

BUOY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of United States provisional patent application serial number 61/605,557, filed March 1, 2012, which is herein incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] Embodiments of the present invention generally relate to a buoy. In particular, embodiments of the present invention relate to an apparatus and method of replacing a bearing assembly of a buoy.

Description of the Related Art

[0003] Mooring assemblies have been used as an interconnect and a mooring point for vessels loading or unloading gas or liquid products. The mooring assembly may include a buoyant body rotatably coupled to a turret using a bearing assembly. The turret is geostationally fixed while the buoyant body is free to weathervane around the turret. Therefore, the bearing assembly is an important component of the mooring assembly.

[0004] When the bearing assembly is damaged, the process of repairing the bearing assembly is generally a complicated operation. In some instances, the mooring assembly may transfer to another location for repair. Such operations are often costly due to production down time.

[0005] There is a need, therefore, for a method of removing a bearing assembly from a mooring assembly for repair or replacement at an offshore location. There is also a need for a mooring assembly configured to allow repair or replacement of a bearing assembly while located offshore.

SUMMARY OF THE INVENTION

[0006] In one embodiment, a method of removing a bearing assembly from the buoy includes providing the buoy with a bearing assembly for coupling a buoyant body to a turret and a bearing retainer configured to retain the bearing assembly and to releasably attach to the turret. The method also includes releasably attaching the bearing retainer to the turret; coupling the bearing retainer to the bearing assembly; releasing the bearing assembly from the buoyant body and the turret; and removing the bearing retainer and the bearing assembly from the buoy. The method may also include lifting the turret relative to the buoyant body and locking the turret to the buoyant body.

[0007] In another embodiment, a buoy includes a turret coupled to a buoyant body using a bearing assembly; a deckhouse disposed on the buoyant body; and a bearing retainer configured to retain the bearing assembly for transport and to releasably attach to the turret. The buoy may also include a locking mechanism having an inner opening in the turret; an outer opening in the buoyant body; and a locking member configured for insertion through the inner and outer openings. In one embodiment, the inner opening is out of alignment with the outer opening during operation of the buoy. The buoy may further include a detachable cover on the deckhouse, wherein the cover is configured to attach to the bearing retainer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0009] Figure 1 shows a partial cross-sectional view of an exemplary embodiment of a buoy. Figure 1A is an enlarged partial view of the buoy of Figure 1.

[0010] Figure 2 shows a partial cross-sectional view of the buoy of Figure 1 during an exemplary bearing assembly removal process. Figure 2A is an enlarged partial view of the buoy of Figure 2 and shows the bearing retainer attached to the bearing assembly.

[0011] Figure 3 shows a partial cross-sectional view of the buoy of Figure 1 during an exemplary bearing assembly removal process. Figure 3A is an enlarged partial view of the buoy of Figure 3 and shows the turret locked to the buoyant body.

[0012] Figure 4 shows a partial cross-sectional view of the buoy of Figure 1 during an exemplary bearing assembly removal process. Figure 4 shows the bearing retainer and the bearing assembly being lifted toward a cover.

[0013] Figure 5 shows a partial cross-sectional view of the buoy of Figure 1 during an exemplary bearing assembly removal process. Figure 5 shows the bearing retainer, the bearing assembly, and the cover being lifted toward a vessel.

DETAILED DESCRIPTION

[0014] Figure 1 shows an exemplary embodiment of a mooring assembly such as a catenary anchor leg mooring ("CALM") buoy 100. Figure 1 shows a perspective view with a partial cross-sectional view of the buoy 100. The buoy 100 may include a buoyant body 10 rotatably coupled to a turret 20. The buoyant body 10 is configured to be partially submerged in water. As shown, the buoyant body 10 has a hexagonal shape, although any suitable shape is contemplated. For example, the shape of the buoyant body 10 may be, including but not limited to, a square, circle, pentagon, or octagon.

