(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 May 2014 (22.05.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/077953 A1

(51) International Patent Classification:
G02B 6/36 (2006.01) *H02G 3/02* (2006.01)

(21) International Application Number:
PCT/US2013/061331

(22) International Filing Date:
24 September 2013 (24.09.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

61/728,020	19 November 2012 (19.11.2012)	US
13/791,248	8 March 2013 (08.03.2013)	US
13/832,665	15 March 2013 (15.03.2013)	US

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(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, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, 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, 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).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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

(54) Title: OPTICAL FIBER / ELECTRICAL COMPOSITE CABLE ASSEMBLY WITH SEALED BREAKOUT KIT

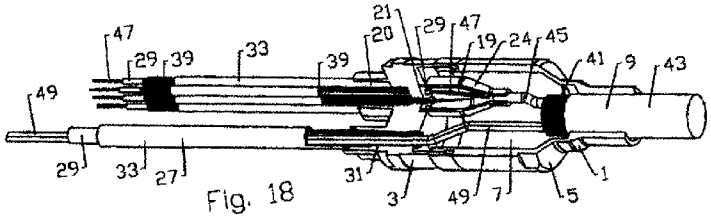

Fig. 18

(57) Abstract: A cable breakout kit has a cable portion, an inner wall portion and a furcation portion with at least one fiber port. The cable portion and the furcation portion are dimensioned to couple with one another, enclosing a furcation area. The inner wall portion is coupled to the furcation portion and a fiber bundle of the cable, enclosing a fiber area within the furcation area; the fiber area is coupled to the at least one fiber port. An assembly including a cable with a fiber and an electrical conductor utilizes a transition housing to pass the fiber and conductor to respective furcation tubes, isolated from one another.

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OPTICAL FIBER / ELECTRICAL COMPOSITE CABLE ASSEMBLY WITH SEALED BREAKOUT KIT

BACKGROUND

Field of the Invention

This invention relates to hybrid electrical and optical cable assemblies. More particularly, the invention relates to a electrical and optical hybrid cable with an in-line transition housing between the hybrid cable and individual termination jumpers for the several conductors of the cable.

Description of Related Art

The wireless communications industry is changing from traditional signal delivery from ground based transceivers delivering/receiving the RF signal to/from the antenna atop the radio tower via bulky/heavy/high material cost metal RF coaxial cable to optical signal delivery to a tower top mounted transceiver known as a remote radio unit (RRU) or remote radio head (RRH) with implementation of FTTA (Fiber To The Antenna) cabling.

FTTA cabling may be simplified where power and/or control signal conductors are provided with optical signal conductors in a single hybrid cable.

Optical conductors may be fragile, requiring great care to properly terminate.

Prior hybrid cable RRU/RRH terminations have employed an over-voltage protection and/or distribution box for terminating each of the electrical and optical conductors as individual jumpers. These additional enclosures require field termination of the several conductors atop the radio tower, increasing installation time and labor requirements. Further, each break in the conductors provides another opportunity for signal degradation and/or environmental fouling.

Factory terminated hybrid cable assemblies are known. However, these assemblies may apply splices to the conductors, require a relatively large in-line break-out/splice enclosure and/or utilize environmental seals which fail to positively interlock the jumpers therewith, which may increase the potential for cable and/or individual conductor damage to occur.

Therefore, an object of the invention is to provide an optical fiber/electrical cable assembly with sealed breakout kit and/or cable assembly and method of use that overcomes deficiencies in the prior art.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, where like reference numbers in the drawing figures refer to the same feature or element and may not be described in detail for every drawing figure in which they appear and, together with a general

description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the invention.

Figure 1 is a schematic isometric view of an exemplary transition housing.

Figure 2 is schematic side view of the transition housing of Figure 1.

Figure 3 is a schematic side view of a cable portion of the transition housing of Figure 1.

Figure 4 is schematic cut-away side view of the cable portion of Figure 3.

Figure 5 is a schematic isometric view of a furcation portion of the transition housing of Figure 1.

Figure 6 is a schematic cut-away side view of the furcation portion of Figure 5.

Figure 7 is a schematic end view of the transition end of the furcation portion of Figure 6.

Figure 8 is a schematic isometric cut-away view of the transition housing of Figure 1.

Figure 9 is schematic side section view of the transition housing of Figure 8.

Figure 10 is another schematic isometric cut-away view of the transition housing of Figure 1.

Figure 11 is schematic side section view of the transition housing of Figure 10.

Figure 12 is a schematic isometric view of the inner wall portion and end stop of the transition housing of Figure 1.

Figure 13 is a schematic cut-away side view of the inner wall portion of Figure 12.

Figure 14 is a schematic isometric view of an alternative inner wall portion.

Figure 15 is a schematic cut-away side view of the inner wall portion of Figure 14.

Figure 16 is a schematic isometric view of an exemplary conductor furcation tube.

Figure 17 is a schematic isometric view of an exemplary fiber furcation tube.

Figure 18 is a schematic isometric partial cut-away view of a transition housing with cable and furcation tubes installed.

Figure 19 is another schematic isometric partial cut-away view of the transition housing and cabling of Figure 18.

Figure 20 is a schematic isometric view of the transition housing and cabling of Figure 18.

Figure 21 is a schematic isometric view of one end of an exemplary cable assembly with a transition housing and connector terminated furcation tubes installed

Detailed Description

The inventor has recognized that individual conductors of a hybrid electrical and optical conductor cable may be broken out into individual jumpers, without requiring termination and/or or splicing of the individual and/or groups of related conductors, by removing outer protective layers of the hybrid cable and providing protective sheaths for each of the conductors and/or conductor groups, the protective sheaths positively interlocked with the hybrid cable via a transition housing.

A typical hybrid cable, for example an FTTA cable, includes multiple metal (such as copper) conductors and single or multiple optical fibers in a subunit. A fiber subunit may include multiple optical fibers (such as 250um or 900um). In order to connect conductors and/or fibers directly to the RRH, optical fiber and power conductors are separated from the hybrid cable as individual jumpers, the jumpers protected with separate furcation tubes.

A transition housing 1, for example as shown in Figures 1-15, surrounds the transition of the hybrid cable to the furcation tubes. The transition housing 1 may be provided, for

example, as a polymer or metal material housing with a cable portion 3 (Figures 3 and 4) and a furcation portion 5 (Figures 5-7) that mate within one another to enclose a break-out area 7 (best shown in Figures 8-11). The transition housing 1 may be formed, for example, by injection molding, machining and/or insert molding.

