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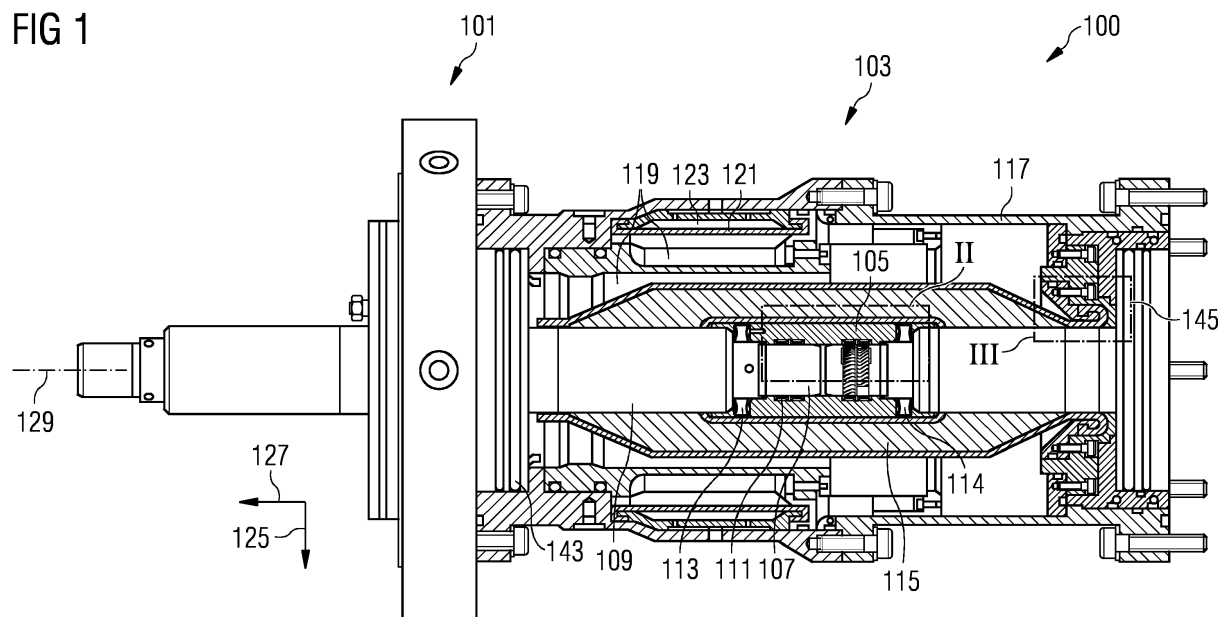
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(54) SUBSEA CONNECTOR

(57) It is described a connector (103, 403) for electrically connecting two pins (409, 451) in a subsea environment, the connector comprising: a conductive sleeve (105) for sliding in the two pins from opposite sides and for electrically contacting the two pins with each other; for each pin (109, 409, 451), a rubber ring (113, 114) surrounding a portion of the respective pin axially outside the conductive sleeve; an elastomer moulding (115) surrounding the conductive sleeve and the two rubber rings;

a casing (117) providing an internal space (119) fillable with oil, a diaphragm (121) in a wall of the casing allowing compensation of the pressure in the internal space with an outside pressure, wherein the elastomer moulding (115), the rubber rings (113, 114) and the conductive sleeve (105) are located within the internal space (119), wherein the rubber rings are configured to at least partly transmit a pressure applied to the elastomer moulding towards radially inwards.

FIG 1**EP 3 376 605 A1**

Description

Field of invention

[0001] The present invention relates to a connector (also referred to as a pin-to-pin adapter or CMI gland) for electrically connecting two pins in a subsea environment, further relates to a connector system and still further relates to a method for electrically connecting two pins in a subsea environment.

Art Background

[0002] In a subsea application, such as exploration of oil or gas, or in a subsea electricity network, it may be necessary to connect two equipment portions electrically. Thereby, the different electrical devices (such as pumps, transformers, hubs, etc.) may have different configurations of electrical pins. Therefore, an adapter, in particular pin-to-pin adapter, also referred to as connector or common module interface (CMI), may be required.

[0003] In subsea connectors, there may be two main classifications of assembly:

- front ends and cable. These may be the assemblies/components which carry the electric current through the connectors. These may include the plug and receptacle.
- glands. The common module interface gland may be used for connecting two front ends together. This assembly may include an adapter whose role is to provide the contacts between the two items to be joined.

[0004] The adapter (CMI gland) may be used for directly joining two front ends. Due to unknown lengths within each assembly (in particular due to unknown pin lengths) (unknown machine lengths, temperature variations, etc.), the contact pins in the gland must be positioned so that the two assemblies can be fully brought together for all material conditions. This may necessitate that there is a void between the two front ends (in particular the two electrical pins) during normal assembly and operation so that the worst cases can be accounted for.

[0005] The issue with this void or gap may be that the contact region may require a stress control termination moulding across the pins to control how the electric field transfers from one assembly to the next. This moulding may be elastomeric so that it is not able to resist the pressure forces from the hydrostatic pressure at high depths in the sea without being fully supported. Therefore, the stress control termination moulding may extrude into and may be damaged by any gaps or voids in the support structure. This may create a problem in that the dry-mate may require a gap to ensure that assembly can occur whereas the stress control termination moulding (which may be a key enabler for the dry-mate) cannot

accommodate any gaps at all.

[0006] WO 2016/146667 A2 discloses a conductor assembly with two conductive core parts, in particular a first conductive core part and at least a second conductive core part, wherein the first conductive core part is axially movably arranged in respect to the at least one second conductive core part, wherein an insulating sleeve is provided that is axially movably arranged in respect to the first conductive core part and the second conductive core part wherein at least one loading arrangement is embodied in such a way so that the first conductive core part is loaded in an axial direction against the at least one second conductive core part. Due to the loading, an insulating sleeve is clamped between the first conductive core part and the second conductive core part.

[0007] In conventional systems it has been observed that the front ends (including the pins) may be subject to high load during typical subsea applications for example at hydrostatic pressures between 300 bar and 500 bar.

[0008] Thus, there may be a need for a connector for electrically connecting two pins in a subsea environment, there may be a need for a connector system and there may be a need for a method for electrically connecting two pins in a subsea environment, wherein a reliable electrical connection of two electrical pins may be achieved while preventing high load on the pin equipment and avoiding (or at least reducing) damage of components, in particular front ends including electrical pins.

Summary of the Invention

[0009] This need may be met by the subject matter according to the independent claims. Advantageous embodiments of the present invention are described by the dependent claims.

[0010] According to an embodiment of the present invention it is provided a connector (also referred to as pin to pin adapter or common module interface (CMI) gland) for electrically connecting two pins in a subsea environment, the connector comprising: a conductive sleeve for sliding in the two pins from opposite sides and for electrically contacting the two pins with each other; for each pin, a rubber ring surrounding a portion of the respective pin axially outside the conductive sleeve; an elastomer moulding surrounding the conductive sleeve and the two rubber rings; a casing providing an internal space fillable with oil, a diaphragm in a wall of the casing allowing compensation of the pressure in the internal space with an outside pressure, wherein the elastomer moulding, the rubber rings and the conductive sleeve are located within the internal space, wherein the rubber rings are configured to at least partly transmit a pressure applied to the elastomer moulding towards radially inwards.

[0011] The connector is configured to electrically connect two pins under high hydrostatic pressure such as between 300 bar and 500 bar, for example for subsea operations or explorations. The pin may be made from a conductive material, such as copper or a copper alloy.

