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(54) Co-axial cable connector

(57) Connecting device (100) adapted for electrically connecting two or more coaxial cables together, said device being a unitary piece of non-conducting structure presenting:
- an equal number of conductor receiving areas (112) as there are cables to be connected, each conductor receiving areas adapted for mating with the conductor portion of the cable
- an equal number of shield receiving areas (116) as there are cables to be connected, each shield receiving areas adapted for mating with the shield portion of the cable

wherein all of said conductor receiving areas are connected electrically with one another, and
wherein all of said shield receiving areas are connected electrically with one another, and
wherein the conductor receiving areas are electrically isolated from said shield receiving areas.

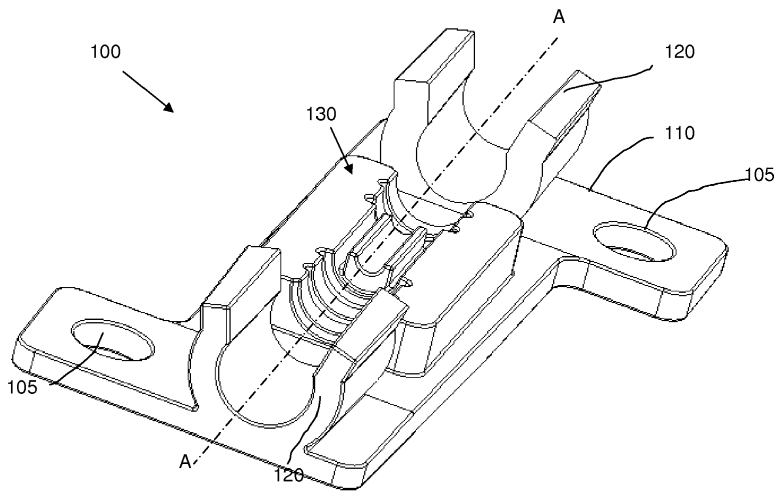

FIGURE 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to cable connectors.

BACKGROUND OF INVENTION

[0002] This section introduces aspects that may be helpful in facilitating a better understanding of the invention. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] Co-axial cables of all types are often connected or joined together coaxially. Such connections may for example be using a matching set of male and female SMA connectors. Such connectors may not be appropriate for all situations as they may be over-engineered, too expensive, and/or difficult to assemble together.

[0004] For example, feeding networks, such as used in mobile network base station antennas, typically apply coaxial cables as electromagnetic feedline and distribution systems. With the current trend for higher order multiband antennas (triple-, quadruple-, penta--, hexa-band, and more) the complexity of these feeding networks gets higher and the total number of feed lines is increasing. Standard connectors are typically applied at connection points between these coaxial cables. While these provide high performance their key disadvantage is their financial and labour cost - especially if in modern multiband antennas up to ~100 of these connections are required.

[0005] Many such connectors are also over engineered for the task, as base station antennas are typically required to handle 650-2700MHz vs 0-18GHz possible in SMA connectors. Furthermore, such situations require as few assembly parts as possible and as few specialized tools as possible, whereas SMA connectors require specialty assembly tools and up to 5 separate parts for the connecting pieces. Furthermore, few (dis)connection cycles are required, vs 500+ cycles engineered for SMA.

[0006] Though SMA connectors are highlighted hereabove, such problems are also common with other standard connector devices, such as N, 7/16, and other connector types depending on the power level transiting into the cables, the frequency band targeted, the loss at the junction, and the PIM level (passive intermodulation distortion) required.

[0007] A simpler and cheaper connector is sought, in particular one suitable for use in RF applications.

SUMMARY

[0008] In view of the foregoing, an embodiment herein provides a connector as claimed in claim 1.

[0009] Other embodiments also comprise a method as claims in claim 11.

[0010] These embodiment allow for a cost reduced connecting device :

- having good RF + PIM behaviour within a large but appropriate frequency bandwidth;
- limiting the number of necessary parts to perform the global connection. Having large number of parts to assemble means related several assembling and soldering operations which are RF + PIM risky and costly;
- integrating fixing means permitting a practical and easy fixture of the cables onto a support. Existing solutions require additional parts to fix the cables and he connector onto a mechanical support.

BRIEF DESCRIPTION OF THE FIGURES

[0011] These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings, in which:

FIG. 1 illustrates a typical co-axial cable;

FIG. 2 illustrates a connecting device according to a first embodiment;

FIG.3 illustrates a detailed view of the device of FIG 2;

FIG.4 illustrates assembled coaxial cables a device according to FIG 2;

FIG.5 illustrates a pair of assembled coaxial cables according to another embodiment;

FIG. 6 illustrates a three cable connector according yet another embodiment;

FIG. 7 illustrates a cable connector connecting different gauge cables according yet another embodiment;

FIGS 8A-8D illustrate parts for manufacturing steps for a connector according to yet another embodiment.

