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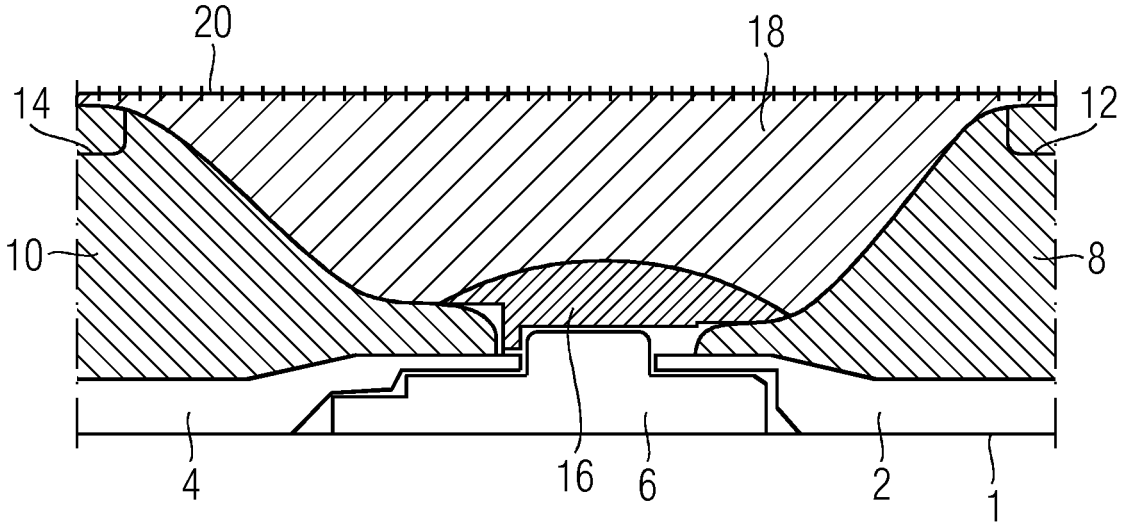
(71) Applicant: **Siemens Aktiengesellschaft**
80333 München (DE)

(72) Inventors:
- **Plant, Christopher**
  LA1 4EE Lancaster (GB)
- **Wyatt, Robert**
  LA12 7DL Ulverston (GB)

(54) **Connector**

(57) A connector for deployment underwater and for electrically connecting an underwater cable to an underwater electrical installation; the connector comprising: a first connector part comprising a first conductive core; a second connector part comprising a second conductive core, the second conductive core being arranged to be electrically connected to the first conductive core to form an electrical connection; an insulating body which, when the first and second conductive cores are electrically connected, is radially outwardly of and circumferentially around the electrical connection; and a conductive stress control portion which, when the first and second conductive cores are electrically connected, is in electrical contact with the electrical connection and is located radially between the electrical connection and the insulating body.

FIG 1



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Description

Field of the invention

[0001] The invention relates to a connector for deployment underwater and for electrically connecting an underwater cable to an underwater electrical installation.

Background

[0002] It is known to connect an underwater cable to a bulkhead of an underwater electrical installation. This achieved by providing a first connector part on the cable and a second connector part on the electrical installation for connection with the first connector part. The first connector part comprises a pin in an insulating bushing, the pin having a socket for receiving a pin of the second connector part. Additionally an insulating body is provided on the first connector part and provides a socket for receiving the second connector part.

[0003] The present invention is concerned with providing a connector for deployment underwater and for electrically connecting an underwater cable to an underwater electrical installation which has improved electrical properties.

Summary

[0004] The present invention provides a connector for deployment underwater and for electrically connecting an underwater cable to an underwater electrical installation; the connector comprising: a first connector part comprising a first conductive core; a second connector part comprising a second conductive core, the second conductive core being arranged to be electrically connected to the first conductive core to form an electrical connection; an insulating body which, when the first and second conductive cores are electrically connected, is radially outwardly of and circumferentially around the electrical connection; and a conductive stress control portion which, when the first and second conductive cores are electrically connected, is in electrical contact with the electrical connection and is located radially between the electrical connection and the insulating body.