The conductive sleeve may in particular have an essentially cylindrical shape having a slightly larger inner diameter than an outer diameter of the pins to be connected. The two pins may be slid into the conductive sleeve from opposite ends.

[0012] The rubber ring may surround a portion of the pin where the pin is free of an insulating layer, such as an insulating plastic cladding or cover. The rubber ring may transmit a force exerted from the elastomer moulding axially towards the end of the respective pin (and also, in particular, radially inwards). Thereby, pressure forces may be transmitted using the rubber ring axially towards the pin. Thereby, a pressure differential across the connector (in particular in the mated state having connected thereto a first pin from a first side and a second pin from the second side) may be reduced. Both the rubber ring as well as the elastomer moulding may be elastic, flexible materials which may deform under hydrostatic pressure which may essentially reside within the internal space due to the pressure compensation via the diaphragm. The connector may substantially have a cylindrical shape. The diaphragm may be flexible/deformable but may be sealed tight against water and oil which may be present within the internal space. Oil may be present surrounding (at least a portion) of a radially outer surface of the elastomer moulding. As an outside hydrostatic pressure increases, the outside pressure may be transmitted via the diaphragm to the internal space such that the oil may act on the elastomer moulding, thereby compressing the elastomer moulding. An inner surface of the elastomer moulding (at least a portion thereof) may be in contact with an outer radial surface of the rubber ring (at least in a mated state wherein a pin is inserted through the respective rubber ring) such that the pressure force acting on the elastomer moulding may be (at least partly) transmitted to or towards the rubber ring, in particular in a radial direction or in all different directions. Thereby, pressure equilibration may be promoted, at least reducing a pressure differential within the connector.

[0013] According to an embodiment of the present invention, the connector further comprises for each rubber ring, a pair of supporting rings (also referred to as anti-extrusion rings), in particular sandwiching the respective rubber ring, the pair of supporting rings being arranged to support the respective rubber ring to at least reduce or even prevent extrusion when subjected to high pressure.

[0014] The supporting rings may be contacting each rubber ring from both axial sides. The supporting rings may be slightly deformable but may be not as soft as the respective rubber ring. Thus, the supporting rings may be configured not to extrude into any gaps or voids around them, even under high pressure. The rubber ring may be relatively soft such that the rubber ring easily deforms under high pressure which may have, without the pair of supporting rings, the risk to extrude into a gap or void surrounding the rubber ring. When the supporting rings are arranged axially surrounding the respective rubber

ring, extrusion of material of the rubber ring into any gaps or voids may be reduced or even avoided.

[0015] The supporting rings may be made of or may comprise polytetrafluoroethylen (PTFE, Teflon) or a similar material which has similar mechanical properties as PTFE. Both, the rubber ring as well as the supporting ring, may be made of electrically insulating material. Electrically insulating material may, however, not be required as the inner layer of the stress control moulding may create a shielded chamber and so there may be no electrical stress in the region of the rubber/PTFE rings. In other embodiments the rubber ring as well as the supporting ring, may be made of electrically conducting material.

[0016] According to an embodiment of the present invention, in each pair of supporting rings, a first supporting ring is between a respective axial end of the conductive sleeve and one axial end of the respective rubber ring and a second supporting ring is between another axial end of the respective rubber ring and a plastic sleeve of the respective pin.

[0017] The plastic sleeve may be made of an electrically insulating material. The plastic sleeve of the respective pin may press in the axial direction onto the rubber ring, in response to which the rubber ring may deform and may bulge out in the radial direction to contact the radially inner surface of the elastomer moulding. Thereby, a pressure transmission from the elastomer moulding towards the rubber ring and from there to other surrounding elements is enabled.

[0018] According to an embodiment of the present invention, the supporting rings essentially completely fill a radial space between the pin and the elastomeric moulding axially external to the rubber rings, in particular also in the demated state.

[0019] When the supporting rings essentially completely fill a radial space between the pin and the elastomer moulding, they may form an effective barrier for the rubber ring to prevent extrusion of portions of the rubber ring into any surrounding voids or gaps. Thus, the sandwiching supporting rings may confine the rubber rings in a space axially between the pair of supporting rings.

[0020] According to an embodiment of the present invention, at least one supporting ring of each pair of supporting rings has a small pin or point, which may push/insert into a portion of the respective rubber ring, in particular when pressed together in a state mated with a pin, to hold the rubber ring in place.

[0021] Thereby, the rubber ring may be hold in place, in particular in the mated state, in which a pin is guided through the rubber ring to be electrically contacted within the conductive sleeve.

[0022] According to an embodiment of the present invention, at atmospheric pressure and/or in a demated state, the rubber ring has a smaller radial extension than the elastomeric moulding (and the conductive sleeve), such that a radial void is present between a radial outer surface of the rubber ring and the elastomeric moulding,

wherein the rubber ring has in particular a rectangular cross-sectional shape.

[0023] The single-demated state is a state of the connector in which only one pin is connected to the connector. In the completely demated state, not any pin is connected to the connector. In the single-mated state, one pin is connected to the connector, in the completely mated state, two pins are connected to the connector from opposite sides. In the mated state a pin is contacting the conductive sleeve at the side of the connector under consideration. In the demated state no pin is present in the conductive sleeve at the side of the connector under consideration.

[0024] According to an embodiment of the present invention, in a mated state, the rubber ring bulges out such that the radial void is filled and the radial outer surface of the rubber ring touches and presses/pushes against the elastomeric moulding, thereby allowing the elastomeric moulding to transmit a pressure force to the rubber ring which may create a hydrostatic, compensating force on all surfaces it comes in contact with. When the radial void is filled with the material of the deformed rubber ring, an effective contact to the elastomeric moulding is achieved, such as to enable a pressure transmission.

[0025] According to an embodiment of the present invention, the elastomer moulding comprises a conductive layer at a radial inner face thereof, the conductive layer surrounding the conductive sleeve, the rubber rings, the pairs of supporting rings and a portion of the pins axially outside the rubber rings and the supporting rings, in particular further surrounding a portion of a plastic sleeve of the pins.

[0026] The conductive layer at the radial inner face of the elastomer moulding may effectively form a Faraday cage in order to provide an electrical shielding. The electrostatic potential of the conductive layer at the radial inner face may be substantially at earth potential. Thereby, an electrostatic field which may be present surrounding the pins may be shielded by the conductive layer at the radial inner face of the elastomer moulding. The conductive layer may also be elastic and may deform similar to the other material of the elastomer moulding. The elastomer moulding may further comprise, at a radial outer face, also another conductive layer for providing a shielding effect.

[0027] According to an embodiment of the present invention, the conductive sleeve comprises, at an inner face, at least two axially spaced apart electrical contact areas, each in particular comprising multilams, the conductive sleeve in particular made of copper or a copper alloy.

[0028] Thereby, when a pin is inserted into the conductive sleeve, a radial outside surface of the respective pin may contact with a radially inner surface of the electrical contact area at the radial inner surface of the conductive sleeve. The electrical contact areas may be made of resilient material providing a force towards radially inwards for ensuring a reliable electrical contact.

[0029] According to an embodiment of the present invention, the conductive sleeve essentially has a cylindrical shape having a single inner diameter for accommodating both pins.

5 **[0030]** In other embodiments, the conductive sleeve may comprise a first axial portion and a second axial portion having different inner diameters for accommodating pins having different outer diameters.

