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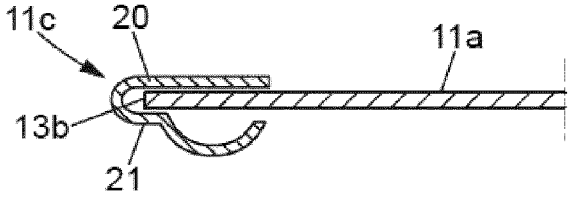
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FIG. 7




(57) Abstract: The present invention relates to an electrical connector comprising : - at least one housing, and - the shield comprising at least one shield plate (11a) made of electrically conducting material. The electrical connector comprises a contact piece (11c), made of an electrically conducting material, comprising a strip and a plurality of wings, the strip being attached along the front end (13b) of the shield plate (11a).

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# ELECTRICAL CONNECTOR, ASSEMBLY OF SUCH ELECTRICAL CONNECTOR AND ITS METHOD OF MANUFACTURE.

The present invention relates to electrical connectors, assemblies of such electrical connectors and their method of manufacture.

Due to the electricity passing through wires held in an electrical connector, such electrical connector generates and is sensitive to electromagnetic radiations. One strives to improve the electromagnetic compliance of the electrical connector by providing them with a shield.

For example, an electrical connector comprising:

- an electrically insulating housing, comprising at least one receptacle to receive an electrical contact and defining an interface region extending along a longitudinal axis, and
- an electromagnetic shield fixed to the housing and surrounding at least the receptacle.

is already disclosed in the document WO 2012/056,325.

Nevertheless, the electromagnetic compliance of such electrical connector always needs to be improved.

To this aim, it is provided a shield comprising a main part and a contact piece.

The main part is made of at least one shield plate, made of electrically conducting material. It comprises a substantially cylindrical portion extending along a longitudinal axis from a rear end to a front end.

The contact piece is, preferably, a formable contact piece and is made of an electrically conducting material. It

comprises a strip attached to the front end of the shield. The contact piece also comprises a plurality of wings, extending from the strip along the longitudinal axis.

This therefore separates two functions of the shield. As usual, the shield is rigid for assembly with the housing, whereby mechanical stress encountered by the connector during assembly and/or use can be withstood. However, the contact piece does not need to be made of such a strong material. Therefore, using a formable material enables to tailor it for shielding requirements only.

In some embodiments, one might also use one or more of the features as defined in the claims.

Of course, different features, alternatives and/or embodiments of the present invention can be combined with each other in various arrangement to the extent that they are not incompatible or mutually exclusive of others.

The present invention will be better understood and other features and advantages will become apparent upon reading the following detailed description including embodiments for illustrative purposes with reference to the figures, presented as non-limitative examples, which can be used to complete the understanding of the present invention and the description and, where appropriate, contribute to its definition, in which:

- Figure 1 is a perspective view of a connection assembly according to the present invention,
- Figure 2 is a perspective exploded view of a part of a connector of Figure 1,
- Figure 3 is a sectional view along line III-III on Figure 2,
- Figure 4 is a perspective view of a part of a

shield of the connector of Figure 2,

- Figure 5 is a perspective view of an example of a ring for the shield of Figure 4,
- Figures 6 to 8 are sectional views, along line VI-VI on Figure 5, respectively, of the ring, of the shield and the ring, and of the shield assembly,
- Figure 9 is a perspective view of an embodiment of a part of a comparative connector, and
- Figure 10 is a graph showing the result of a comparative test between the embodiment of Figure 2 and that of Figure 9.

It should be noted that, on figures, structural and/or functional elements which are common to different embodiments may have the same reference sign. Thus, unless otherwise stated, these elements have structural, dimensional and material properties which are identical.

Figure 1 schematically shows a connection assembly 1 comprising a first connector 2 and a second connector 3. The first connector 2 and the second connector 3 are complementary in that they are suitable to be mated with one another.

The first connector 2 and the second connector 3 each comprise electrical contacts, which are to be mated with the electrical contacts of the other connector and a housing, in which electrical contacts are arranged.

For example, the first connector 2 can be provided at the end of an electrical cable 4 provided with at least one wire 5, and alternatively with a plurality of wires 5. The cable 4 can be connected, at the other end, with another electrical appliance.

The second connector 3 can be electrically connected to another electrical appliance, not currently shown. It can for example be fastened, screwed to this not shown electrical appliance.

The second connector 3 can be provided as an inner housing 6 in which electrical contacts 7 are arranged. A shield 8 is provided, which surrounds the inner housing 6.

The second connector 3 can be provided with an outer housing 9 which surrounds the shield 8. The outer housing 9 can provide additional functions, such as attachment to the electrical appliance, lock on the first connector 2, … .

In addition, the inner housing 6 comprises at least one receptacle to receive electrical contacts 7 and defining an interface region extending along a longitudinal axis.

Since the receptacle extends from a first end to a second end, at which ends the electrical contacts 7 are interfaced with other conducting parts, it is understood that the term "surround" designates the fact that the shield 8 extends from an first open end to an second open end, and peripherally envelops the electrical contact 7 around a path from the first end to the second end.

