port for sealing an engagement interface between the first fiber tube inserted into the tubular body and the tubular body; and a second resilient seal ring accommodated in the inner wall of the second insertion port for sealing an engagement interface between the second fiber tube inserted into the tubular body and the tubular body.

According to another exemplary embodiment of the present invention, the fiber tube connector further comprises: a first spacer provided on the inner wall of the first insertion port and on one side of the first resilient barb member facing to the inner wall of the tubular body to prevent the first resilient barb member from excessive deformation or damage; and a second spacer provided on the inner wall of the second insertion port and one side of the second resilient barb member facing to the inner wall of the tubular body to prevent the second resilient barb member from excessive deformation or damage.

According to another exemplary embodiment of the present invention, the fiber tube connector further comprises: a first movable member mounted in the first insertion port of the tubular body and a second movable member mounted in the second insertion port of the tubular body. The first movable member has a first pressure portion facing to the first resilient barb member, and the first movable member is movable from a first position for releasing the first resilient barb member to a second position for pressing the first resilient barb member. When the first movable member is located at the first position, the first resilient barb member is held in a first state which allows the first fiber tube to be inserted towards inside of the tubular body, and prevent the first fiber tube from being pulled out towards outside of the tubular body; and when the first movable member is located at the second position, the first resilient barb member is pressed by the first pressure portion and held in a second state which allows the first fiber tube to be pulled out towards outside of the tubular body. The second movable member has a second pressure portion facing to the second resilient barb member, and the second movable member is movable from a first

position for releasing the second resilient barb member to a second position for pressing the second resilient barb member. When the second movable member is located at the first position, the second resilient barb member is held in a first state which allows the second fiber tube to be inserted towards inside of the tubular body, and prevent the second fiber tube from being pulled out towards outside of the tubular body; and when the second movable member is located at the second position, the second resilient barb member is pressed by the second pressure portion and held in a second state which allows the second fiber tube to be pulled out towards outside of the tubular body.

According to another exemplary embodiment of the present invention, the power cable connector comprises: a crimping tube constructed to crimp a conductor core of the first power cable of the first optical and electric hybrid cable with a conductor core of the second power cable of the second optical and electric hybrid cable; and an insulation sleeve constructed to be sleeved outside the crimping tube and insulation layers of the first and second power cables so that the insulation sleeve is acted as sections of insulation layers of the first and second power cables which are stripped.

According to another exemplary embodiment of the present invention, the connection device further comprises: a layer of waterproof band bound on a junction of the first optical and electric hybrid cable and the second optical and electric hybrid cable for wrapping hermetically the fiber tube connector and the power cable connector of the connection device therein.

According to another aspect of the present disclosure, there is provided a method for connecting a first optical and electric hybrid cable and a second optical and electric hybrid cable, the first optical and electric hybrid cable having a first power cable and a first fiber tube for receiving a fiber therein, and the second optical and electric hybrid cable having a second power cable and a second fiber tube for receiving the fiber therein,

the method comprising steps of:

providing a connection device described in the above embodiments;

coupling the first fiber tube with the second fiber tube by means of the fiber tube connector of the connection device, and electrically connecting the first power cable and the second power cable by means of the power cable connector of the connection device; and

inserting the fiber into the first fiber tube and the second fiber tube, which have been coupled with each other.

In the connection devices according to various embodiments of the present invention, the fiber tubes in two optical and electric hybrid cables are firstly coupled with each other by means of the fiber tube connector, and then a whole fiber is inserted into a pair of fiber tubes, which have been coupled with each other, thus the optical connection of two optical and electric hybrid cables is achieved. An optical connection of two optical and electric hybrid cables is achieved in a convenient and quick manner only using the fiber tube

connector, instead of using a fiber connection box having fiber connector, fiber adapter, fiber-arranging tray, fiber-coiling tray, shrinkable tube, etc., therefore, the connection device according to the embodiments of the present invention is very simple in structure.

Other characteristics and advantages of the present disclosure will be made clear by the following detailed description, the comprehension of which will be facilitated by reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The present invention will be further described in detail with reference to the accompanying drawings, in which:

Fig.1 is a schematic view showing a first optical and electric hybrid cable, a second optical and electric hybrid cable and a connection device for connecting the first optical and electric hybrid cable and the second optical and electric hybrid cable according to a first exemplary embodiment of the present invention;

Fig.2a is a cross-section view of the first optical and electric hybrid cable and the second optical and electric hybrid cable according to the first exemplary embodiment of the present invention, wherein fibers are not inserted into fiber tubes of the first optical and electric hybrid cable and the second optical and electric hybrid cable;

20 Fig.2b is a cross-section view of the first optical and electric hybrid cable and the second optical and electric hybrid cable according to the first exemplary embodiment of the present invention, wherein the fibers are inserted into fiber tubes of the first optical and electric hybrid cable and the second optical and electric hybrid cable;

Fig.3a is a schematic view showing that a first fiber tube and a second fiber tube in Fig.1 are coupled with each other via a fiber tube connector;

Fig.3b is a schematic view showing the fiber tube connector of the connection device in Fig.1 for coupling the first fiber tube with the second fiber tube;

Fig.4 is a schematic view showing a first optical and electric hybrid cable, a second optical and electric hybrid cable and a connection device for connecting the first optical and electric hybrid cable and the second optical and electric hybrid cable according to a second exemplary embodiment of the present invention;

Fig.5 is a schematic view showing a first optical and electric hybrid cable, a second optical and electric hybrid cable and a connection device for connecting the first optical and electric hybrid cable and the second optical and electric hybrid cable according to a third exemplary embodiment of the present invention; and

Fig.6 is a schematic view showing a first optical and electric hybrid cable, a second optical and electric hybrid cable and a connection device for connecting the first optical and electric hybrid cable and the second optical and electric hybrid cable according to a fourth

exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

5

Exemplary embodiments of the present disclosure will be described hereinafter in detail with reference to the attached drawings, wherein the like reference numerals refer to the like elements. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiment set forth herein; rather, these embodiments are provided so that the present disclosure will be thorough and complete, and will fully convey the concept of the disclosure to those skilled in the art.