10 **[0031]** According to an embodiment of the present invention, the rubber rings are soft so that they move/deform at forces much lower than the applied pressure force and are the rubber rings are incompressible. Incompressible means that the volume of the rubber ring will not change as the hydrostatic pressure forces are applied. 15 This is essential as if the material was compressible its volume would reduce under hydrostatic pressure and thereby allow the stress control moulding to extrude into the space.

20 **[0032]** Thereby, the rubber rings effectively may act as pressure transmitters from the internal space towards other components surrounding the rubber rings.

25 **[0033]** According to an embodiment of the present invention it is provided a connector system comprising at least one pin (or also a second pin) and a connector according to one of the precedingly described embodiments, wherein the pin is inserted into the conductive sleeve of the connector and in particular wherein the other ring is inserted into the conductive sleeve from the other axial side.

30 **[0034]** It should be understood that features, individually or in any combination, disclosed, described, applied or provided for a connector for electrically connecting two pins in a subsea environment may also be applied, individually or in any combination, to a method of electrically 35 connecting two pins in a subsea environment according to an embodiment of the present invention and vice versa.

40 **[0035]** According to an embodiment of the present invention it is provided a method of electrically connecting two pins in a subsea environment, the method comprising: sliding into a conductive sleeve the two pins from opposite sides and electrically contacting the two pins with each other, wherein for each pin, a rubber ring surrounds a portion of the respective pin axially outside the conductive sleeve, wherein an elastomer moulding surrounds the conductive sleeve and the two rubber rings, 45 wherein the elastomer moulding, the rubber rings and the conductive sleeve are located within an internal space of a casing, the internal space being filled with oil, the method further comprising: allowing compensation of a pressure in the internal space with an outside pressure by a diaphragm in a wall of the casing; at least partly transmitting a pressure applied to the elastomer moulding towards radially inwards using the rubber rings.

50 **[0036]** Embodiments of the present invention are now described with reference to the accompanying drawings. The invention is not restricted to the illustrated or described embodiments.

Brief Description of the Drawings

[0037]

Fig. 1 schematically illustrates in a sectional view a connector system comprising a connector according to an embodiment of the present invention;

Fig. 2 illustrates a magnified view of a portion of the view illustrated in Fig. 1;

Fig. 3 illustrates a magnified view of a portion of Fig. 1;

Fig. 4 schematically illustrates a connector system completely mated from both sides according to an embodiment of the present invention;

Fig. 5 schematically illustrates a sectional magnified view of a portion of the embodiment illustrated in Fig. 4;

Fig. 6 schematically illustrates in a side view an area around a rubber ring in a demated state;

Fig. 7 schematically illustrates a side view in a region around a rubber ring in a mated state; and

Fig. 8 schematically illustrates a sectional view of a pin arrangement which may be comprised in a connector system according to an embodiment of the present invention.

Detailed Description

[0038] The illustration in the drawings is in schematic form. It is noted that in different figures, similar or identical elements are provided with the same reference signs or with reference signs, which are different from the corresponding reference signs only within the first digit.

[0039] The connector system 100 schematically illustrated in Fig. 1 in a partially sectional view comprises a pin arrangement 101 and a connector 103 according to an embodiment of the present invention. Thereby, the pin arrangement 101 is mated to the connector 103, but the other end of the connector 103 (also referred to as pin-to-pin adapter or CMI gland) remains free not mated to another pin arrangement or front end having an electrical pin protruding.

[0040] The connector 103 comprises a conductive sleeve 105 into which two pins from opposite sides can be slit in and for electrically contacting the pins with each other. In the illustrated embodiment in Fig. 1, only one bare end 107 of a pin 109 which belongs to the pin arrangement 101 is inserted into the conductive sleeve 105 and contacts via electrical contact areas 111 comprised in an inner surface of the conductive sleeve 105 the bare end 107 of the pin 109. In an area spaced apart from the

conductive sleeve, the pin 109 comprises a plastic cladding for electrical insulation.

[0041] The connector 103 further comprises for each pin, a rubber ring 113, 114 surrounding a portion of the respective pin axially outside the conductive sleeve 105. The connector further comprises an elastomer moulding 115 surrounding the conductive sleeve 105 and the two rubber rings 113, 114. The connector 103 further comprises a casing 117 providing an internal space 119 which is filled with oil. The connector further comprises a diaphragm 121 in a wall of the casing 117 allowing compensation of the pressure in the internal space 119 with an outside pressure. Thereby, the space region 123 is in communication with an outside so that the space region 123 is filled with seawater during a subsea exploration procedure.

[0042] The rubber rings 113, 114 are configured to at least partly transmit a pressure applied to the elastomer moulding 115 towards radially inwards. Thereby, the radial direction 125 is perpendicular to an axial direction 127 parallel to a longitudinal axis 129 of the pin 109 and therefore also parallel to the longitudinal axis of the conductive sleeve 105.

[0043] As is illustrated in Fig. 1, between the pin arrangement 101 and the connector 103, a seal 143 is arranged as an annular seal. The pin arrangement 101 may be bolted to the connector 103.

[0044] The detail rectangle 131 is illustrated in a magnified manner in Fig. 2. Thereby, it is in more detail illustrated that the contact elements 111 arranged at a radial inner surface 133 of the conductive sleeve 105 contact the conductive bare end 107 of the pin 109. In the illustration of Fig. 2, the other end (on the right hand side in Fig. 2) of the connector is not mated with another pin arrangement such that the multilam 135 forming the electrical contact areas 111 are visible. The connector further comprises for each rubber ring 113, 114 a pair of supporting rings comprising an inner supporting ring 137 and an outer supporting ring 139, wherein the pair of supporting rings 137, 139 is arranged to support the respective rubber ring 114 to at least reduce or even prevent extrusion when subjected to high pressure. Thereby, the inner supporting ring or first supporting ring 137 is between a respective axial end 106 of the conductive sleeve 105 and one axial end 116 of the respective rubber ring 114. A second supporting ring or outer supporting ring 139 is between (in the mated state) another axial end of the respective rubber ring, in particular the other axial end 118 and a plastic sleeve of the respective pin, which is in the mated state located in the region 141.

[0045] Fig. 3 illustrates in a magnified view another detail 145 from Fig. 1. Thereby, a sealing skirt 147 in the moulding is illustrated to retain the oil in the internal space 119. Furthermore, a portion of a further supporting ring 140 is illustrated axially outwards from the sealing skirt 147. Thereby, the further supporting ring 140 is provided for at least reducing or even avoiding extrusion due to high pressure.

[0046] Fig. 4 schematically illustrates a connector system 400 according to an embodiment of the present invention, here in a completely mated state having a pin arrangement 401 connected on one end of the connector 403 and having a plug front end 449 connected to another end of the connector 403. Thereby, the pin 409 of the pin arrangement 401 is electrically connected to the pin 451 of the plug front end 449 in that both are inserted in the conductive sleeve 405 of the connector 403 being contacted to each other via the electrical contact elements 411.

[0047] The rubber rings and supporting rings 114, 137, 139 may be arranged and configured as is illustrated in the detailed view of Fig. 2.

[0048] Furthermore, a detailed view of the connection region of the connector system illustrated in Fig. 1 or 4 is illustrated in a sectional view in Fig. 5. Thereby, it is illustrated that the pin 409 has inserted the conductive bare region 407 into the conductive sleeve 405 and electrically contacts the conductive sleeve 405 via the electrical contact elements 411. Further, the pin 450 of the plug front end 449 has also inserted its conductive bare ends 451 from another end of the connector 403 into the sleeve 405 and electrically contacts the conductive sleeve 405 via the electrical contact elements 411.

