(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 511 519 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.07.2019 Bulletin 2019/29

(51) Int Cl.:
E21B 47/01 *(2012.01)* ***E21B 47/12*** *(2012.01)*

(21) Application number: **18151895.2**

(22) Date of filing: **16.01.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

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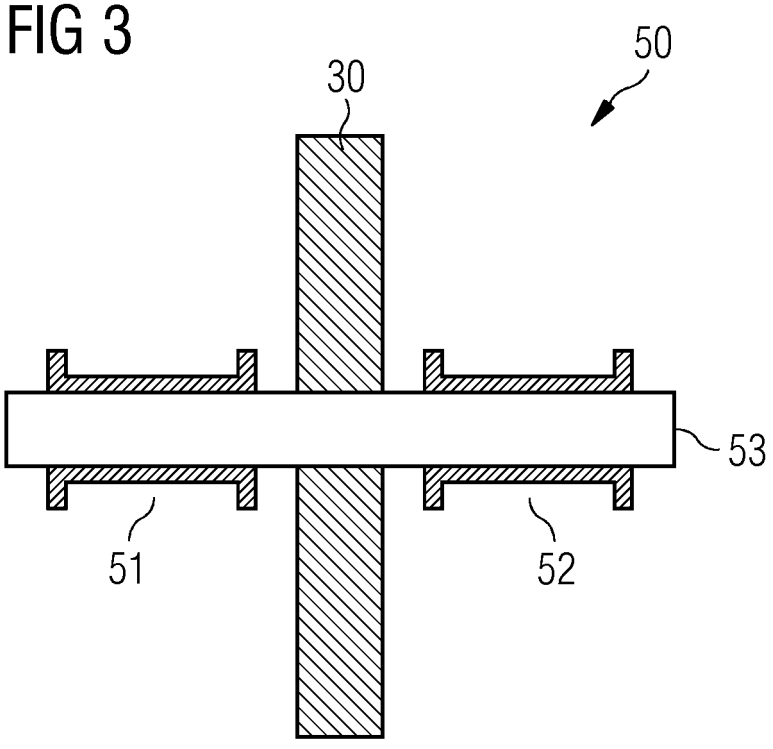
(54) SUBSEA HOUSING ASSEMBLY

(57) The present invention relates to a subsea housing assembly comprising a subsea housing having a first and a second housing portion. The first housing portion (10) comprises a first electrical connection (15) for data communication and the second housing portion (20) comprises a second electrical connection (25) for data communication. A wall (30) provides separation between the first housing portion and the second housing portion. The subsea housing assembly further comprises an inductive coupler (50) comprising a first coupling section (51) disposed in the first housing portion and a second coupling section (52) disposed in the second housing portion. The inductive coupler is configured to provide inductive coupling across the wall for providing at least a data communication between the first electrical connection and the second electrical connection. The inductive coupler further comprises a magnetic coupling element (53) which traverses the wall and extends into the first housing portion and into the second housing portion, wherein the magnetic coupling element is made from a material different than that of the wall.

FIG 3



EP 3 511 519 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a subsea housing assembly and to a subsea sensor.

BACKGROUND

[0002] Subsea sensors such as temperature sensors or pressure sensors are essential components of any subsea processing facility. A subsea sensor may for example be mounted to a pipe section through which a process fluid flows, such as a gas, a liquid, or a multiphase fluid which can include gaseous, liquid and solid constituents. The process fluid pressure in some applications can be very high, for example in excess of 1,000 or 1,400 bar. While it is important for the process of extracting the process fluid to measure those high pressures with high accuracy it is similarly important to ensure that no process fluid leaks into the seawater under any circumstances.

[0003] European patent application EP 3269921 discusses a subsea housing assembly having a wall 30 providing a separation between a first housing portion 10 and a second housing portion 20 wherein a data communication is being provided between the first and second housing portions, through said wall, by way of inductive coupling 50. In the embodiments discussed in EP 3269921 the wall is integrally formed with a housing body 12 and the coils 51, 52 forming the inductive coupler are placed on either side of the wall. As housing body 12 and wall 30 are typically made of metal having a certain minimum thickness in order to withstand the high pressures the performance of the inductive coupling will generally not be optimal.

[0004] It is therefore an object of the present invention to provide a subsea housing assembly and a subsea sensor wherein the performance of the inductive coupling is improved.

SUMMARY

[0005] In accordance with one aspect of the present invention there is provided a subsea housing assembly comprising a subsea housing having a first and a second housing portion. The first housing portion comprises a first electrical connection for data communication and the second housing portion comprises a second electrical connection for data communication. A wall provides separation between the first housing portion and the second housing portion. The subsea housing assembly further comprises an inductive coupler comprising a first coupling section disposed in the first housing portion and a second coupling section disposed in the second housing portion. The inductive coupler is configured to provide inductive coupling across the wall for providing at least a data communication between the first electrical connection and the second electrical connection. The inductive coupler further comprises a magnetic coupling element which traverses the wall and extends into the first housing portion and into the second housing portion, wherein the magnetic coupling element is made from a material different than that of the wall.

[0006] In a preferred embodiment the wall is a pressure barrier configured to resist a predetermined minimum pressure difference across the wall.

[0007] In a preferred embodiment the inductive coupler may further be configured to inductively supply electrical power from the electrical connection in the second housing portion to the electrical connection in the first housing portion.

