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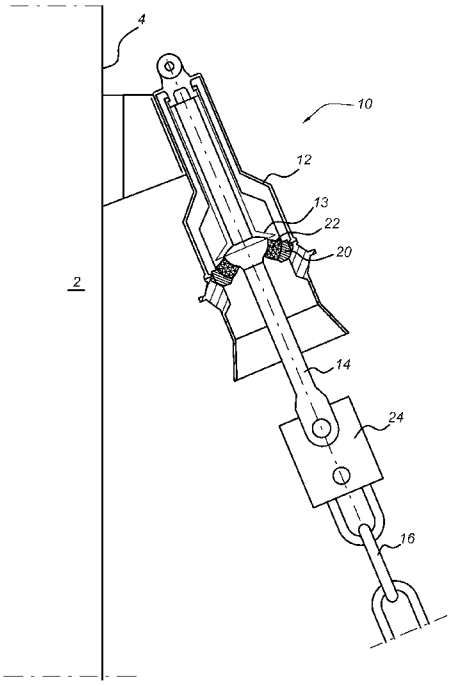
[Continued on next page]

(54) Title: CONNECTOR ARRANGEMENT FOR CONNECTING A MOORING LINE TO A FLOATING STRUCTURE AND FLOATING STRUCTURE COMPRISING SUCH A CONNECTOR ARRANGEMENT

Fig. 1



(57) Abstract: A connector arrangement for connecting a mooring line to a floating structure, includes a mechanical interface attached to a hull of the floating structure, and connectable to the mooring line; a connector element for connecting the mooring line to the mechanical interface;and a foundation that is arranged between the mechanical interface and the connector element for transferring a load from the connector element to the mechanical interface. The foundation comprises an elastic body in contact with the mechanical interface.

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Connector arrangement for connecting a mooring line to a floating structure and Floating Structure comprising such a connector arrangement.

Field of the invention

The present invention relates to a connector arrangement for connecting a mooring line to a floating structure. Additionally, the invention relates to a floating structure comprising such a connector arrangement. Moreover, the present invention relates to a method for manufacturing such a connector arrangement.

Background

In offshore technologies, use is made of floating structures for storage and/or production of hydro-carbon fluids, from undersea gas or oil fields. Such floating structures comprise floating storage and offloading (FSO) and floating production, storage and offloading (FPSO) vessels. Other types of floating structures include floating energy storage or energy production structures (based on either electrical or chemical principle of operations).

Such a floating structure may be secured at its position, by a structure of a number of mooring lines (or mooring legs), which connect to anchoring facilities at or in the seabed, geographically distributed i.e., spread around the position.

During use, a mooring leg, made-up completely or partially of chain links, between the floating structure and the anchoring facility, is exposed to forces caused by motions of the floating structure as exposed to sea and weather. Such forces give rise to some fatigue phenomena which could cause a chain link to fail:

- Tension-Tension
- OPB (Out of Plane Bending)
- IPB (In Plane Bending).

OPB and IPB fatigue occurs on the links of a mooring chain, near the connection to the floating structure, where due to the relatively high tension, the chain links do not rotate with respect to each other because of interlink friction. Rather than rotating, the links start to bend in order to follow the continuously changing floating structure motions (roll, pitch yaw, etc).

The chain is connected to the floating structure by means of a chain connector. The main issue with OPB and IPB are the motions (behaviour) of the floating structure with respect to the chain connector and the mooring leg.

It is on object of the present invention to provide a connector arrangement that reduces or removes the adverse effects of OPB and IPB.

Summary of the invention

The above object is achieved by a connector arrangement for connecting a mooring line to a floating structure, comprising:

a mechanical interface attached to a hull of the floating structure, and connectable to the mooring line;

a connector element for connecting the mooring line to the mechanical interface;

and a foundation that is arranged between the mechanical interface and the connector element for transferring a load from the connector element to the mechanical interface,

wherein the foundation comprises an elastic body in contact with the mechanical interface.

The invention provides that by means of the elastic foundation the overall bending stiffness of the connection between the top of the mooring line and the floating structure which is anchored to the chain, is reduced. Thanks to this lowered connection stiffness (typically < 20kNm/dg), the bending stresses induced in the mooring line by the motions of the floating structure are reduced and the fatigue life of the mooring line is increased.