[0049] The first supporting ring 437 and the second supporting ring 439 sandwich the rubber ring 114 in between and confine the rubber ring 114 in the axial direction into a particular region. Thereby, the first supporting ring and the second supporting ring 437, 439 completely fill the radial distance 440 between the bare pin 451 and a radially inner surface 453 of the elastomeric moulding 415.

[0050] In particular, the elastomeric moulding 415 comprises a conductive layer 455 at a radial inner face, wherein the conductive layer 455 surrounds the conductive sleeve 405, the rubber rings 414 and 413 on both sides of the connector 403, the pairs of supporting rings 437, 439 and a portion of the pins 409, 450 axially outside the rubber rings 413, 414 and also outside the supporting rings 437, 439. In particular, the conductive layer 455 even reaches a portion of a plastic sleeve of the pins 409, 450. In particular, in the regions 409, 450, the pin is surrounded by the plastic sleeve.

[0051] Fig. 6 illustrates in a schematic side view a portion around a rubber ring 414 also illustrating the first or inner supporting ring 437 and the second or outer supporting ring 439 in the demated state, in which no pin is inserted through the rubber ring 414 and also not inserted into the conductive sleeve 405. As can be appreciated from Fig. 6, the rubber ring 414 has substantially a rectangular cross-sectional shape. A radial void 410 is present between an radial outer surface of the rubber ring 414 and the elastomeric moulding 415,

[0052] Fig. 7 illustrates a situation in a mated state wherein a pin 450 in particular comprising a plastic sleeve is inserted into the conductive sleeve 405 with its conductive bare portion 451. As can be taken from Fig. 7,

thereby, the rubber ring 414 bulges out by a distance Δr such that the rubber ring 414 contacts a (in Fig. 7 not illustrated) elastomer moulding, as is illustrated in Fig. 5 and labelled with reference sign 415. Thereby, a pressure transmission from the elastomeric moulding 415 via the rubber ring 414 towards surrounding elements is enabled.

[0053] Thus, after fitting the pin into the conductive sleeve, the rubber ring 414 bulges so it can interact with the stress control termination moulding 415 over the top. As can be appreciated from Fig. 5, there is an axial gap 457 between the pins 407 and 451 when arranged for contacting the conductive sleeve 405, such as tolerate slight length uncertainties due to manufacturing and/or temperature expansion.

[0054] Fig. 8 schematically illustrates in a cross-sectional view the pin arrangement 101 comprised in the connector arrangement illustrated in Fig. 1. The pin arrangement 101 comprises a silver plated copper core 159 which is surrounded by a plastic insulation 161 thereby forming the portion 109 of the pin. The conductive bare portion 107 of the pin protrudes out of the plastic cladding 161. The pin arrangement 101 further comprises seal grooves 163 for sealing, when the pin arrangement 101 is connected to the connector 103, as is illustrated in Fig. 1. Further seals 165 are provided for sealing the plastic cladding 161 with the core 159.

[0055] According to embodiments of the present invention, the depth pressure is allowed to act on part of the end face of the front ends in the gland, i.e. the crimp is part compensated to reduce (not remove) the differential pressure force to a level which is easier to manage in the design of the front ends. According to embodiments, this may be achieved by replacing part of the conventionally provided metal ring with a soft rubber ring (the one used according to an example application has 15 Shore hardness). The exact composition of the ring is not important, it just needs to be relatively soft so that it moves/deforms at forces much lower than the applied pressure force and the ring should be incompressible.

The soft rubber ring may be kept into place by an anti-extrusion ring (also referred to as supporting rings) on either side: one of which interfaces with the metal work used to make the contact and the other interfaces with the end of the pin. These PTFE rings are to ensure that the soft rubber ring and the stress control termination moulding (also referred to as elastomeric moulding) cannot extrude into any gaps or voids. These PTFE rings may have a slight point in them. The purpose of this point is to "grab" the rubber ring during its compression to ensure that it cannot extrude straight out of the top of the groove in which it sits.

[0056] During the fitting of a front end into the gland, the soft rubber ring may be compressed so that it may bulge outwards, pushing on the inside of the stress control termination moulding. Once the pressure is applied to the outside of the stress control termination moulding, it can then transmit the force to the soft rubber ring which

may create a hydrostatic, compensating force on all of the surfaces it comes into contact with. According to an embodiment of the present invention, thereby, the area which is not pressure compensated is reduced from 60 mm diameter to a 40 mm diameter which may reduce the differential pressure force by 55%.

[0057] According to embodiments of the present invention it is possible to have an extended/second ring to fully compensate the crimp area but this has not been fully considered yet because it may increase the complexity of the solution as it would require cross-drillings or similar in the metal work to transmit the pressure to the very centre of the crimp. Further, the part compensated crimp may reduce the pressure loading to a level which is acceptable to the current design.

[0058] According to embodiments of the present invention, the soft rubber ring (at each side of the connector) may be in contact with the inside of the stress control termination moulding which may allow pressure to be transmitted down to smaller diameters. This may reduce differential pressure forces acting on the front ends whilst still preventing the creation of any extrusion gaps which would damage the stress control termination moulding. This is achieved without the need to gauge lengths, to perform liquid fills and allows the front end to be terminated and pressure cycled multiple times without having to refurbish the gland. According to exemplary embodiments, the use of the soft rubber rings fills the variable length gaps between assembly, transmits pressure axially and thereby performs pressure compensation, and the use of anti-extrusion rings may hold the soft rubber ring and prevent it from extruding into other locations. Using embodiments of the present invention enable dry-mate technology to be performed.

[0059] It should be noted that the term "comprising" does not exclude other elements or steps and "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

Claims

1. Connector (103, 403) for electrically connecting two pins (409, 451) in a subsea environment, the connector comprising:

a conductive sleeve (105) for sliding in the two pins from opposite sides and for electrically contacting the two pins with each other;
for each pin (109, 409, 451), a rubber ring (113, 114) surrounding a portion of the respective pin axially outside the conductive sleeve;
an elastomer moulding (115) surrounding the conductive sleeve and the two rubber rings;
a casing (117) providing an internal space (119)

fillable with oil,
a diaphragm (121) in a wall of the casing allowing compensation of the pressure in the internal space with an outside pressure,
wherein the elastomer moulding (115), the rubber rings (113, 114) and the conductive sleeve (105) are located within the internal space (119),

wherein the rubber rings are configured to at least partly transmit a pressure applied to the elastomer moulding towards radially inwards.

2. Connector according to the preceding claim, further comprising:

for each rubber ring (113, 114), a pair of supporting rings (137, 139), in particular sandwiching the respective rubber ring, the pair of supporting rings being arranged to support the respective rubber ring to at least reduce or even prevent extrusion when subjected to high pressure.

3. Connector according to the preceding claim, wherein the supporting rings (137, 139) are made of or comprise PTFE.

4. Connector according to one of the preceding claims 2 or 3, wherein in each pair of supporting rings, a first supporting ring (137) is between a respective axial end (106) of the conductive sleeve (105) and one axial end (116) of the respective rubber ring (114) and a second supporting ring (139) is between another axial end (118) of the respective rubber ring (114) and a plastic sleeve of the respective pin.

