TRUNNION MOUNTED PIVOTING RISER SUPPORT FOR OFFSHORE MOORING SYSTEMS

Inventors: Caspar N. Heyl, Houston, TX (US); Miles A. Hobdy, Houston, TX (US)

Correspondence Address:
GARY L. BUSH
ANDREWS, KURTH, MAYOR, DAY, CALDWELL, KEETON, L.L.P.
600 TRAVIS, SUITE 4200
HOUSTON, TX 77002 (US)

Assignee: FMC TECHNOLOGIES, INC.

Appl. No.: 10/199,888
Filed: Jul. 18, 2002

Related U.S. Application Data
Provisional application No. 60/306,351, filed on Jul. 18, 2001.

Publication Classification
Int.Cl. 7 E02D 5/54; E02D 5/74
U.S. Cl. 405/224; 405/224.2; 114/230.1

ABSTRACT
A riser connected by a trunnion mounted/pivoting riser support to a disconnectable body or to a riser table of a permanently connected turret. The trunnion includes a trunnion housing and trunnion pivot. The trunnion housing is arranged to allow a riser to pass through it and up to a vessel turret where the disconnectable body is connected to the turret. The trunnion pivot allows the trunnion housing and riser to pivot about a horizontal axis, allowing a disconnectable body to submerge to the sea floor.
TRUNNION MOUNTED PIVOTING RISER SUPPORT FOR OFFSHORE MOORING SYSTEMS

RELATED APPLICATION

BACKGROUND OF THE INVENTION
[0002] 1. Field of the Invention
[0003] This invention relates generally to mooring systems for offshore production vessels such as FSO’s and FPSO’s. In particular the invention relates to mounting systems by which a riser is secured to a disconnectable body to a turret or the like.
[0004] 2. Description of the Prior Art
[0005] Prior art disconnectable turret moored systems have fixed a riser to a disconnectable buoy which disconnects from the turret and sinks to a neutrally buoyant position. The connection of the riser to the disconnectable buoy has typically not allowed the end of the riser to rotate about an axis perpendicular to its own longitudinal axis.
[0006] A published international patent application PCT/ NO95/00202 of publication WO 96/14237 shows a flexible riser connected to a disconnectable buoy, but the end of the flexible riser is fixed to a non-rotatably fixed transition pipe. The disconnectable buoy is designed to sink to the sea floor upon disconnection, and the riser contacts the sea floor.
[0007] 3. Identification of Objects of the Invention
[0008] An object of the invention is to provide an improved connecting structure between the end of a product riser and a disconnectable body to allow the end of the riser to rotate about a horizontal axis that is essentially perpendicular to the longitudinal axis of the riser.
[0009] Another object of the invention is to provide a disconnectable body which may or may not have buoyancy with a riser coupling arrangement which is arranged and designed to rotate about a horizontal axis so that after disconnection, the riser can rotate with respect to the body as the body descends from the bottom of the vessel toward the ocean floor.

SUMMARY OF THE INVENTION
[0010] The objects identified above, along with other advantages and features of the invention, are incorporated in a trunnion support which is connected to a disconnectable riser body or buoy or a riser table of a turret and carries an upper end of a riser. The trunnion includes a trunnion housing and trunnion pivot. The trunnion housing allows for a riser to pass through it for connection to a turret conduit after the body is connected to the turret. The trunnion housing also allows for the attachment of a riser bend stiffener. The trunnion pivot allows the trunnion housing and riser to pivot about a horizontal axis, which is perpendicular to the longitudinal axis of the riser.