[0008] In a preferred embodiment the magnetic coupling element may be mounted in the wall by way of an interference fit such as a press fit or a shrink fit.

[0009] In a preferred embodiment the magnetic coupling element may be welded to the wall. It should be noted that the interference fitting and the welding can be combined to improve pressure resistance of the joint.

[0010] In preferred embodiments, in order to increase the pressure resistance of the joint between wall and magnetic coupling element the thickness of the wall may increase near the joint so as to increase the area of contact between the wall and the coupling element.

[0011] In a preferred embodiment the magnetic coupling element is made of soft magnetic material, preferably soft iron.

[0012] In a preferred embodiment the wall is made of a non-magnetic material, preferably a non-magnetic metal, for example Iconel 625.

[0013] In a preferred embodiment the first coupling section and/or the second coupling section of the inductive coupler comprise(s) at least one respective coil arranged on a respective section of the magnetic coupling element. As an example, the coil in the second housing section may be driven by an AC current that can be modulated for data communication. The resulting electromagnetic field can induce a magnetic flow in the magnetic coupling element which in turn can induce a current in the coil of the first coupling section in the first housing portion. Electrical power and data communication signals (which can include control signals) may thus be transferred into the first housing portion. Similarly, a modulated current can be provided to the coil of the first coupling section, which induces a respective magnetic flow in the magnetic coupling element which in turn induces a respective current in the second coupling section, for example for transferring sensor data or the like.

[0014] In embodiments of the present invention the magnetic coupling element is essentially cylindrical and extends into both housing sections such that the first and second coupling sections, including any number of coils, can be mounted in full on respective ends of the magnetic coupling elements. In other embodiments the cross section of the magnetic coupling element does not need to be constant over its length; for example the diameter may vary in the case of an essentially circular cross section

so as to improve the magnetic flux.

[0015] In accordance with another aspect of the present invention there is provided a subsea sensor comprising a subsea housing assembly according to the present invention and further comprising a sensor element disposed in the first housing portion, wherein the first electrical connection is configured for providing communication with the sensor element, and wherein the second electrical connection is configured to provide at least a sensor output of the subsea sensor.

[0016] By providing a subsea housing assembly with such inductive coupler, a data communication can be established through the wall of the subsea housing without using conventional glass penetrators which require a glass to metal sealing and need to be tested at 2.5 times the operating pressure, requiring the entire sensor to be designed to reliably withstand 2.5 times the operating pressure. With an inductive coupler it should be possible to test at only 1.5 times the operating pressure thereby reducing the design and testing requirements considerably. Additionally, problems associated the manufacture of glass to metal junctions and reduced insulation resistance of such penetrators may be avoided.

[0017] In some configurations, a single electrical line may be provided for power supply and data communication, for example by providing a respective modulation on the power line. In other embodiments, separate lines may be provided and may be part of the respective electrical connection, for example dedicated lines for power supply and data communication. In some embodiments, the sensor may only be a passive sensor, and only the electrical power required to read such passive sensor may be transmitted by means of the inductive coupler. In other applications, further electric and/or electronic components may be provided in the first housing portion, for example for operating the sensor element or processing sensor data. The inductive coupler's first and second coupling sections preferably provide inductive coupling for both data communication and power transfer. In other embodiments, the inductive coupler may comprise further coupling sections, for example for separately transferring electrical power and communication signals.

[0018] The first housing portion may for example comprise a sensor assembly including diaphragms, such as a process diaphragm and a sensor diaphragm, a sensor element, medium filled channels or the like and may further include a first pressure barrier that provides separation between the pressure prevailing in such medium filled channels and the first chamber. As an example, a process diaphragm may transmit the pressure of the process fluid to such medium (e.g. oil) present in the channels, which in turn applies the pressure to a sensor element. Accordingly, if such first pressure barrier fails and process fluid or process fluid pressure is transmitted into the first chamber, such fluid/pressure can be confined to within the first housing portion by means of the wall which constitutes a second pressure barrier.

[0019] The first housing portion may be sealed against a metal body by means of a metal seal, in particular a metal gasket. As an example, the subsea housing assembly may be part of a subsea sensor, and the first housing portion may be sealed against a pipe section, for example a pipeline section or a flow duct in a Christmas tree or the like. The first housing portion may comprise a mounting flange for mounting the subsea housing assembly to such metal body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a schematic diagram showing a subsea housing assembly and a subsea sensor wherein the wall is integrally formed with a housing body and the coils forming the inductive coupler are placed on either side of the wall as discussed in embodiments of EP 3269921.

Fig. 2 is a schematic diagram showing a subsea housing assembly mounted to a pipe section.

Figs. 3, 4 and 5 show details of the subsea housing assembly's inductive coupler according to embodiments of the present invention.

DETAILED DESCRIPTION

[0021] Fig. 1 is a schematic of a subsea housing assembly 100 that is part of a subsea sensor 200. The subsea housing assembly 100 includes a first housing portion 10 and a second housing portion 20. The first housing portion 10 includes a first housing body 12 and a first chamber 11. The second housing portion 20 includes a second housing body 22 and a second chamber 21. The first and second housing bodies 12, 22 include flanges 18, 28, respectively, by means of which they are fixedly attached to each other. In the present example, both housing portions are bolted together.