10

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

15

According to a general concept of the present disclosure, there is provided a connection device for connecting a first optical and electric hybrid cable and a second optical and electric hybrid cable, the first optical and electric hybrid cable having a first power cable and a first fiber tube for receiving a fiber therein, and the second optical and electric hybrid cable having a second power cable and a second fiber tube for receiving the fiber therein. The connection device comprises a fiber tube connector for coupling the first fiber tube with the second fiber tube, and a power cable connector for electrically connecting the first power cable and the second power cable, wherein the fiber is inserted into the first fiber tube and the second fiber tube after the first fiber tube and the second fiber tube have been coupled together.

20

25

Fig.1 is a schematic view showing a first optical and electric hybrid cable 100, a second optical and electric hybrid cable 200 and a connection device for connecting the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 according to a first exemplary embodiment of the present invention; Fig.2a is a cross-section view of the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 according to the first exemplary embodiment of the present invention, wherein fibers 130 are not inserted into fiber tubes 120, 220 of the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200; and Fig.2b is a cross-section view of the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 according to the first exemplary embodiment of the present invention, wherein the fibers 130 are inserted into fiber tubes 120, 220 of the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200.

30

35

As shown in Figs.2a and 2b, in an exemplary embodiment of the present invention, the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 have the same internal structure, however, the present disclosure is not limited to the embodiments illustrated, the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 may have different internal structures.

Further referring to Figs.2a and 2b, in the embodiment illustrated, the first optical and electric hybrid cable 100 comprises three first power cables 110 and three first fiber tubes 120. As shown clearly in Fig.2a, three first power cables 110 are intertwined with each other, and three first power cables 110 are tangential to each other with peripheries thereof. Three first power cables 110 are wrapped by a layer of first metal shielding layer 102 outside three first power cables 110, and insulation filling materials 101 are filled into the gap between the first metal shielding layer 102 and three first power cables 110. As manufacturing the first optical and electric hybrid cable 100, three first fiber tubes 120 are embedded in the insulation filling materials 101.

In the embodiment shown in Fig.2a, the first optical and electric hybrid cable 100 further comprises a first insulation layer 103 wrapped outside the first metal shielding layer 102, a second metal shielding layer 104 wrapped outside the first insulation layer 103, and an outer sheath layer 105 wrapped outside the second metal shielding layer 104. As shown in Fig.2a, each first power cable 110 comprises a conductor cone 111, insulation material layer (not shown) wrapped outside the conductor cone 111, and a metal shielding layer wrapped outside the insulation material layer (not shown).

In an exemplary embodiment of the present invention, the fibers 130 may be inserted into the first fiber tubes 120, respectively, after the first fiber tubes 120 have been embedded in the insulation filling materials 101, thus it avoids the fibers 130 from being overheated and thereby being damaged when pouring the molten insulation filling materials 101.

Similarly, in the embodiment shown in Figs.2a and 2b, the second optical and electric hybrid cable 200 comprises three second power cables 210 and three second fiber tubes 220. As shown clearly in Fig.2a, three second power cables 210 are intertwined with each other, and three second power cables 210 are tangential to each other with peripheries thereof. Three second power cables 210 are wrapped by a layer of first metal shielding layer 202 outside three second power cables 210, and insulation filling materials 201 are filled into the gap between the first metal shielding layer 202 and three second power cables 210. As manufacturing the second optical and electric hybrid cable 200, three second fiber tubes 220 are embedded in the insulation filling materials 201.

In the embodiment shown in Fig.2a, the second optical and electric hybrid cable 200 further comprises a first insulation layer 203 wrapped outside the first metal shielding layer 202, a second metal shielding layer 204 wrapped outside the first insulation layer 203, and an outer sheath layer 205 wrapped outside the second metal shielding layer 204. As shown in

Fig.2a, each second power cable 210 comprises a conductor cone 211, insulation material layer (not shown) wrapped outside the conductor cone 211, and a metal shielding layer wrapped outside the insulation material layer (not shown).

5 In an exemplary embodiment of the present invention, the fibers 130 may be inserted into the second fiber tubes 220, respectively, after the second fiber tubes 220 have been embedded in the insulation filling materials 201, thus it avoids the fibers 130 from being overheated and thereby being damaged when pouring molten insulation filling materials 201.

10 Further referring to Fig.1, in the embodiment illustrated, the connection device for connecting the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 primarily comprises three power cable connectors 400 and three fiber tube connectors 300. Three power cable connectors 400 are constructed to electrically connect three first power cables 110 of the first optical and electric hybrid cable 100 and three second power cables 210 of the second optical and electric hybrid cable 200, respectively.
15 Three fiber tube connectors 300 are constructed to couple three first fiber tubes 120 of the first optical and electric hybrid cable 100 with three second fiber tubes 220 of the second optical and electric hybrid cable 200, respectively.

In an exemplary embodiment of the present invention, the fibers 130 are inserted into the first fiber tubes 120 and the second fiber tubes 220 after the first fiber tubes 120 and the second fiber tubes 220 have been coupled together, it thereby achieves the optical connection of the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200. Thus, the connection device may achieve the optical connection of two cables 100, 200 without using a fiber optic splicing box.

Fig.3a is a schematic view showing that the first fiber tube 120 and the second fiber tube 220 in Fig.1 are coupled with each other via the fiber tube connector 300; and Fig.3b is a schematic view showing the fiber tube connector 300 of the connection device in Fig.1 for coupling the first fiber tube 120 with the second fiber tube 220.

As shown in Figs.1, 3a and 3b, in an exemplary embodiment of the present invention, the fiber tube connector 300 primarily comprises: a tubular body 301 having a first insertion port (left port in Fig.3b) and a second insertion port (right port in Fig.3b) opposite to the first insertion port; a first resilient barb member 311 provided on the inner wall of the first insertion port; and a second resilient barb member 312 provided on the inner wall of the second insertion port.

35 In the embodiment illustrated, as shown in Figs.1 and 3b, the first fiber tube 120 and the second fiber tube 220 are inserted into the tubular body 301 through the first insertion port and the second insertion port, respectively. The first resilient barb member 311 is configured to only allow the first fiber tube 120 to be inserted towards inside of the tubular body 301, and prevent the first fiber tube 120 from being pulled out towards outside of the

tubular body 301; and similarly, the second resilient barb member 312 is configured to allow the second fiber tube 220 to be inserted towards inside of the tubular body 301, and prevent the second fiber tube 220 from being pulled out towards outside of the tubular body 301.