[0005] The provision of the conductive stress control portion means that the electrical field around the electrical connection can be controlled and in particular regions of high electrical stress can be avoided. This means that the electrical connection between the first and second conductive cores can be of any shape, and for example may include sharp corners, without affecting the performance or lifetime of the connector. Preferably the stress control portion is shaped so as to control the electrical stresses around the electrical connection. For example, preferably the stress control portion has a smooth radially outer surface.

[0006] The provision of the stress control portion means that the connector can be reliably used at higher voltages. For example, it may be adapted to handle alternating root mean square (RMS) voltages up to 20 or 30 or 40 or 50 or 60 or 70 or 80 or 90 or 100 or 110 or 120 or 130 or 140 kV or above.

[0007] Preferably the first connector part is for connection to an underwater cable. Preferably the second connector part is for connection to an underwater electrical installation such as an underwater or subsea transformer. For example the second conductive core may be arranged to extend across the bulkhead of the electrical installation.

[0008] The first connector part may be provided on the underwater cable at a first location, such as a first factory, and the second connector part may be provided on the underwater electrical installation at a separate second location, such as a second factory, before the two connector parts are brought together in a common location, such as on a deployment vessel at sea, to form the electrical connection.

[0009] In a preferred embodiment the first and second conductive cores are pins.

[0010] Preferably the first connector part and the second connector part are designed to be mated out of water, for example onshore or on the deck of a vessel, and then deployed underwater or subsea, i.e. the connector is a dry mate connector.

[0011] In a preferred embodiment the connector comprises a pressure compensation means. For example the pressure compensation means may be a flexible diaphragm which is provided radially outwardly of the insulating body. This means that volume changes due to temperature and pressure changes when the connector is deployed underwater can be accommodated. Pressure in the region of the electrical connection can be balanced with respect to external pressure, so as to inhibit ingress of water or contaminants into the connector.

[0012] In a preferred embodiment the first connector part comprises a first insulating bushing circumferentially around the first conductive core and the second connector part comprises a second insulating bushing circumferentially around the second conductive core. In other words, each of the conductive cores is provided with insulation in addition to the insulating body provided around the electrical connection. When the first and second conductive cores are electrically connected preferably the insulating body extends axially between the first and second insulating bushings and in a preferred embodiment is in direct contact with the two bushings.

[0013] Preferably when the first and second conductive cores are electrically connected, the conductive stress control portion extends axially from a position radially outwardly of the first insulating bushing to a position radially outwardly of the second insulating bushing. This means that the stress control portion entirely envelopes the electrical connection thereby shielding it from electrical stresses.

[0014] The first connector part may comprise a first conductive layer embedded in, or on, the first insulating

bushing, and the second connector part may comprise a second conductive layer embedded in, or on, the second insulating bushing. The first or second conductive layers may be a tubular mesh embedded in the respective bushing.

[0015] In a preferred embodiment the conductive layer is provided on or near to a radially outwardly facing surface of each of the insulating bushings.

[0016] Preferably the conductive layer in or on each of the bushings is formed of copper.

[0017] In a preferred embodiment a conductive layer is provided on the radially outer surface of the insulating body.

[0018] The conductive layer may be applied to the insulating body by any known means such as spraying. This means that a conductive layer which has a good interface with the insulating body can be provided.

[0019] When a conductive layer is provided in, or on, the bushings and a conductive layer is provided on the insulating body, when the first and second conductive cores are electrically connected, preferably the conductive layer on the insulating body axially overlaps the conductive layers on the first and second insulating bushings. This overlap forms an electrical shield radially outwardly of the electrical connection.

[0020] When the connector is in use the conductive layers in (or on) the bushings and the conductive layer on the insulating body are preferably electrically connected to earth such that they act as an earth screen. This will protect components radially outwardly of the earth screen, for example pressure compensation means, from electrical stresses which may increase the lifetime of the connector.