[0022] The first housing body 12 substantially surrounds the first chamber 11. In particular, the first housing portion 10 includes a wall 30 that provides a pressure barrier. This allows application of a high pressure difference across the walls of the first housing body 12. The wall 30 provides separation between the first chamber 11 and the second chamber 21. Accordingly, a safe and reliable sealing can be provided between the first and second chambers 11, 21 that is capable of withstanding high pressure differences, for example in excess of 1,000 or even 2,000 bar.

[0023] At the other end, the first housing portion 10 may simply be closed, for example by means of a closing plate or the like. Such configuration may be employed when the subsea housing assembly 100 is used for a subsea canister, such as a subsea electronic canister or a control canister or control module. In the embodiment of Fig. 1, the subsea housing assembly 100 is used for

a subsea sensor 200 and a first pressure barrier 17 is provided in the first housing portion 10. The first pressure barrier 17 provides sealing of the first chamber 11 towards a part of the first housing portion 10 in which a sensor element 61 is located and exposed to high pressures, such as the high pressure of a process fluid. Note that such exposure may be a direct exposure, or an indirect exposure, for example via a respective process diaphragm and a pressure transmission fluid such as oil or the like.

[0024] When embodied as subsea sensor as in Fig. 1, the first chamber 11 may comprise sensor electronics 62, such as control electronics, data processing electronics and the like. The first chamber 11 may be a pressure resistant chamber in which a predefined pressure is maintained, even when the subsea housing assembly 100 is installed at a subsea location. Such pressure may be a pressure below 10 bar, it may preferably be a pressure below 5, or even below 1.5 bar. A close to atmospheric pressure may prevail in the first chamber 11, which may thus be termed an atmospheric chamber. Chamber 11 may be filled with a gas, such as nitrogen, or a gas mixture, such as air or a mixture of nitrogen with other gasses. It may thus be possible to operate conventional electric and electronic components within chamber 11.

[0025] Accordingly, in the configuration of the subsea housing assembly as illustrated in Fig. 1, high pressures, such as of a process fluid, can effectively be confined to within the first chamber 11, even if the first pressure barrier 17 fails. The first pressure barrier 17 may for example comprise a feed through for an electric connection to the sensor element 61, or the sensor element 61 may itself be configured so as to constitute a pressure barrier. Under certain conditions, such pressure barrier may fail, thus allowing high pressure fluid to enter chamber 11. Wall 30 is constructed such that it provides a second barrier so that the pressure can be confined effectively within the first housing portion 10.

[0026] For providing a data communication with an electronic component within the first housing section 10, an inductive coupler 50 comprising a first coupling section 51 and a second coupling section 52 is provided. The first coupling section 51 is disposed in the first chamber 11 and connected to an electrical connection 15 that provides at least data communication, in particular with the sensor element 61 or the sensor electronics 62 in the example of Fig. 1. The second coupling section 52 is disposed in the second chamber 21 and is connected to a second electrical connection 25 in the second housing portion 20. The inductive coupler 50 provides at least data communication between the first and second electrical connections 15, 25 across the wall 30. Besides transmitting data communications, the coupler 50 may also be configured to transfer power from the electrical connection 25 to the electrical connection 15.

[0027] In order to improve the performance of the inductive coupler 50 a magnetic coupling element 53 is provided as shown in Fig. 3. Magnetic coupling element 53 traverses wall 30 such that the barrier function of wall 30 is not impeded. In particular, the opening in wall 30 through which magnetic coupling element 53 traverses is sealed by the magnetic coupling element 53 itself and/or by means of well-known sealing techniques (not shown). In a preferred embodiment magnetic coupling element 53 and wall 30 are in interference fit along their entire contact surface, for example by shrink-fitting and/or force fitting the magnetic coupling element 53 into the opening in wall 30. Alternatively or additionally the magnetic coupling element 53 may be welded to wall 30. In embodiments the wall's thickness may be increased around the junction of wall 30 and magnetic coupling element 53 as shown in Fig. 4, reference numeral 30A, so as to increase the contact surface between wall 30 and magnetic coupling element 53, thereby increasing the sealing area.

[0028] In embodiments both the wall 30 and the magnetic coupling element 53 are made of metal thereby allowing the interference fit to be as reliable as desired. In the preferred embodiment the wall is made of a non-magnetic metal such as Iconel 625 which is often used to construct housings for subsea components. The magnetic coupling element 53 is preferably made of a soft magnetic material so as to propagate magnetic fields. A material suitable for making the magnetic coupling element 53 is known as soft iron.

[0029] The magnetic coupling element 53 is preferably cylindrical because the manufacture of a cylindrical opening in wall 30 and the manufacture of a cylindrical magnetic coupling element 53 is typically more cost-effective than other shapes and allows for an optimal distribution of the stresses caused by the interference or shrink fit. Circumstances may however dictate other shapes such as square cross sections for magnetic coupling element 53 or a cross section that varies along the length of magnetic coupling element 53 and can be implemented without departing from the general principle of the invention described herein.

