DISCONNECTABLE MOORING SYSTEM WITH GROUPED CONNECTORS

Fig. 1

Abstract: A disconnectable mooring system for a weathervaning vessel with a moonpool (5) which extends from deck level to keel level, includes a turret (3) to be held within the moonpool; a swivel unit for transfer of fluids mounted on the turret; a bearing assembly (22) between the turret and the moonpool; a buoy (6) anchored to the seabed via multiple mooring lines (9, 9''), that can be retrieved in the moonpool and be connected to the turret; a locking assembly (7) for mechanically locking the buoy to the turret; at least one riser (8) for transfer of fluids from or to the seabed and being supported by the buoy; the locking assembly includes at least two connectors (10', 10''), each connector provided with a clamp that can be moved in a radially outward direction to connect the buoy to the turret.
Published:

— with international search report (Art. 21(3))
D ISCONNECTABLE MOORING SYSTEM WITH GROUPED CONNECTORS

Field of the invention

The invention relates to a disconnectable mooring system for a weathervaning vessel that is provided with a moonpool which extends from deck level to keel level, a turret to be held within the moonpool, a swivel unit for transfer of fluids mounted on the turret, a bearing assembly between the turret and the moonpool, a buoy anchored to the seabed via multiple mooring lines and that can be retrieved in the moonpool and be connected to the turret, a locking assembly for mechanically locking the buoy to the turret and at least one riser for transfer of fluids from or to the seabed and which is supported by the buoy.

The present invention also relates to a method of mooring a vessel with a disconnectable mooring system according to the present invention.

Background of the invention

A buoy-turret mooring system (BTM) is a disconnectable buoy turret system in which a buoy is connected to a central structural connector which is placed at the lower end of a turret that is placed within a moonpool of a vessel. When the structural connector is opened, the buoy will be disconnected and will sink to a predetermined submerged level due to the weight of the anchor lines that are connected to the buoy.

The present invention relates to the field of internal turret mooring systems that are permanently integrated into the hull of the FPSO vessel. Such a system allows the vessel to passively "weathervane" around multiple anchor legs, while simultaneously transferring fluids, power, and communications signals between the FPSO and the seabed.

The internal turret mooring system consists of a cylindrical turret structure located within a cylindrical moonpool integrated in the hull of the FPSO. A large diameter segmented roller bearing can connect the turret to the moonpool of the vessel. The bearing is mounted to its support structures by high strength, hydraulically pre-tensioned bolts. The main bearing which rotatably supports the turret within the moon pool of a vessel is preferably placed above water level, near the deck of the vessel. There are, depending on
the number of risers, different turret bearing arrangements possible for supporting the turret on the vessel, for example an axial radial bearing system, a segmented bearing system, a bogie wheel system or a sliding bearing system. Located at the top the turret are mooring buoy installation (winches) and production equipment. The swivel stack is located above the turret, with associated piping, manifolds and access arrangements.

The lower section of the turret structure houses the riser buoy that is connected to the turret via a hydraulically activated structural connector at the lower end of the turret. The upper end of each mooring line is connected to an articulated universal joint underneath the buoy. The lower end of each mooring line is connected to an anchor that is embedded into the seabed.

Production well fluids (oil and/or gas) pass between the seabed and the riser buoy via flexible risers. Hydraulic and electrical control umbilicals are also routed between the riser buoy and the seabed. At the bottom of the buoy the risers and umbilicals are routed for example slidable through tubular guides (I-tubes) to a riser deck at the top of the buoy.

The top of the buoy has a recess where risers and umbilicals terminate. The riser termination flanges are connected to the turret piping via hydraulically actuated fluid connectors. From the turret the fluids that are transferred via the risers are routed to the swivel stack and then via process modules at the deck, to tanks of the FPSO.

The riser buoy is a fabricated steel cylindrical shell structure. The size has been determined based on the buoyancy required for keeping the risers and anchor legs at the specified underwater level in disconnected mode. The compartments have been designed to secure that the buoy is still floating with the accidental flooding of two annular or one internal compartment. The buoy is further conical shaped such that it will not contact other turret parts during disconnection.

The volume of the buoy is such that it will sink to a predetermined depth upon disconnection from the turret, due to the weight of the anchor lines. The buoy is connected to the turret with several structural connectors.
In these turret-mooring systems, one important issue is how to keep the connectors in the dry permanently with the variations in draft of the vessel, i.e. even when the vessel is fully loaded with hydrocarbons.