[0012] It is to be noted that the figures are not drawn to scale.

DETAILED DESCRIPTION OF EMBODIMENTS

[0013] The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[0014] It should be noted that the term 'antenna', though illustrative of only one application amongst many, ought to be understood as the final complete Base Station Antenna in mobile communication networks, comprising, if any, several arrays of several frequency bands, polarizations, tilt ranges etc.

[0015] Furthermore, the term 'cable' ought to be understood as a coaxial cable of any type, eg. SM141, SM250, etc. Such a cable 10 is illustrated at figure 1, and comprises a central conductor 12 (usually a solid copper, stranded copper or copper plated steel wire), surrounded by a dielectric 14. The dielectric is then surrounded by a metallic, conductive braid and/or foil known as a shield 16. Finally, the shield 16 is enclosed and protected by an isolating jacket 18. Each component of the cable 10 may be selectively exposed depending on the design need, though in a typical installation case the cable 10 will be stripped as illustrated on figure 1.

[0016] Figure 2 illustrates a connector 100 according to a first embodiment, adapted for connecting axially two co-axial cables along the axial direction A-A.

[0017] The connector 100 comprises a support structure 110 onto which are positioned two cable clip structures 120, and a connection section 130 disposed between said pair of cable clip structures 120. The cable clips 120 and the connection section 130 are longitudinally aligned along the axis A.

[0018] The connector 100 is preferably manufactured in one piece using non-conducting material, such as a plastic, for example as a result of a molding operation.

[0019] The support structure 110 may comprise fixing means 115 adapted for securing onto an antenna frame or other support element of an external device. Fixing means 105 may comprise mounting holes, unitary mounting brackets, unitary mounting clips, or other mounting fixtures, as appropriate for the mounting needs.

[0020] The cable clip structure 120 are sized at an appropriate dimension to receive and secure against the outer jacket 18 of an appropriate cable 10, in such a way as to relieve stress off the cable 10 and to stabilize the cable 10 before the joining operation.

[0021] The connection section 130 is adapted for:

- receiving and electrically connecting the conductor 12 of a first cable (not shown) to the conductor 12 of a second cable (not shown), and for
- receiving and electrically connecting the shield 16 of said first cable to the shield 16 of said second cable (not shown).

[0022] As shown in greater detail at figure 3, the connection section 130 comprises :

- a first shield receiving area 116A and a second shield receiving area 116B disposed along the central axis A on both extremity regions of the connection section 130; and
- a first conductor receiving area 112A and a second conductor receiving area 112B disposed along the central axis A in a central region of the connection section 130 between said first and second shield receiving areas 116A,B.

[0023] The first shield receiving area 116A and the second shield receiving area 116B are electrically connected to one another. The first conductor receiving area 112A and the second conductor receiving area 112B are also electrically connected to one another. The shield receiving areas 116A, B do not communicate electrically with the conductor receiving areas 112A, B.

[0024] As show at figure 3 and highlighted with dots and hachures, the mating surfaces of the receiving areas 112A, 112B, 116A, 116B are coated in an electrical conducting surface layer, e.g. a metallic layer. The metallization and respect of non-metalized areas can for example be achieved using classical plastic or polymer metallization processes, or other processes as for instance "Laser Direct Structuring", patented by LPKF Laser & Electronics AG and as perfected by Molex®. The metallization specification i.e. the process used, the metallization depth of conductive materials used are function of global performances and costs targeted. For example and without limitations, copper, tin, silver, gold, brass etc. may be used, within a thickness of some microns or tens of microns depending on frequency bands targeted (i.e. some hundreds of MHz to some GHz).

[0025] Each of the receiving areas 112A, 112B, 116A, 116B are formed as semi cylindrical concave hollows adapted for receiving the respective part of the cable 10 of the appropriate gauge. In particular,

- the first and second shield receiving areas 116A, 116B are adapted to espouse the shield portion 16 of a first and second cable 10A, 10B respectively, and are sized for the appropriate cable gauge;
- the first and second conductor receiving areas 112A, 112B are adapted to espouse the conductor portion 12 of a first and second cable 10A, 10B respectively, and are sized for the appropriate cable gauge.

[0026] The cables 10 are fixed in places by soldering the shield 16 and the conductor 12 portions of the cable 10 into place onto the metalized conducting surface layer. In a particularly advantageous embodiment, the receiving sections 112A, 112B, 116A, 116B may comprise semi-annular gutters 118 adapted for easing the flow of solder around the cable 10 portions.