[0030] The first and second coupling sections 51, 52 may for example be implemented as coils which are preferably placed on or around either end of magnetic coupling element 53 as shown in Figs. 3 and 4. An alternating current (AC) provided to the second coupling section 52 may for example create a alternating magnetic field in magnetic coupling element 53 which in turn induces a current in the first coupling section 51 which then may be used to provide electric power to electric and electronic components comprised in the first housing portion 10 including sensor electronics 62 and sensor element 61. For data transmission, modulation may be provided. As an example, the current applied to the coil 52 may be modulated, and such modulation will lead to a modulation of the current induced in the first coupling section 51. For this purpose, a receiver/transmitter 56 can be provided in the second housing portion 20 and can be coupled to the second electrical connection 25. Unit 56 can include a receiver and a transmitter, and it may modulate control

signals received on line 41 for transmission via the inductive coupler 50, and it may demodulate signals received from the second coupling section 52 for further transmission via the line 41. Note that the transmitter/receiver 56 may also be located at a different position, for example at the other end of line 41, at a topside location, or at a subsea data processing hub.

[0031] Similarly, a transmitter/receiver 55 is provided in the first housing portion 10 in chamber 11 and is connected to the first electrical connection 15 and the first coupling section 51. Unit 55 may for example detect a modulation of a current received from the first coupling section 51 and may provide corresponding control signals to the sensor electronics 62. Unit 55 may further receive sensor data from the sensor electronics 62 and may modulate such sensor data onto a signal that is provided to the first coupling section 51, so that an alternating magnetic field is created in magnetic coupling element which is coupled to second coupling section 52 and induces a current therein that is detected and demodulated by transmitter/receiver unit 56. Accordingly, data recorded by the sensor element 61 can be communicated on line 41, without requiring electric wires that penetrate wall 30 which provides the secondary pressure barrier.

[0032] Inductive couplers 51 and 52 may comprise plural coupling sections, for example some dedicated to the transfer of electrical power and others dedicated to the transfer of data communications. Preferably, power and data communications are transmitted by the same coupling sections.

[0033] In yet other embodiments multiple magnetic coupling elements 53 may be provided so as to provide multiple coupling paths to avoid signal degradation by magnetic interference of the inbound and the outbound signal and/or power transmission, or to provide redundancy (not shown).

[0034] As the pressure is confined to within the first housing portion 10 by means of wall 30, the sealing of the second housing portion 20 is facilitated. In particular, the second chamber 21 can be a pressure compensated chamber the pressure of which is balanced to the surrounding ambient pressure, in particular the subsea pressure when the housing assembly 100 is installed subsea. The differential pressure across the walls of the second housing body 22 is accordingly relatively low. In the example of Fig. 1, the housing body 22 has an opening in which the second coupling section 52 is located. This opening is sealed against the first housing body 12, for example by means of O-ring seals 29. Double seals are preferably provided.

[0035] The second chamber 21 may be filled with a substantially incompressible medium, in particular a dielectric liquid or gel, such as oil or the like. The electric and electronic components of the unit 56 can be adapted to operate in such environment, or, as mentioned above, unit 56 may be located outside the chamber 21, for example in a subsea canister to which the sensor 200 is connected or topside. Pressure compensation can occur by means of a dedicated pressure compensator forming part of the subsea housing assembly 100 (not shown). In other embodiments, the subsea housing assembly 100 may be connected to a subsea cable in form of an oil filled hose, wherein the inner volume of such hose is filled with a dielectric liquid (in particular oil) and is pressure compensated against the ambient environment due to the flexibility of the hose. Pressure compensation of the second chamber 21 can occur via such hose, for example by allowing a flow communication through the opening 26 between the inner volume of the hose and the chamber 21, or by providing some pressure transmitting element in the opening, such as a membrane or bellows.

[0036] In other configurations the second chamber 21 may be a pressure resistant chamber. As an example, a predefined pressure below 10 bar, preferably below 5 bar or below 1.5 bar, such as close to atmospheric pressure may be maintained in chamber 21. For this purpose, a penetrator providing a pressure barrier can be provided in the opening 26. Since such penetrator has to withstand the differential pressure between the interior pressure of chamber 21 and the external subsea pressure when installed subsea, the pressure difference is relatively low compared to the pressure difference that can prevail when a barrier is exposed to the pressure of process fluid, such as the barrier provided by wall 30.

[0037] The second housing portion 20 may for example comprise a fitting or connector for providing a connection to a subsea cable. In other configurations, a further unit, such as a control module or the like, may be mounted directly to the subsea housing assembly 100.

[0038] By providing the inductive coupler 50, problems related to insulation resistance that occur with conventional glass penetrators may be overcome. In particular, insulation resistance would in such case be measured between the metal cage provided by the first and second housing bodies 12, 22 and the respective coupling section 51, 52, so that insulation resistance can be kept high. In particular, since no glass penetrators are used, the insulation resistance can also be maintained during high pressure testing.

[0039] In Fig. 2, an embodiment of a subsea housing assembly 100 that is part of an embodiment of a subsea sensor 200 is illustrated. The explanations provided above with respect to Figs. 1, 3 and 4 are equally applicable to the embodiment of Fig. 2. In Fig. 2, the subsea housing assembly 100 is mounted to a subsea pipe 80 through which a process fluid flows. As shown the first housing body 12 is pressed against the subsea pipe 80 by means of the mounting flange 16 and sealed by means of the seal 19 which may for example be a metal gasket. Note that two seals 19 may be provided to provide a double barrier.

[0040] Sensor element 61 may for example measure temperature and/or pressure of the process fluid flowing through the pipe section 80, and respective readings may be modulated and transmitted by the transmitter/receiver 55 via the inductive coupler 50.