In solutions where the vessel is intended for receiving a buoy or a turret in a submerged receiving space at the bottom of the vessel, having the connection above water level is preferred in order to facilitate repair and maintenance of the connection means while it also limit the corrosion and wear of these means. These solutions are still not ideal as depending on the draft of the vessel, there is no guarantee that the connectors when in connecting the buoy, will stay permanently above sea water level, even when the tanks of the vessel are fully loaded. Solutions such as protecting the connectors with a cage or a cover around them, or alternatively a cage in the turret that could be drained off are also not ideal as due to its location, the water barrage can easily get damaged during reconnection or even worse create the risk of entanglement of the buoy against the receiving turret cone during reconnection.

It is an object of the invention to provide an improved disconnectable submerged buoy-turret mooring system which can be operated safely, which is easy to maintain and which can be disconnected and connected quickly while guaranteeing that the connectors that connects the mooring buoy are not in the water, even when the vessel is fully in a fully loaded position. Further, according to the present invention, the connection deck diameter of the buoy can be optimized which is advantageous as the overall diameter of a buoyant turret mooring has a significant influence on the cost of the system.

**Summary of the Invention**

The above mentioned objects can be achieved as according the present invention the locking assembly comprises at least two connectors, each connector provided with a clamp that can be moved in radially outward direction to connect the buoy to the turret.
Further according to the present invention the connectors of the locking assembly are grouped in specific sectors on the turret structure, the groups of mooring lines and the clamping areas of the groups of connectors also being on the same azimuth sectors of the buoy.

It is also an object of the present invention to have the buoy comprising two rings and locally reinforced structures between said rings. According to the present invention, the locally reinforced structures are aligned with the groups of mooring lines and the groups of connectors in order to optimize the load path between mooring lines and the weather vaning system.

Another object of the present invention is an improved load transfer between the grouped mooring lines that are connected to the buoy and the connectors of the turret. A further object of the present invention is a method to moor a vessel with the equipment as claimed.

**Brief description of the drawings:**

The invention will be further described below in connection with exemplary embodiments with reference to the accompanying drawings, wherein

FIG. 1 shows a vessel and a buoy in a disconnected state, the connector member or riser deck being supported on the buoy,

FIG. 2 shows a vessel and a buoy in a connected situation

FIG. 3a shows the reinforcement on the buoy structure and FIG. 3b shows the reinforcement on the turret structure transferring the mooring loads

FIG. 4a shows a top view of a mooring buoy according to the prior art

FIG. 4b shows a top view of a mooring buoy according to the present invention

FIG. 1 and 2 show a disconnectable mooring system according to the present invention, with a vessel 1 with a moonpool 5 extending from deck till keel level, a turret 3 placed within the moonpool 5, a swivel unit mounted on the turret 3, a bearing assembly 22 (see attached fig 1) for rotatably mounting the turret with respect to the vessel, a buoy anchored to the seabed via several groups of mooring lines 9’, 9” and 9’’ and which is retrievable into the moonpool 5 of the vessel 1 and connectable to the turret 3, a locking
assembly 7 for locking the buoy 6 to the turret 3 and three groups of three risers 8', 8", 8"
being supported by the buoy 6, the locking assembly 7 being an assembly of several
connectors 10', 10", 10" grabbing a connector flange at the top of the buoy 6 from the
inside. Figure 1 also shows that turret 3 comprises reinforced structures 14 located
between a turret top ring 15 supporting the connectors and a turret bottom ring 16.

FIG. 2 shows that the load path between the buoy and the lower turret cylinder can be
optimized by aligning (in a vertical direction) the groups of mooring lines and the groups
of connectors on the same azimuth sectors. The load path between the mooring lines and
the weathervaning system is optimized and transferred via locally re-enforced structure
between two structural rings: one at lower radial stopper level and one at upper connector
level. It is noted that the radial stoppers would also be grouped as these are the load path
between the buoy and turret cylinder at the bottom of the turret cylinder level. It also
clearly appears that the turret top ring 15 supporting the connectors is surrounding the
buoy top ring 11 and the turret bottom ring 16 is surrounding the buoy bottom ring 12.
Further, it is also clearly shown that the locally reinforced structures 14 of the turret
structure 3 are aligned with the groups of mooring lines 9', 9", 9" and the groups of
connectors 10', 10", 10" in order to optimize (shorten) the load path between mooring
lines and the connectors of the turret.