[0027] Figure 4 illustrates the above embodiments with the first and second cables 10A,B securely soldered into place. The cable joining operation may be performed as followed:

- clamping the jackets 18 of the cables 10A, 10B into the clip structure 120 of the connector 100. This integrated clamping allows for a stability of the cable ends enabling to safely and quickly do the cable soldering operation.
- once the cables 10 stabilized, the conductor 12 and the shield 16 may be positioned appropriately into their respective receiving areas 112, 116, and soldered into place using conventional techniques and tools.
- advantageously, though not illustrated, the soldering operation can be followed by steps to protect the soldered area. Such protection may be performed by covered the exposed metallic areas with protection glue, gel, or foam, or by placing a heat shrink jacket around the area and the cable braid, or placing a rigid cover over the connecting device 100.

[0028] In a variant, illustrated at figure 5, it is of course possible for the support structure 110 of the connector 100 to support a plurality of pairs of clip structures 120 and connection sections 130, thereby connecting a plurality of pairs of cables on a single connector 100.

[0029] Similarly, as illustrated at figure 6, it is possible to modify the features to provide connections between three of more cables 10A,B,C. More generally, the support structure 110 may feature:

- as many clip structures 120 as there are cables 10 to be joined,
- each clip structure to be aligned with conductor receiving areas 112 and shield receiving areas 116, and
- all shield receiving areas 116 to be connected to each other electrically, and all conductor receiving areas 112 to be connected to each other electrically.

[0030] In yet another variant illustrated at figure 7, these same features can be modified to fit cables of different gauges, here SM141 and SM250 cable types. In particular, the conductor receiving area 112 and the shield receiving area 116 of the connection section can be made appropriately larger to be compatible with different gauge cables.

[0031] Nevertheless, the invention isn't limited to a specific manufacturing process, such as metalized plastics. In yet another variant, the support structure 110 of the connector 100 may be entirely molded of non conducting material (figure 8A), and metalized surfaces can be replaced by separate thin copper (or brass or other metal) foils as shown in figure 8B and figure 8C:

- a shield receiving foil 1160 (figure 8B)
- a conductor receiving foil 1120 (figure 8C).

[0032] More particularly, the metallic foils 1160, 1120 are adapted to be fitted inside the shield receiving areas 116 (figure 8B) and conductor receiving areas 112 (figure 8C), respectively, which may be positioned into place mechanically (figures 8D), for example via glue or mechanical fixation (eg. melting the four pins present at figure 8A or any other fixing device or method). Then, the inner core foil 1120 destined for the conductor receiving area 112 is placed on top of the central post, and, two cables are plugged onto the device via the clips, and soldered to the foils.

[0033] The embodiment of figure 8A-8D has the advantage of creating elements in separate processes which may be advantageous for mass manufacturing. Another advantage of this embodiment is that of providing better conductivity for high power application when metallic layer deposition onto the non-metallic surface of the connector support structure 110 may provide insufficient thickness capabilities.

[0034] In yet another embodiment, non illustrated, the metalized surface of the shield receiving area 116, corresponding to the ground potential, can also be partially extended to the support structure 110, and even underneath the support structure 110, to allow for either a capacitive coupling from the cable ground potential up to the antenna frame to be performed, as even a direct DC electrical contact if needed. This effect may be interesting for instance if the cables need to be grounded to the antenna frame, as for lightning protection or EMC cancellation effects.

[0035] Of course, it is possible to combine features from the different embodiments described hereabove.

[0036] The preceding embodiments demonstrate excellent RF performance characteristics. Typically, considering cables lengths of 50mm connected across a connector 100 such as that illustrated at figure 5 achieves:

- an insertion loss better than 0.03dB @ 3 GHz (cables losses substracted) ;
- an impedance matching better than 40 dB in the 500 MHz - 3 GHz band (50 Ohms) ;
- an insulation between adjacent cables better than 60 dB in the 500 MHz - 3 GHz band.

Claims

1. Connecting device (100) adapted for electrically connecting two or more coaxial cables together, each coaxial cable (10) comprising a central conductor and a metallic shield around said conductor, said device being a unitary piece of non-conducting structure presenting:

   - an equal number of conductor receiving areas (112) as there are cables to be connected, each conductor receiving areas adapted for mating with the conductor portion of the cable;
   - an equal number of shield receiving areas (116) as there are cables to be connected, each shield receiving areas adapted for mating with the shield portion of the cable;
   wherein all of said conductor receiving areas are connected electrically with one another, and
   wherein all of said shield receiving areas are connected electrically with one another, and
   wherein the conductor receiving areas are electrically isolated from said shield receiving areas.

2. A connecting device according to claim 1, wherein said conductor and shield receiving areas have metallic coating deposited on non-conductive structure and adapted for making electrical contact with said conductor portion and said shield portion of the cable respectively.