[0021] Preferably in use the conductive cores and the stress control portion will be at high voltage and the conductive layers of the bushings and the insulating body will be earthed. This will create an electric field therebetween which is accommodated by the insulating bushings and the insulating body.

[0022] In a preferred embodiment the connector comprises a conductive connecting piece between the first conductive core and the second conductive core which forms the electrical connection. In other words the conductive connecting piece is located between the two conductive cores to provide a continuous electrical connection.

[0023] When the connector comprises a conductive connecting piece it is preferable that the stress control portion extends axially over the region where each conductive core engages with the conductive connecting piece. This means that the stress control portion can effectively control the stresses around the electrical connection.

[0024] In a preferred embodiment the first conductive core comprises a first socket and the second conductive core comprises a second socket and a first end portion the conductive connecting piece is received in the first socket and a second end portion of the conductive connective piece so as to form the electrical connection. This allows the connector parts to be easily electrically connected prior to deployment of the connector to an underwater location.

[0025] In a preferred embodiment the conductive connecting piece comprises a central portion axially between the two end portions which are received in the sockets of the conductive cores. Preferably the central portion of the conductive connecting piece has a dimension in the radial direction which is greater than the diameter of the conductive cores, i.e. the central portion of the conductive connecting piece extends radially outwardly of the conductive cores. Preferably the central portion is in direct contact with the stress control portion. This ensures that there is a good electrical connection between the electrical connection and the stress control portion.

[0026] In an embodiment the stress control portion is a metal piece. Alternatively the stress control portion may be a conductive moulding such as a silicone moulding.

[0027] When the stress control portion is a conductive silicone moulding the stress control portion may be flexible. This means that it can be stretched around the electrical connection which causes it to be energised onto the electrical connection to thereby ensure that the electrical connection therebetween is reliable.

[0028] In a preferred embodiment the insulating body is moulded onto the stress control portion. When the stress control portion is a moulding this forms an overmoulding, i.e. the stress control portion is moulded and then the insulating body is moulded onto the moulded stress control portion. This ensures that the interface between the stress control portion and the insulating body does not contain any air gaps.

[0029] In a preferred embodiment the insulating body forms a socket for receiving a portion of the second connector part, for example the second insulating bushing, during mating of the connector parts. The second connector part may plug into the insulating body during mating of the connector parts. This means that the connector parts can easily be fitted together to form the connection before being deployed to an underwater location.

[0030] In a preferred embodiment the stress control portion forms a socket for receiving a portion of the second connector part during mating of the connector parts, for example for receiving an end of the conductive core and the bushing of the second connector part.

[0031] For example the first connector part, which may comprise the first conductive core and its insulating bushing, the conductive connecting piece, the stress control portion and the insulating body which forms a socket, may be provided on an underwater cable at a first location, and the second connector part, which may comprise the second conductive core and its insulating bushing, may be provided on the underwater electrical installation at a separate second location before the two connector parts are brought together, by inserting the second connector part into the socket formed by the insulating body on the first connector part, at a common location to form

the electrical connection. Alternatively the first connector part may be provided on the underwater electrical installation and the second connector part may be provided on the underwater cable.

[0032] It is to be understood that the features mentioned above and those yet to be explained below can be used not only in the respective combinations indicated, but also in other combinations or in isolation, without leaving the scope of the present invention.

Brief description of the drawings

[0033] Certain preferred embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:

Fig. 1 shows an axial cross sectional view of part of a dry-mate connector according to a first embodiment of the invention;

Fig. 2 shows an axial cross sectional view of part of the first connector part of the connector shown in Fig. 1;

Fig. 2 shows an axial cross sectional view of part of the second connector part of the connector shown in Fig. 1;

Figure 3 shows an axial cross sectional view of part of a dry-mate connector according to a second embodiment of the invention; and

Figure 4 shows the moulding of the dry-mate connector shown in Figure 2.