The cable portion 3 includes a cable port 9 dimensioned to receive the hybrid cable. The cable port 9 may be dimensioned to enable the cable portion 3 to be drawn over the cable end and any shielding and/or outer jacket of the hybrid cable during installation to allow mounting the furcation portion 5 close to the end of the outer jacket. The cable portion 3 can then be drawn toward the seated furcation portion 5 for sealing of the furcation area 7. The mating between the cable and furcation portions 3, 5 may be, for example, via threads, interference and/or snap fit, or alternatively via fasteners such as screws or bolts. The cable and/or furcation portions 3, 5 may include one or more adhesive ports 11 for injecting an adhesive and/or sealant into the furcation area 7 and/or exhausting these areas as the adhesive and/or sealant is applied.

The adhesive may be an epoxy with elastomeric properties.

The furcation portion 5 includes one or more conductor ports 13 and fiber ports 15. The conductor ports 13 may be dimensioned to receive conductor furcation tubes therethrough, into the furcation area 7.

The conductor furcation tubes 27 may include, for example, an inner tube 29, a metallic shield layer 31 and outer jacket 33, for example as shown in Figure 16. Shielded conductor furcation tubes 27 are described in detail in commonly owned US Patent Application No. 13/791,248, titled “Shielded Electrical Conductor Furcation Assembly” filed 8 March 2013 by Nahid Islam, hereby incorporated by reference in its entirety. The fiber furcation tubes 35 may include, for example, an inner jacket 37, a fiber and strength layer 39 and outer jacket 33, for example as shown in Figure 17. Damage-resistant fiber furcation tubes 35 are described in detail in commonly owned US Patent Application No. 13/832,131, titled “Rugged Furcation Tube” filed 15 March 2013 by Nahid Islam, hereby incorporated by reference in its entirety. For example, each fiber furcation tube 35 may be dimensioned to receive either 900um or 250um optical fibers. Further, each fiber furcation tube 35 may include multiple inner tubes 29, within the inner jacket 37, for separate fibers and/or fiber bundles. The inner tubes 29 may be dimensioned to pass through the fiber ports 15, into the fiber area 19, as shown for example in Figure 18.

The fiber ports 15 may be dimensioned with a furcation shoulder 17 (see Figure 6) dimensioned to seat the fiber and strength layer 39 and/or outer jacket 33 of a fiber furcation tube 37, the remainder of the fiber port 15 dimensioned to pass the fiber and/or fiber bundle therethrough. Several fiber ports 15 may be grouped together with an adhesive well 20 projecting from the furcation end 18, for adhering several fiber furcation tubes 35 further to one another, to increase a pull-off resistance characteristic of each individual fiber furcation tube and/or allow an increased amount of adhesive to

be applied thereto, so that the furcation end 18 is provided with an elastomeric characteristic to protect the individual fiber furcation tubes 35 from buckling against a lip of the respective fiber ports 15.

The conductor ports 13 may also include a furcation shoulder 17 at the furcation end 18, to allow an increased amount of adhesive to be applied thereto, so that the furcation end 18 is provided with an elastomeric characteristic to increase a pull-off resistance characteristic and/or protect the conductor furcation tubes 27 from buckling against a lip of the conductor port 13.

The fibers 47 are isolated from the furcation area 7 to prevent their immobilization in adhesive injected within the furcation area 7. Thereby, the fibers 47 may be isolated from stresses generated by thermal expansion differentials that may exist between metal and/or polymeric portions of the assembly and the fibers. That is, the fibers 47 are free floating between the cable 43 and the fiber furcation tube 35.

The fiber area 19 (see Figures 8 and 9) wherein the individual fibers transition from the fiber bundle 45 of the cable 43 to their respective fiber furcation tubes 35 may be provided, for example, via an inner wall portion 24 that seats into a fiber area shoulder 21 (see Figure 7-9) of the transition end 23 of the furcation portion 5 surrounding the fiber ports 15 and is sealed against a fiber bundle 45 of the cable 43 by an end stop 25 sealing between an outer jacket of the fiber bundle 45 and the inner wall portion 24. Where the inner wall portion 24 is cylindrical, the end stop 25 may be provided as a

polymeric annular gasket or the like, seated sealing on an inner diameter against the outer jacket of the fiber bundle 45 and on an outer diameter against an inner diameter of a bore of the inner wall portion 24, as shown for example in Figures 12 and 13. Alternatively, the inner wall portion 24 may be formed with, for example, a conical reduction proximate the transition end 23, wherein the transition end 23 has an inner diameter proximate an outer diameter of the outer jacket of the fiber bundle 45, for example as best shown in Figures 14, 15 and 18. One skilled in the art will appreciate that that the fiber bundle 45 may be a fiber subunit of the cable 43 which encloses a single fiber 47 or a plurality of fibers 47.

To manufacture an assembly, for example as shown in Figures 18-21, the cable 43 has the outer jacket 33 and any shield 41 stripped back to expose desired lengths of the fiber 47, electrical conductors 49 and/or fiber bundles 45. The cable portion 3 is advanced over the conductors and over the outer jacket 33 of the cable 43 and the end stop 25 (if present) and inner wall portion 24 advanced over the fiber bundle 45. The furcation portion 5 is advanced over the conductors, each of the conductors and/or conductor bundles inserted to respective fiber and/or conductor furcation tubes 35, 27, the conductor furcation tubes 27 passed through conductor ports 13 and fiber furcation tubes 35 seated in their respective furcation shoulders 17, for example as shown in Figures 18 and 19. The metallic shield layer 31 of the conductor furcation tubes 27 may be coupled to a drain wire and/or the shield 41 of the cable 43, for example via a shield interconnection, such as a tie wire, fastener, soldering or the like. The shield interconnection and fiber area 19 (inner wall portion 24 sealed against the transition end

23 of the furcation portion 25 by seating in the fiber area shoulder 21 and closed by the end stop 24) are enclosed by returning the cable portion 3 towards the furcation portion 5 and coupling them together (see Figure 19).

The furcation area 7 may then be sealed/encapsulated by injecting a desired adhesive (also known as a sealant or caulk) into the adhesive port(s) 11 of the cable and/or furcation portions 3, 5, until the adhesive is observed, for example, at the cable port 9 and/or conductor ports 13. Further adhesive may be applied to seal the fiber furcation tubes 35 into the furcation shoulders 17 of the fiber ports 15 and the fiber furcation tubes 35 to one another within the adhesive well 20 of the furcation portion 5. Splaying a fiber portion of the fiber and strength layer 39 so that it extends within the furcation shoulder 17 and/or further into the adhesive well 20 (see Figure 30) provides secure retention of the fiber furcation tubes to the furcation portion 5 and thereby to the assembly.

The transition housing 1, individual conductor ports 13 and/or the adhesive well 20 may be further sealed by applying shrink tube or pultruded seals therearound.