According to an aspect, the invention provides a connector arrangement as described above, wherein the elastic body has a spherical or hemispherical outer surface, that is arranged to contact the mechanical interface, and an internal surface that is arranged to receive the connector element.

Advantageously, the shape of the elastic body allows rotating displacements of the connector element due to both in-plane and out-of-plane directions of movement of the connected mooring line.

According to an aspect, the invention provides a connector arrangement as described above, wherein the elastic body is configured for elastic deformation to

allow a displacement of the connector element due to a rotation of the mooring line with respect to the floating structure.

According to an aspect, the invention provides a connector arrangement as described above, wherein the elastic body comprises a stack of a plurality of elastic layers; in which stack, elastic layers are separated by an intermediate metal plate.

Such a stack allows an improved elastic deformation of the elastic body in comparison with the deformation of a monolithic elastic body under same conditions.

According to an aspect, the invention provides a connector arrangement as described above, wherein the connector element extends through the elastic body, the elastic body forming a collar around the connector element.

According to an aspect, the invention provides a connector arrangement as described above, wherein the connector element is a rod, the rod connecting on one end to the mooring line and on the other end to the mechanical interface.

According to an aspect, the invention provides a connector arrangement as described above, wherein the connector element is an intermediate chain, the intermediate chain connecting on one end to the mooring line and on the other end to the mechanical interface.

According to an aspect, the invention provides a connector arrangement as described above, wherein the foundation further comprises an in-use submerged antifriction ball or roller bearing in contact with the mechanical interface.

In an embodiment, the antifriction ball or roller bearing is self-lubricated with sea water during use.

Advantageously, the elastic body is complemented by a low friction bearing that is operated underwater without maintenance and without lubrication (except sea water). An example of such a bearing is a Polycrystalline Diamond type (PCD) bearing. In a preferred embodiment the low friction bearing is a spherical ball or roller bearing based on PCD technology in order to achieve a very low friction coefficient (<0.05) at low speeds (<10mm/s) for a large range of contact pressures corresponding to the mooring line pretensions and operating tension (typically between 100 tons to 500 tons). Another advantage of PCD bearing is the ability to handle the very large contact pressures associated with extreme design events such as 10000 year return period storms. The low friction of the bearing will reduce the

OPB and IPB moments imposed on the top chain and therefore will increase the fatigue life of the chain.

According to an aspect, the invention provides a connector arrangement as described above, wherein the mechanical interface comprises secondary rotating means for rotating the mechanical interface with respect to the hull.

According to an aspect, the invention provides a connector arrangement as described above, wherein the secondary rotating means are embodied as bushings located between the one end of the rod and the mooring line.

According to an aspect, the invention provides a connector arrangement as described above, wherein the secondary rotating means are embodied as bushings located at the connection of the mechanical interface with the hull.

Also, the present invention relates to a floating structure comprising a connector arrangement for connecting a mooring line to said floating structure as described above.

According to an aspect, the invention provides a floating structure as described above, wherein the floating structure is an offshore production and/or storage vessel, floating at sea, with one or more mooring lines attached to the seabed; the one or more mooring lines each being connected to the floating structure by a respective one of said connector arrangement.

Typically, the floating structure is an offshore production and/or storage vessel for oil, gas, electricity, compressed gas or other energy source medium.

Also, the invention relates to a method for manufacturing a connector arrangement as described above, of for manufacturing a floating structure comprising such a connector arrangement.

Advantageous embodiments are further defined by the dependent claims.

Brief description of drawings

The invention will be explained in more detail below with reference to drawings in which illustrative embodiments thereof are schematically shown. They are intended exclusively for illustrative purposes and not to restrict the inventive concept, which is defined by the appended claims.

Figure 1 shows a schematic perspective view of a connector arrangement in accordance with an embodiment of the invention;

Figure 2 shows a schematic view of a connector arrangement in accordance with an embodiment of the invention;

Figure 3 shows a schematic view of a connector arrangement according to an embodiment of the invention;

Figure 4 shows a schematic view of an elastic body in accordance with an embodiment of the invention, and

Figure 5 shows schematically a floating structure moored to a seabed by means of mooring lines.