Detailed description

[0034] Referring to Figure 1, part of a dry-mate connector is shown (the Figure only shows one half of the connector in the radial direction and the connector is symmetrical about line 1). The dry-mate connector is electrically connecting a subsea cable (not shown) to a subsea transformer (not shown). The dry mate connector comprises a first conductive pin 2 which is connected at one end to the subsea cable (not shown) and a second conductive pin 4 which extends across the bulkhead of the subsea transformer (not shown).

[0035] The first conductive pin 2 is electrically connected to the second conductive pin 4 via a conductive connecting piece 6. The first and second conductive pins 2, 4 and the connecting piece 6 are all made of copper. Each of the pins 2, 4 comprises a socket, each of which receive one end of the conductive connecting piece 6. The connecting piece 6 thus has an end portion at each end which is received in the respective sockets of the pins 2, 4 and a central portion which is located between the two pins.

[0036] The central portion of the connecting piece 6 has a diameter which is greater than the outer diameter of the pins 2, 4. When the connecting piece 6 is received in each of the sockets in the pins 2, 4 the axially facing end surfaces of the pins abuts against the axially facing end surfaces of the central portion of the conductive connecting piece 6. The central portion of the conductive connecting piece extends radially beyond the radial outer surface of each of the pins 2, 4.

[0037] The first conductive pin 2 is surrounded by an electrically insulating bushing 8 and the second conductive pin 4 is surrounded by an electrically insulating bushing 10. Each of the insulating bushings 8, 10 are formed of an insulating epoxy material. Additionally each of the insulating bushings 8, 10 are provided with a conductive mesh 12, 14 embedded in the bushing and near the radially outwardly facing surface of each of the bushings 8, 10. The embedded conductive meshes 12, 14 are made of copper.

[0038] The connector also comprises a conductive stress control piece 16. When the first and second pins 2, 4 are electrically connected via the connecting piece 6, the conductive stress control piece 16 is in electrical connection with the conductive connecting piece 6.

[0039] The conductive stress control piece 16 axially overlaps and is radially outwardly of an end portion of each of the bushings 8, 10 and the end of each of the pins 2, 4 to thereby provide an effective stress control of the electrical connection.

[0040] An insulating body 18 is provided radially outwardly of the electrical connection and the stress control piece 16. The insulating body is a rubber moulding.

[0041] The insulating body 18 is in direct contact with each of the insulating bushings 8, 10 and the stress control piece 16. The insulating body extends axially over and radially outwardly of the embedded conductive mesh 12, 14 provided in each of the bushings. The insulating body is provided on its radially outwardly facing surface with a thin conductive layer.

[0042] When the first and second pins 2, 4 are electrically connected the conductive layer 20 on the insulating body 18 axially overlaps the conductive mesh 12, 14 in each of the insulating bushings 8, 10.

[0043] In use, the pins 2, 4, the conductive connecting piece 6 and the stress control piece 16 are at high voltage and the conductive meshes in the bushings 12, 14 and the conductive layer on the insulating body 20 are earthed such that they act as an earth screen. This will protect components radially outwardly of the earth screen, for example a pressure compensation means (not shown), from electrical stresses. This will create an electric field which is accommodated by the insulating bushings 8, 10 and the insulating body 18.

[0044] Fig 2 shows the first connector part (of Fig. 1) in an unmated condition and Fig 3 shows the second connector part (of Fig. 1) in an unmated condition.

[0045] The first connector part comprises the first pin 1, the first insulating bushing 8 which is provided with the conductive mesh 12. In the socket in the pin is provided

the conductive connecting piece 6. Radially outwardly of the connecting piece is the stress control piece 16 and the insulating body 18 which is coated with the conductive layer 20. The insulating body 18 and the stress control piece 16 provide a socket for receiving the second connector piece. The first connector part is provided on a cable (not shown) at a first location.

[0046] At a second location, which may be remote from the first location, the second connector part shown in Fig. 3 is provided on a transformer which is for deployment underwater. The second connector part comprises the second pin 4 which is surrounded by bushing 10 which is provided with conductive layer 14. The first and second connector parts are brought to a common location. The second connector part is inserted into the socket formed by the first connector part which brings the second pin 4 into electrical contact with the connecting piece 6 of the first connector part to form the electrical connection as shown in Fig. 1. The connector can then be deployed underwater.