Therefore, at one of the ends, the shield 8 may have a substantially cylindrical portion 8d about an interface direction and surrounding the receptacle.

The shield 8 is provided in an electrically conductive material, whereas the inner housing 6 and the outer housing 9 are provided in electrically insulating material.

The shield 8 extends from a rear end 8a, where the shield 8

can be placed in electrical communication with a shield of the electrical appliance, and an front end 8b, which opposite to the rear end 8a.

Similarly, the first connector 2 comprises an inner housing 10 in which electrical contacts are arranged at the end of the wires 5. A shield 11 is provided, which surrounds the inner housing 10.

The second connector 3 can be provided with an outer housing 12 which surrounds the shield 11.

The shield 8 of the second connector 3 and the shield 11 of first connector 2 are to be placed in contact when the first connector 2 and the second connector 3 are properly mated with one another.

The shield 11 of the first connector 2 is also an electrically conducting material. The inner housing 10 and the outer housing 12 are made of an insulating material.

In addition, the inner housing 10 comprises at least one receptacle 25 to receive electrical contacts and defining an interface region extending along a longitudinal axis Z. Consequently, the shield 11 surrounds the receptacle 25. For example, the inner housing 10 has two receptacles 25.

Referring now to Figure 2, the longitudinal direction Z, or mating direction Z, therefore defining a longitudinal axis Z, is indicated as the direction along which the first connector 2 is mated to the second connector 3. A direction X, or transversal direction X, and a direction Y are provided in a plane normal to the longitudinal direction Z.

For example, in the present example, the direction X is the

direction along which the two receptacles 25 are offset. However, the invention could be implemented with any number of contact receptacles, for example one receptacle and any arrangement thereof.

As can be seen on Figure 2, the shield 11 of the first connector 2 is provided with at least two shield plates 11a, 11b, preferably two rigid shield plates 11a, 11b, provided on either side of the inner housing 10. Preferably, the shield plates 11a, 11b are similar, so that the shield plate 11a only will be described in details below.

The shield plate 11a is provided from a thin metal sheet which extends along the longitudinal axis Z from a rear end 13a to a front end 13b. As can be seen, the front end 13b extends sensibly straight along the peripheral direction, surrounding the longitudinal axis Z.

The shield plate 11a further comprises lateral wings 14a, 14b, which will overlay lateral wings 14a, 14b of the shield plate 11b for an electrical connection between the two shield plates 11a, 11b. Alternatively, this part could be provided from one or more shield plates.

Assembly system is provided to assemble the shield plates 11a, 11b to the inner housing 10. The shield plates 11a, 11b are provided each with slots 15, which are shaped to receive corresponding protruding fingers 16, protruding from a main body of the inner housing 10. This system is exemplary only.

The outer housing 12 can be locked to the inner housing 10 by any suitable means. For example, it may comprise flexible tongues, not visible, which will cooperate with

some of the fingers 16 to retain the outer housing 12 on the inner housing 10, with the shield plates 11a, 11b which interposed there between.

Referring now to Figure 5, the shield 11 of the first connector 2 is also provided with a contact piece 11c, preferably a formable contact piece 11c.

The contact piece 11c is made of an electrically conductive material. Advantageously, the contact piece 11c is more formable than the material of the shield plates 11a, 11b. For example, whereas the shield plate 11a can be provided from tin plated copper alloy $CuFe_2P$ with a thickness of 0.3 mm, the contact piece 11c can be provided from beryllium copper (CuBe2), stainless steel, cupro-silicone, cupro-nickel,… .

Generally speaking, materials of the contact piece 11c and/or of the shield plates 11a, 11b can be characterized by the following properties:

- An elasticity modulous (Young modulous) between 100 and 250 GPa, more preferably between 120 and 160 GPa or alternatively, preferably between 200 and 205 GPa, and/or
- an electrical conductivity (%IACS) between 20 and 30, particularly between 22 and 25.

Such materials have many advantages, as will be described below.

According to a particular embodiment, the contact piece 11c is provided as a single unitary part comprising a strip 17 and a plurality of individual wings 18 extending from the strip 17.

The strip 17 extends along a peripheral direction about the longitudinal axis Z and can be easily shaped to match with the shape of the front end 13b of the shield plates 11a, 11b.

The wings 18 are similar to one another and extend from the strip 17 along the longitudinal direction Z.

As can be seen in particular on Figure 6, the wing 18 is sensibly U-shaped, having a base 19 which links together a first leg 20 and a second leg 21. Preferably, the first leg 20 and the second leg 21 are sensibly parallel to one another.

The first leg 20 extends from the strip 17 to the base 19 along the longitudinal direction Z. The second leg 21 extends from the base 19 along an opposite direction to the longitudinal direction Z, toward the rear end 17a of the strip 17.

The second leg 21 can further comprise a protrusion 22 which protrudes radially inward, in the present example, and comprises a free end 23 of the wing 18.