Further referring to Fig.3b, in the embodiment illustrated, the fiber tube connector 300 further comprises a first resilient seal ring 321 provided on the inner wall of the first insertion port and a second resilient seal ring 322 provided on the inner wall of the second insertion port. The first resilient seal ring 321 is constructed to seal an engagement interface between the tubular body 301 and the first fiber tube 120 inserted into the tubular body 301. The second resilient seal ring 322 is constructed to seal an engagement interface between the tubular body 301 and the second fiber tube 220 inserted into the tubular body 301.

Further referring to Fig.3b, in the embodiment illustrated, the fiber tube connector 300 further comprises a first spacer 331 provided on the inner wall of the first insertion port and a second spacer 332 provided on the inner wall of the second insertion port. The first spacer 331 is provided on one side of the first resilient barb member 311 facing to the inner wall of the tubular body 301 to support the first resilient barb member 311 when being pressed outward radially, thereby preventing the first resilient barb member 311 from excessive deformation or damage. The second spacer 332 is provided on one side of the second resilient barb member 312 facing to the inner wall of the tubular body 301 to support the first resilient barb member 311 when being pressed outward radially, thereby preventing the second resilient barb member 312 from excessive deformation or damage.

Further referring to Fig.3b, in the embodiment illustrated, the fiber tube connector 300 further comprises: a first movable member 341 mounted in the first insertion port of the tubular body 301 and a second movable member 342 mounted in the second insertion port of the tubular body 301.

In an exemplary embodiment of the present invention, the first movable member 341 has a first pressure portion 3410 extending toward the first resilient barb member 311. The first movable member 341 is movable from a first position for releasing the first resilient barb member 311 to a second position for pressing the first resilient barb member 311. When the first movable member 341 is located at the first position, the first resilient barb member 311 is not pressed by the first pressure portion 3410 of the first movable member 341 and held in a first state which allows the first fiber tube 120 to be inserted towards inside of the tubular body 301, and prevent the first fiber tube 120 from being pulled out towards outside of the tubular body 301. When the first movable member 341 is located at the second position, the first resilient barb member 311 is pressed by the first pressure portion 3410 and held in a second state which allows the first fiber tube 120 to be pulled out towards outside of the tubular body 301.

Similarly, in an exemplary embodiment of the present invention, the second movable member 342 has a second pressure portion 3420 extending toward the second resilient barb

member 312. The second movable member 342 is movable from a first position for releasing the second resilient barb member 312 to a second position for pressing the second resilient barb member 312. When the second movable member 342 is located at the first position, the second resilient barb member 312 is not pressed by the second pressure portion 3420 of the second movable member 342 and held in a first state which allows the second fiber tube 220 to be inserted towards inside of the tubular body 301, and prevent the second fiber tube 220 from being pulled out towards outside of the tubular body 301. When the second movable member 342 is located at the second position, the second resilient barb member 312 is pressed by the second pressure portion 3420 and held in a second state which allows the second fiber tube 220 to be pulled out towards outside of the tubular body 301.

It is noted that, in the present disclosure, the fiber tube connector is not limited to the embodiment illustrated, it also may have any other structures as long as two fiber tubes may be coupled with each other.

As shown in Fig.1, in an exemplary embodiment of the present invention, the power cable connector 400 may comprise a crimping tube (not shown) and an insulation sleeve (not shown). The crimping tube is constructed to crimp the conductor core 111 (see Fig.2) of the first power cable 110 of the first optical and electric hybrid cable 100 with the conductor core 121 (see Fig.2) of the second power cable 120 of the second optical and electric hybrid cable 200. The insulation sleeve is constructed to be sleeved outside the crimping tube and insulation layers of the first and second power cables 110, 210 so as to be acted as sections of insulation layers of the first and second power cables 110, 210 which are stripped.

It is noted that, any types of power cable connectors in the prior art may be used as the power cable connector in the present disclosure, as long as two power cables may be connected electrically.

Although not shown, in an exemplary embodiment of the present invention, the connection device for connecting the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 further comprises a layer of waterproof band bound on a junction of the first optical and electric hybrid cable 100 and the second optical and electric hybrid cable 200 for wrapping hermetically the fiber tube connector 300 and the power cable connector 400 therein.

According to another embodiment of the present invention, there is provided a method for connecting a first optical and electric hybrid cable 100 and a second optical and electric hybrid cable 200, comprising steps of:

providing a connection device described in the above embodiments;
coupling the first fiber tube 120 with the second fiber tube 220 by means of the fiber tube connector 300 of the connection device, and electrically connecting the first power cable 110 and the second power cable 210 by means of the power cable connector 400 of the connection device; and

inserting the fiber 130 into the first fiber tube 120 and the second fiber tube 220, which have been coupled with each other.

Fig.4 is a schematic view showing a first optical and electric hybrid cable 100', a second optical and electric hybrid cable 200' and a connection device for connecting the first optical and electric hybrid cable 100' and the second optical and electric hybrid cable 200' according to a second exemplary embodiment of the present invention.

In the embodiment shown in Fig.4, each of the first optical and electric hybrid cable 100' and the second optical and electric hybrid cable 200' comprises three power cables 110 and two fiber tubes 120. Accordingly, in the embodiment shown in Fig.4, the connection device for connecting the first optical and electric hybrid cable 100' and the second optical and electric hybrid cable 200' comprises three power cable connectors 400 and two fiber tube connectors 300.

The main difference of the second embodiment shown in Fig.4 from the first embodiment shown in Fig.1 lies in that each of the first optical and electric hybrid cable 100' and the second optical and electric hybrid cable 200' only comprises two fiber tubes 120, and the connection device for connecting the first optical and electric hybrid cable 100' and the second optical and electric hybrid cable 200' only comprises two fiber tube connectors 300. Except that, the second embodiment shown in Fig.4 is identical to the first embodiment shown in Fig.1.

Fig.5 is a schematic view showing a first optical and electric hybrid cable 100'', a second optical and electric hybrid cable 200'' and a connection device for connecting the first optical and electric hybrid cable 100'' and the second optical and electric hybrid cable 200'' according to a third exemplary embodiment of the present invention.

In the embodiment shown in Fig.5, each of the first optical and electric hybrid cable 100'' and the second optical and electric hybrid cable 200'' comprises three power cables 110 and one fiber tube 120. Accordingly, in the embodiment shown in Fig.5, the connection device for connecting the first optical and electric hybrid cable 100'' and the second optical and electric hybrid cable 200'' comprises three power cable connectors 400 and one fiber tube connector 300.