The assembly may be further completed by applying desired connectors to each of the conductors at the end of their respective furcation tubes, as best in Figure 21.

A grounding lug may be applied to the transition housing and/or a grounding lead may be routed from the junction of the cable shield/drain wire and conductor furcation tube

shields to the sidewall of the assembly (if conductive) or in a sealed fashion to an exterior of the assembly to provide a ready grounding point for the cable assembly.

In a further embodiment, the inner wall portion 24 may be provided including the fiber port(s) 15 at the furcation end 18. Thereby, the furcation portion 5 may be simplified to require only a corresponding fiber area shoulder 21 to receive the inner wall portion 24, and a much larger port to surround and communicate the fiber ports 15 of the inner wall portion 24, to the adhesive well 20. Thereby, the manufacture of the furcation portion 5 is simplified by transferring the formation of these several small holes to a much smaller overall element, the inner wall portion 24, where the overall scale of the element is closer to that of the dimensions of the fiber port(s) 15, simplifying the corresponding mold and/or machining requirements.

One skilled in the art will appreciate that the assembly provides a splice-free cable conductor distribution with significant pull-apart strength and improved environmental sealing in an assembly with minimal dimensions that eliminates the need for distribution boxes and/or on-site conductor termination during installation. Further, because the fibers 47 and/or electrical conductors 49 may lay freely within their respective inner tubes 29 from the transition housing 1 to the connector 51, the fibers 47 and/or electrical conductors 49 are free of thermal expansion and or tensile stress that may be applied to their respective fiber and conductor furcation tubes 35, 27.

Table of Parts

1	transition housing
3	cable portion
5	furcation portion
7	furcation area
9	cable port
11	adhesive port
13	conductor port
15	fiber port
17	furcation shoulder
18	furcation end
19	fiber area
20	adhesive well
21	fiber area shoulder
23	transition end
24	inner wall portion
25	end stop
27	conductor furcation tube
29	inner tube
31	metallic shield layer
33	outer jacket
35	fiber furcation tube
37	inner jacket

39	fiber and strength layer
41	shield
43	cable
45	fiber bundle
47	fiber
49	electrical conductor
51	connector

Where in the foregoing description reference has been made to materials, ratios, integers or components having known equivalents then such equivalents are herein incorporated as if individually set forth.

While the present invention has been illustrated by the description of the embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details, representative apparatus, methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departure from the spirit or scope of applicant's general inventive concept. Further, it is to be appreciated that improvements and/or modifications may be made thereto without departing from the scope or spirit of the present invention as defined by the following claims.

Claims

I claim:

1. A cable breakout kit, comprising:

a cable portion;

a furcation portion with at least one fiber port; and

an inner wall portion;

the cable portion and the furcation portion dimensioned to couple with one another, enclosing a furcation area;

the inner wall portion coupled to the furcation portion and a fiber bundle of the cable, enclosing a fiber area within the furcation area; the fiber area coupled to the at least one fiber port.

2. The cable breakout kit of claim 1, wherein the inner wall portion couples with the fiber bundle via an end stop seated on an outer diameter of the fiber bundle, the inner wall portion seating against an outer diameter of the end stop.

3. The cable breakout kit of claim 1, wherein the inner wall portion is dimensioned to seat against an outer diameter of the fiber bundle.

4. The cable breakout kit of claim 1, further including at least one fiber furcation tube and at least one conductor furcation tube.

5. The cable breakout kit of claim 4, wherein the at least one conductor furcation tube includes a metallic shield layer.

6. The cable breakout kit of claim 1, further including an adhesive well projecting from a furcation end, surrounding the at least one fiber port.

7. The cable breakout kit of claim 6, wherein the adhesive well surrounds a plurality of the fiber ports.

8. The cable breakout kit of claim 1, further including a furcation shoulder at a furcation end of the at least one fiber port; the furcation shoulder dimensioned to receive a fiber and strength layer of a fiber furcation tube.

9. The cable breakout kit of claim 1, wherein the at least one fiber port is dimensioned to receive an inner tube of a fiber furcation tube into the fiber area.

10. A method for furcating a cable, comprising steps of:

inserting the cable through a cable port of a cable portion;

inserting at least one fiber of the cable through an inner wall portion and a furcation portion;

inserting the fiber through a fiber furcation tube and seating the fiber furcation tube in at least one fiber port of the furcation portion;

inserting an electrical conductor of the cable through the furcation portion and a conductor furcation tube and seating the conductor furcation tube in a conductor port of the furcation portion; and

coupling the cable portion and the furcation portion to one another, enclosing a furcation area therewithin.

11. The method of claim 10, further including filling the furcation area with an adhesive.

12. The method of claim 11, wherein the furcation area is filled with the adhesive via an adhesive port through one of the cable portion and the furcation portion.

13. The method of claim 10, wherein the inner wall portion is coupled to the furcation portion and a fiber bundle of the cable, forming a fiber area isolated from the furcation area.

14. The method of claim 10, wherein a metallic shield layer of the conductor furcation tube extends into the furcation area.

15. The method of claim 10, wherein a metallic shield layer is coupled to a shield of the cable.

16. The method of claim 10, wherein there is a plurality of the fibers distributed though a plurality of the fiber ports.

17. The method of claim 15, wherein an adhesive well at a furcation end of the furcation portion surrounds the fiber ports; and the adhesive well is filled with an adhesive.

18. A furcated cable assembly, comprising

a cable with a fiber and an electrical conductor;

a transition housing coupled to the cable, a fiber furcation tube and a conductor furcation tube;

the fiber passing through the transition housing and into the fiber furcation tube;

the electrical conductor passing through the transition housing and into the conductor furcation tube;

the electrical conductor passing through a furcation area of the transition housing and the fiber passing through a fiber area of the transition housing, which is isolated from the furcation area.