The pitch P by which two adjacent wings 18 are separated along the peripheral direction is quite small, for example, equal to 0.5 mm, for a material of thickness 0.1 mm.

Hence, the pitch P between two adjacent wings along the peripheral direction can be as small as five times the material thickness. The formability of the above materials enables to provide such packed wings 18.

As can be seen on Figure 7, the shield plate 11a is assembled in any suitable way onto the contact piece 11c.

For example, the strip 17 is wrapped around the front end 13b of the shield plates 11a, 11b.

In such way, the front cylindrical portion of the shield plates 11a, 11b is held between the first leg 20 and the second leg 21 of the piece contact 11c.

In the case of a plurality of shield plates 11a, 11b, the strip 17 also helps maintaining the shield plates 11a, 11b together.

The length of the strip 17 along the peripheral direction can be designed according to the periphery of the shield plates 11a, 11b, so that the gap between peripheral ends 24a, 24b of the strip 17 is not higher than the pitch P between two adjacent wings 18, when the strip 17 is assembled to the shield plates 11a, 11b.

The high formability of the material of the contact piece 11c enables to conform to any common shield shape. However, if necessary, one could provide a plurality of such contact pieces 11c, each assembled to a respective part of a shield plate or plates, if necessary, in order to cope with specific geometrical requirements. Preferably, these contact pieces are spaced from one another along the peripheral direction by not much than the pitch P.

As can be seen on Figure 8, when the first connector 2 and the second connector 3 are mated with one another, the shield 8 of the second connector 3 and the shield 11 of the first connector 2 are placed in electrical contact, so as to surround the electrical contact provided therein. In particular, the protrusions 22 of the wings 18 are placed in the contact with the shield 8 of the second connector 3.

Thus, in the assembled position of the connection assembly, the second leg 21 also forms a holding portion 26 which is pressed in contact with the shield plate 11a or 11b to further hold the shield plate 11a and the contact piece 11c together. Further, with the free end 23 in electrical contact with the shield plate 11a, the current can flow directly from the shield plate 11a to the shield 8 of the second connector 3, with therefore a reduced current path.

Figure 9 now shows a comparative example of a connector 102 which is similar to the first connector 2 described in relation with Figures 1 to 8, except that the contact wings 118 are provided integrally formed in the shield plates 111a, 111b.

Otherwise detailed, all reference numbers in relation with the comparative example of the connector 102 are those used for the first connector 2 described in relation with Figures 1 to 8 with addition of 100.

Hence, these shield plates 111a, 111b are provided with windows 112 in which the elastic contact tongues 118 extend, extending from a cylindrical portion close to the front edge, along the opposite axis to the longitudinal axis Z. Since the material of the shield plate 111a, 111b is stiff, and has to handle stresses to the assembly of the inner housing, the outer housing and the shield together, the pitch between neighbours contact tongues 118 is much larger in the comparative embodiment than in the embodiment of Figures 1 to 8 .

Figure 10 shows the results of an attenuation efficiency test, performed both for the embodiment of Figures 1 to 8 (refer to as E.1. on Figure 10), and on the comparative embodiment of Figure 9 (refer to as C.E. on Figure 10).

For both embodiments, the efficiency, in dB, is plotted as a function of the excitation frequency, from 10 Hz to 1 GHz. The difference between the two graphs, shown as reference Δ on Figure 10, shows the better efficiency of the embodiment of Figures 1 to 8 according to the present invention, compared to the comparative embodiment, for all frequencies, and in particular for frequencies over 1 MHz.

The graphs in Figure 10 represent the measured shielding effectiveness Eff. of mated connector assemblies in two configurations.

For the comparative embodiment (C.E.), the plug part is provided with spaced discrete contacts at the edge portion of the shield. For the embodiment according to the present invention (E.1.), the contact piece 11c is placed at the front end 13b of the shield plate 11a.

The shielding effectiveness Eff. has been obtained from transfer impedance test following a triaxial method according to the IEC 62153-4-3 standard (Metallic communication cables test methods - Part 4-3 : Electromagnetic compatibility (EMC) - Surface transfer impedance - Triaxial method).

For each configuration, the connection assembly is tested alone, without any contribution of cable or equipment connected at its extremities.

Although the present invention was disclosed with reference to the interface region between the first connector 2 and the second connector 3, notably between the interface regions of the receptacles 25, the shield and the outer housing with those of the first connector 2 and the second

connector 3, it will be understood that providing a shield as above is possible also in other places, where it is necessary to interface the shield with a mating shield on a mating electrical system, for example with the shield of the electrical cable 4, if applicable.

Further, whereas the present invention is related to straight contact and receptacles, it could be applied to any shape of receptacles, notably right angle receptacles. In such case, the longitudinal direction Z is the direction of the receptacle at the interface with the mating counter part.

The invention was described for a female shield but could be modified for a male shield. In such case, the protrusions 22 could protrude radially outward.

Obviously, the present invention is not limited to embodiments which are here above described and provided only as examples. It also includes different modifications, and alternatives that may be considered by the person skill in the art as part of the present invention, including all combinations of different embodiments here above described, taken alone or in combination.