The main difference of the third embodiment shown in Fig.5 from the first embodiment shown in Fig.1 lies in that each of the first optical and electric hybrid cable 100'' and the second optical and electric hybrid cable 200'' only comprises one fiber tube 120, and the connection device for connecting the first optical and electric hybrid cable 100'' and the second optical and electric hybrid cable 200'' only comprises one fiber tube connector 300. Except that, the third embodiment shown in Fig.5 is identical to the first embodiment shown in Fig.1.

Fig.6 is a schematic view showing a first optical and electric hybrid cable 100''', a second optical and electric hybrid cable 200''' and a connection device for connecting the

first optical and electric hybrid cable 100''' and the second optical and electric hybrid cable 200''' according to a fourth exemplary embodiment of the present invention.

In the embodiment shown in Fig.6, each of the first optical and electric hybrid cable 100''' and the second optical and electric hybrid cable 200''' comprises one power cable 110 and one fiber tube 120. Accordingly, in the embodiment shown in Fig.6, the connection device for connecting the first optical and electric hybrid cable 100''' and the second optical and electric hybrid cable 200''' comprises one power cable connector 400 and one fiber tube connector 300.

The main difference of the fourth embodiment shown in Fig.6 from the first embodiment shown in Fig.1 lies in that each of the first optical and electric hybrid cable 100''' and the second optical and electric hybrid cable 200''' only comprises one power cable 110 and one fiber tube 120, and the connection device for connecting the first optical and electric hybrid cable 100''' and the second optical and electric hybrid cable 200''' only comprises one power cable connector 400 and one fiber tube connector 300. Except that, the fourth embodiment shown in Fig.6 is identical to the first embodiment shown in Fig.1.

It is noted that, the present disclosure is not limited to the embodiments as illustrated, each of the first optical and electric hybrid cable and the second optical and electric hybrid cable may comprise any number of power cables and any number of fiber tubes, accordingly, the connection device may comprise any number of power cable connectors and any number of fiber tube connectors. In other words, the number of power cables and the number of fiber tubes accommodated in the first optical and electric hybrid cable and the second optical and electric hybrid cable, the number of power cable connectors and the number of fiber tube connectors of the connection device may depend on requirements, rather than being limited to the embodiments shown in Figs.1-6. For example, each optical and electric hybrid cable may comprise two, four or more power cables, and each optical and electric hybrid cable may comprise four, five or more fiber tubes. Accordingly, the connection device may comprise two, four or more power cable connectors and four, five or more fiber tube connectors.

It should be appreciated for those skilled in this art that the above embodiments are intended to be illustrated, and not restrictive. For example, many modifications may be made to the above embodiments by those skilled in this art, and various features described in different embodiments may be freely combined with each other without conflicting in configuration or principle.

Although several exemplary embodiments have been shown and described, it would be appreciated by those skilled in the art that various changes or modifications may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

As used herein, an element recited in the singular and proceeded with the word "a" or

"an" should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to "one embodiment" of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to
5 the contrary, embodiments "comprising" or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property.

What is claimed is,

1. A connection device for connecting a first optical and electric hybrid cable (100) and a second optical and electric hybrid cable (200), the first optical and electric hybrid cable (100) having a first power cable (110) and a first fiber tube (120) for receiving a fiber (130) therein, and the second optical and electric hybrid cable (200) having a second power cable (210) and a second fiber tube (220) for receiving the fiber (130) therein,

the connection device comprising:

a fiber tube connector (300) for coupling the first fiber tube (120) with the second fiber tube (220); and

a power cable connector (400) for electrically connecting the first power cable (110) and the second power cable (210),

wherein the fiber (130) is inserted into the first fiber tube (120) and the second fiber tube (220) after the first fiber tube (120) and the second fiber tube (220) have been coupled together.

2. The connection device according to claim 1, wherein

the first optical and electric hybrid cable (100) and the second optical and electric hybrid cable (200) comprise one or more power cables (110, 210), respectively; and

the connection device comprises one or more power cable connectors (400) for electrically connecting the power cables (110, 210) of the first optical and electric hybrid cable (100) and the second optical and electric hybrid cable (200), respectively.

3. The connection device according to claim 2, wherein

the first optical and electric hybrid cable (100) and the second optical and electric hybrid cable (200) comprise one or more fiber tubes (120, 220), respectively; and

the connection device comprises one or more fiber tube connectors (300) for coupling the fiber tubes (120, 220) of the first optical and electric hybrid cable (100) and the second optical and electric hybrid cable (200), respectively.

4. The connection device according to claim 3, wherein

all power cables (110, 210) in the first optical and electric hybrid cable (100) or the second optical and electric hybrid cable (200) are wrapped in a metal shielding layer (102, 202), and insulation filling materials (101, 201) are filled into the gap between the metal shielding layer and the power cables (110, 210); and

the fiber tubes (120, 220) of the first optical and electric hybrid cable (100) or the second optical and electric hybrid cable (200) are embedded in the insulation filling materials (101, 201).

5. The connection device according to claim 4, wherein
the first optical and electric hybrid cable (100) and the second optical and electric
hybrid cable (200) comprise three power cables (110, 210) and three fiber tubes (120, 220),
5 respectively;

the connection device comprises three power cable connectors (400) and three fiber
tube connectors (300); and

the three power cables (110, 210) of the first optical and electric hybrid cable (100) or
the second optical and electric hybrid cable (200) are intertwined with each other, and
10 tangential to each other with peripheries thereof.

6. The connection device according to claim 1, wherein the fiber tube connector (300)
comprises:

a tubular body (301) having a first insertion port and a second insertion port opposite to
15 the first insertion port;

a first resilient barb member (311) provided on the inner wall of the first insertion port;
and

a second resilient barb member (312) provided on the inner wall of the second
insertion port, wherein

20 the first fiber tube (120) and the second fiber tube (220) are inserted into the tubular
body (301) through the first insertion port and the second insertion port, respectively;

the first resilient barb member (311) is configured to allow the first fiber tube (120) to
be inserted towards inside of the tubular body (301), and prevent the first fiber tube from
being pulled out towards outside of the tubular body (301); and

25 the second resilient barb member (312) is configured to allow the second fiber tube
(220) to be inserted towards inside of the tubular body (301), and prevent the second fiber
tube from being pulled out towards outside of the tubular body (301).