[0041] To the port opening 26 of the second housing portion 20, a subsea cable in form of an oil filled hose 40 is mounted. Note that the subsea cable may form part of the subsea sensor 200 and that a (wet mate or dry mate) connector may be provided at the other end of the subsea cable 40 for connecting the sensor 200 to another subsea device or to a topside installation. In the example of Fig. 2 line 41 of subsea cable 40 is directly connected to electrical connection 25 and second coupling section 52. It will be apparent to those with skills in the art that in other embodiments further electric and electronic components such as the transmitting/receiving unit 56 can be provided. Again, it is noted that the opening 26 may in some embodiments allow a flow communication between the interior of subsea cable 40 and the second chamber 21, while in other embodiments, separation may be provided. Such separation can be provided by a pressure transmitting element such as a membrane, or by means of a penetrator which allows the maintaining of a pressure difference across the opening 26.

[0042] Figs. 3 and 4 show embodiments of the invention wherein the magnetic core 53 is essentially a soft magnetic rod requiring only one traversal of wall 30. In applications where the open magnetic coupling of a rod configuration is insufficient a closed configuration may be employed, shown schematically in Fig. 5, thereby improving the magnetic flux between the coupling sections 51 and 52. In the embodiment of Fig. 5 the wall 30 is traversed twice by a closed core magnetic coupling element 53 which can be constructed from a U- or C-shaped core section and an I-shaped core section as is well known in the art. For this and other embodiment(s) a square cross section may be chosen for the magnetic coupling element 53 instead of a circular cross section so as to allow the construction of magnetic coupling element 53 from electrically isolated thin metal layers, as is also well known in the art. Other closed core shapes such as oval shapes having two parallel cylindrical sections for traversing the wall 30 may also be employed. Of course it is possible to provide an increased wall thickness as shown in Fig. 4 for the two traversal points that are required for such an embodiment.

[0043] The subsea housing assembly 100 is described above with respect to the use in a subsea sensor 200, yet it is to be understood that it may also be used in other applications, in particular where the integrity of a pressure barrier is of importance, for example for protecting electric and electronic components. Such applications may include the application in a subsea control unit where the integrity of a one atmospheric chamber needs to be ensured. Other applications are equally conceivable.

[0044] While specific embodiments 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 respects 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 subsea housing assembly, comprising:

- a subsea housing;
- a first housing portion (10) of the subsea housing, wherein the first housing portion (10) comprises a first electrical connection (15) for data communication;
- a second housing portion (20) of the subsea housing, wherein the second housing portion (20) comprises a second electrical connection (25) for data communication;
- a wall (30) providing separation between the first housing portion (10) and the second housing portion (20) of the subsea housing; and
- an inductive coupler (50) comprising a first coupling section (51) disposed in the first housing portion (10) and a second coupling section (52) disposed in the second housing portion (20), wherein the inductive coupler (50) is configured to provide inductive coupling across the wall (30) for providing at least a data communication between the first electrical connection (15) in the first housing portion (10) and the second electrical connection (25) in the second housing portion (20);

characterized in that

the inductive coupler (50) further comprises a magnetic coupling element (53) which traverses the wall (30) and extends into the first housing portion (10) and into the second housing portion (20), wherein the magnetic coupling element (53) is made from a different material than the wall (30).

2. The subsea housing assembly according to claim 1, wherein the wall (30) is a pressure barrier configured to resist a predetermined minimum pressure difference across the wall (30).

3. The subsea housing assembly according to claim 1 or 2, wherein the inductive coupler (50) is further configured to inductively supply electrical power from the electrical connection (25) in the second housing portion (20) to the electrical connection (15) in the first housing portion (10).

4. The subsea housing assembly according to any of the preceding claims, wherein the first housing portion (10) comprises at least a first chamber (11), wherein the first chamber (11) is a pressure resistant chamber in which a predetermined pressure, in particular a pressure of less than 10 bar, is maintained when the subsea housing assembly (100) is installed subsea.

5. The subsea housing assembly according to any of

the preceding claims, wherein the subsea housing is a subsea housing of a subsea electrical device (200), wherein the first housing portion (10) comprises at least a first chamber (11), and wherein electric and/or electronic components of the subsea electrical device (200) are disposed in the first chamber (11).

6. The subsea housing assembly according to any of the preceding claims, wherein the second housing portion (20) comprises at least a second chamber (21), wherein the second chamber (21) is a pressure compensated chamber that is pressure balanced against an ambient pressure, in particular against the seawater pressure when installed subsea.

7. The subsea housing assembly according to claim 6, wherein the second housing portion (20) comprises a pressure compensator providing said pressure compensation, and/or wherein the second housing portion (20) is connected to a subsea cable (40) in form of an medium filled hose, wherein the second chamber (21) is pressure compensated via the medium filled hose (40).

8. The subsea housing assembly according to any of the preceding claims, wherein the wall (30) is a pressure barrier providing separation between a first chamber (11) in the first housing portion (10) and a second chamber (21) in the second housing portion (20), wherein the first chamber (11) is a pressure resistant chamber or a pressure compensated chamber, and wherein the second chamber (21) is a pressure resistant chamber or a pressure compensated chamber.

9. The subsea housing assembly according to any of the preceding claims, wherein the magnetic coupling element (53) is mounted in the wall (30) by way of an interference fit.