## CLAIMS

1. Electrical connector (2) comprising:

- at least one housing (10,12) comprising at least one receptacle (25) to receive an electrical contact, the receptacle (25) defining an interface region extending along a longitudinal axis (Z),
- a shield (11) assembled to the housing (10,12) and surrounding at least the receptacle (25),

**wherein** the shield (11) comprises at least one shield plate (11a, 11b), made of electrically conducting material, comprising a substantially cylindrical portion (8d) extending along the longitudinal axis (Z) from a rear end (13a) to a front end (13b), and

**wherein** the electrical connector (2) comprises a contact piece (11c), made of an electrically conducting material, comprising a strip (17) and a plurality of wings (18), the strip (17) being attached along the front end (13b) of the shield plate (11a, 11b).

2. Electrical connector (2) according to claim 1, **wherein** the substantially cylindrical portion (8d) is provided around the interface region of the receptacle (25).

3. Electrical connector (2) according to claim 1 or 2, **wherein** the wings (18) are folded according to a U-shaped cross-section having a first leg (20) and a second leg (21) separated by a base (19).

4. Electrical connector (2) according to claim 3, **wherein** the front end (13b) is tightly held between the first leg (20) and the second leg (21).

5. Electrical connector (2) according to claim 3 or 4, **wherein** the strip (17) extends from the first leg (20) or the second leg (21).

6. Electrical connector (2) according to any of the preceding claims, **wherein** the wings (18) extend from the strip (17) toward the shield plate (11a, 11b).

7. Electrical connector (2) according to any of the preceding claims, **wherein** the wings (18) protrude radially with respect to the strip (17).

8. Electrical connector (2) according to any of the preceding claims, **wherein** the wings (18) each comprise a holding portion (26) pressing on the shield plate (11a, 11b).

9. Electrical connector (2) according to any of the preceding claims, **wherein** the electrical connector (2) comprises an inner housing (10) comprising the receptacle (25) and surrounded by the shield (11), and an outer insulating housing (12) surrounding the shield (11), the inner housing (10), outer housing (12) and the shield (11) being assembled together.

10. Electrical connector (2) according to any of the preceding claims, **wherein** the shield (11)comprises at least two shield plates (11a, 11b), the contact piece (11c) holding the shield plates (11a, 11b) together.

11. Electrical connector (2) according to any of the preceding claims, **wherein** the electrical connector (2) comprises at least one wire (5) partly extending in the receptacle (25).

12. Electrical connector (2) according to any of the preceding claims, **wherein** the strip (17) is provided transverse to the longitudinal axis (Z) and surrounds the interface region of the receptacle (25),

13. Electrical connector (2) according to any of the preceding claims, **wherein** the wings (18) extend from the strip (17) along the longitudinal axis (Z).

14. Connector assembly comprising:

- a first connector (2) according to any of claims 1 to 13,
- a second connector (3) comprising at least one housing (6, 9) comprising :
  - o at least one receptacle,
  - o an electrical contact (7) received in the receptacle, and
  - o an shield (8),

**wherein** the shield (11) of the first connector (2) and the shield (11) of the second connector (3) are mated together, when the first connector (2) and the second connector (3) are mated together.

15. Connector assembly according to claim 14, **wherein** the wings (18) are in contact with the shield (8) of the second connector (3).

16. Method of manufacturing an electrical connector comprising the following step:

a) providing a housing with at least one receptacle (25) to receive an electrical contact, the receptacle (25) defining an interface region extending along a longitudinal axis (Z),

b) providing a shield (11) by:

i. providing at least one shield plate (11a, 11b), made of electrically conducting material, comprising a substantially cylindrical portion extending along a shield longitudinal axis (Z) from a rear end (13a) to a front end (13b),

ii. providing a contact piece (11c), made of an electrically conducting material, comprising a strip (17) and a plurality of wings (18),

iii. attaching the strip (17) to the front end (13b) of the shield plate (11a, 11b), and

c) assembling the shield (11) to the housing (11a, 11b) with the shield (11) surrounding at least the receptacle (25).

17. Method according to claim 16, **wherein** the step b)iii) comprises a step consisting in wrapping the strip (17) along a periphery of the front end (13b).