7. The connection device according to claim 6, wherein the fiber tube connector (300)
30 further comprises:

a first resilient seal ring (321) provided on the inner wall of the first insertion port for
sealing an engagement interface between the tubular body (301) and the first fiber tube (120)
inserted into the tubular body; and

a second resilient seal ring (322) provided on the inner wall of the second insertion port
35 for sealing an engagement interface between the tubular body (301) and the second fiber
tube (220) inserted into the tubular body.

8. The connection device according to claim 7, wherein the fiber tube connector (300)

further comprises:

a first spacer (331) provided on the inner wall of the first insertion port and one side of the first resilient barb member (311) facing to the inner wall of the tubular body (301) to prevent the first resilient barb member (311) from excessive deformation or damage; and

- 5 a second spacer (332) provided on the inner wall of the second insertion port and one side of the second resilient barb member (312) facing to the inner wall of the tubular body (301) to prevent the second resilient barb member (312) from excessive deformation or damage.

- 10 9. The connection device according to claim 8, wherein the fiber tube connector (300) further comprises:

a first movable member (341) mounted in the first insertion port of the tubular body (301), wherein the first movable member (341) has a first pressure portion (3410) extending toward the first resilient barb member (311), and the first movable member (341) is movable
15 from a first position for releasing the first resilient barb member (311) to a second position for pressing the first resilient barb member (311); when the first movable member (341) is located at the first position, the first resilient barb member (311) is held in a first state which allows the first fiber tube (120) to be inserted towards inside of the tubular body (301), and prevent the first fiber tube from being pulled out towards outside of the tubular body (301);
20 and when the first movable member (341) is located at the second position, the first resilient barb member (311) is pressed by the first pressure portion (3410) and held in a second state which allows the first fiber tube (120) to be pulled out towards outside of the tubular body (301); and

a second movable member (342) mounted in the second insertion port of the tubular
25 body (301), wherein the second movable member (342) has a second pressure portion (3420) extending toward the second resilient barb member (312), and the second movable member (342) is movable from a first position for releasing the second resilient barb member (312) to a second position for pressing the second resilient barb member (312); when the second movable member (342) is located at the first position, the second resilient barb member (312)
30 is held in a first state which allows the second fiber tube (220) to be inserted towards inside of the tubular body (301), and prevent the second fiber tube from being pulled out towards outside of the tubular body (301); and when the second movable member (342) is located at the second position, the second resilient barb member (312) is pressed by the second pressure portion (3420) and held in a second state which allows the second fiber tube (220)
35 to be pulled out towards outside of the tubular body (301).

10. The connection device according to claim 1, wherein the power cable connector (400) comprises:

a crimping tube constructed to crimp a conductor core (111) of the first power cable (110) of the first optical and electric hybrid cable (100) with a conductor core (121) of the second power cable (120) of the second optical and electric hybrid cable (200); and

5 an insulation sleeve constructed to be sleeved outside the crimping tube and insulation layers of the first and second power cables (110, 210), so that the insulation sleeve is acted as sections of insulation layers of the first and second power cables (110, 210) which are stripped.

11. The connection device according to claim 1, further comprising:

10 a layer of waterproof band bound on a junction of the first optical and electric hybrid cable (100) and the second optical and electric hybrid cable (200) for wrapping hermetically the fiber tube connector (300) and the power cable connector (400) of the connection device therein.

15 12. A method for connecting a first optical and electric hybrid cable (100) and a second optical and electric hybrid cable (200), the first optical and electric hybrid cable (100) having a first power cable (110) and a first fiber tube (120) for receiving a fiber (130) therein, and the second optical and electric hybrid cable (200) having a second power cable (210) and a second fiber tube (220) for receiving the fiber (130) therein,

20 the method comprising steps of:

providing a connection device according to claim 1;

coupling the first fiber tube (120) with the second fiber tube (220) by means of the fiber tube connector (300) of the connection device, and electrically connecting the first power cable (110) and the second power cable (210) by means of the power cable connector (400) of the connection device; and

25 inserting the fiber (130) into the first fiber tube (120) and the second fiber tube (220), which have been coupled with each other.