19. The cable assembly of claim 18, wherein the furcation area is filled with an adhesive.

20. The cable assembly of claim 18, wherein the fiber is free floating between the cable and the fiber furcation tube.

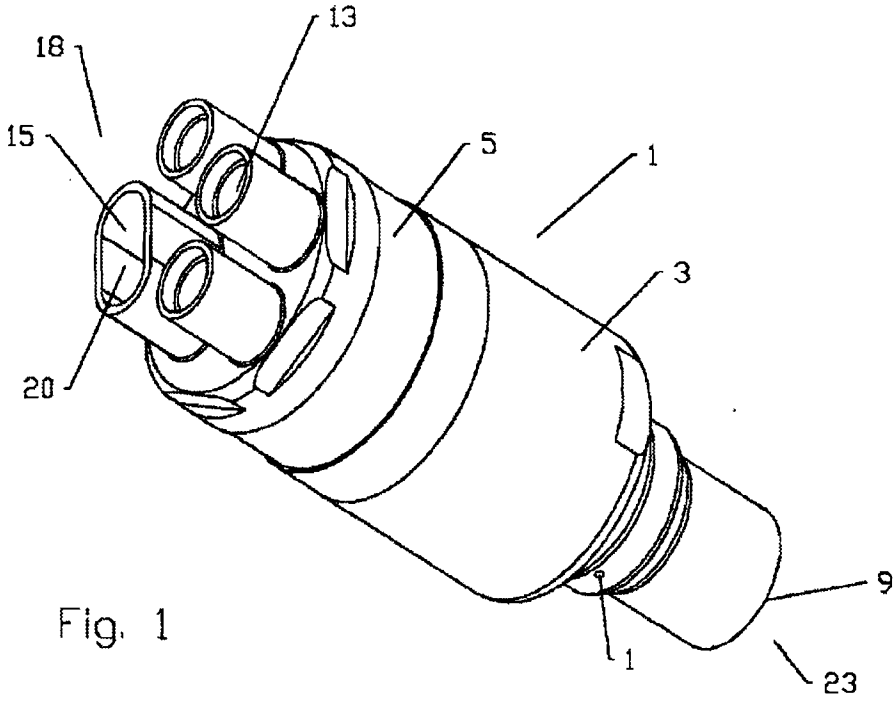

Fig. 1

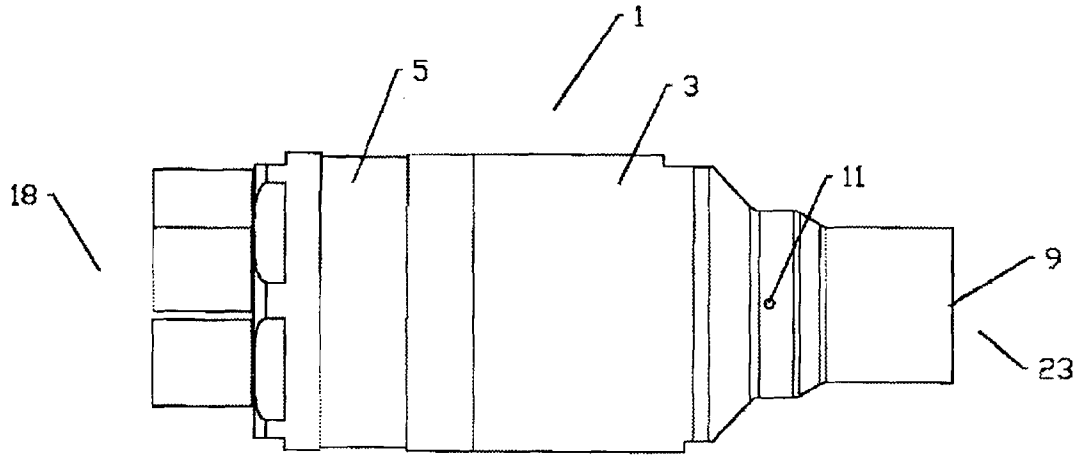

Fig. 2