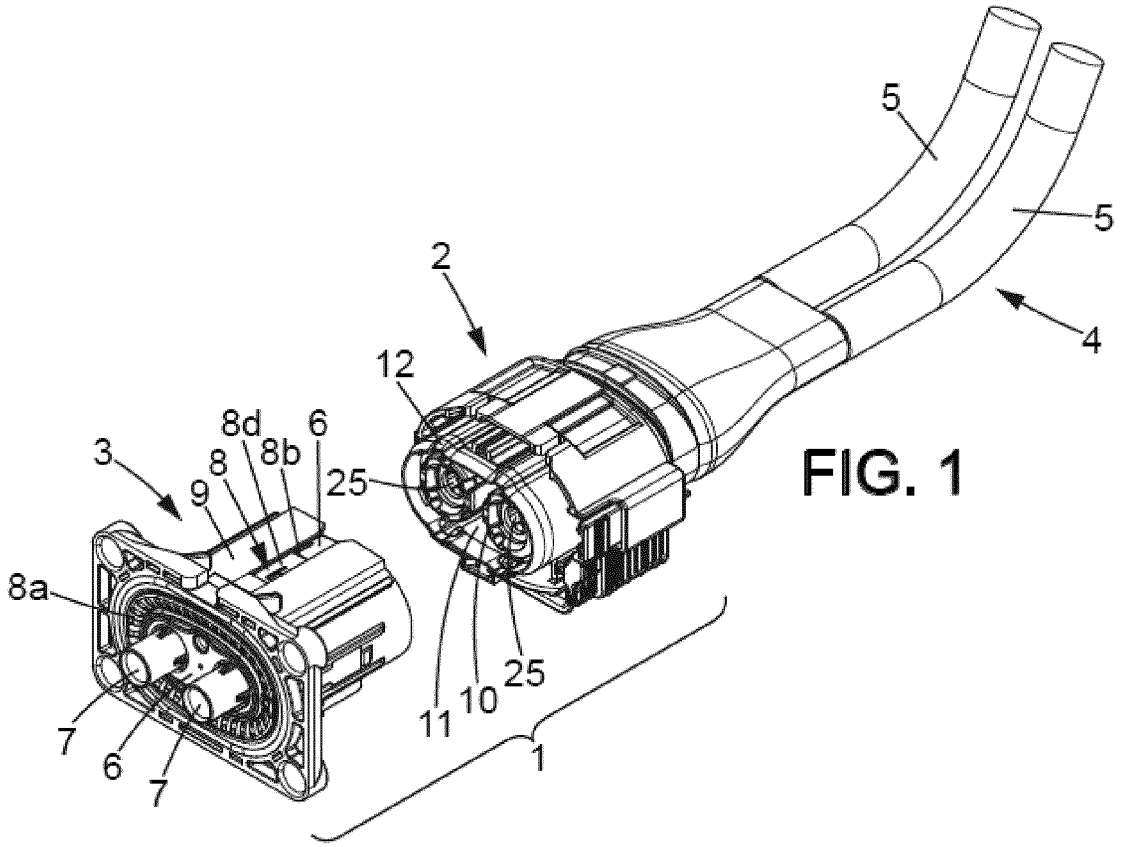

5
5
2
4
12
3
8d
8
8b
6
9
25
8a
7
6
7
11
10
25
1

FIG. 1

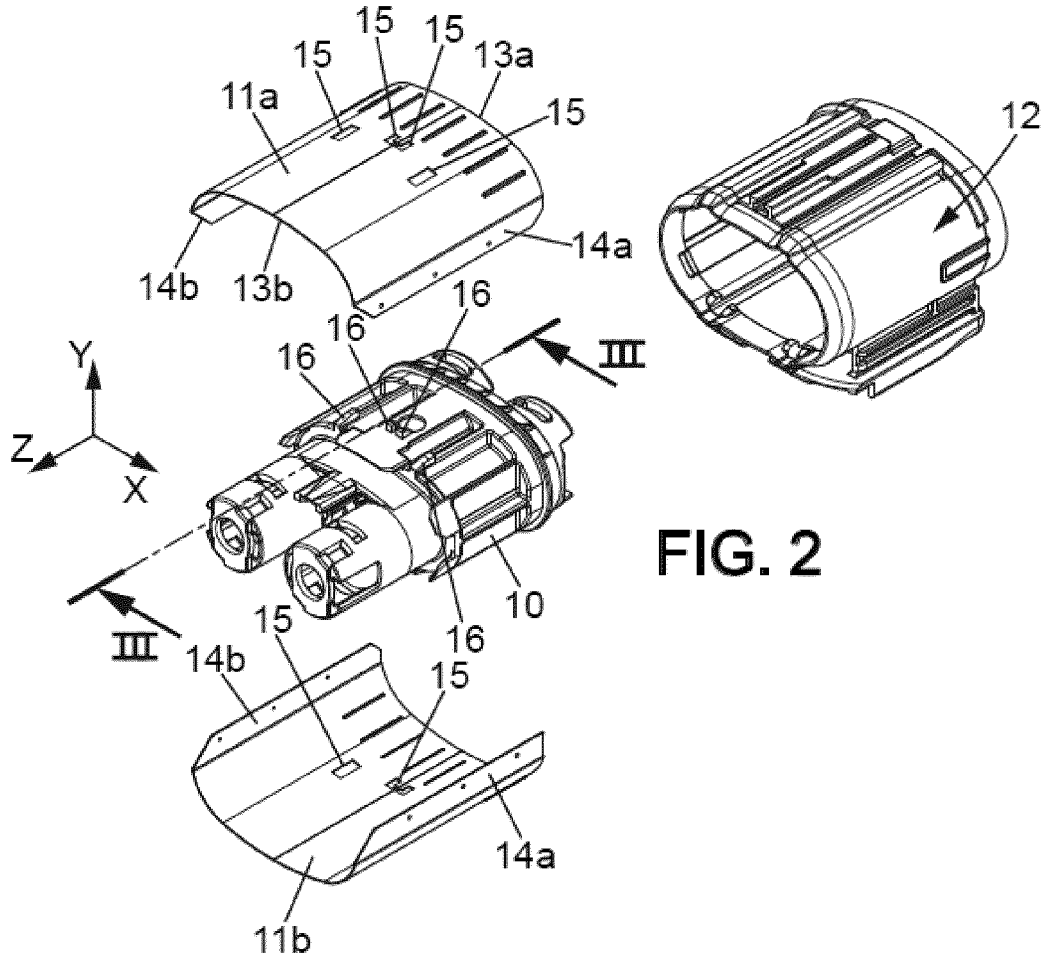

15
15
15
13a
11a
15
12
14a
14b
13b
16
16
16
III
Y
Z
X
10
III
15
14b
16
15
14a
11b