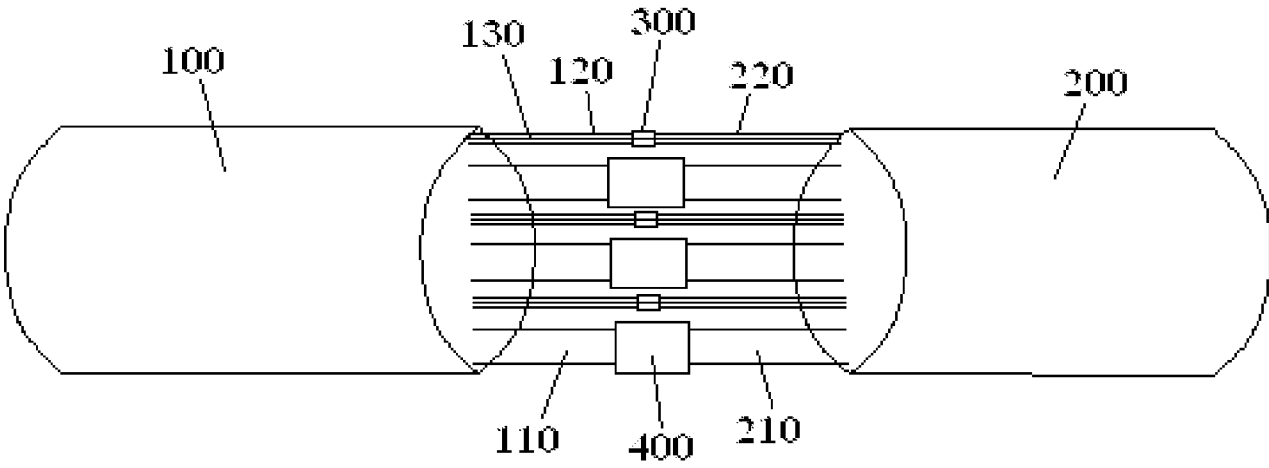


Fig. 1

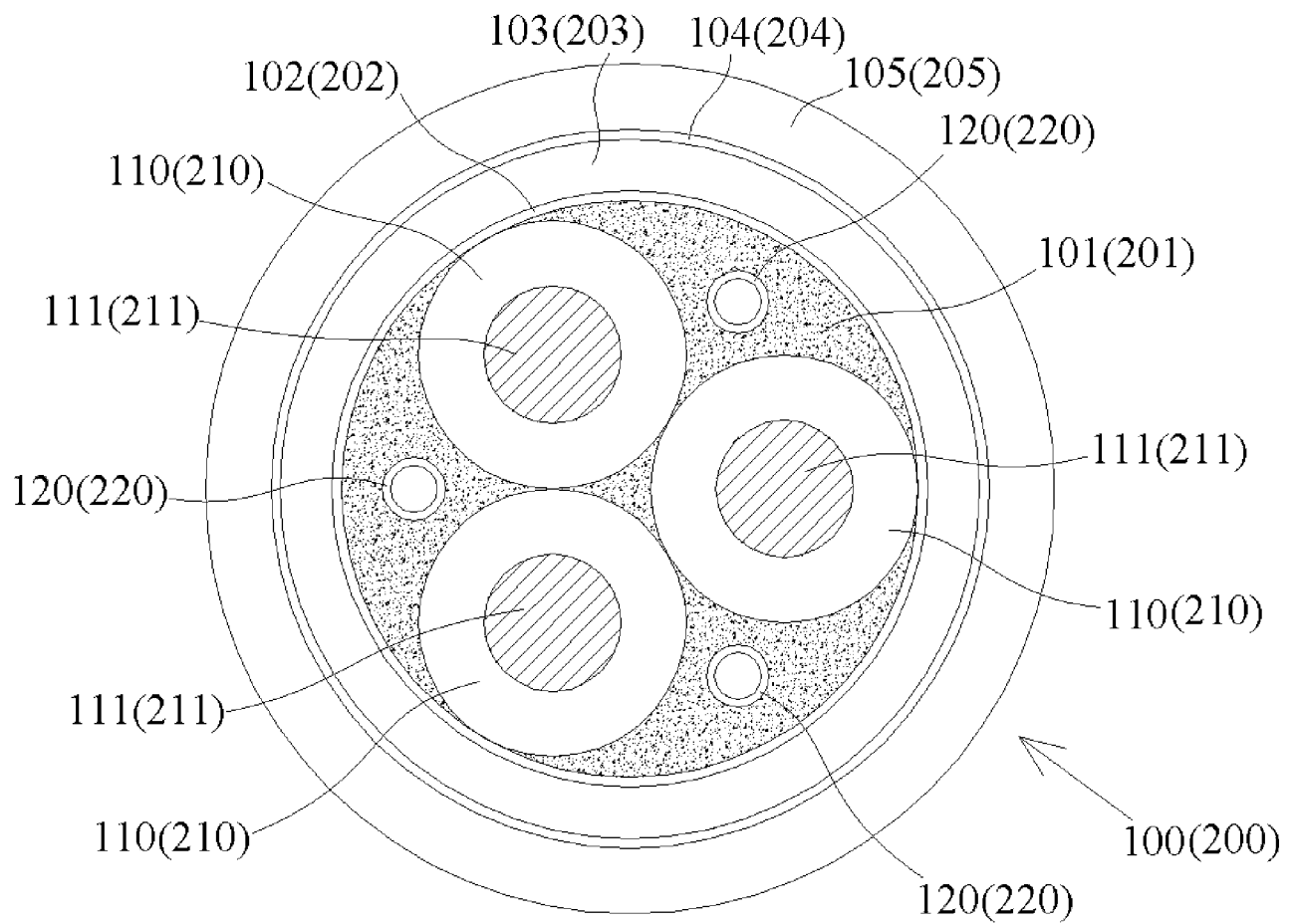


Fig. 2a

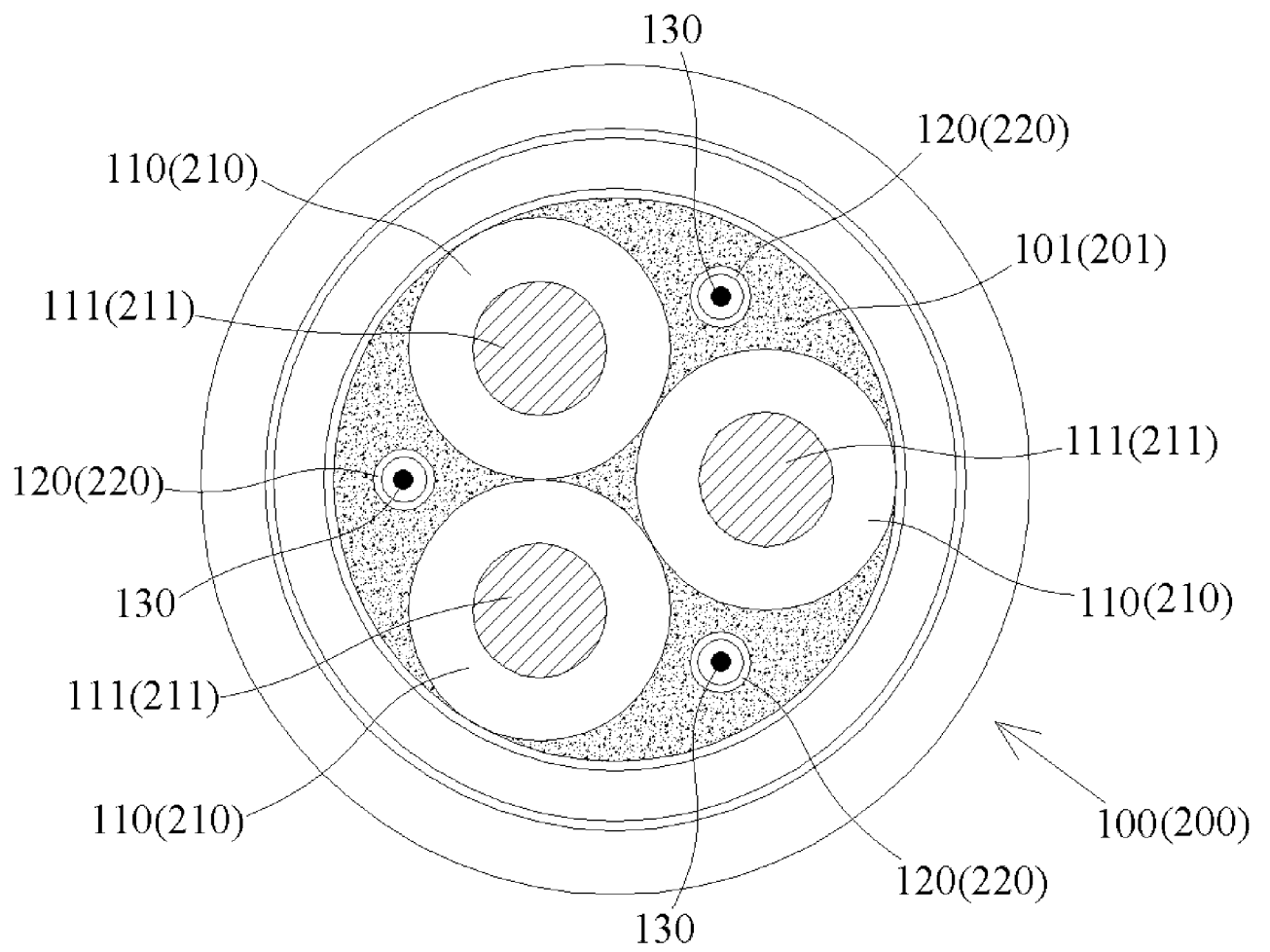


Fig. 2b

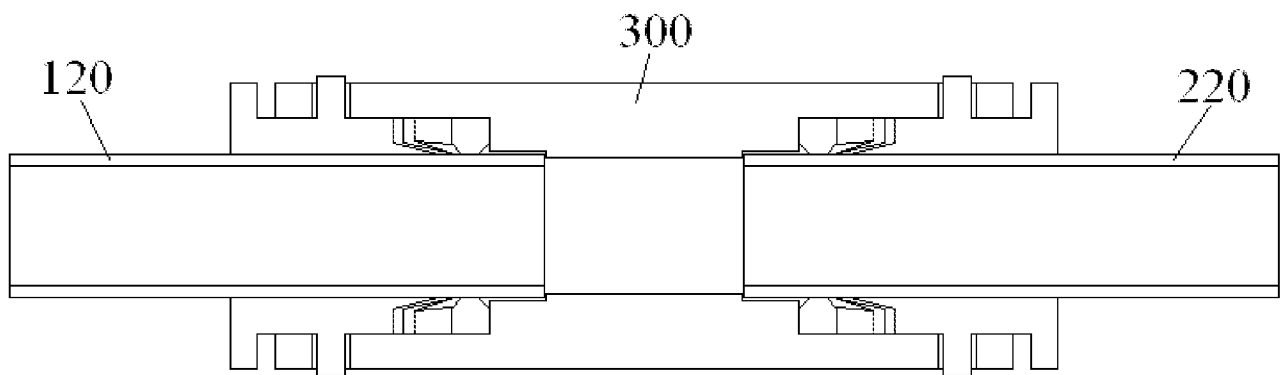


Fig. 3a

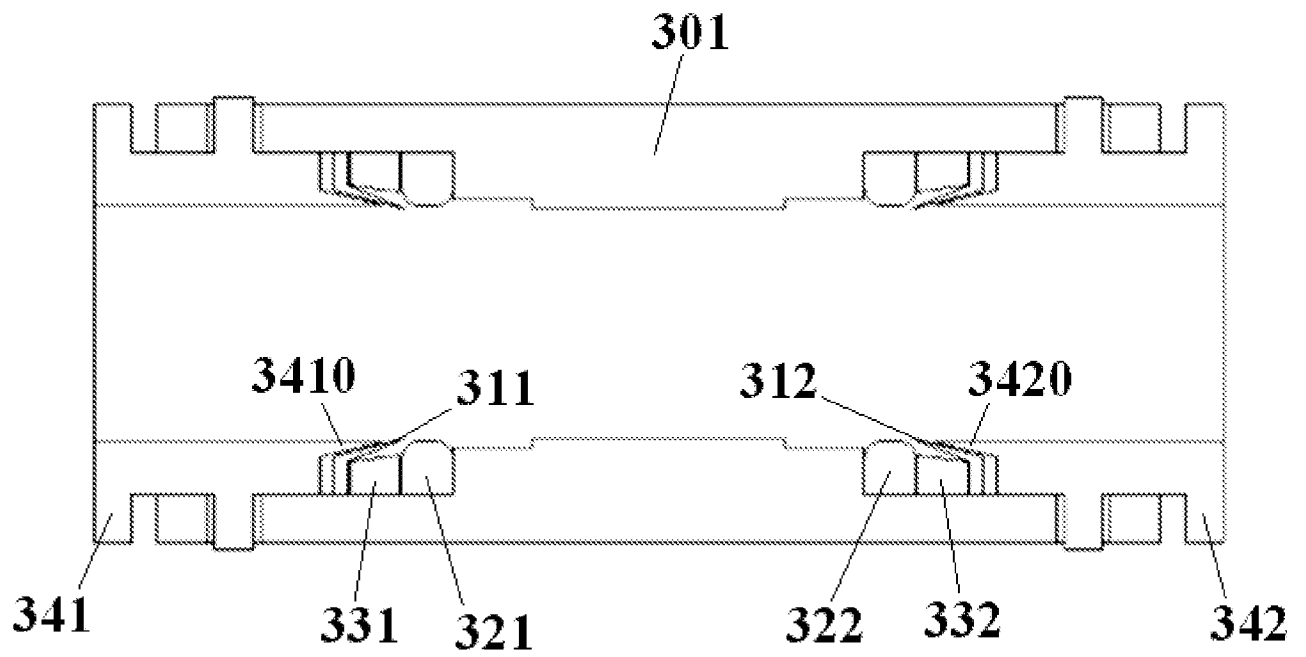


Fig. 3b

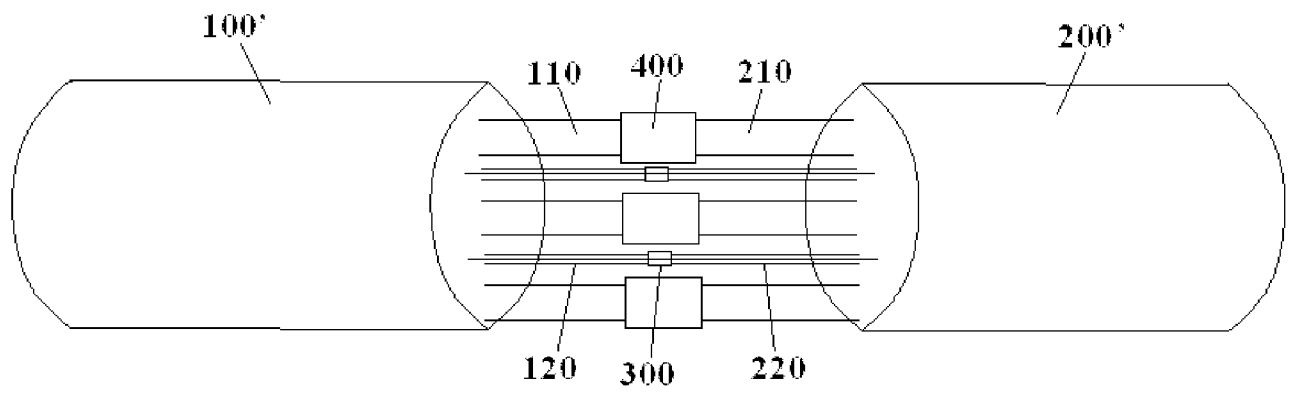


Fig. 4

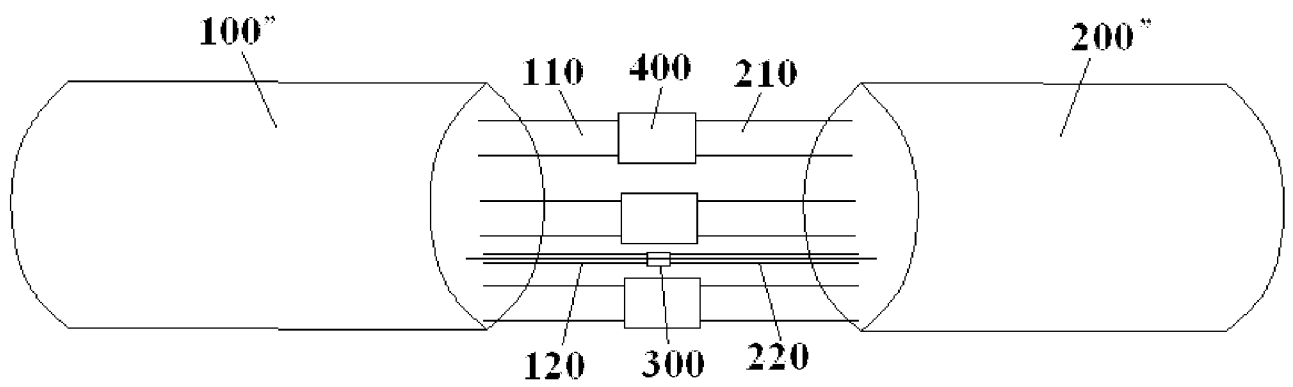


Fig. 5

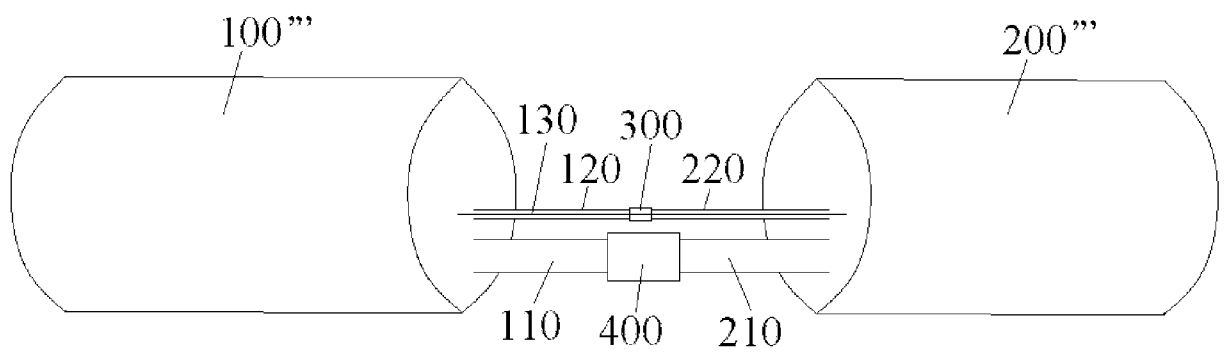


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/055123

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B6/44
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B H01B H02G H01R

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 410 735 A2 (BICC PLC [GB]) 30 January 1991 (1991-01-30)	1-3,12
Y	figures 1,2 -----	4-11