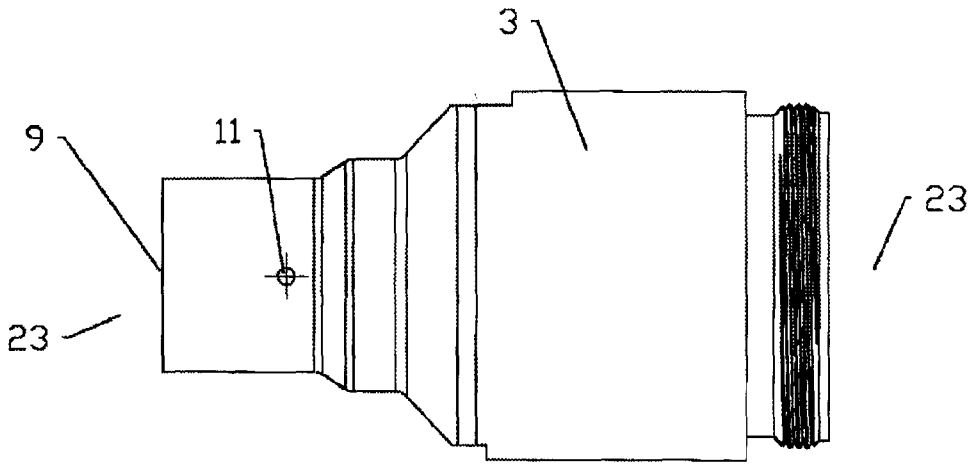

Fig. 3

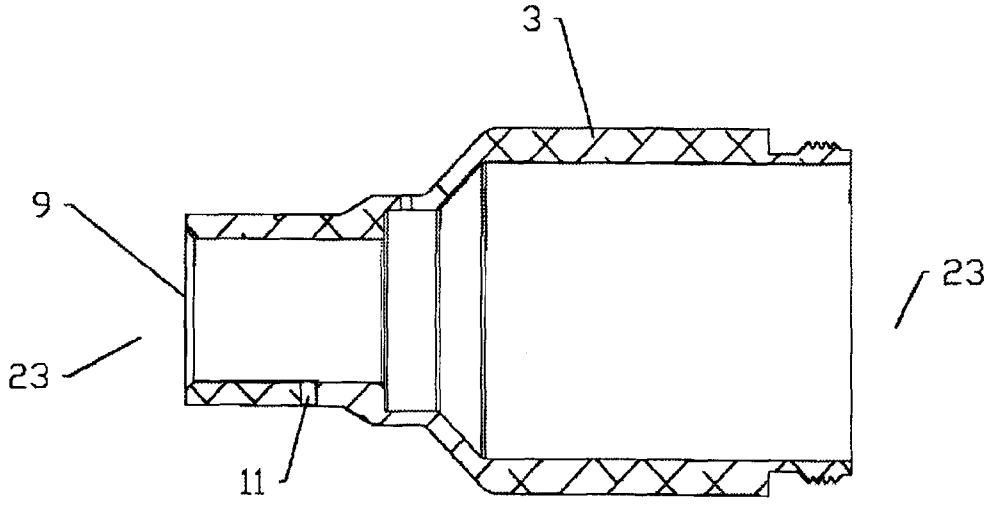

Fig. 4

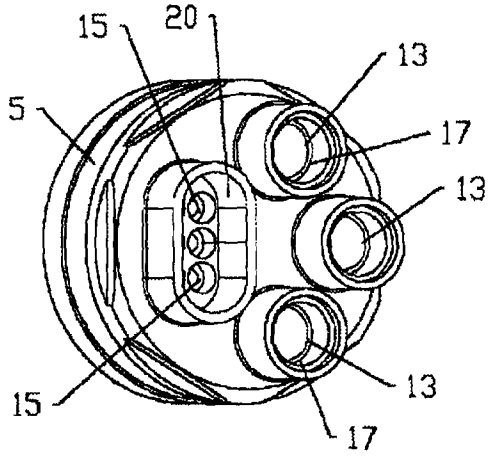

Fig. 5

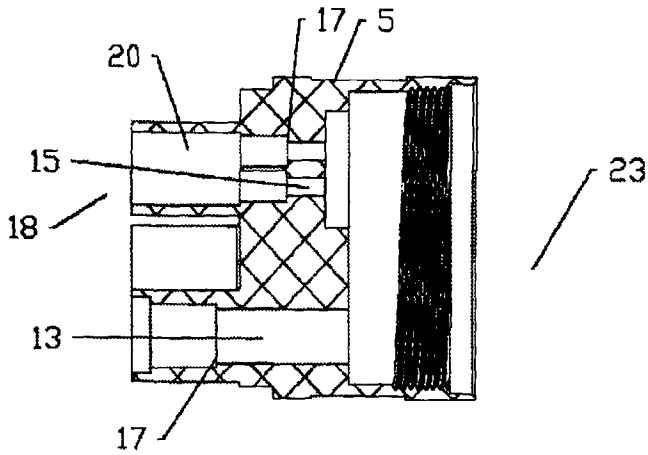

Fig. 6

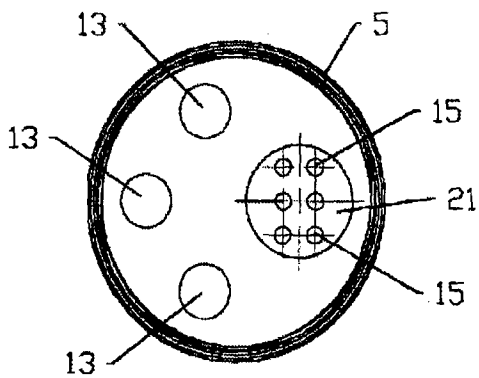

Fig. 7

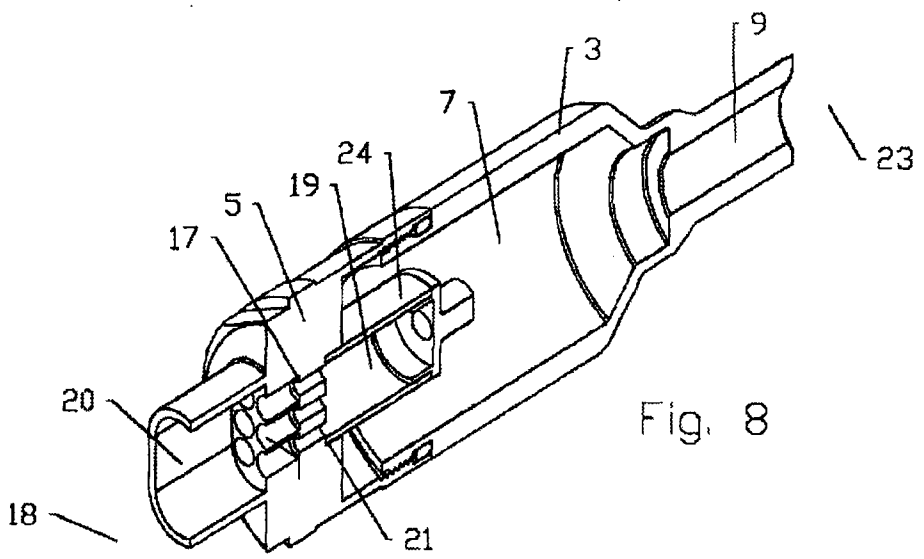

Fig. 8

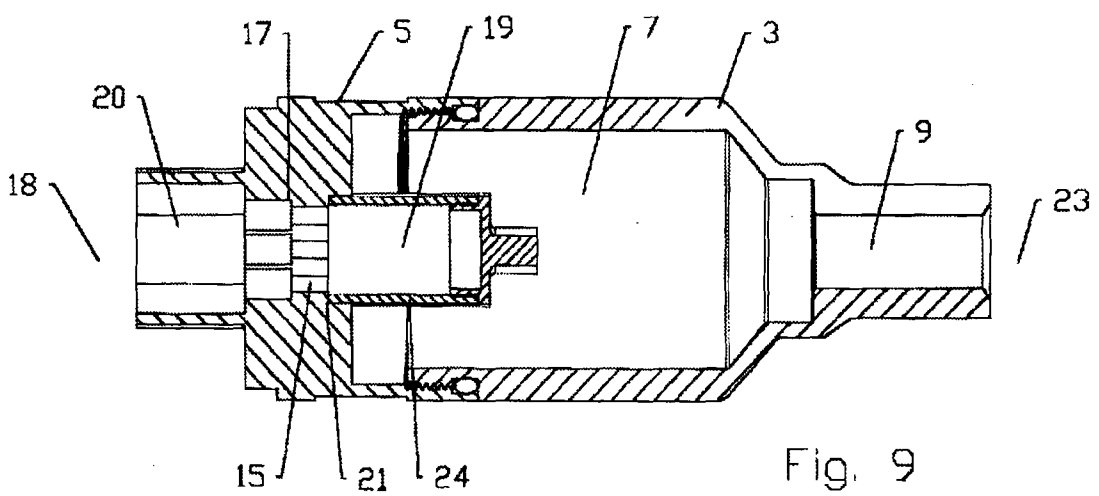