Detailed description of embodiments

Figure 1 shows a schematic perspective view of a connector arrangement in accordance with an embodiment of the invention.

According to this embodiment, the connector arrangement relates to a mooring line latching system 10. The latching system 10 comprises a receiving connector part 12, that is mechanically connected to a hull 2 of a floating structure 4, such as an FPSO or FSO structure or vessel.

The receiving connector part 12 comprises an internal volume 13 in which a connector element 14 that can be coupled to a mooring line or mooring chain 16 can be received. The receiving connector part 12 thus has the function of a mechanical interface between the hull of the floating structure and the mooring line 16.

In the internal volume 13 of the receiving connector part 14, a foundation 20 is arranged which provides a mechanical coupling between the receiving connector part 12 and the connector element 14. By means of this mechanical coupling a mechanical load can be transferred from the connector element 14 to the receiving connector part 12. Typically , the connector element 14 is a rod that at the end distal to the hull is connected to a latch and at the other end is connected to the mooring line.

The foundation 20 comprises an elastic body 22 that is coupled on an outer surface with the receiving connector part 12 and on an inner surface with the connector element 14.

In an embodiment, the elastic body 22 has a spherical or hemispherical outer surface, that is arranged to contact the foundation at the receiving connector part, and has an internal surface that is arranged to receive the connector element.

Due to the elastic body, a flexible coupling is achieved between the receiving connector part 12 and the connector element 14 (rod). The flexible coupling compensates rotation of the connector element 14 and of the mooring line attached to the connector element (i.e., a rotation relative to the receiving connector part 12 and in general relative to the hull) by an elastic deformation of the elastic body which substantially removes or compensates the occurrence of bending stress in the chain shackles of the top of the mooring line attached to the connector element 14.

In a preferred further embodiment, the elastic body 22 comprises a stack of elastic layers which are separated by intermediate metallic plates.

As the elastic body can only handle limited deformations and correspondingly limited rotations, a first additional rotating coupling 24 may be provided between the connector element 14 and the mooring line 16. The first additional coupling is only activated when a rotation of the mooring line exceeds the rotating elastic deformation of the elastic body 22.

In a further embodiment, the elastic body 22 can be complemented by a submerged antifriction roller or ball bearing which will reduce the OPB and IPB moment imposed on connector part 12 and mooring chain 16. This low friction bearing is typically operated underwater without maintenance and without lubrication (except sea water).

Figure 2 shows a schematic view of a connector arrangement 11 in accordance with an embodiment of the invention.

In this embodiment, the connector arrangement 11 is largely identical to the embodiment of the connector arrangement 10 as described with reference to Figure 1. In this embodiment, a second additional rotating coupling 26 is arranged between the body of the receiving connector part 12 and the hull of the floating structure. It is noted that the second additional rotating coupling 26 may replace the first additional coupling 24 or may be arranged as a further coupling in addition to the first additional coupling 24 (not shown in figure 2).

Figure 3 shows a schematic view of a connector arrangement according to an embodiment of the invention.

According to this embodiment, the connector arrangement relates to a chain connector 40 . The chain connector 40 comprises a chain connector arm 42, that is mechanically connected to a hull of a floating structure, such as an FPSO or FSO structure or vessel.

The chain connector arm 42 comprises an internal volume 43 in which a connector element 44 that can be coupled to a mooring line or mooring chain 16 can be received.

Typically, the connector element 44 is an intermediate chain that at the end proximate to the hull is connected to a chain tensioning system (not shown) and at the other end is connected to the mooring line or mooring chain.

In the internal volume 43 of the chain connector arm 42, a foundation 46 is arranged which provides a mechanical coupling between the chain connector arm 42 and the intermediate chain 44.

In an embodiment, the intermediate chain is resting on a ratchet stopper (schematically shown). The ratchet is resting on the elastomeric foundation.

By means of this mechanical coupling a mechanical load can be transferred from the intermediate chain 44 to the chain connector arm 42.

The chain connector arm 42 thus has the function of a mechanical interface between the hull of the floating structure and the mooring line 16.