Grouping the structural connectors per sectors optimizes the mooring load path in the
buoy and the turret. For example, a mooring system can consists of three or more groups
of mooring lines as shown, which include a buoy 6 and turret 3 both being organized in
three or more strong sectors making a natural structural link that matches each group of
mooring lines with its corresponding group of structural connectors.

FIG. 3a and 3b are showing the structural components transferring the loads more clearly.
These structural components carrying the loads comprise as shown in FIG.3a structural
rings 11, 12 and vertical sectors of locally reinforced structures 13 which are located
between said rings 11, 12 making the transition between the rings. According to the
present invention, the locally reinforced structures 13 have to be designed to be large
enough for allowing inspection from the inside and access to the radial stoppers for adjustment, maintenance or even change-out.

FIG. 3b shows the (lower) turret part with structural rings 15, 16 and vertical sectors of locally reinforced structures 14 which are located between said rings 15, 16 making the transition between the rings. According to the present invention, the locally reinforced structures 14 have to be designed to be large.

FIG. 4a shows a top view of a mooring buoy 6 according to the prior art. The structural connectors 20 are equally distributed over a circle and each grabs an upper connection flange of the buoy 6 from the outside; each connector 17 is provided with a clamp 18 that can be moved in a radially inward direction to connect the buoy to the turret.

Figure 4a also shows 3 concentric "layers" of equipments that are defined as following:
- R1 is the radius of space taken by the snatch load absorber of pulling system used for the buoy reconnection,
- R2 is the radius of the space taken by the riser termination and corresponding fluid connectors,
- R3 is the radius of connection deck itself where the structural connectors grab the buoy.

In an alternative embodiment of the present invention (not shown), the diameter of the connection deck can also be reduced by grouping the structural connectors in specific sections on the turret (3), while each connector being provided with a clamp that can be moved in a radially inward direction to connect the buoy to the turret.

FIG. 4b shows a top view of a mooring buoy 6 according to the present invention.

This figure clearly shows the optimized arrangement of the connection deck of the mooring buoy 6 (which is the top of the mooring buoy 6) which has a conical shape.

The structural connectors are grabbing an upper connection flange of the buoy 6 from the inside as each connector 17 is provided with a clamp 18 that can be moved in a radially outward direction to connect the buoy to the turret.

In order to avoid a significant increase in the diameter of the connection deck - in comparison with connectors grabbing the outside of connection flange at the top of the
buoy - the structural connectors are grouped into three sectors 10', 10" 10" dedicated to the structural connectors. These connection sections are separated from each other by (three) sectors that are dedicated to the fluid connectors.

FIG. 4b also shows 3 concentric "layers" of equipments and as can be seen the radius R3 can be made much smaller due to a group wise arrangement of the connectors.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art, and consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.
CLAMS

1. Disconnectable mooring system for a weathervaning vessel that is provided with a moonpool (5) which extends from deck level to keel level, comprising:

- a turret (3) to be held within the moonpool (5);
- a swivel unit for transfer of fluids mounted on the turret (3);
- a bearing assembly between the turret and the moonpool (3);
- a buoy (6) anchored to the seabed via multiple mooring lines (9', 9'', 9'''), and that can be retrieved in the moonpool (5) and be connected to the turret (3);
- a locking assembly (7) for mechanically locking the buoy (6) to the turret (3);
- at least one riser (8) for transfer of fluids from or to the seabed and being supported by the buoy (6), characterized in that the locking assembly (7) comprises at least two connectors (17), each connector (17) provided with a clamp (18) that can be moved in a radially outward direction to connect the buoy (6) to the turret (3).

2. Disconnectable mooring system according to claim 1 wherein the connectors (17) are grouped in specific sectors (10', 10'', 10''') on the turret (3).

3. Disconnectable mooring system according to claim 2 wherein the mooring lines (9', 9'', 9'''') are grouped, each group of mooring lines (9', 9'', 9''') being aligned with a group of connectors (10', 10'', 10''') when the buoy (6) is connected to the turret (3) to optimize the load path between mooring lines and turret.

4. Disconnectable mooring system according to any of the preceding claims wherein the main structure of the buoy (6) comprises a upper buoy ring (11) and a lower buoy ring (12), and reinforced structures (13) interconnecting said rings (11, 12).