5. Connector according to one of the preceding claims 2 to 4, wherein the supporting rings (437, 439) essentially completely fill a radial space (440) between the pin (451) and the elastomeric moulding (415, 455) axially external to the rubber rings.

6. Connector according to one of the preceding claims 2 to 5, wherein at least one supporting ring of each pair of supporting rings has a small pin or point, which may push/insert into a portion of the respective rubber ring, in particular when pressed together in a state mated with a pin, to hold the rubber ring in place.

7. Connector according to one of the preceding claims, wherein, at atmospheric pressure and/or in an demated state, the rubber ring (414) has a smaller radial extension than the conductive sleeve, such that a radial void (410) is present between an radial outer surface of the rubber ring (414) and the elastomeric moulding (415), wherein the rubber ring has in particular a rectangular cross sectional shape.

8. Connector according to one of the preceding claims, wherein, in a mated state, the rubber ring bulges out such that the radial void (410) is filled and the radial outer surface of the rubber ring touches and pushes against the elastomeric moulding (415),
thereby allowing the elastomeric moulding to transmit a pressure force to the rubber ring which may create a hydrostatic, compensating force on all surfaces it comes in contact with.
9. Connector according to one of the preceding claims, wherein the elastomer moulding (415) comprises a conductive layer (455) at a radial inner face thereof, the conductive layer surrounding the conductive sleeve (405), the rubber rings (413, 414), the pairs of supporting rings (437, 439) and a portion of the pins (409, 450) axially outside the rubber rings and the supporting rings, in particular further surrounding a portion of a plastic sleeve of the pins.
10. Connector according to one of the preceding claims, the conductive sleeve comprising, at an inner face, at least two axially spaced apart electrical contact areas (111, 411), each in particular comprising multilayers, the conductive sleeve in particular made of copper or a copper alloy.
11. Connector according to one of the preceding claims, the conductive sleeve (105, 405) essentially having a cylindrical shape having a single inner diameter for accommodating both pins.
12. Connector according to one of the preceding claims, wherein the rubber rings (413, 414) are soft so that they move/deform at forces much lower than the applied pressure force and incompressible.
13. Connector system (100, 400), comprising:
at least one pin (109, 409); and
a connector (103, 403) according to one of the preceding claims,
wherein the pin is inserted into the conductive sleeve of the connector.
14. Method of electrically connecting two pins (409, 450) in a subsea environment, the method comprising:
sliding into a conductive sleeve (105, 405) the two pins from opposite sides and electrically contacting the two pins with each other,
wherein for each pin, a rubber ring (114, 413, 414) surrounds a portion of the respective pin axially outside the conductive sleeve,
wherein an elastomer moulding (115, 415) surrounds the conductive sleeve and the two rubber rings,
wherein the elastomer moulding, the rubber

rings and the conductive sleeve are located within an internal space (119) of a casing (117), the internal space being filled with oil,
the method further comprising:

allowing compensation of a pressure in the internal space (119) with an outside pressure by a diaphragm in a wall of the casing; at least partly transmitting a pressure applied to the elastomer moulding towards radially inwards using the rubber rings.