The foundation 46 comprises an elastic body 48 that is coupled on an outer surface with the chain connector arm 42 and on an inner surface with the intermediate chain 14.

In an embodiment, the elastic body 48 has a spherical or hemispherical outer surface, that is arranged to contact the foundation at the receiving connector part, and has an internal surface that is arranged to receive the intermediate chain 44.

As the elastic body can only handle limited deformations and correspondingly limited rotations, bushings 54 for the purpose of an additional rotating coupling may be provided between the chain connector arm 42 and the hull of the floating structure. The bushings 54 are only activated when a rotation of the mooring line exceeds the rotating elastic deformation of the elastic body 22.

Figure 4 shows a schematic view of an elastic body in accordance with an embodiment of the invention.

In an embodiment, the elastic body 22, 48 has an hemispherical outer shape 50 and an internal surface 52, shaped to receive the connector element 14. Instead of being hemispherical, the outer surface may be spherical.

The inner surface is arranged for receiving the connector element, e.g., the connector rod 14 or the intermediate chain 44. The outer surface is arranged to be positioned on a foundation in the receiving connector part or in the internal volume of the chain connector arm.

Both hemispherical and spherical outer surface shapes allows a rotating displacement of the connector element captured in the inner surface with respect to the foundation.

Figure 5 shows schematically a floating structure 100 moored to a seabed by means of mooring lines.

The connector arrangement of the present invention can be used on floating structures 100, that float on sea 120 and that are moored by means of mooring lines 16 attached to the seabed 130. Such floating structures may be associated with offshore production and/or storage vessels (FPSO or FSO).

The mooring lines 16 are coupled to the floating structure 100 by means of the connector arrangement 10; 11; 40 in accordance with an embodiment of the invention.

It is noted that in an alternative embodiment, the elastic body is modified with an underwater antifriction ball or roller bearing, self-lubricated with sea water in contact with the mechanical interface.

According to a further embodiment, the antifriction bearing has a spherical or hemispherical outer surface, that is arranged to contact the mechanical interface, and has an internal surface that is arranged to receive the connector element.

According to yet a further embodiment, the antifriction bearing is configured to allow a displacement of the connector element due to a rotation of the mooring line with respect to the floating structure.

According to an embodiment, the antifriction bearing comprises a Polycrystalline Diamond roller or ball bearing.

Other alternatives and equivalent embodiments of the present invention are conceivable within the idea of the invention, as will be clear to the person skilled in the art. The scope of the invention is limited only by the appended claims.

5

Claims

1. Connector arrangement for connecting a mooring line to a floating structure, comprising:
a mechanical interface attached to a hull of the floating structure, and connectable to the mooring line;
a connector element for connecting the mooring line to the mechanical interface;
and a foundation that is arranged between the mechanical interface and the connector element for transferring a load from the connector element to the mechanical interface,
wherein the foundation comprises an elastic body in contact with the mechanical interface.

2. Connector arrangement according to claim 1, wherein
the elastic body has a spherical or hemispherical outer surface, that is arranged to contact the mechanical interface, and has an internal surface that is arranged to receive the connector element.

3. Connector arrangement according to claim 2, wherein the elastic body is configured for elastic deformation to allow a displacement of the connector element due to a rotation of the mooring line with respect to the floating structure.

4. Connector arrangement according to claim 3, wherein the elastic body comprises a stack of a plurality of elastic layers; in which stack, the elastic layers are separated by an intermediate metal plate.

5. Connector arrangement according to any one of the preceding claims 2 – 4, wherein the connector element extends through the elastic body,
the elastic body forming a collar around the connector element.

6. Connector arrangement according to claim 5, wherein
the connector element is a rod, the rod connecting on one end to the

mooring line and on the other end to the mechanical interface.

7. Connector arrangement according to claim 5, wherein the connector element is an intermediate chain, the intermediate chain connecting on one end to the mooring line and on the other end to the mechanical interface.

8. Connector arrangement according to any one of the preceding claims, wherein the mechanical interface comprises secondary rotating means for rotating the mechanical interface with respect to the hull.

9. Connector arrangement according to claim 8 as far as dependent on claim 6, wherein the secondary rotating means are embodied as bushings located between the one end of the rod and the mooring line.