5. Disconnectable mooring system according to claim 4 wherein the upper buoy ring (11) is located at the top of the buoy (6) and the lower buoy ring (12) is located below the upper buoy ring (11) and above the connection points of the mooring lines (9', 9'', 9'''').
6. Disconnectable mooring system according to any of the preceding claims, wherein the turret (3) comprises an upper turret ring (15) that supports the connectors (17; 10', 10", 10\")*, a lower turret bottom ring (16) and one or more reinforcement structures (14) interconnecting the upper and lower turret rings (15, 16).

7. Disconnectable mooring system according to claim 6 wherein the reinforced structure (14) is aligned with a groups of mooring lines (9', 9", 9\") and a group of connectors (10', 10", 10\") when a buoy (6) is connected to the turret (6), so to optimize the load transfer between mooring lines and the turret (3).

8. Disconnectable mooring system for a weathervaning vessel that is provided with a moonpool (5) which extends from deck level to keel level, comprising:
- a turret (3) to be held within the moonpool (5);
- a swivel unit for transfer of fluids mounted on the turret (3);
- a bearing assembly between the turret and the moonpool (3);
- a buoy (6) anchored to the seabed via multiple mooring lines (9', 9", 9\") and that can be retrieved in the moonpool (5) and be connected to the turret (3);
- a locking assembly (7) for mechanically locking the buoy (6) to the turret (3);
- at least one riser (8) for transfer of fluids from or to the seabed and being supported by the buoy (6),
characterized in that the locking assembly (7) comprises at least four connectors (17), each connector (17) provided with a clamp (18) that can be moved in a radially direction to connect the buoy (6) to the turret (3), the connectors (17) and the mooring lines (9', 9", 9\") being placed in groups.

9. Disconnectable mooring system according to claim 8, characterized in that a group of connectors (10', 10", 10\") and a group mooring lines (9', 9", 9\") are vertically aligned.

10. A method of mooring a weathervaning vessel that is provided with a moonpool (5) which extends from deck level to keel level, comprising the steps of:
- connect a turret structure (3) in the moonpool (5) via a bearing assembly;
- connect a buoy (6) which is provided with at least one riser, to the seabed via mooring lines;
- retrieving the buoy (6) structure into the moonpool (5) of the vessel;
- locking the buoy (6) to the turret structure using connectors (10', 10", 10") as claimed in any one of the preceding claims.
**INTERNATIONAL SEARCH REPORT**

International application No:
PCT/EP2011/065661

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. B63B21/50

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 practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>FR 2 928 898 AI (SAI PEM S A SA [FR] SAI PEM SA [FR]) 25 September 2009 (2009-09-25) page 14, line 4 - page 23, line 2; figures 1-8</td>
<td>1-10</td>
</tr>
<tr>
<td>X</td>
<td>US 2008/166936 AI (LINDBLADE STEPHEN P [US]) 10 July 2008 (2008-07-10) paragraph [0050] - paragraph [0055]; figures 1-4b</td>
<td>1-3, 8-10</td>
</tr>
<tr>
<td>A</td>
<td>GB 2 160 166 A (EXXON PRODUCTION RESEARCH CO) 18 December 1985 (1985-12-18) page 4, line 21 - page 5, line 18; figures 4,5</td>
<td>1-4, 8-10</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier document but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y"- document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "A" document member of the same patent family

**Date of the actual completion of the international search**

30 November 2011

**Date of mailing of the international search report**

07/12/2011

**Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016**

Authorized officer

Raffael 1i, Leonardo
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR 2928898</td>
<td>25-09-2009</td>
<td>CA 2714637 AI</td>
<td>08-10-2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 2252500 AI</td>
<td>24-11-2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR 2928898 AI</td>
<td>25-09-2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KR 20100124734 A</td>
<td>29-11-2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2011110724 AI</td>
<td>12-05-2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2009122099 AI</td>
<td>08-10-2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2008086225 A2</td>
<td>17-07-2008</td>
</tr>
<tr>
<td>US 5823131</td>
<td>20-10-1998</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>GB 2160166</td>
<td>18-12-1985</td>
<td>CA 1220385 AI</td>
<td>14-04-1987</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 2160166 A</td>
<td>18-12-1985</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 61009387 A</td>
<td>16-01-1986</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO 852289 A</td>
<td>09-12-1985</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 4604961 A</td>
<td>12-08-1986</td>
</tr>
</tbody>
</table>