FIG. 2

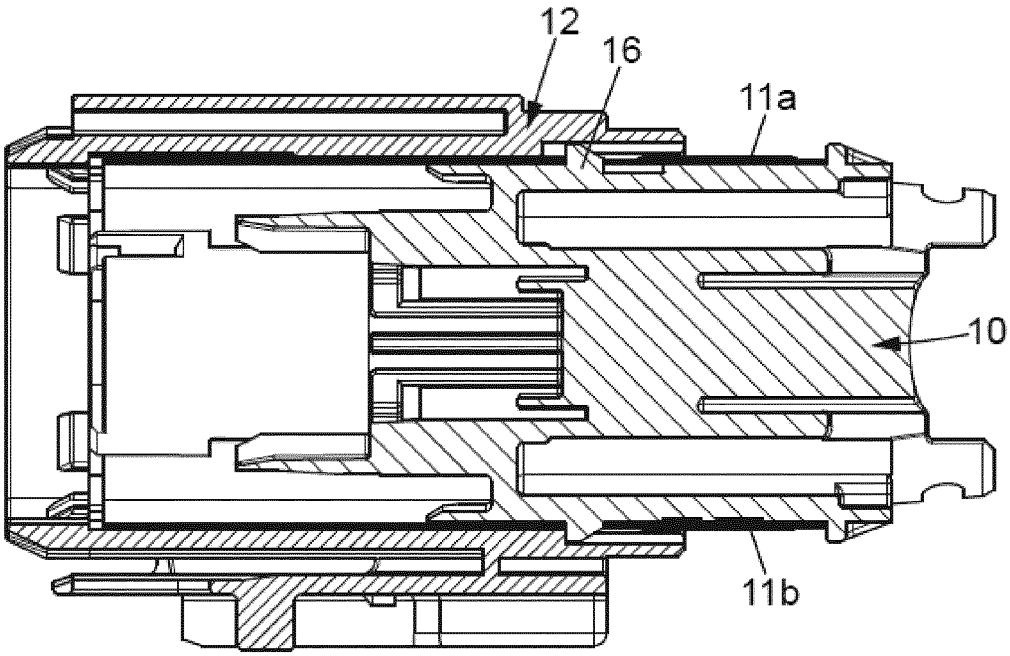



FIG. 3

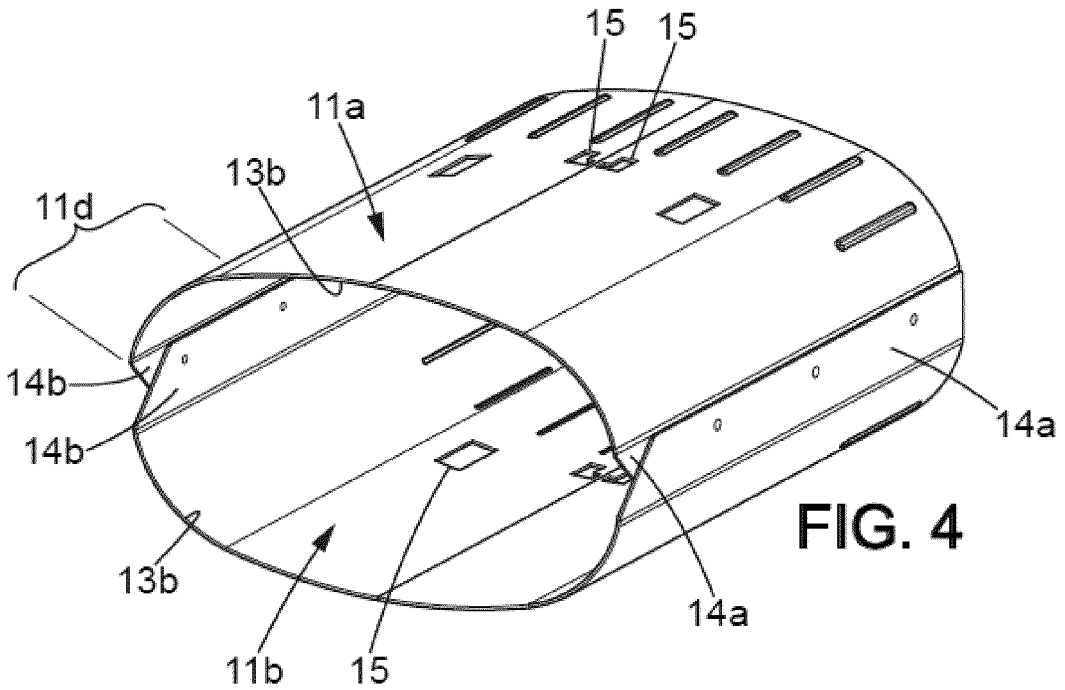



FIG. 4