10. Connector arrangement according to claim 8 as far as dependent on claim 6 or on claim 7, wherein the secondary rotating means are embodied as bushings located at the connection of the mechanical interface with the hull.

11. Connector arrangement according to claim 1, wherein the foundation further comprises an antifriction ball or roller bearing in contact with the mechanical interface; said bearing being configured as a submerged bearing during use.

12. Connector arrangement according to claim 11, wherein the antifriction bearing has a spherical or hemispherical outer surface, that is arranged to contact the mechanical interface, and has an internal surface that is arranged to receive the connector element.

13. Connector arrangement according to claim 12, wherein the antifriction bearing is configured to allow a displacement of the connector element due to a rotation of the mooring line with respect to the floating structure.

14. Floating structure comprising a connector arrangement for connecting a mooring line to said floating structure according to any one of the preceding claims 1 – 13.

15. Method for manufacturing a connector arrangement for connecting a mooring line to a floating structure a mechanical interface attached to a hull of the floating structure, and connectable to the mooring line;
a connector element for connecting the mooring line to the mechanical interface;
and a foundation that is arranged between the mechanical interface and the connector element for transferring a load from the connector element to the mechanical interface,
wherein the foundation comprises an elastic body in contact with the mechanical interface;
the method comprising:
-- attaching the mechanical interface to a hull of the floating structure;
-- mounting the connector element on the mechanical interface, such that the connector element is mounted on the foundation.