FIG 1

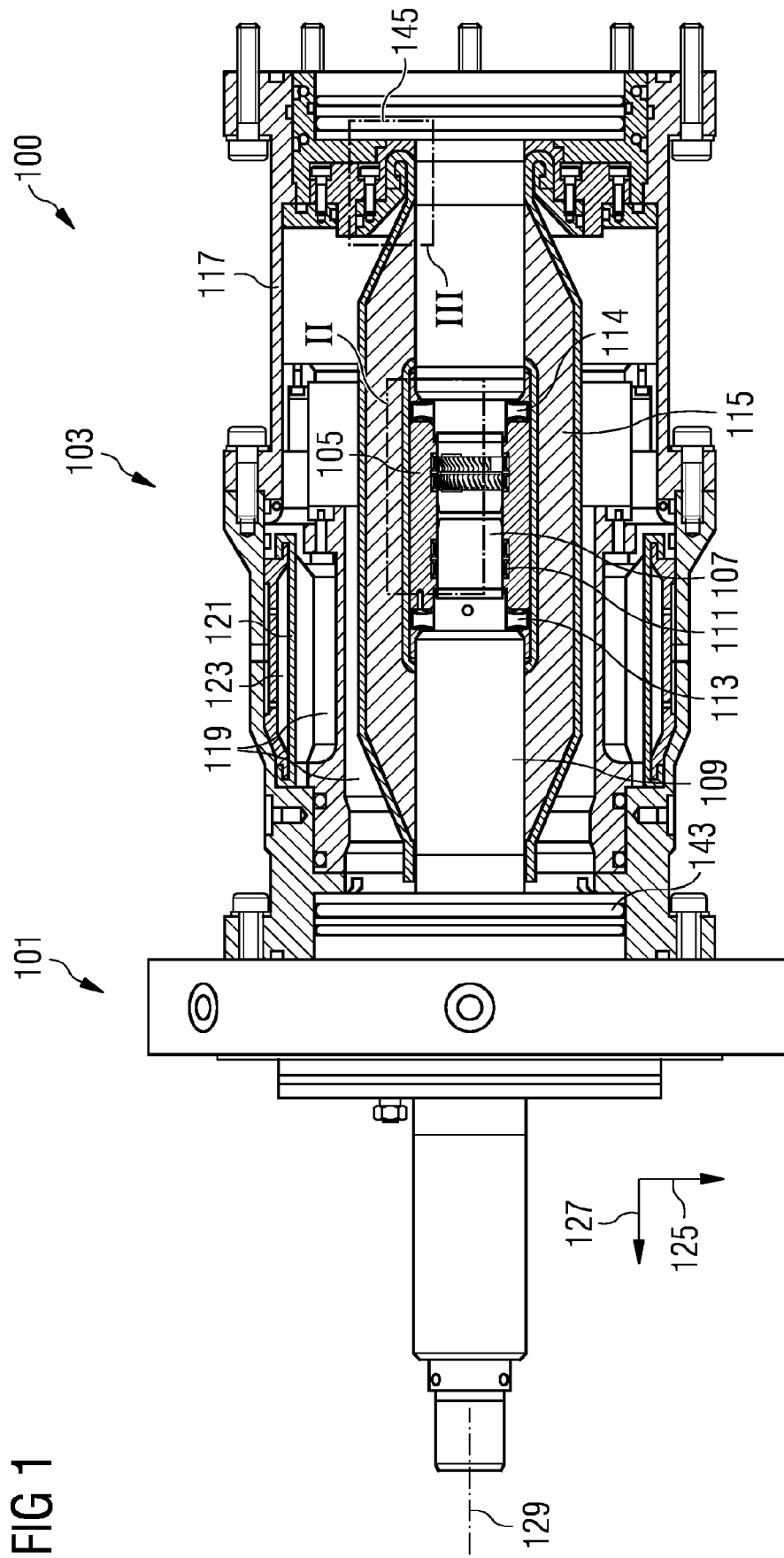


FIG 2

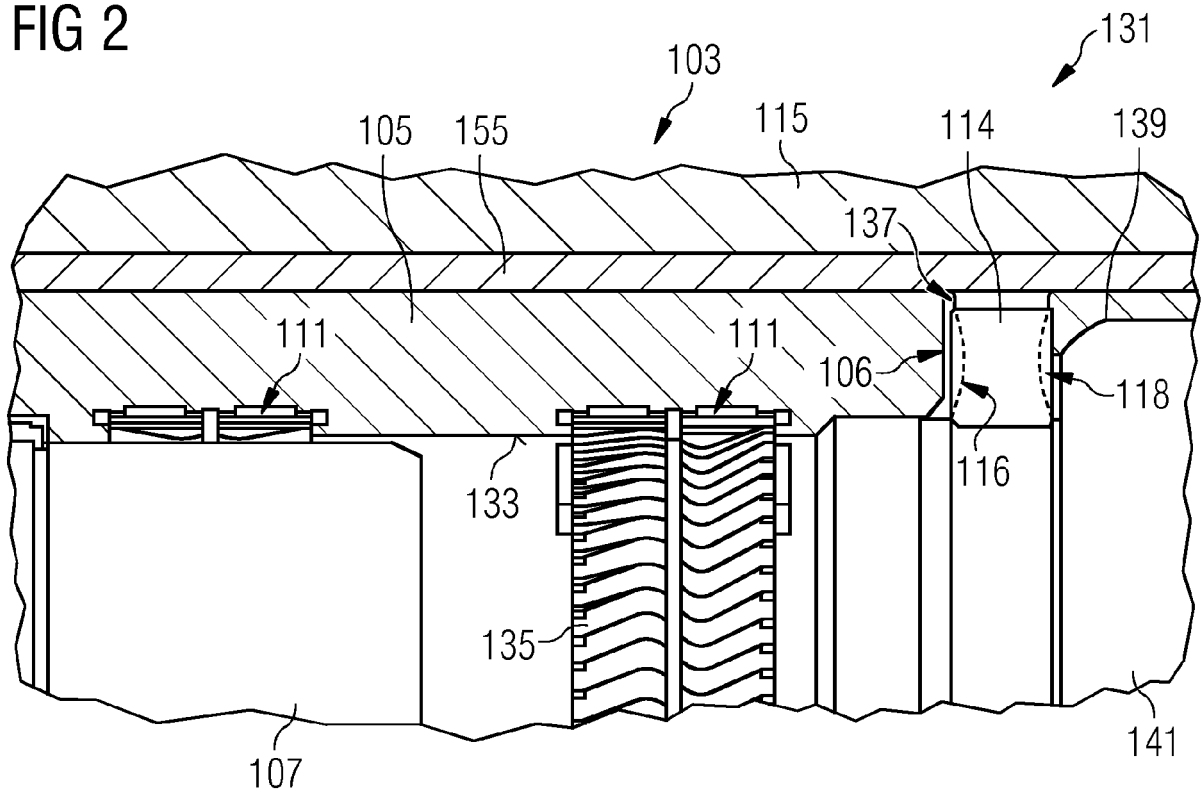


FIG 3

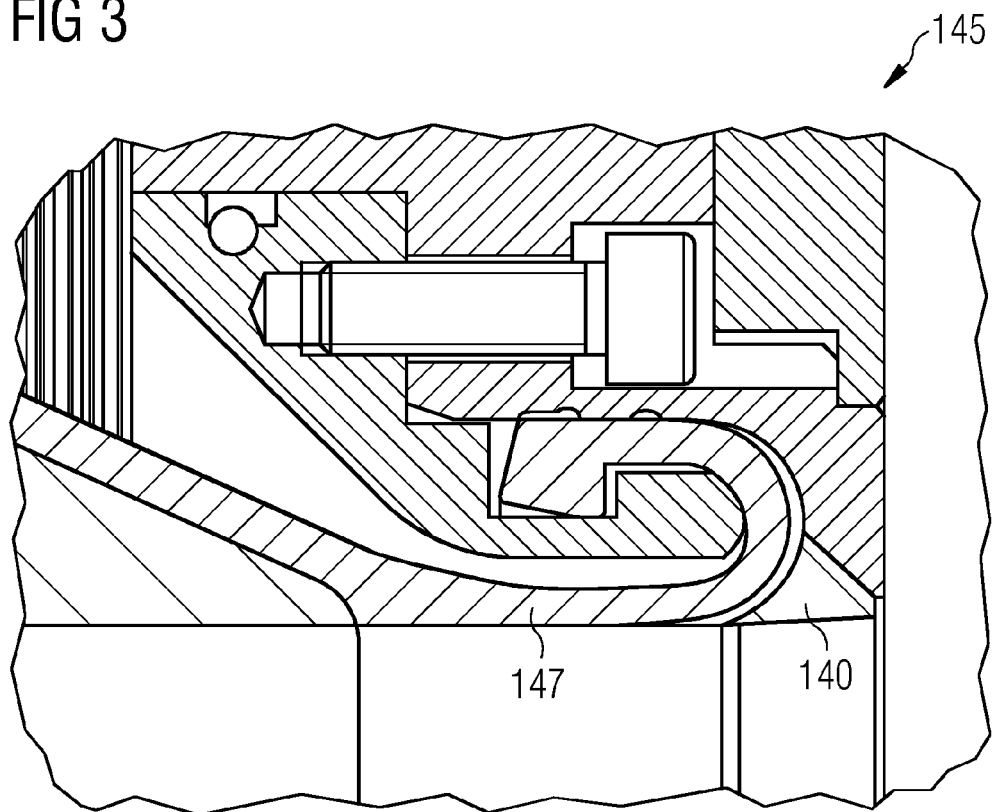


FIG 4

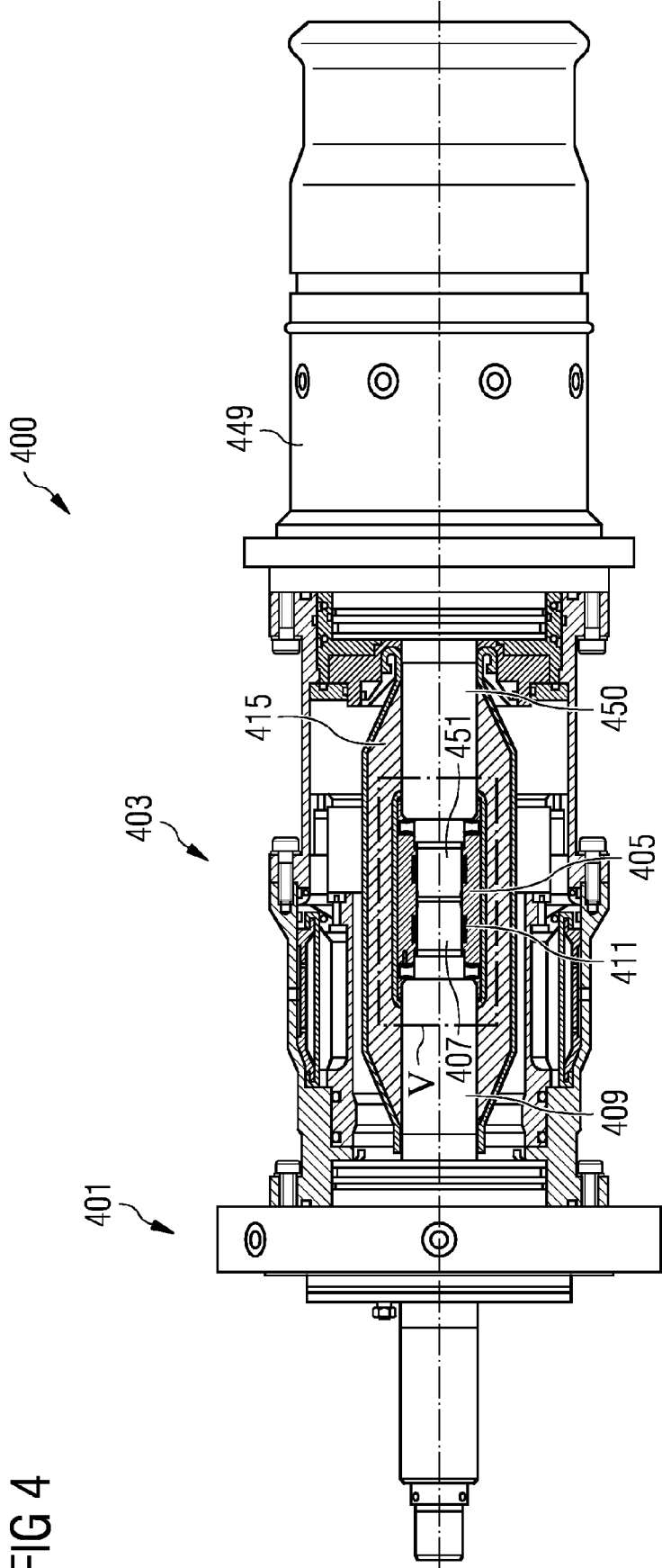


FIG 5

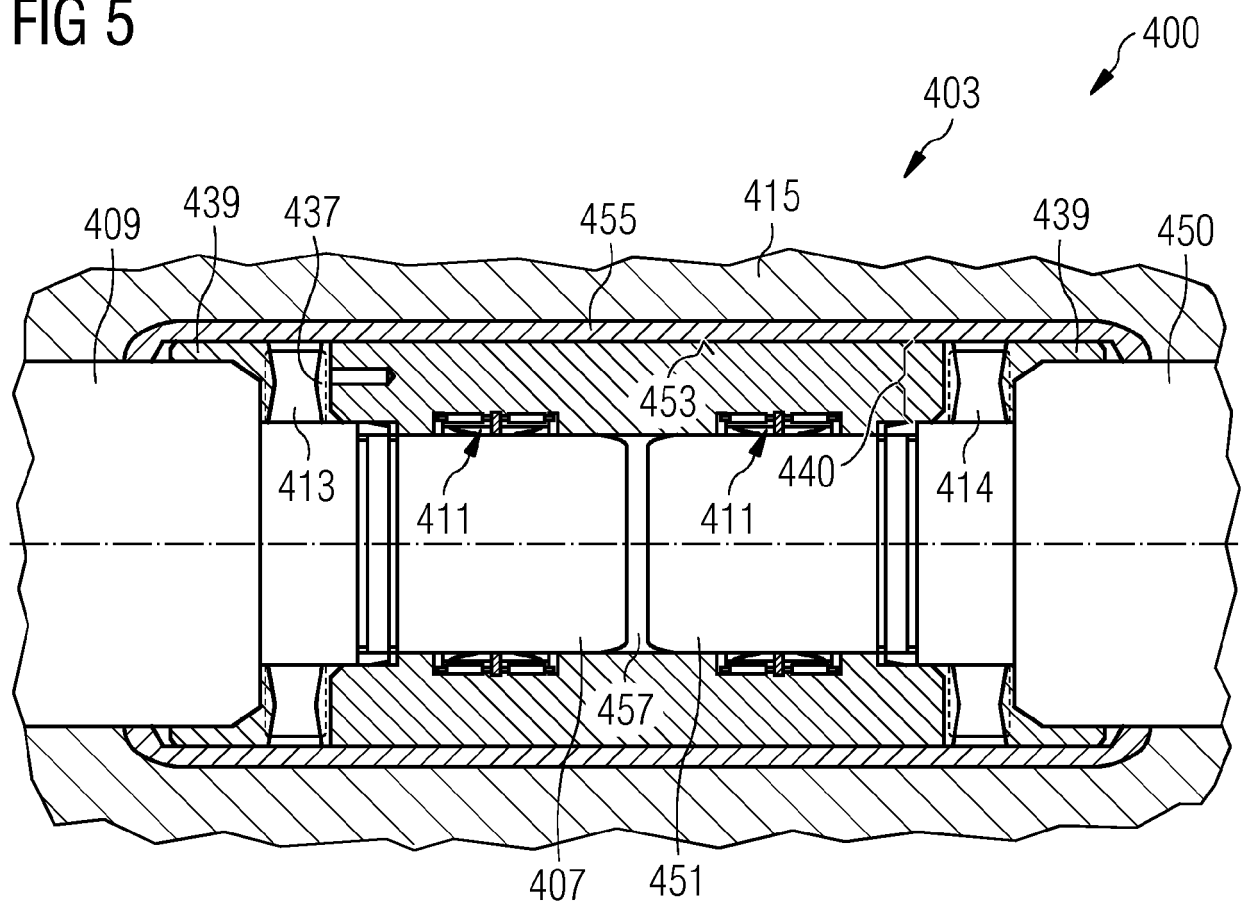


FIG 6

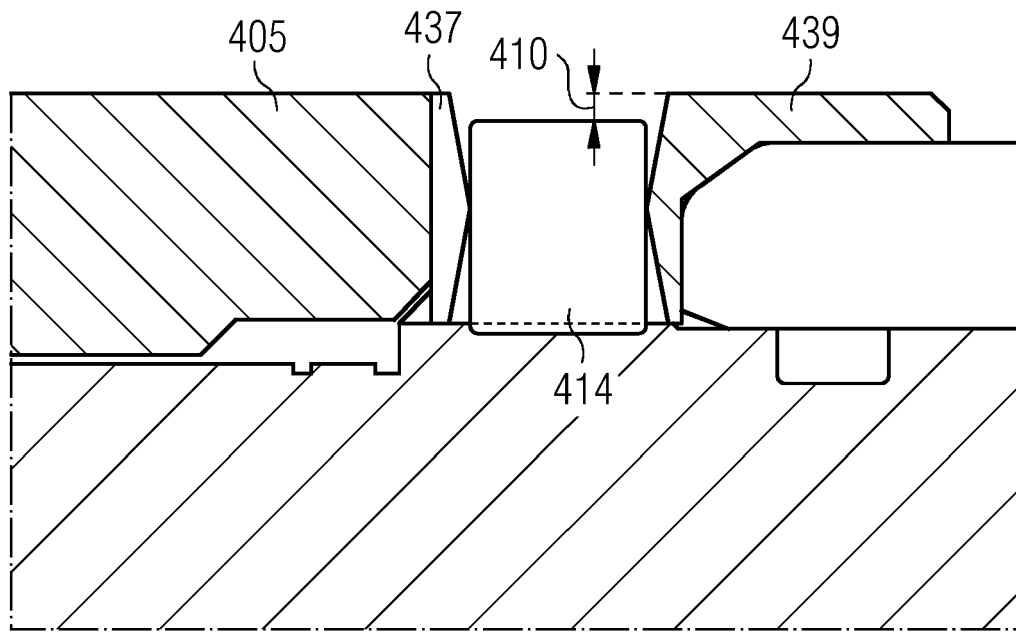


FIG 7

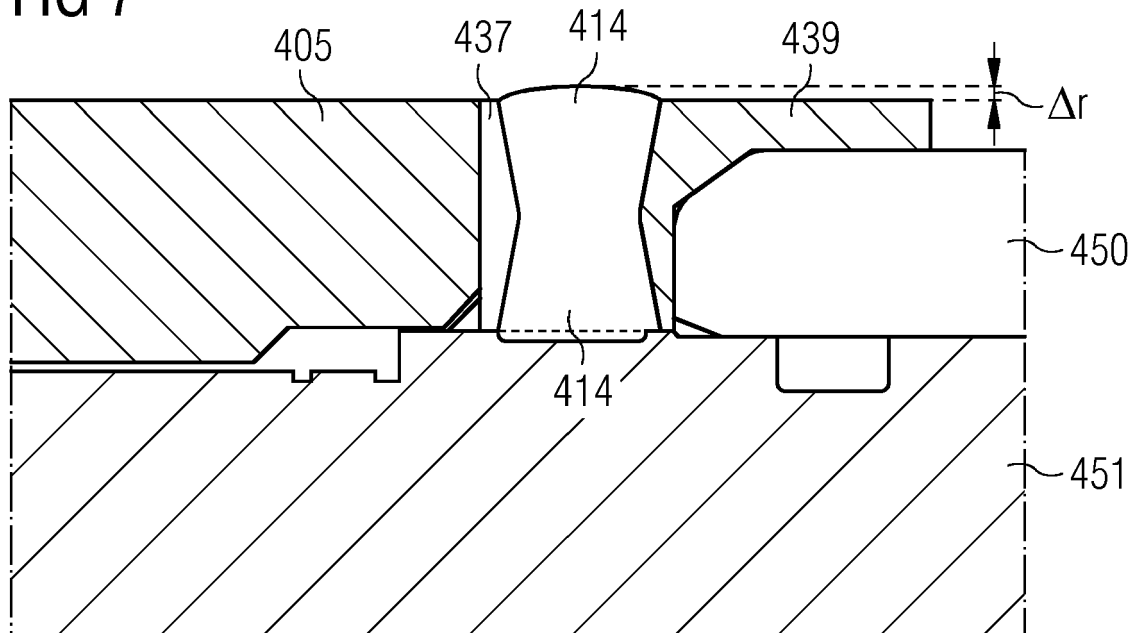
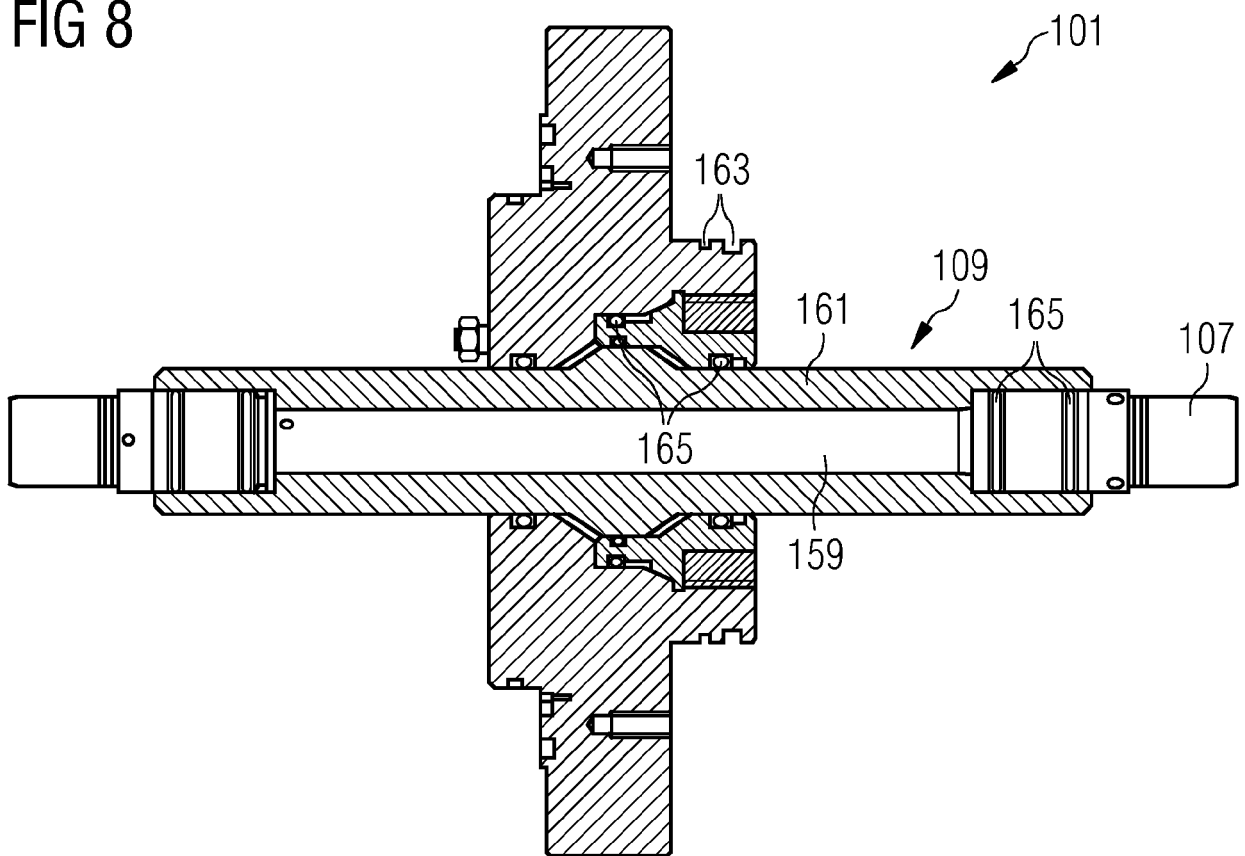


FIG 8





EUROPEAN SEARCH REPORT

Application Number
EP 17 16 0860

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 381 117 A2 (NEXANS [FR]) 14 January 2004 (2004-01-14) * paragraph [0028] - paragraph [0049]; figures 1,2 *	1-14	INV. H01R13/523 H01R13/533