10. The subsea housing assembly according to any of the preceding claims, wherein the magnetic coupling element (53) is welded to the wall (30).

11. The subsea housing assembly according to any of the preceding claims, wherein the thickness of the wall (30) increases near the magnetic coupling element (30) so as to increase the area of contact between the wall and the magnetic coupling element.

12. The subsea housing assembly according to any of the preceding claims, wherein the magnetic coupling element is made of a soft magnetic material, preferably soft iron.

13. The subsea housing assembly according to any of the preceding claims, wherein the wall is made of a non-magnetic material, preferably a non-magnetic metal, preferably Iconel 625.

14. The subsea housing assembly according to any of the preceding claims, wherein the first coupling section (51) and/or the second coupling section (52) of the inductive coupler (50) comprise(s) at least one respective coil arranged on a respective section of the magnetic coupling element (53).

15. A subsea sensor comprising a subsea housing assembly (100) according to any of the preceding claims, wherein the subsea sensor (200) comprises a sensor element (61) disposed in the first housing portion (10), wherein the first electrical connection (15) is configured for providing communication with the sensor element (61), and wherein the second electrical connection (25) is configured to provide at least a sensor output of the subsea sensor (200).

FIG 1

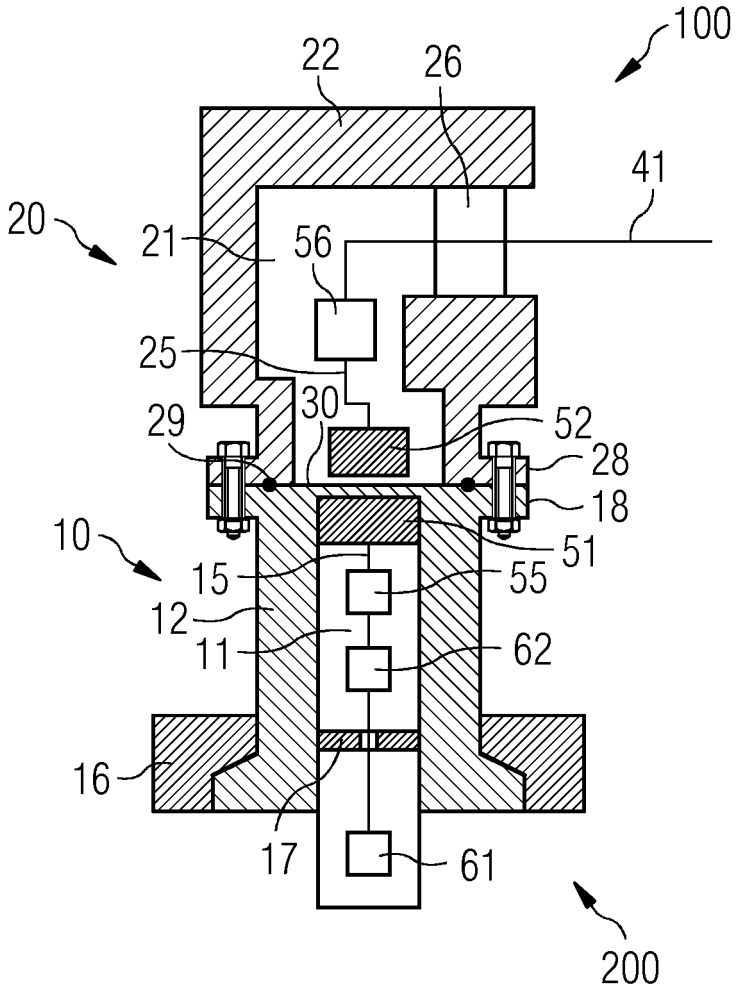

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FIG 2

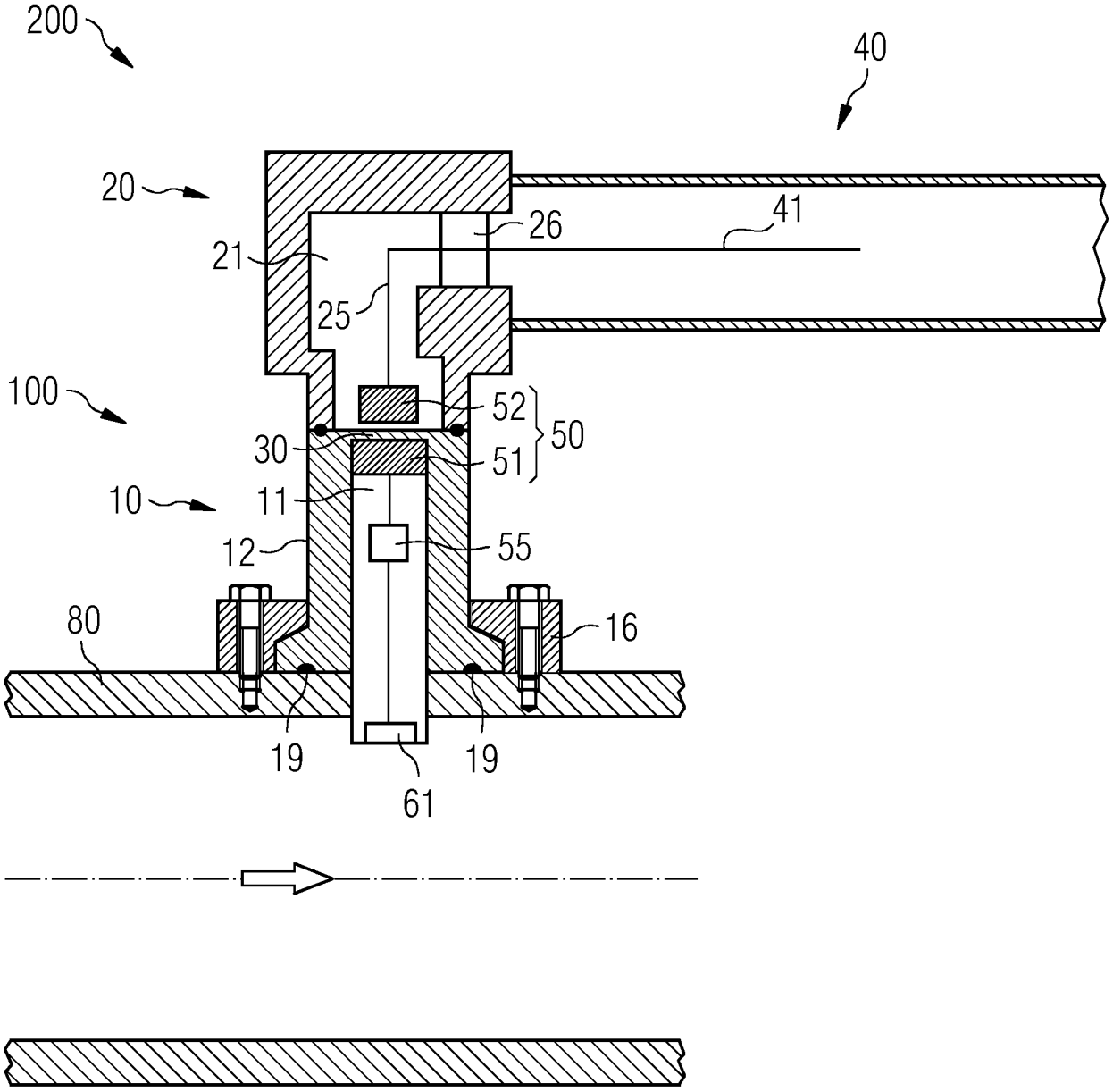


FIG 3

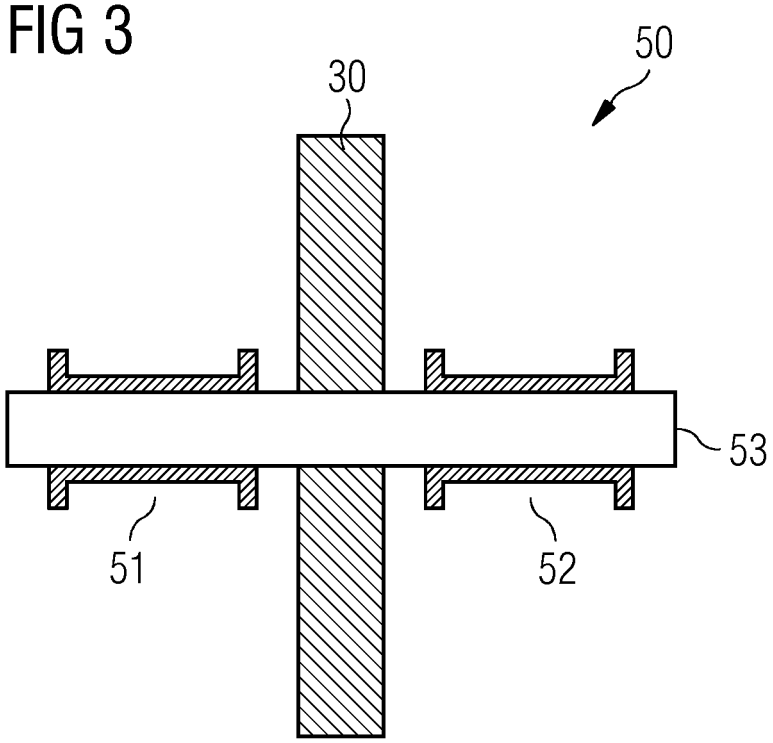


FIG 4

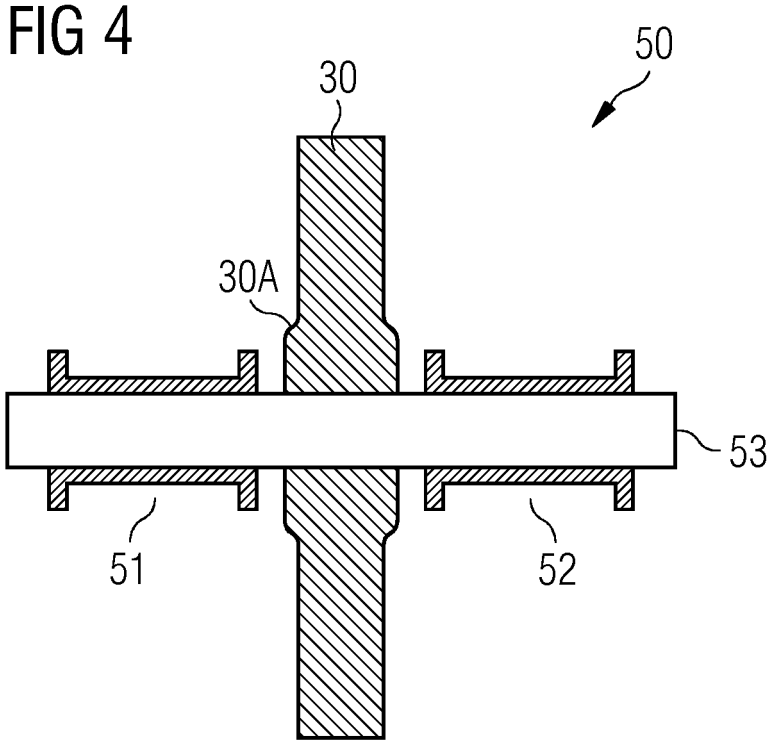
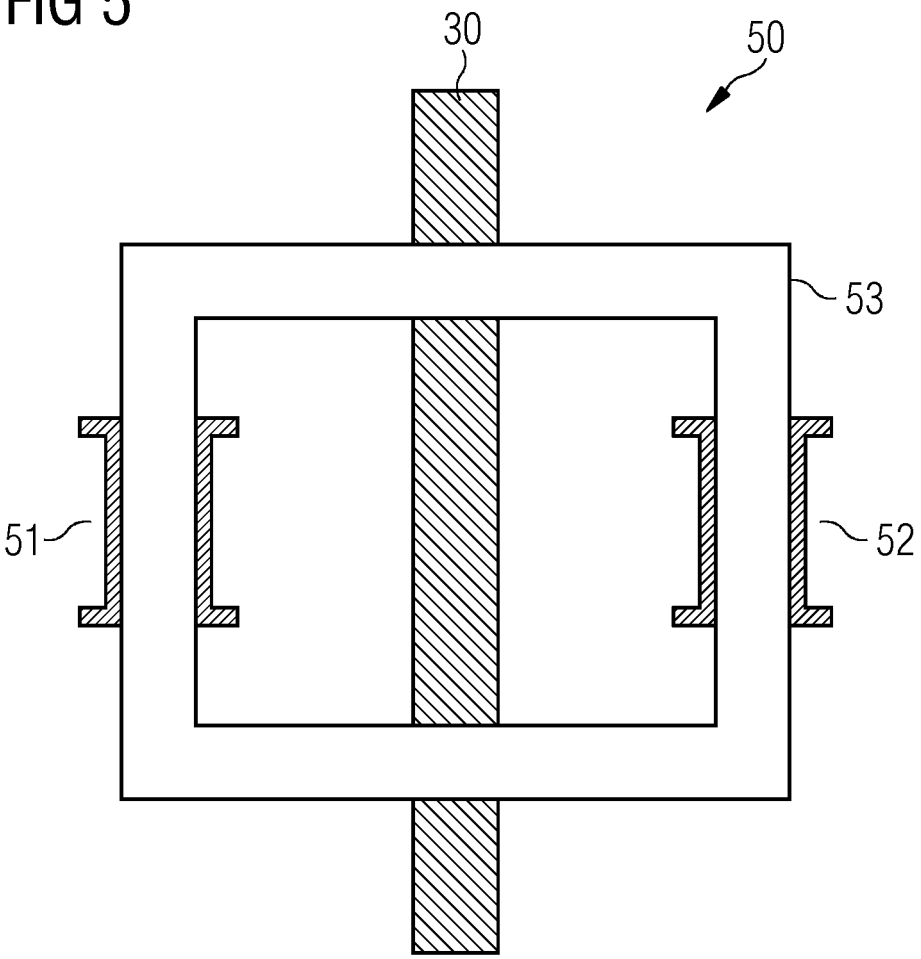


FIG 5



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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 1895

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	US 2010/011853 A1 (ANTHONY VENERUSO [US] ET AL) 21 January 2010 (2010-01-21) * page 3, paragraph 40 - paragraph 42; figures 3A,3B *	1,15	INV. E21B47/01 E21B47/12
A	US 7 847 671 B1 (RIACHENTSEV VALERI [US] ET AL) 7 December 2010 (2010-12-07) * abstract; figures 2,3 *	1,15	