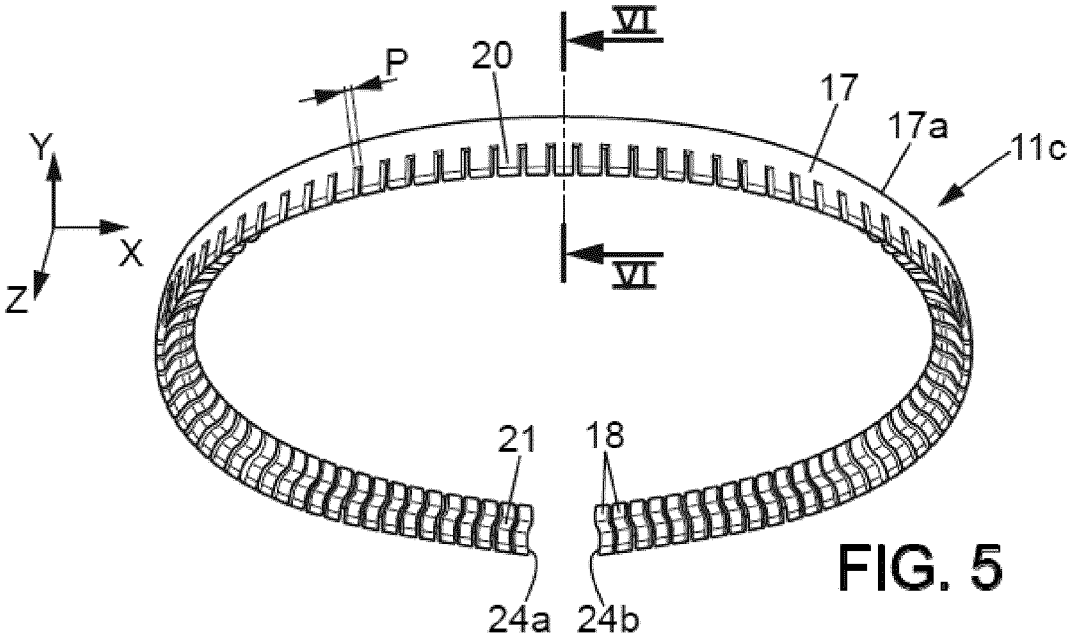



FIG. 5

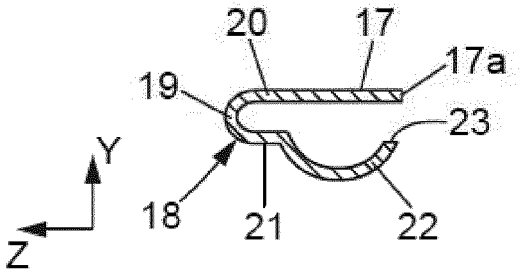
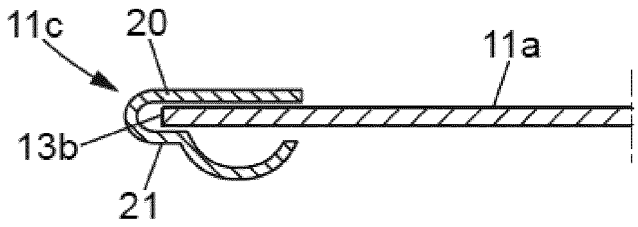