Fig. 1

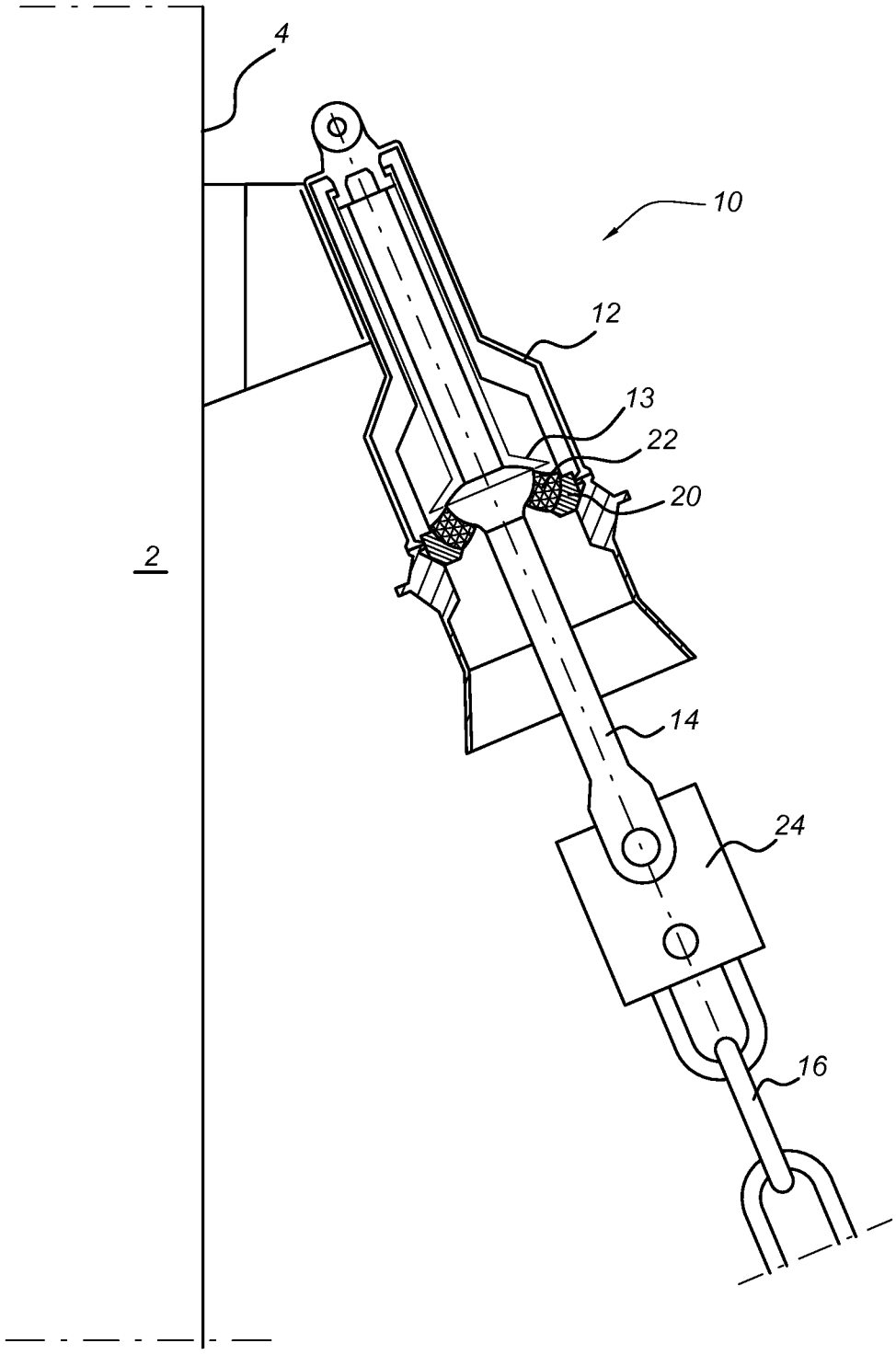


Fig. 2

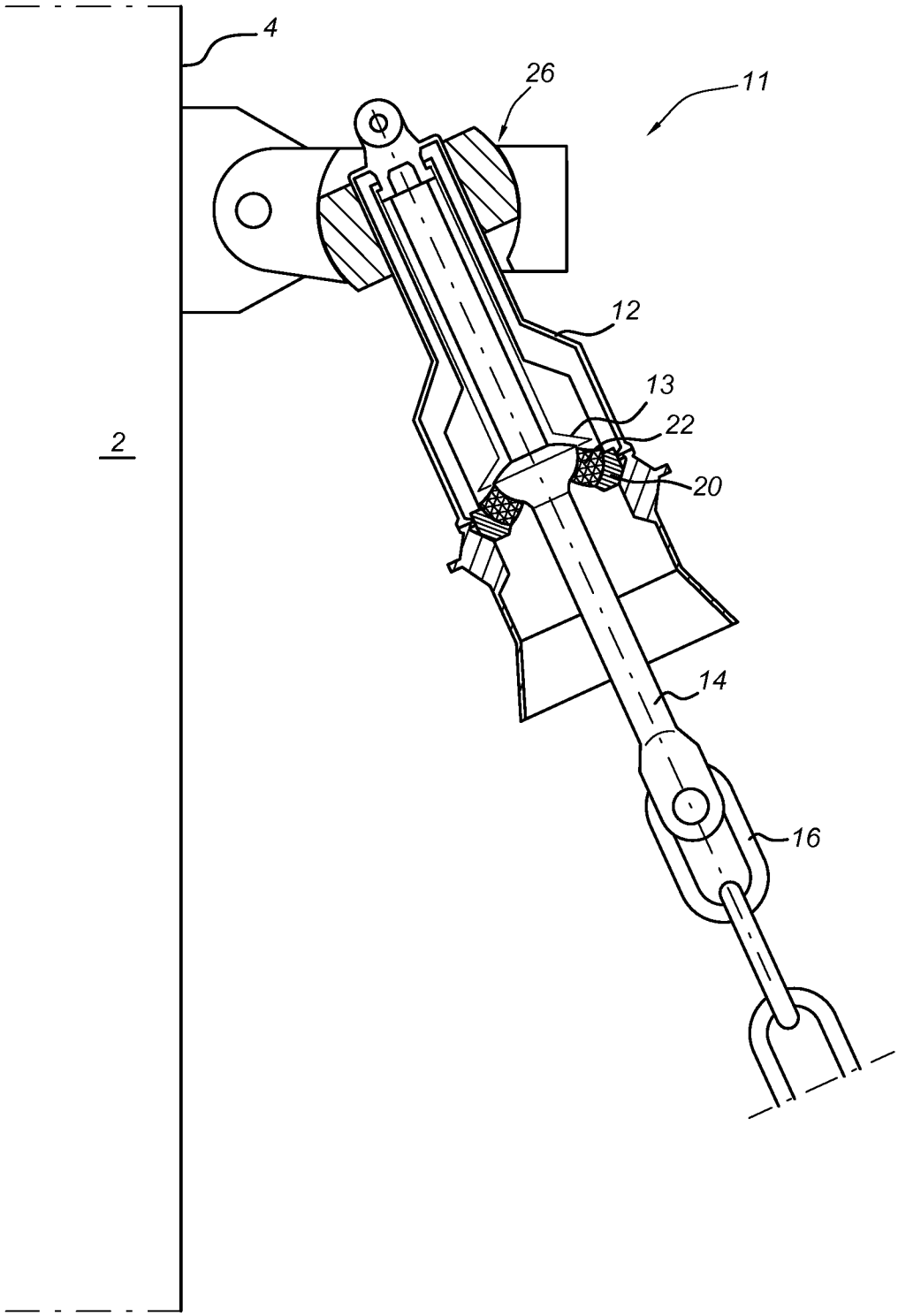


Fig. 3

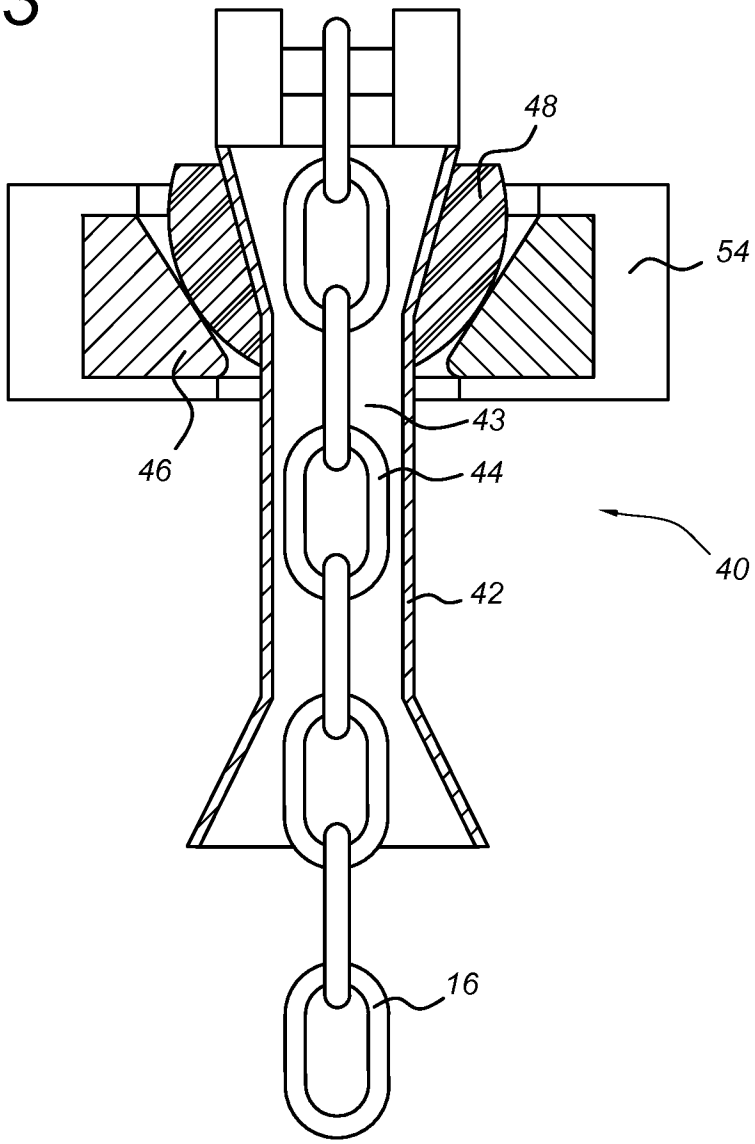


Fig. 4

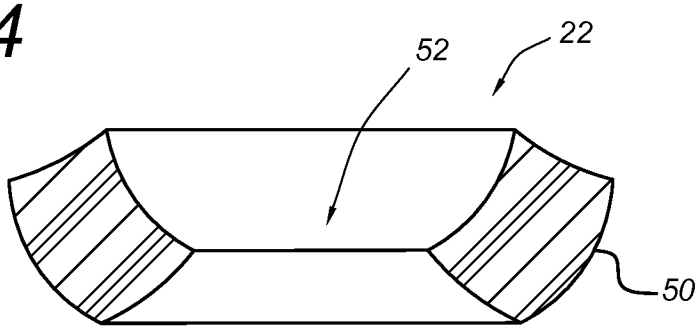
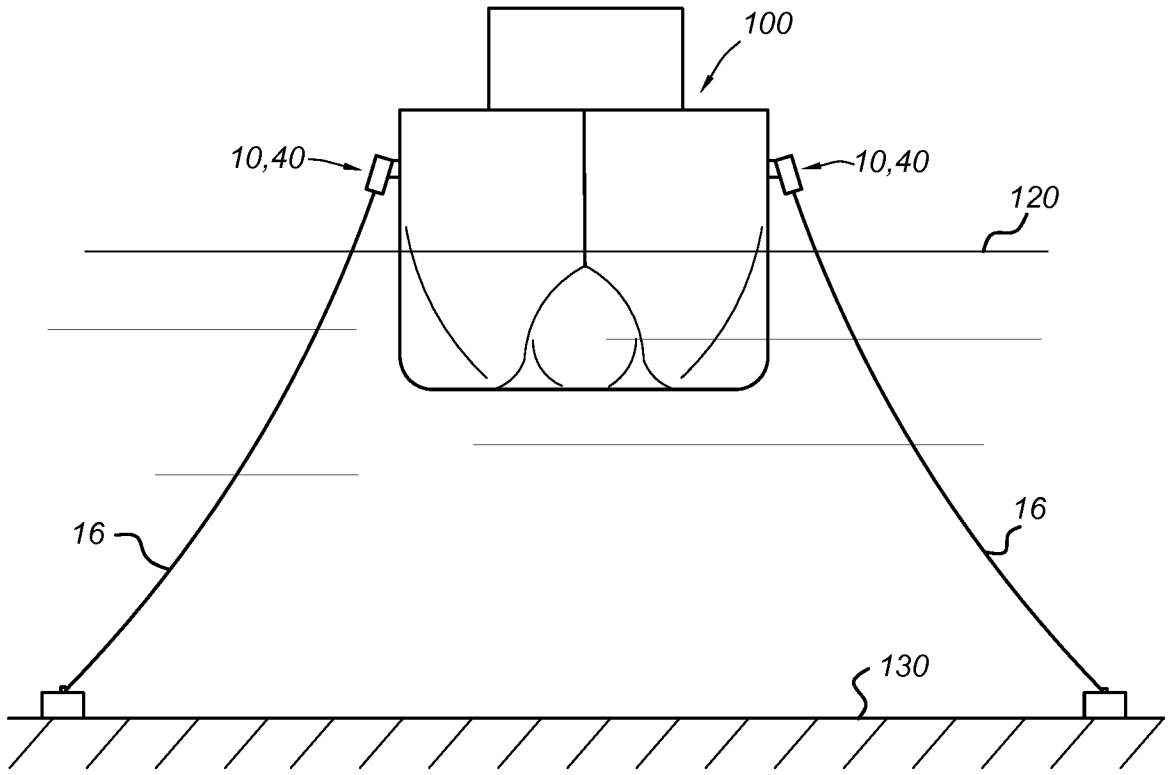


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/072456

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B21/10 B63B21/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 873 678 A (MOSES CHARLES J [US]) 23 February 1999 (1999-02-23) column 1, line 14 - line 20 column 4, line 62 - column 5, line 21 figures -----	1-6, 8-10,14, 15
X	GB 2 496 860 A (SUBSEA 7 LTD [GB]) 29 May 2013 (2013-05-29) page 11, line 24 - line 29 page 12, line 16 - line 33 figures ----- -/--	1-5,7, 14,15

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

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2016	26/10/2016

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1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/072456

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/026953 A1 (RTI ENERGY SYSTEMS INC [US]) 3 April 2003 (2003-04-03) page 7, line 15 - page 8, line 5 page 8, line 20 - page 9, line 7 page 10, line 13 - line 19 figures -----	1,11-15
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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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