A	EP 2 811 584 A1 (SIEMENS AG [DE]) 10 December 2014 (2014-12-10) * figure 2 *	1-14	ADD. H01R13/52
A,D	WO 2016/146667 A2 (SIEMENS AG [DE]) 22 September 2016 (2016-09-22) * figure 4 *	1-14	
A	WO 2011/060075 A2 (TELEDYNE ODI INC [US]; CAIRNS JAMES L [US]) 19 May 2011 (2011-05-19) * figures 3,5 *	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01R
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 August 2017	Examiner Philippot, Bertrand
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 16 0860

5

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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22-08-2017

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 1381117	A2	14-01-2004	BR 0302296 A	08-09-2004
			EP 1381117 A2	14-01-2004
			NO 319369 B1	25-07-2005
			US 2004097131 A1	20-05-2004

EP 2811584	A1	10-12-2014	AU 2014276986 A1	12-11-2015
			EP 2811584 A1	10-12-2014
			EP 2979331 A1	03-02-2016
			EP 3046187 A1	20-07-2016
			EP 3062400 A1	31-08-2016
			US 2016126641 A1	05-05-2016
			US 2016211588 A1	21-07-2016
			US 2016211589 A1	21-07-2016
			WO 2014195239 A1	11-12-2014

WO 2016146667	A2	22-09-2016	EP 3070789 A1	21-09-2016
			WO 2016146667 A2	22-09-2016

WO 2011060075	A2	19-05-2011	EP 2499706 A2	19-09-2012
			US 2011130024 A1	02-06-2011
			WO 2011060075 A2	19-05-2011

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2016146667 A2 [0006]