[0015] The turret 20 is positioned inside the buoyant body 10. A chain table 8 is attached to the lower end of the turret 20. Catenary anchor chains may be attached

to the chain table 8 to anchor the buoy 100. Other exemplary anchoring devices include a chain, a steel wire, a polyester chain, and combinations thereof. For example, in deep water, a combination of steel chains and steel wire or a combination of steel chains and polyester chains may be used to anchor the buoy. The turret 20 may include a support bracket 26 to facilitate handling of the turret 20. For example, the support bracket 26 may be engaged in order to lift or lower the turret 20. In one embodiment, the support bracket 26 is a short platform extending radially inward. Any suitable number of support brackets may be provided, for example, two, four, six, or eight. In one example, six support brackets 26 may be circumferentially spaced apart in the turret 20. The turret 20 may also include other components such as a swivel.

[0016] The buoyant body 10 is rotatably coupled to the turret 20 using a bearing assembly 40. The bearing assembly 40 includes an outer ring 41 coupled to an inner ring 42 using bearing devices 43 such as ball bearings or three race roller bearings. As shown in Figure 1A, the outer ring 41 is attached to an outer flange 11 of the buoyant body 10, and the inner ring 42 is attached to an inner flange 22 of the turret 20. In one embodiment, the inner and outer rings 41, 42 are attached to the respective inner and outer flanges 11, 22 using a plurality of inner and outer bolts 31, 32. The inner and outer rings 41, 42 may optionally sit in a recess on the flanges 11, 22.

[0017] A deckhouse 50 is disposed above the turret 20 and the buoyant body 10. The deckhouse 50 may have a smaller size than the buoyant body 10 and may have the same or a different shape than the buoyant body 10. In one embodiment, a detachable cover 55 is provided in the ceiling of the deckhouse 50. A plurality of lift brackets 52 are disposed on the outer surface of the deckhouse 50 for receiving a cable or other lifting mechanism.

[0018] A bearing retainer 60 is provided for retaining the bearing assembly 40 to facilitate transport of the bearing assembly 40. In one embodiment, the bearing retainer 60 is initially releasably connected to the cover 55. The bearing retainer 60

is configured to attach to a plurality of locations on the bearing assembly 40. For example, the bearing retainer 60 may be an adapter beam having two or more ends that are attachable to the bearing assembly 40. In another embodiment, the bearing retainer 60 may be an adapter beam having six ends arranged like a spoke. In this respect, the bearing retainer 60 may attach to the bearing assembly 40 at six different locations. It contemplated that the adapter beam may include any suitable number of spoke ends, such as four, five, or eight ends. In another example, the bearing retainer 60 may be a polygon such as a square, pentagon, hexagon, or octagon. In this example, the bearing retainer 60 may attach to the bearing assembly 40 at the "corners" of the polygon. In yet another example, the bearing retainer 60 may be a ring having substantially the same diameter as the bearing assembly 40 and at least one cross-beam. In this example, the bearing assembly 40 may attach to the ring of the bearing retainer 60. In one embodiment, the adapter beam may have a flange at it lower end for attachment to the bearing assembly 40. The flange of the adapter beam may have openings configured to align with the openings in the inner and outer rings 41, 42 to receive bolts 31, 32.

[0019] The bearing retainer 60 also includes a plurality of connector stands 65. The connector stands 65 are configured to attach to the support bracket 26 on the turret 20. In one embodiment, the connector stands 65 extend below the bearing retainer 60 and include a flange 66 on the lower end. Each connector stand 65 may be attached to the support bracket 26 using a bolt 62 or other suitable attachment members.

[0020] In one embodiment, the buoy 100 may optionally include a locking mechanism to rotationally and axially lock the turret 20 to the buoyant body 10. As shown in Figure 1A, turret 20 may include an inner lock opening 23 that can be coupled to an outer lock opening 13 in the buoyant body 10 using a locking member 80. During normal operation of the buoy 100, the inner lock opening 23 is out of alignment with the outer lock opening 13. To align the openings 13, 23, the turret 20 is raised relative to the buoyant body 10. The turret 20 may be raised using

hydraulics, mechanics, buoyancy, and combinations thereof. For example, mechanical or hydraulic jacks 70 may be used to raise the turret 20 relative to the buoyant body 10. The locking member 80, such as a locking pin, may be inserted through both openings 13, 23 after alignment, thereby rotationally and axially locking the turret 20 to the buoyant body 10. As shown, the openings 13, 23 are positioned above the floor of the deckhouse 50. However, it is contemplated that the openings 13, 23 may be positioned below the floor of the deckhouse 50, or the openings 13, 23 may be provided above and below the floor of the deckhouse 50. A plurality of locking pins and openings 13, 23 may be used to lock the turret 20 to the buoyant body 10.