Fig. 9

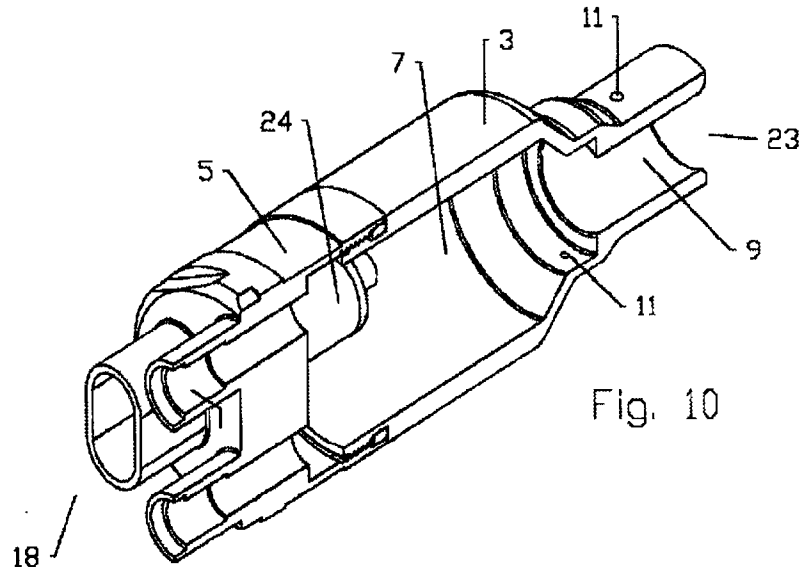

Fig. 10

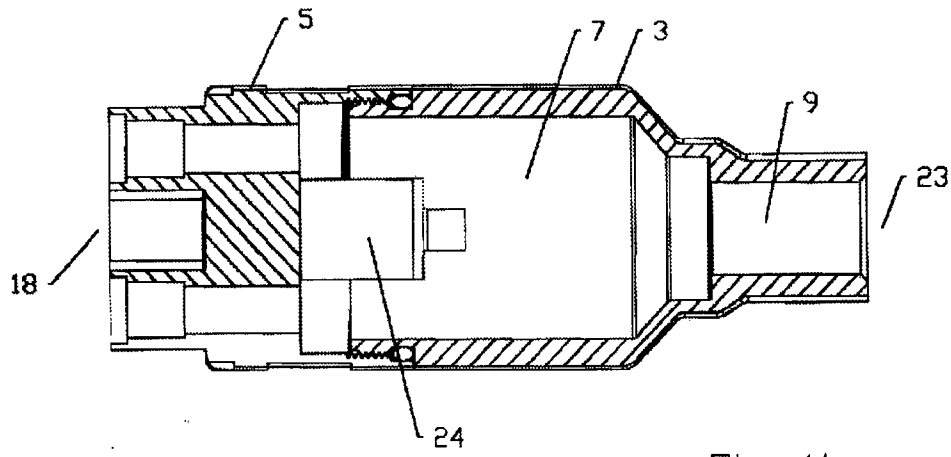

Fig. 11

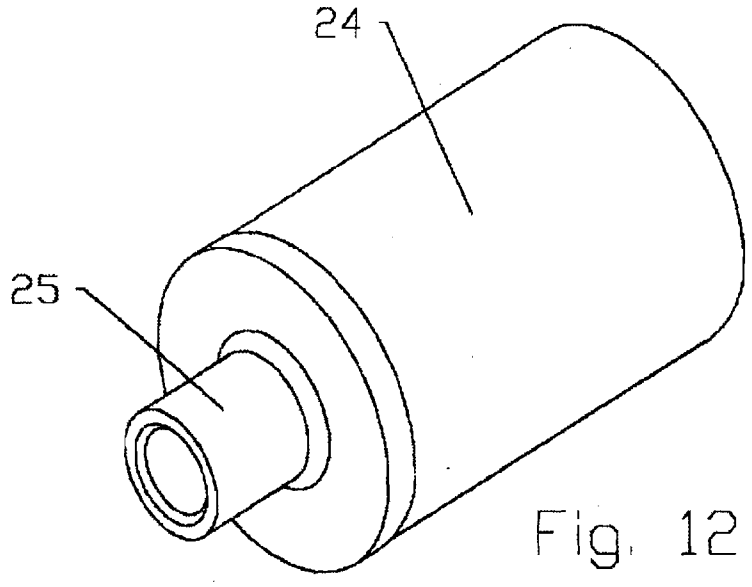

Fig. 12

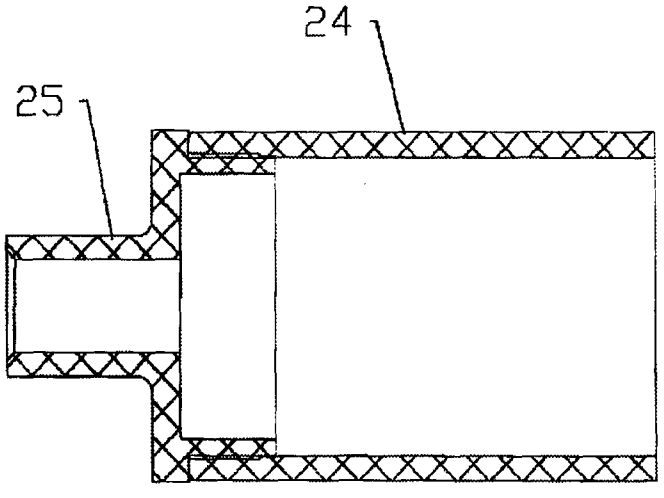

Fig. 13

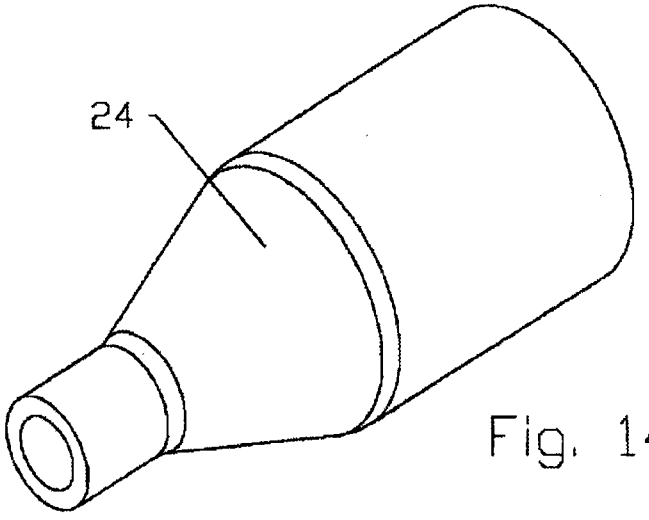

Fig. 14

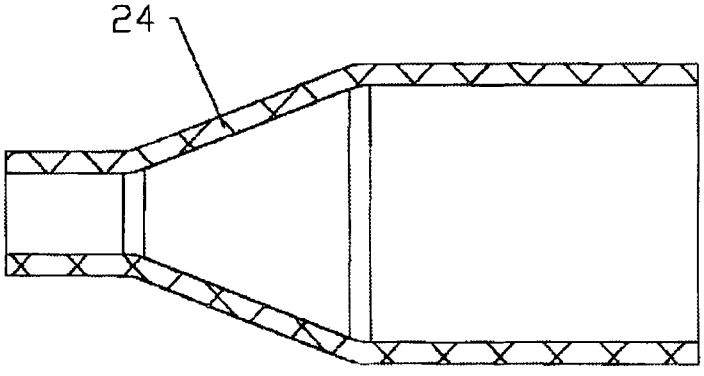