BRIEF DESCRIPTION OF THE DRAWINGS
[0011] The invention is described by reference to the drawings of which:
[0012] FIG. 1 shows riser shapes for a prior art riser connection to a disconnectable buoy where the connection at the top of the riser is not free to rotate with respect to an axis perpendicular to the longitudinal axis of the riser and the buoy is not designed to rest on the sea floor;
[0013] FIG. 2 shows a riser shape which can be achieved with the top end of the riser capable of rotation with respect to a disconnectable body or buoy, where the body is designed to sink and contact the sea floor when disconnected from the vessel;
[0014] FIG. 3 is an elevation view of a riser support housing that includes a trunnion mounted on a support structure such as a disconnectable body or riser table so that the riser is capable of rotation with respect to an axis that is perpendicular to its longitudinal axis;
[0015] FIG. 4 is a cross section taken along lines 4-4 of FIG. 3 and further showing a bend stiffener connected beneath the riser support housing.
[0016] FIG. 5 shows an alternative arrangement where the riser support housing includes a coupling that is pivoted with respect to a body or riser table.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION
[0017] FIG. 1 of the drawings illustrates a prior art disconnectable mooring system of the type illustrated in U.S. Pat. No. 5,240,446 (Boatman & Etheridge). The schematic illustration of FIG. 1 shows that disconnectable buoy 700 has a riser that is rigidly connected to the buoy 700 so that when buoy 700 is disconnected at position A and sinks to submerged equilibrium position B, the upper part of riser 10 cannot rotate with respect to the body of the buoy 700. As a result, the riser 10 and buoy 700 must be designed not to sink further to contact the sea floor 1 in order to obviate contact of the riser 10 on the sea floor and avoid an unstable landing of the buoy on the sea floor. Thus, flotation must be provided in the buoy 700 itself in order to control the equilibrium depth to which the buoy 700 sinks at position B. Flotation devices 15 provide a specific riser configuration as illustrated for position B.
[0018] FIG. 2 of the drawings illustrates schematically the orientation that a riser may assume with respect to a disconnectable body using the trunnion mounted or pivot mounted riser support housing for coupling with a disconnectable body 70. The body 70 may or may not include flotation devices that may be active or passive. For example, body 70 may have buoyancy added to it or deleted from it with sources of pressurized gas on the body which can be remotely activated from the vessel 50. The upper end of the riser 10 is coupled to body 70 by means of a trunnion mounted pivoting riser support 5 so that it is capable of rotation about a horizontal axis (into the plane of the paper). When the body 70 is on the sea floor 1 (at position C), the riser can rotate about the horizontal axis to a near horizontal position. As the body 70 rises the riser 10 rotates about the horizontal axis, and when the body 70 connects to the bottom of the turret T (e.g. position A), the upper part of riser
10 rotates to a near vertical orientation for connection to a fluid conduit with the turret. The rotation of support 5 with respect to body 70 at position A is about ninety degrees different from that at position C.

[0019] FIGS. 3 and 4 show an embodiment of the trunnion mounted pivoting riser support 5 mounted to a support structure 30 of a disconnectable body 70 in a manner which allows a housing 22 to rotate about a horizontal pivot axis 210 thereby allowing for the configuration of the body 70 as shown in FIG. 2 where the body 70 is capable of disconnection from a turret of a disconnectable turret mooring system. Because the body 70 can be lowered all the way to the sea floor and stay at rest there or in a gloryhole or upon receiving a template, the riser support 5 advantageously is constructed to allow ninety degrees rotation with respect to the body 70, but smaller or greater angular rotations may be desirable for particular design parameters.

[0020] FIG. 3 shows an elevation view of trunnion housing 22 and trunnion pivots 24 which are mounted on a support structure 30 of a disconnectable body 70 or alternatively to a riser table permanently connected to a turret or other structure of a FSO or FPSO or other offshore structure. FIG. 4 is a cross-section of FIG. 3 viewed from lines 4-4, showing the details of the trunnion housing 22 with an upper end of riser 10 extending through it.

[0021] The riser 10 and riser fitting 43 have a longitudinal axis 200. The trunnion 20 including trunnion housing 22 and trunnion pivots 24 establish a horizontal pivot axis 210 which is substantially perpendicular to the longitudinal axis 200. The upper end of riser 10, riser end fitting 43, and riser end cap and retrieving device 45 with trunnion 20 can pivot about the horizontal pivot axis 210.

[0022] The trunnion housing 22 is constructed to provide a path for passage of riser 10 as seen in FIG. 4. Such path through trunnion housing 22 allows the riser 10 to be pulled up through a turret after buoy connection as illustrated in U.S. Pat. No. 5,240,446. Riser pull up through a turret conduit is described in copending U.S. patent application No. 60/306,351 filed on Jul. 18, 2001, and incorporated by reference herein. As shown in FIG. 4 the trunnion housing 22 may also contain a curvature defined by radius of curvature 26, which can be equal to the minimum bend radius of riser 10 according to the stiffness characteristics of riser 10. A riser bend stiffener 100 can be added to the trunnion housing 22.

[0023] Alternatively, as shown in FIG. 5, the trunnion pivots 24A can be located away from the trunnion housing 22 with a connecting member or members 65 coupling the trunnion pivots 24A to the trunnion housing 22. The trunnion pivots 24A can be coupled to a riser body or riser table in a manner similar to that described above so that the riser 10 end is capable of near at least ninety degrees rotation with respect to a disconnectable buoy as illustrated in FIG. 2.

[0024] The riser end fitting 43 connected to the distal upper end of the riser is arranged and designed to prevent the riser from being pulled downward through trunnion housing 22. The riser end cap/retrieval device 45 can be arranged and designed as described in the above mentioned copending U.S. patent application to receive equipment from a floating vessel, such as FPSO 50 (FIG. 2) for pulling the upper end of riser 10 up through a turret or the like to establish fluid communication with the fluid conduits on the vessel. For such a pull-in operation, the fitting 43 may not be installed.