X	US 2011/286704 A1 (RUBINSTEIN SCOTT A [US] ET AL) 24 November 2011 (2011-11-24) abstract; figure 1 -----	1-3
Y	US 2010/122844 A1 (EFRAIMSSON LARS [SE] ET AL) 20 May 2010 (2010-05-20) figure 2 -----	4,5,10, 11
Y	US 2013/294735 A1 (BURRIS DONALD ANDREW [US] ET AL) 7 November 2013 (2013-11-07) paragraph [0045] - paragraph [0046]; figure 2 ----- -/--	4,5,10, 11

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 October 2015

Date of mailing of the international search report

21/10/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Jones, Julian

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/055123

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 664 423 A (ROWLEY WILLIAM W [US]) 12 May 1987 (1987-05-12) figure 1 -----	6-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2015/055123

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0410735	A2	30-01-1991	AR 243306 A1 30-07-1993
		AU 627608 B2 27-08-1992	
		AU 5991490 A 21-02-1991	
		CA 2021971 A1 29-01-1991	
		CN 1049916 A 13-03-1991	
		EP 0410735 A2 30-01-1991	
		GB 2235595 A 06-03-1991	
		JP H03137603 A 12-06-1991	
		NZ 234654 A 25-09-1992	
		US 5123075 A 16-06-1992	
US 2011286704	A1	24-11-2011	EP 2402802 A1 04-01-2012
			US 2011286704 A1 24-11-2011
US 2010122844	A1	20-05-2010	CN 101681699 A 24-03-2010
			EP 2145339 A1 20-01-2010
			PL 2145339 T3 30-11-2012
			US 2010122844 A1 20-05-2010
			WO 2008136722 A1 13-11-2008
US 2013294735	A1	07-11-2013	EP 2845044 A1 11-03-2015
			US 2013294735 A1 07-11-2013
			US 2014355941 A1 04-12-2014
			WO 2013165831 A1 07-11-2013
US 4664423	A	12-05-1987	NONE