Fig. 15

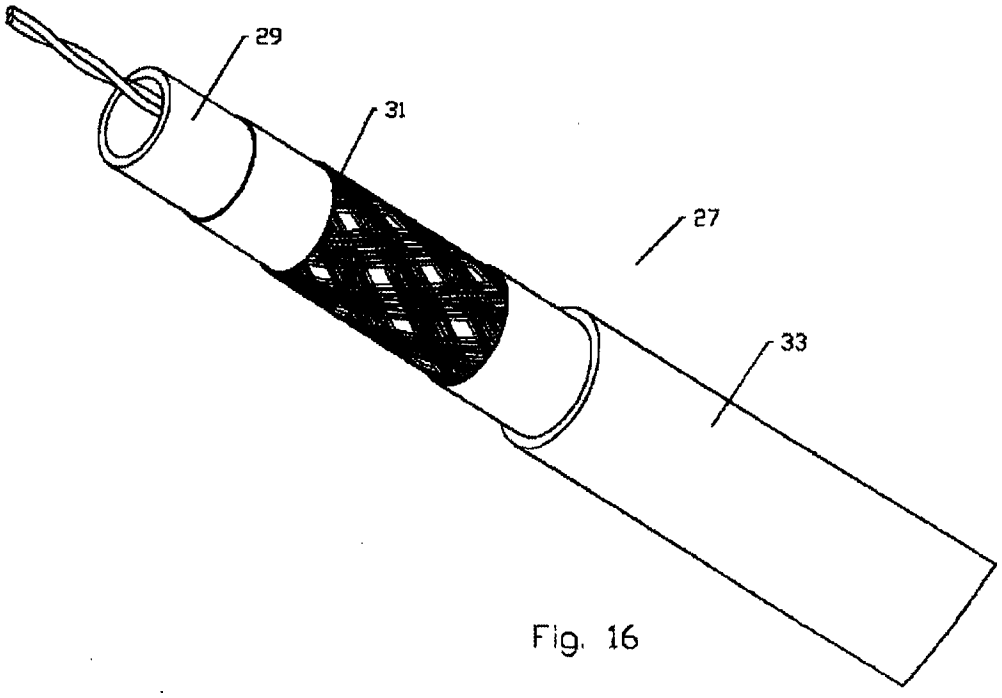

Fig. 16

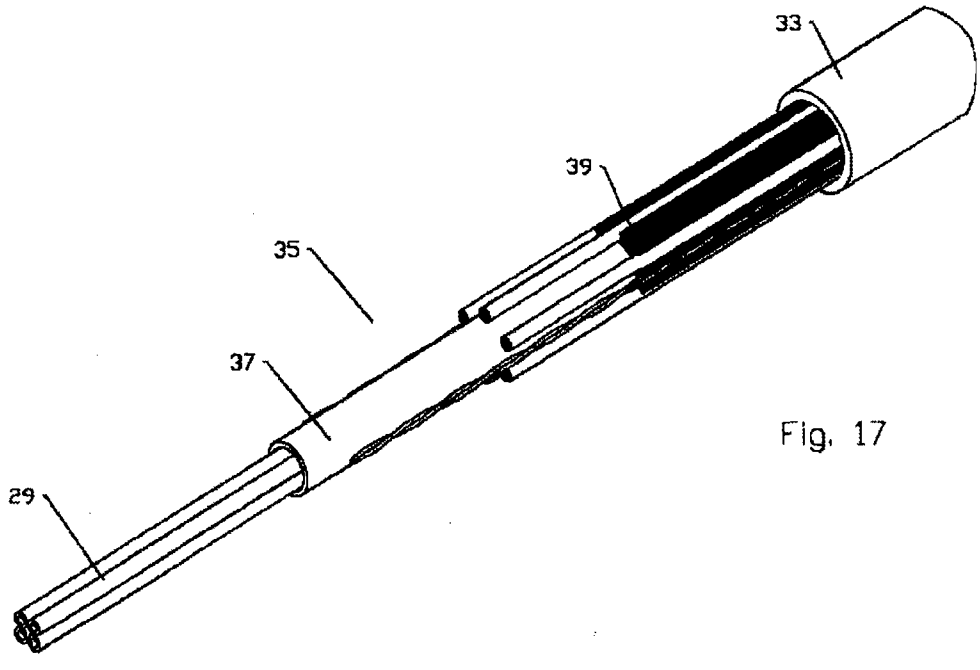

Fig. 17

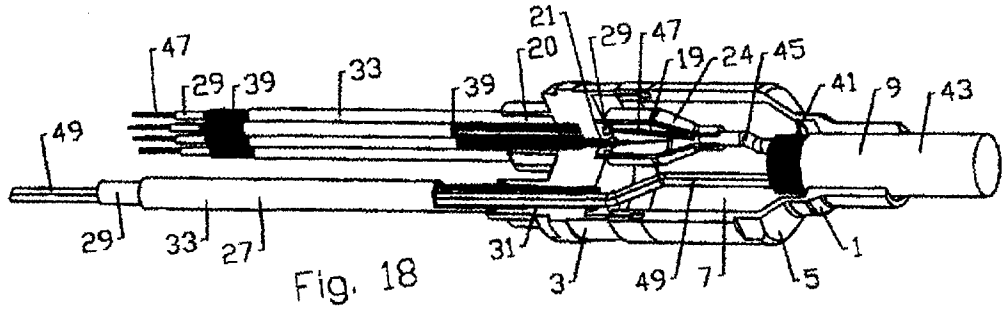
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Fig. 18

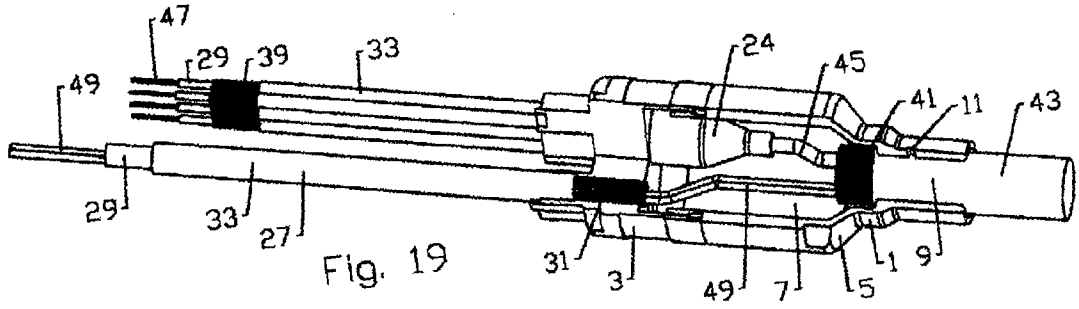
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Fig. 19