3. A connecting device according to claim 2, wherein there is :

   - a single connected metallic coating cover all of said conductor portions of said cables, and
   - a single connected metallic coating cover all of said shield portions of said cables

4. A connecting device according to claim 1, wherein said conductor and shield receiving areas have metallic piece fixed to said non-conductive structure and adapted for making electrical contact with said conductor portion and said shield portion of the cable respectively.

5. A connecting device according to claim 4, wherein there is :

   - a single connecting metallic piece providing electrical connection between all of said conductor portions of said cables, and
   - a single connecting metallic piece providing electrical connection between all of said shield portions of said cables.

6. A connecting device according to any one of the preceding claims, where the conductor and shield receiving areas are semi-cylindrical hollows into the structure.

7. A connecting device according to any one of the preceding claims, further comprising a cable stabilizing structure adapted for stabilizing the cable in a position aligned axially with the shield receiving portion.

8. A connecting device according to any one of the preceding claims, wherein the metallic portion of the shield receiving area extends to the underside of the connecting device adapted for being fixed to an external structure.

9. A connecting device according to claim 8, wherein the external structure is a grounded structure.

10. A connecting device according to any of the preceding claims, wherein the conductor receiving section and/or the shield receiving sections comprise annular hollows adapted for facilitating soldering of the cable portions to the respective receiving sections

11. A method of connecting two or more coaxial cables together, each coaxial cable comprising a central conductor and a metallic shield around said conductor, comprising the steps of:

   - providing a unitary piece of non-conducting structure presenting
   - an equal number of conductor receiving areas as there are cables to be connected, each conductor receiving areas adapted for mating with the conductor portion of the cable, and
   - an equal number of shield receiving areas as there are cables to be connected, each shield receiving areas adapted for mating with the shield portion of the cable
   - providing a metallic portion extending between all of said conductor receiving areas
   - providing a metallic portion extending between all of said shield receiving areas
   Inserting cables to the structure such that each conductor portion of said cable mates with a conductor receiving area, and such that each shield portion of said cable mates with a shield receiving area
   Soldering metallic portions of cable into place.

12. A method according to claim 11, wherein the metallic portions are applied by metallic deposition onto the plastic.

13. A method according to claim 11, wherein the metallic portions are applied by providing a metal foil and fixing it in the appropriate receiving areas.

14. A method according to any one of claims 11 to 13,

wherein the non-conducting structure is one piece molded of non conducting material.