[0047] Fig. 4 shows another embodiment of the present invention. The connector of Fig. 4 has the same components as the connector of Fig. 1 and the equivalent reference numerals (increased by 100) are used accordingly. The difference between the connectors of the first and second embodiment is that rather than the stress control piece 16 of Fig. 1 being a metal piece around which the insulating body 18 is provided, the stress control piece 116 is a conductive moulding such as a conductive silicone.

[0048] The insulating body 118 is directly moulded onto the stress control piece 116, before assembly of the first connector part, to form an overmoulding as shown in Fig. 5. This provides a reliable interface between the stress control piece 116 and the insulating body 118. The overmoulding can then be provided with the first pin 102, the conductive connecting piece 116, and the bushing 108 to form the first connector part. All other aspects of the second embodiment are the same as the first embodiment and will not be described to avoid unnecessary repetition.

[0049] While specific embodiments of the invention are disclosed herein, various changes and modifications can be made without departing from the scope of the invention. The present embodiments are to be considered in all respect as illustrative and non-restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

Claims

1. A connector for deployment underwater and for electrically connecting an underwater cable to an underwater electrical installation; the connector comprising:

- a first connector part comprising a first conductive core (2, 102);
- a second connector part comprising a second conductive core (4, 104), the second conductive core (4, 104) being arranged to be electrically connected to the first conductive core (2, 102) to form an electrical connection;
- an insulating body (18, 118) which, when the first and second conductive cores (2, 102; 4, 104) are electrically connected, is radially outwardly of and circumferentially around the electrical connection; and
- a conductive stress control portion (16, 116) which, when the first and second conductive cores (2, 102; 4, 104) are electrically connected, is in electrical contact with the electrical connection and is located radially between the electrical connection and the insulating body (18, 118).

2. A connector as claimed in claim 1, wherein the first connector part comprises a first insulating bushing (8, 108) circumferentially around the first conductive core (2, 102) and the second connector part comprises a second insulating bushing (10, 110) circumferentially around the second conductive core (4, 104).

3. A connector as claimed in claim 2, wherein, when the first and second conductive cores (2, 102; 4, 104) are electrically connected, the conductive stress control portion (16, 116) extends axially from a position radially outwardly of the first insulating bushing (8, 108) to a position radially outwardly of the second insulating bushing (10, 110).

4. A connector as claimed in claim 2 or 3, wherein the first insulating bushing comprises a first conductive layer (12, 112) and wherein the second insulating bushing comprises a second conductive layer (14, 114).

5. A connector as claimed in any preceding claim, wherein a conductive layer is provided on the radially outer surface of the insulating body.

6. A connector as claimed in claim 5, wherein the conductive layer has been applied to the insulating body by spraying.

7. A connector as claimed in claims 5 or 6 when dependent on claim 4, wherein, when the first and second conductive cores are electrically connected, the conductive layer on the insulating body extends axially over the first conductive layer of the first insulating bushing and the second conductive layer of the second insulating bushing.

8. A connector as claimed in any preceding claim,

wherein the connector comprises a conductive connecting piece between the first conductive core and the second conductive core to form the electrical connection.

9. A connector as claimed in claim 8, wherein the first conductive core comprises a first socket and the second conductive core comprises a second socket and the conductive connecting piece is received at each end thereof in the first and second sockets so as to form the electrical connection.

10. A connector as claimed in any preceding claim, wherein the stress control portion (16) is a metal piece.

11. A connector as claimed in any of claims 1 to 9, wherein the stress control portion (116) is a conductive silicone moulding.

12. A connector as claimed in claim 11, wherein the insulating body (118) is moulded onto the stress control portion (116).

13. A connector as claimed in any preceding claim, wherein the insulating body (18, 118) forms a socket for receiving the second connector part when the first and second connector parts are mated.