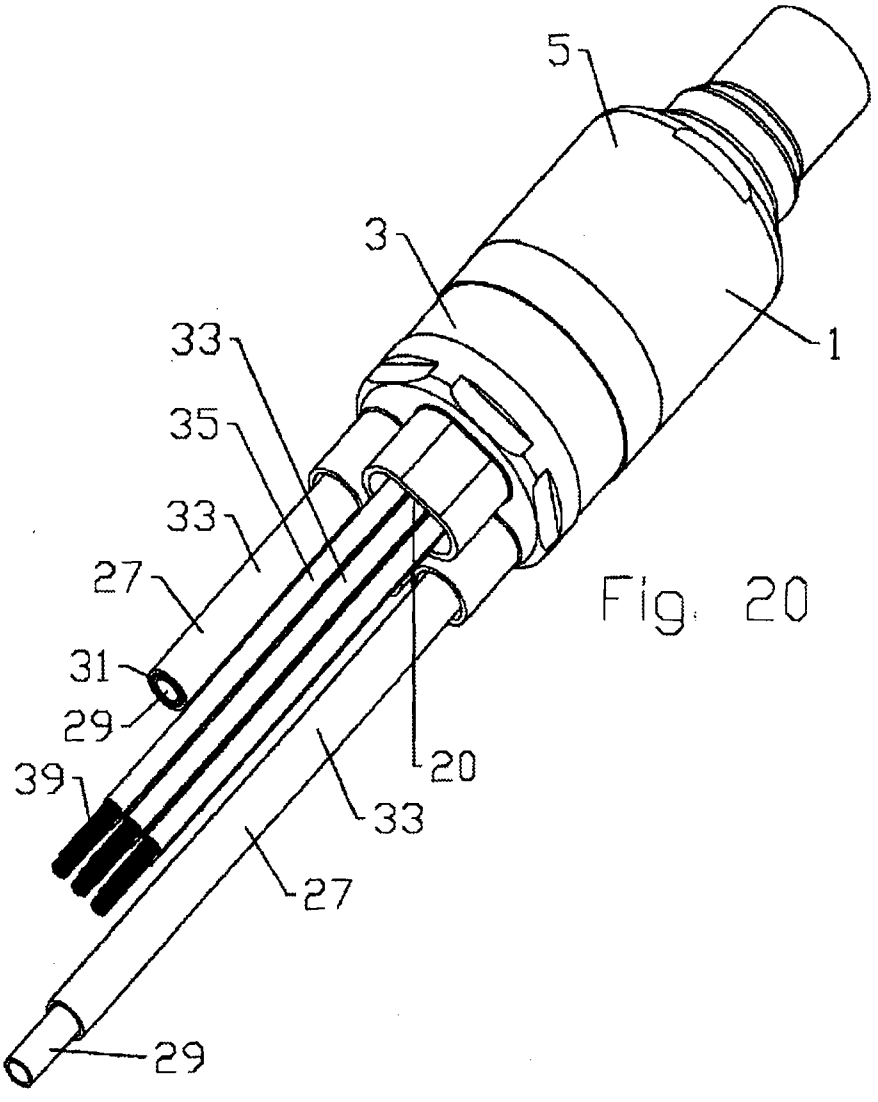

Fig. 20

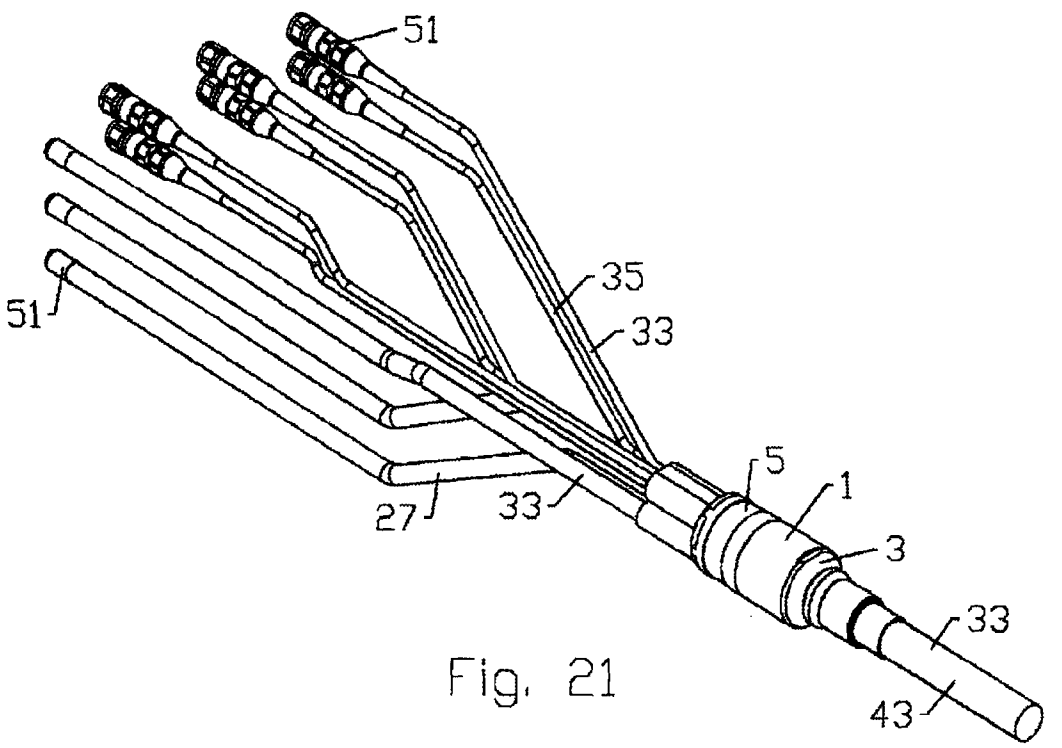

Fig. 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/061331

A. CLASSIFICATION OF SUBJECT MATTER

G02B 6/36(2006.01)i, H02G 3/02(2006.01)i

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 6/36; B05D 5/12; G02B 6/38; G02B 6/44; H02G 3/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: composite, fiber, cable

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0280527 A1 (TAMURA) 17 November 2011 See paragraphs [0018]-[0040] and figures 1-3.	1-20
Y	US 6438299 B1 (BROWN et al.) 20 August 2002 See column 3, line 16 - column 4, line 56 and figures 1-8.	1-20
A	US 2011-0033155 A1 (DAIKUHARA) 10 February 2011 See abstract, paragraphs [0020]-[0039] and figures 1-4.	1-20
A	US 2003-0210875 A1 (WAGNER et al.) 13 November 2003 See abstract, paragraphs [0017]-[0020] and figures 1-3.	1-20
A	US 2011-0091169 A1 (VAN DER MEULEN et al.) 21 April 2011 See abstract, claims 16-18, 21-30 and figures 1-7.	1-20

☐ 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
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"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	Date of mailing of the international search report
17 January 2014 (17.01.2014)	**20 January 2014 (20.01.2014)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/061331

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