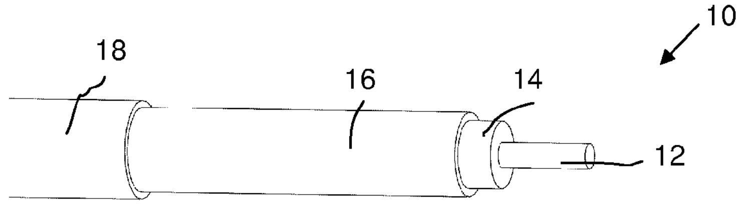

FIGURE 1

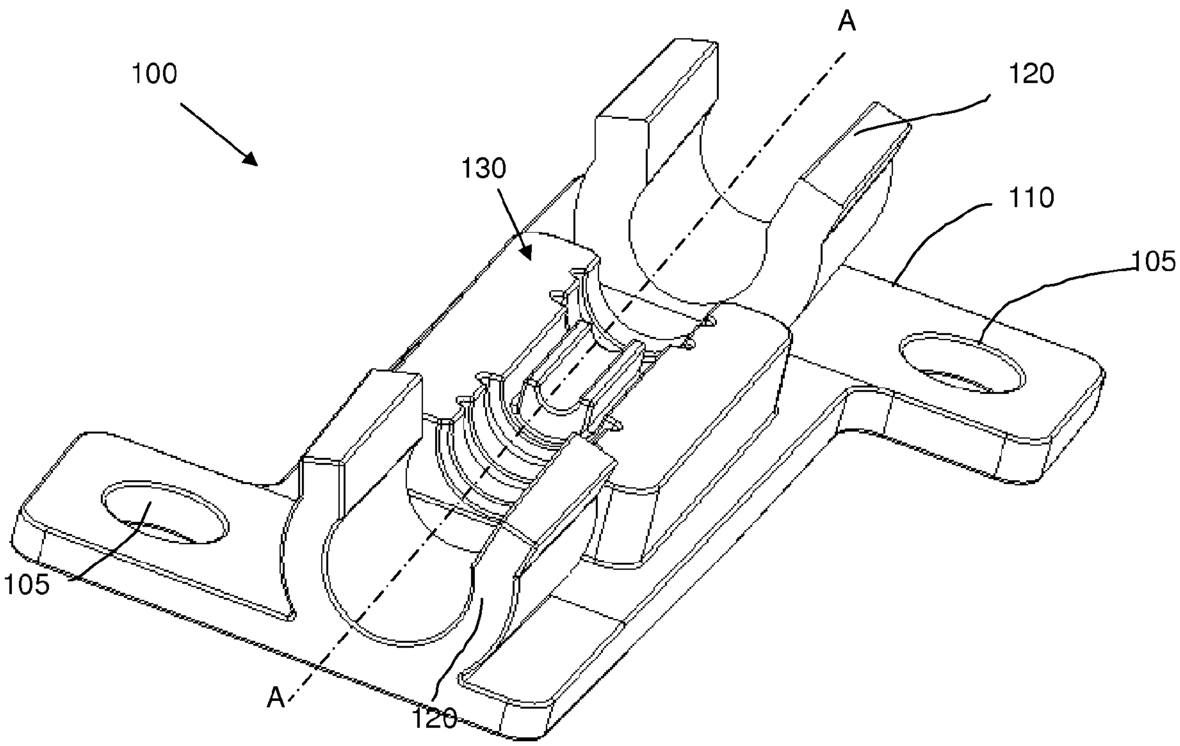

FIGURE 2

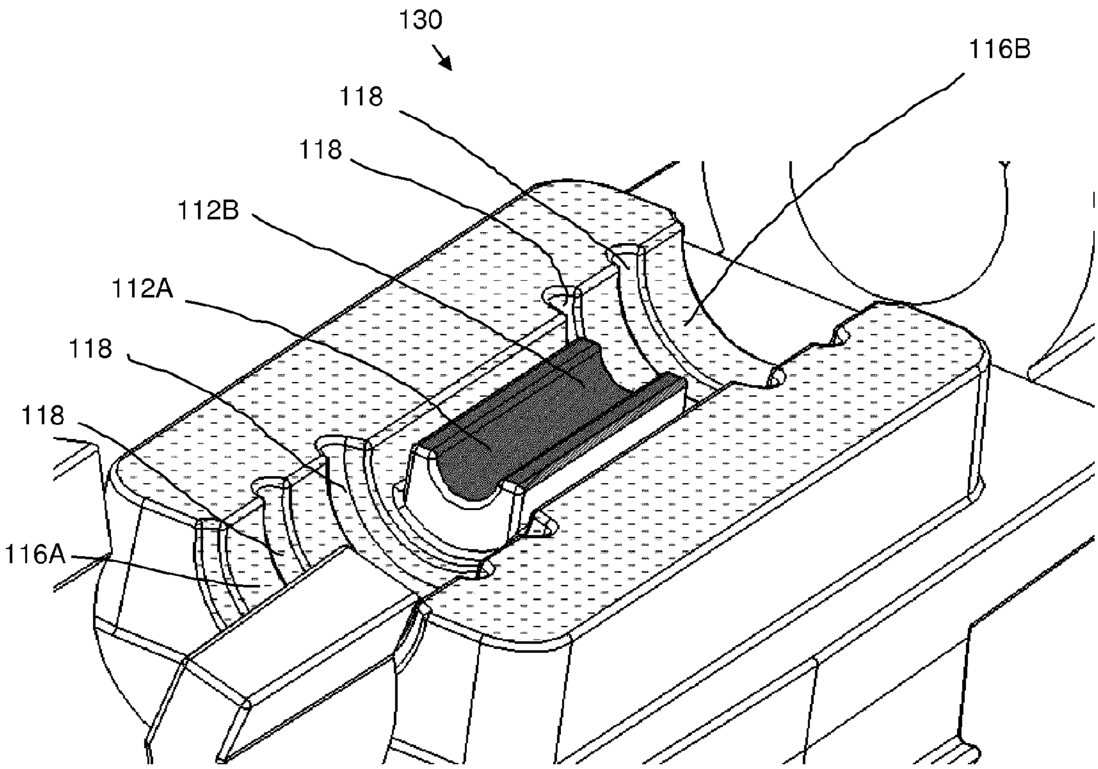

FIGURE 3

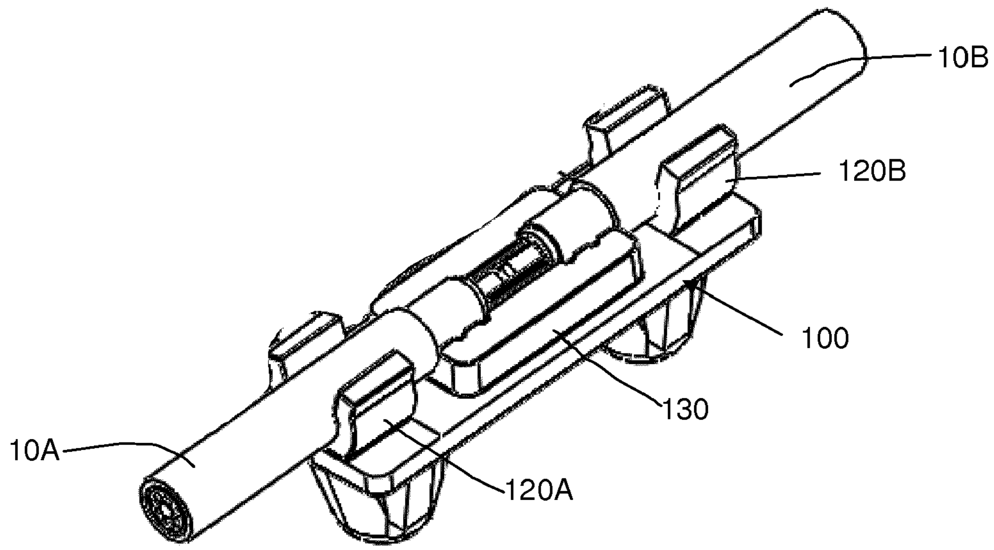

FIGURE 4

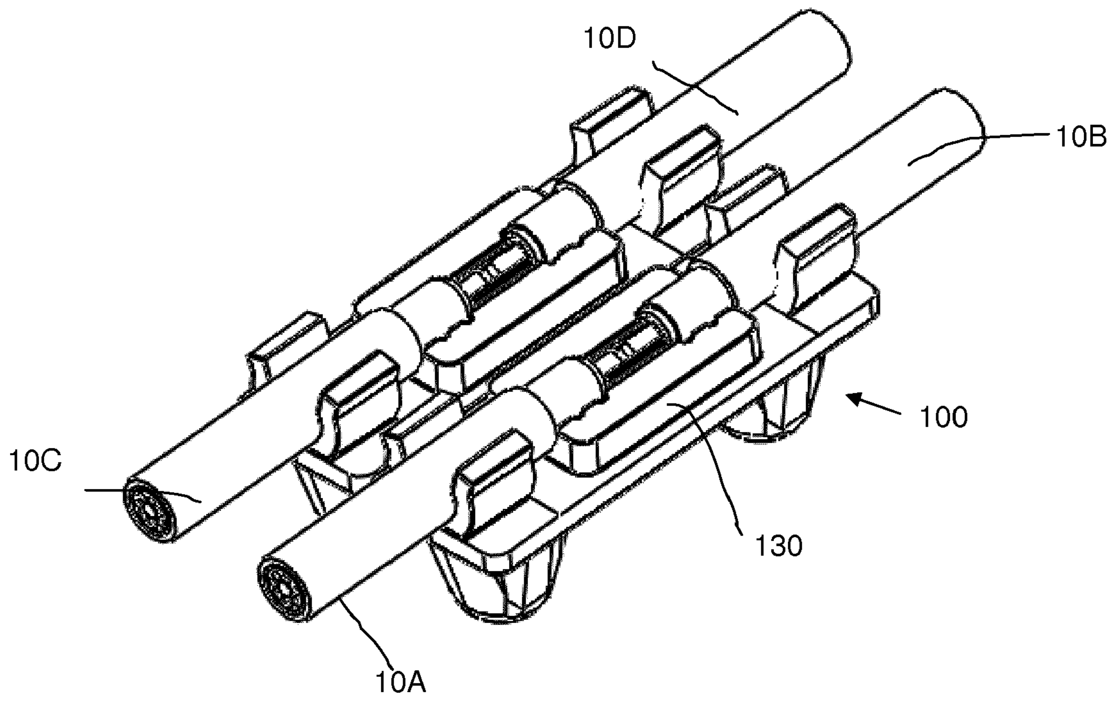

FIGURE 5

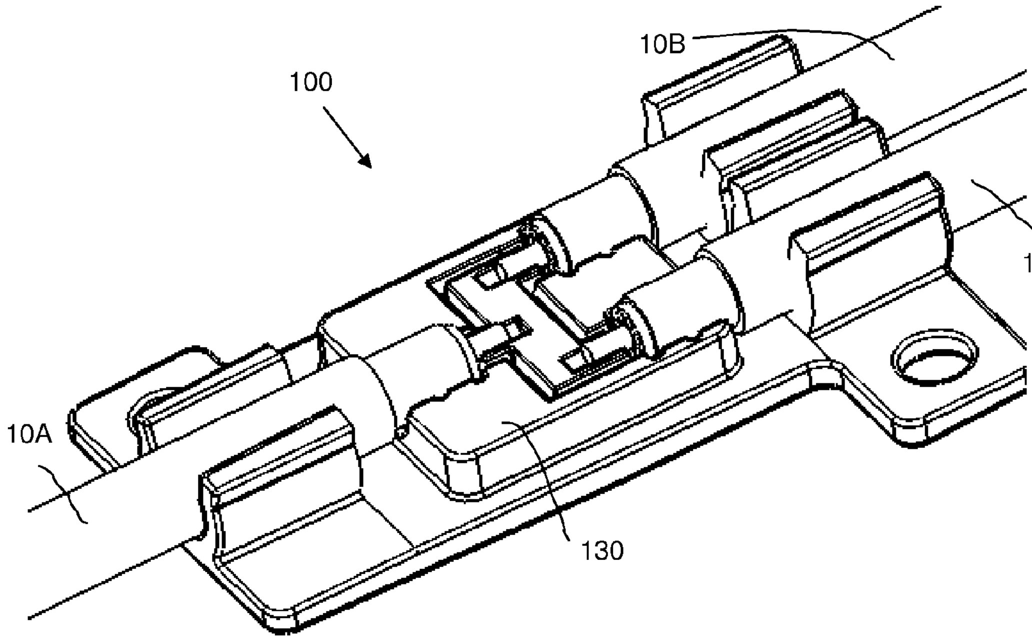

FIGURE 6

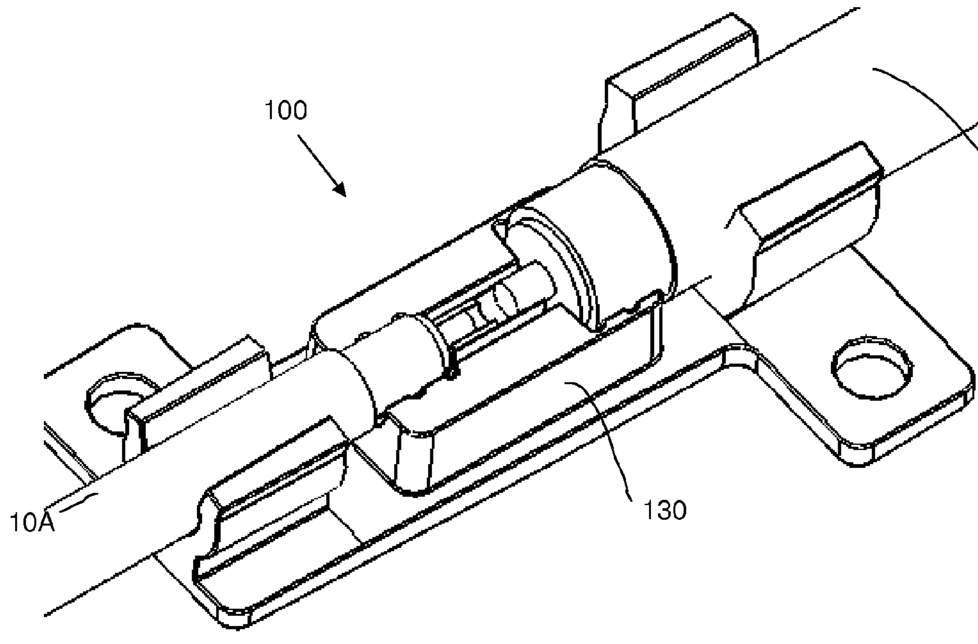

FIGURE 7

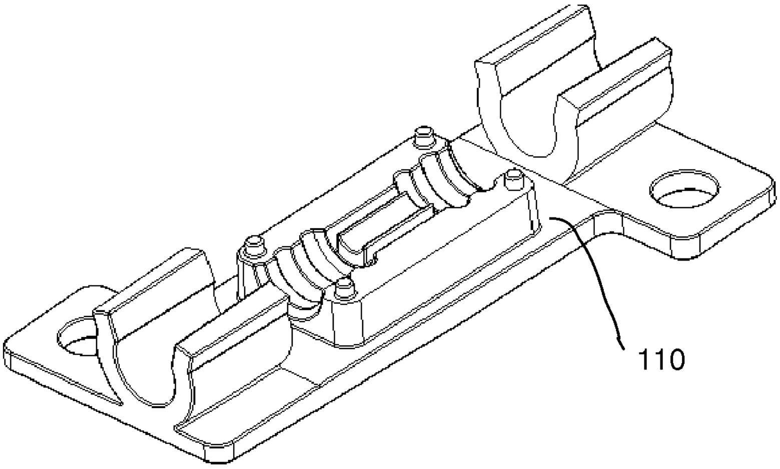

FIGURE 8A

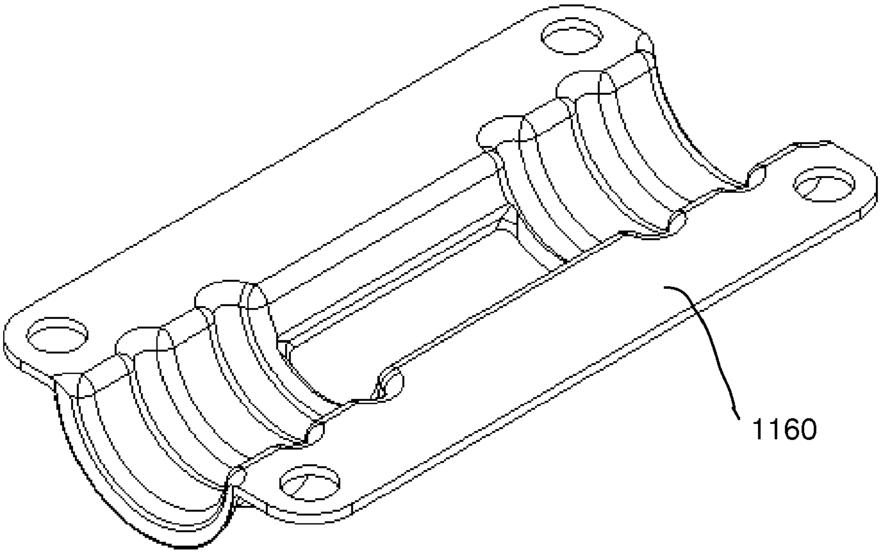

FIGURE 8B

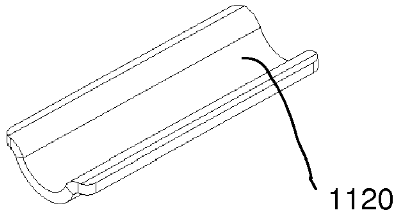