14. A connector as claimed in any preceding claim, wherein the first conductive core is a first conductive pin and the second conductive core is a second conductive pin.

15. A connector as claimed in any preceding claim, wherein the connector is arranged to be mated out of water and then deployed underwater.

FIG 1

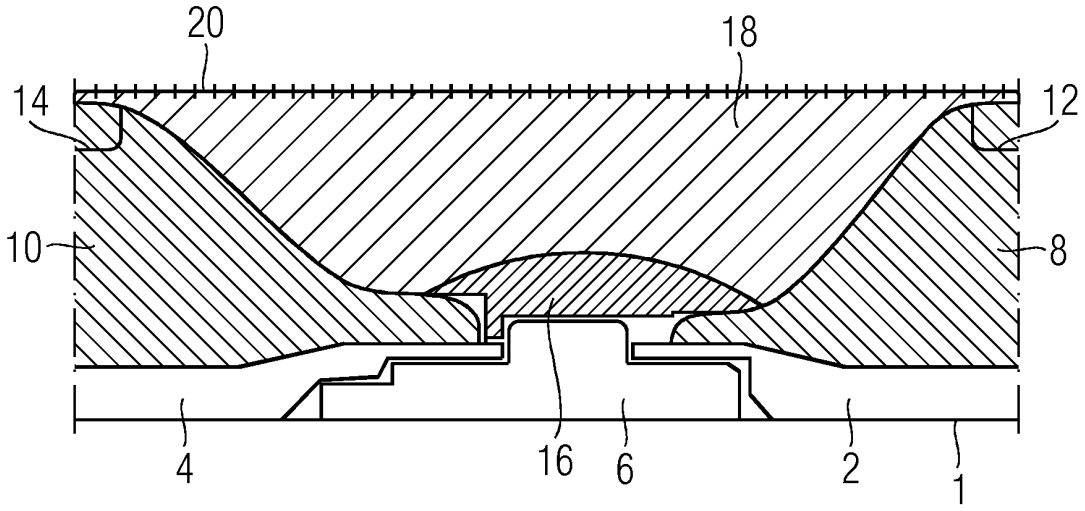


FIG 2

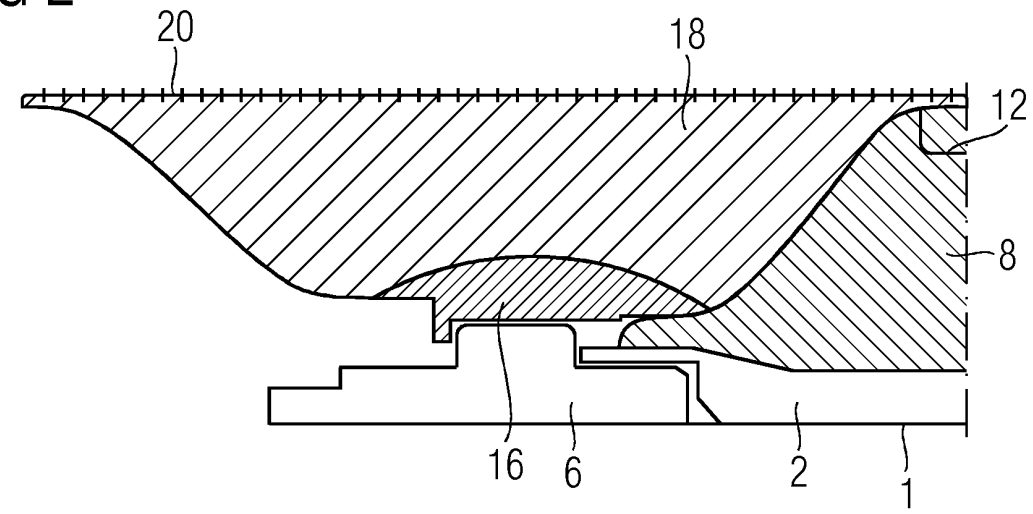


FIG 3

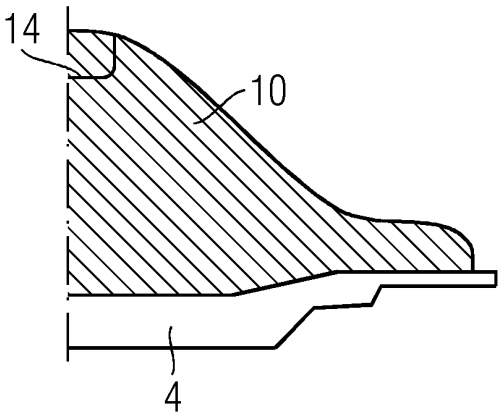


FIG 4

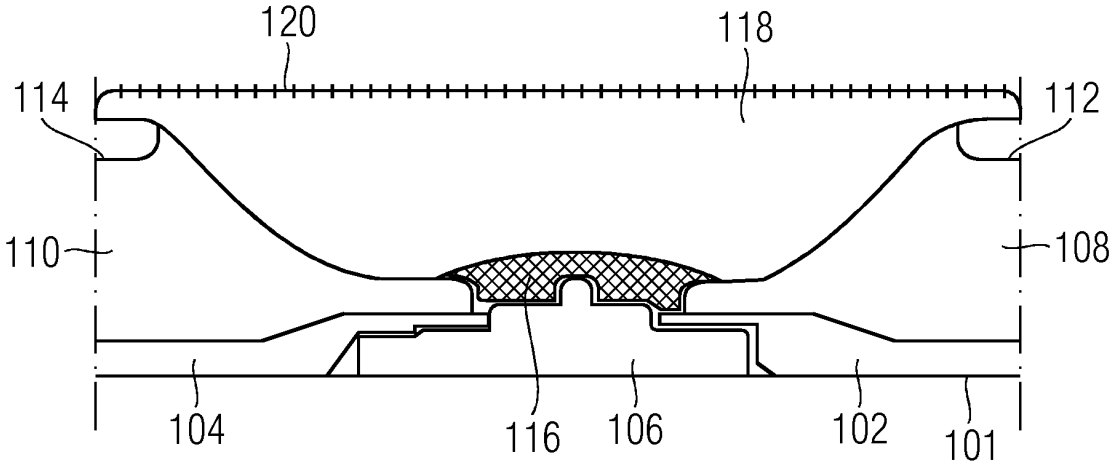
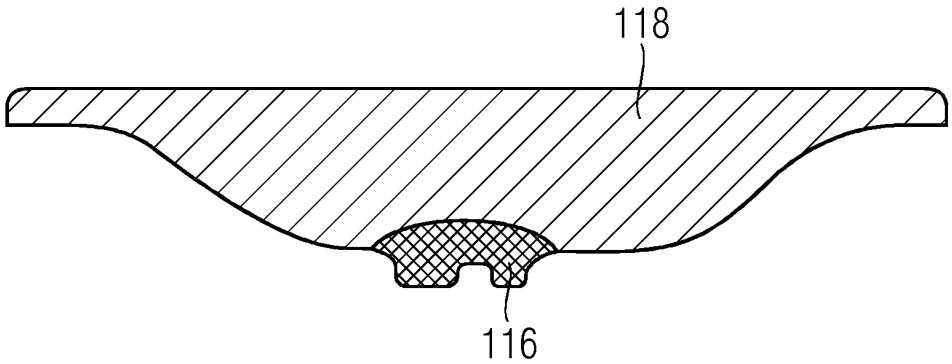


FIG 5



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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 0451

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	US 3 717 717 A (CUNNINGHAM F ET AL) 20 February 1973 (1973-02-20) * column 2, line 12 - column 3, line 25; figures 1,2 *	1-15	INV. H01R13/523 H01R13/53
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A	* paragraphs [0002], [0003]; figure 2 * * paragraph [0020] - paragraph [0024] * * paragraph [0031] *	13	

TECHNICAL FIELDS SEARCHED (IPC)
H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 October 2013	Bouhana, Emmanuel

CATEGORY OF CITED DOCUMENTS

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