[0025] In operation as illustrated in FIG. 2, after body 70 establishes a connection with a vessel’s turret at as position A, the riser end cap 45 is connected to a tension member positioned at an upper deck, and riser 10 is pulled up through the vessel’s turret to establish fluid communication with fluid conduits at an upper deck of the vessel. When the body 70 is disconnected and submerged as at position C, the trunnion mounted pivoting riser support 5 allows the upper end of riser 10 to pivot about the horizontal pivot axis 210. Thus, as body 70 is submerged, pivoting occurs allowing the riser to take a new shape (seen in FIG. 2). Such capability for pivoting allows body 70 to sink to the sea floor as at position C. The design of the riser 10 may or may not call for contact of the riser with the sea floor.

[0026] In an alternative configuration for the trunnion mounted pivoting riser support 5 of FIGS. 3 and 4, the upper end of riser 10 can be directly flanged to the bottom of the trunnion housing 22, such that the trunnion housing 22 passage through it is fluidly coupled to the riser 10 and becomes part of the fluid path. A remotely operated connection to the top of the trunnion housing 22 can be provided for final connection and establishment of fluid communication with the vessel.

[0027] Although the illustration of FIG. 2 shows a body that sinks to contact the sea floor, other disconnectable buoy designs call for a riser support buoy to achieve an equilibrium position in the sea above the sea floor. Where shallow water design conditions obtain, risers tend not to be able to accommodate bending moments unless the buoy depth is well controlled. With this invention where the end of the riser can rotate with respect to the buoy as the buoy sinks toward the sea floor, greater flexibility in the design of the buoy and riser system is provided because the criticality of the depth to which the buoy must achieve equilibrium is eliminated.

[0028] It should be understood that the invention is not limited to the exact details of construction, operation, or embodiments shown and described, because obvious modifications and equivalents will be apparent to one skilled in the art of floating systems. For example, while one embodiment of the supporting structure 30 is shown in FIG. 3, other structures may be used to establish a support for the trunnion 20 and upper end of riser 10. Also, while the trunnion pivots 24 in the embodiment of FIG. 3 are shown in proximity to the trunnion housing 22, such need not be the case in every embodiment of the invention. For example, as described in the alternative embodiment of FIG. 5, the trunnion pivots 24A can be located away from the trunnion housing 22 utilizing connecting members 65 to connect with trunnion housing 22. In such embodiments, the horizontal pivot axis 210 may move to a different location, but still allow the trunnion housing 22, and the upper end of riser 10, to rotate about the pivot axis. Furthermore, while anchor legs are not illustrated for securing the body 20 to the sea floor, it should be understood that, if needed, such anchor legs could be provided. The invention is therefore limited only by the scope of the claims.
What is claimed is:

1. An arrangement for supporting an upper end of a riser to a riser termination body which is connected to an offshore structure comprising,
   a trunnion including a trunnion housing and at least one trunnion pivot connected to said housing,
   said trunnion housing arranged and designed to support said upper end of said riser and having a path by which fluid connection is established between the upper end of said riser and a top position of said housing,
   said trunnion pivot being coupled to said termination body so that said trunnion and said upper end of said riser are capable of rotation about said pivot.

2. The arrangement of claim 1 wherein,
   said upper end of said riser passes through a path through said trunnion housing, and
   a riser end fitting is connected to the upper end of the riser, said riser end fitting being arranged and dimensioned to prevent said riser from being pulled downward through said path of said trunnion housing.

3. The arrangement of claim 1 wherein,
   said at least one trunnion pivot includes two pivot members disposed on opposite sides of said trunnion housing,
   said two pivot members being connected to said riser termination body in an arrangement so that said trunnion housing is capable of rotation with respect to said riser termination body about an axis through said pivots.

4. The arrangement of claim 3 wherein said two pivot members are directly connected to said trunnion housing.

5. The arrangement of claim 1 wherein,
   said trunnion pivot is linked to said trunnion housing by a connection member.

6. The arrangement of claim 2 further comprising,
   a bend stiffener positioned about said riser and connected to a lower end of said trunnion housing.

7. The arrangement of claim 1 wherein,
   said offshore structure is a turret of an offshore production vessel.

8. The arrangement of claim 7 wherein,
   said riser termination body is a disconnectable body arranged and designed for disconnectable connection to said turret of said offshore production vessel,
   said riser includes floatation between a lower end of said riser connected to the sea floor and said upper end of said riser, and
   said trunnion housing is arranged and designed so that said trunnion housing is capable of rotation with respect to said disconnectable body so that said upper end of said riser remains rotatably supported by said body when said body disconnects from said offshore production vessel and sinks toward said sea floor.

* * * * *