FIGURE 8C

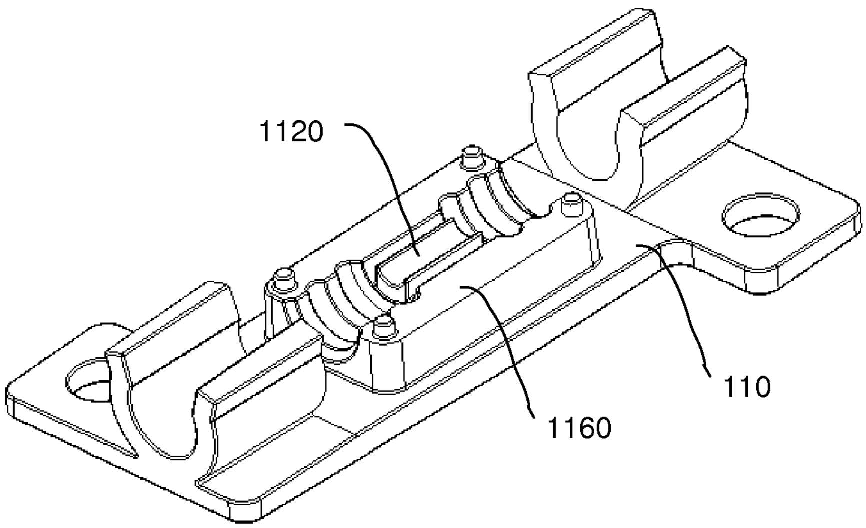

FIGURE 8D

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EUROPEAN SEARCH REPORT

Application Number
EP 14 30 6050

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	WO 2011/127864 A2 (HUAWEI TECH CO LTD [CN]; LUO YINGTAO [CN]; XIAO WEIHONG [CN]) 20 October 2011 (2011-10-20) * the whole document *	1-5,7-14 6	INV. H01R9/05
X	GB 2 319 675 A (WHITAKER CORP [US]) 27 May 1998 (1998-05-27) * the whole document *	1,3-9, 11,13,14	
Y	US 2009/151993 A1 (YAGHMAI ROYA [US] ET AL) 18 June 2009 (2009-06-18) * abstract; figures 4-8 *	6	
A	US 3 151 211 A (REID GILBERT R ET AL) 29 September 1964 (1964-09-29) * the whole document *	1,11	

TECHNICAL FIELDS SEARCHED (IPC)

H01R

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	9 September 2014	Tille, Daniel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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09-09-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011127864 A2	20-10-2011	CN 102204016 A	28-09-2011
		WO 2011127864 A2	20-10-2011
GB 2319675 A	27-05-1998	DE 19752226 A1	28-05-1998
		GB 2319675 A	27-05-1998
		US 5919059 A	06-07-1999
US 2009151993 A1	18-06-2009	US 2009151993 A1	18-06-2009
		US 2009176406 A1	09-07-2009
		US 2009258538 A1	15-10-2009
US 3151211 A	29-09-1964	CH 418425 A	15-08-1966
		DE 1490308 A1	16-01-1969
		GB 1013499 A	15-12-1965
		US 3151211 A	29-09-1964

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