A	GB 2 142 480 A (MARCONI AVIONICS) 16 January 1985 (1985-01-16) * the whole document *	1,15	
A	GB 2 144 274 A (MARCONI AVIONICS) 27 February 1985 (1985-02-27) * the whole document *	1,15	
A	US 2002/135179 A1 (BOYLE BRUCE W [US] ET AL) 26 September 2002 (2002-09-26) * the whole document *	1,15	

TECHNICAL FIELDS SEARCHED (IPC)
E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 July 2018	Morrish, Susan

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
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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10-07-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010011853 A1	21-01-2010	AT 543981 T	15-02-2012
		BR PI0716903 A2	22-10-2013
		CA 2663923 A1	27-03-2008
		EP 1903181 A1	26-03-2008
		US 2010011853 A1	21-01-2010
		WO 2008034761 A1	27-03-2008
US 7847671 B1	07-12-2010	US 7847671 B1	07-12-2010
		WO 2011014608 A2	03-02-2011
GB 2142480 A	16-01-1985	NONE	
GB 2144274 A	27-02-1985	NONE	
US 2002135179 A1	26-09-2002	CA 2378506 A1	23-09-2002
		GB 2375779 A	27-11-2002
		US 2002135179 A1	26-09-2002

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 3269921 A **[0003] [0020]**