FIG. 6

FIG. 7



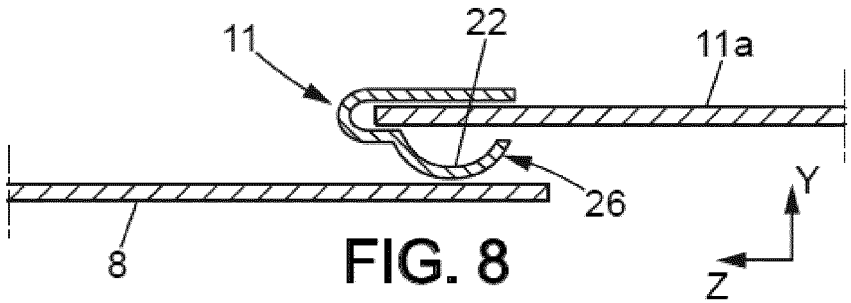




FIG. 8

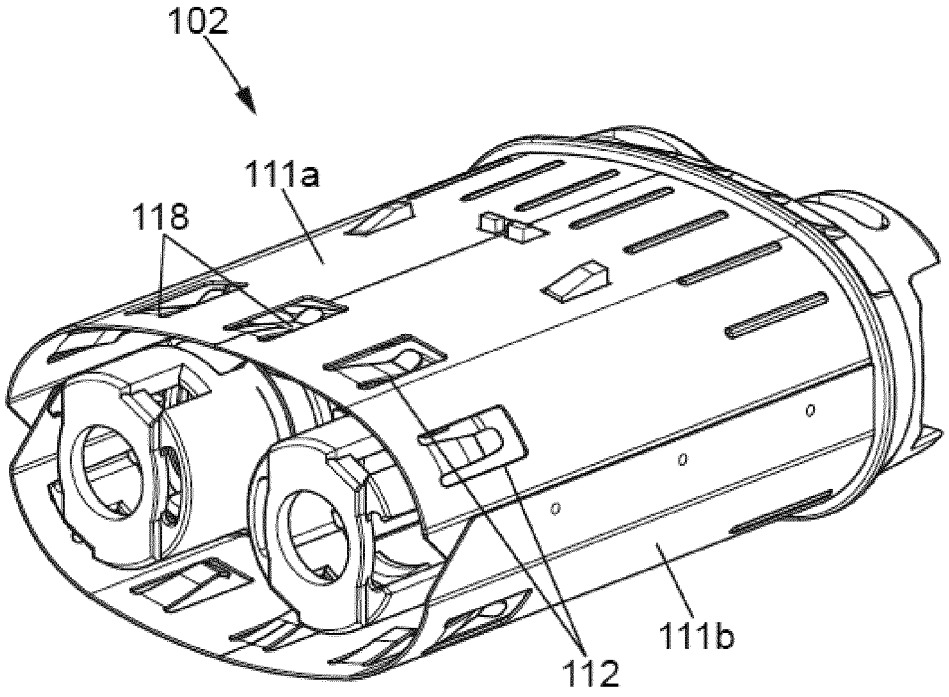



FIG. 9

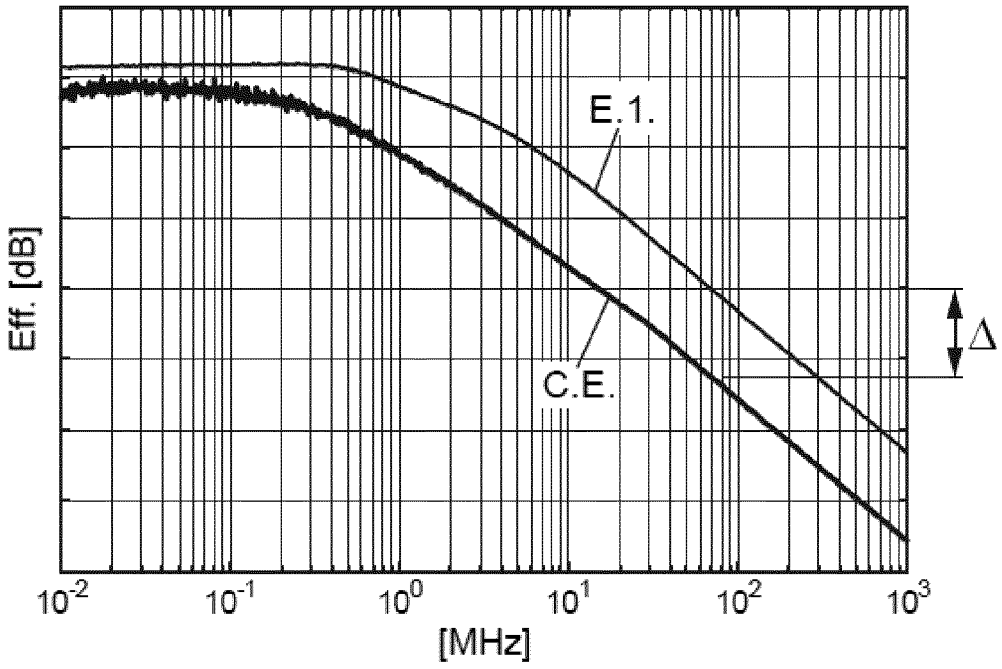



FIG. 10

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/050427

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01R13/6583 H01R103/00
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)
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)
EPO-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 | US 2012/208400 A1 (DE CHAZAL AARON JAMES [US] ET AL) 16 August 2012 (2012-08-16)<br>abstract<br>paragraph [0050] - paragraph [0054]<br>figure 7 | 1-17 |
| X | DE 10 2011 102566 A1 (AMPHENOL TUCHEL ELECT [DE]) 6 September 2012 (2012-09-06)<br>abstract<br>paragraph [0081] - paragraph [0083]<br>figures 2-7,9-10 | 1-17 |
| X | US 2004/132341 A1 (NOGUCHI HIROTAKA [JP] ET AL) 8 July 2004 (2004-07-08)<br>abstract<br>figures 1-36 | 1-17 |

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 29 August 2013 | 05/09/2013 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Pugliese, Sandro |

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