[0021] During operation of the buoy 100, the bearing assembly 40 may require repair or replacement. Before removing the bearing assembly 40, the turret 20 is rotationally locked to the buoyant body 10. In one embodiment, a plate attached to the bearing assembly 40 may be coupled to a vertical pin connected to the floor of the buoyant body 10 to rotationally lock the turret 20 to the buoyant body 10. A plurality of plate and pin locking devices may be used to rotationally lock the turret. To remove the bearing assembly 40, the bearing retainer 60 is released from the cover 55 and lowered toward the bearing assembly 40, as shown in Figures 2 and 2A. A conveyor such as a chain, a cable, a hydraulic cylinder, or a winch may be used to lower the bearing retainer 60. The conveyor may be manually, electrically, hydraulically, or pneumatically operated. Any component that may be an obstacle should be removed prior to lowering the bearing retainer 60. For example, a swivel connected to the turret 20 should be removed if it prevents the attachment of the bearing retainer 60 to the bearing assembly 40. The bearing retainer 60 may be lowered onto a plurality of hydraulic or mechanical jacks 70. The jacks 70 may be positioned on the floor of the deckhouse 50 around the outside of the bearing assembly 40. In another embodiment, the jacks 70 may be positioned inside the turret 20. The bearing retainer 60 may include a receptacle such as a recess for engaging the jacks 70. Any suitable number of jacks 70 may be used to support the bearing retainer 60. As shown, the bearing retainer 60 is an adapter beam having six

spoke ends, and a jack 70 is provided to engage each of the spoke ends. If a ring is used as a bearing retainer, then the jacks 70 may engage and support the ring.

[0022] Then, the bearing retainer 60 is attached to the bearing assembly 40. In this respect, the connector stand 65 is attached to the support bracket 26 of the turret 20 by bolting the flange 66 of the connector stand 65 to the support bracket 26. It must be noted that, in another embodiment, the jacks 70 may be placed under the bearing retainer 60 after the bearing retainer 60 lands on the support bracket 26 or attaches to the support bracket 26. Thereafter, the outer bolts 31 connecting the outer ring 41 of the bearing assembly 40 to the buoyant body 10 are removed.

[0023] Referring now to Figures 3 and 3A, the hydraulic or mechanical jacks 70 are actuated to slightly lift the bearing retainer 60. In turn, the turret 20 is raised relative to the buoyant body 10, thereby placing the inner locking opening 23 into alignment with the outer locking opening 13. A locking pin 80 is then inserted through both openings 13 and 23 to axially lock the turret 20 to the buoyant body 10. The locking pin 80 may also assist with rotationally locking the turret 20 to the buoyant body 10. Figure 3A shows the existence of a gap between the outer ring 41 of the bearing assembly 40 and the flange 11 of the buoyant body 10 as a result of raising the turret 20. In another embodiment, instead of removal, the outer bolts 31 are loosened sufficiently to allow the turret 20 to be lifted to align the openings 13, 23. In one example, the outer bolts 31 are loosened sufficiently to allow the turret 20 to be lifted at least 7 mm; preferably, at least 12 mm.

[0024] Referring to Figure 4, after locking the turret 20, the bearing retainer 60 is lowered by lowering the jacks 70 until the weight of the turret 20 is carried by the locking pins 80, then the outer bolts 31, if not already removed, and the inner bolts 32 are removed to disconnect the bearing assembly 40 from the turret 20 and the buoyant body 10. Thereafter, the connector stand 65 is disconnected from the support bracket 26 of the turret 20. The bearing retainer 60 is then lowered on to the bearing assembly 40, which is then attached to the adapter beam of the bearing retainer 60. For example, the outer ring 42 and the inner ring 41 may be bolted to

the adapter beam. The bearing retainer 60 and the attached bearing assembly 40 may now be raised by the conveyor to the cover 55. Then, the bearing retainer 60 is re-attached to the cover 55.

[0025] As shown in Figure 5, another conveyor 85 such as a chain or cable is attached to the lift brackets 52 of the cover 55. A crane may be used to move the cover 55, the bearing retainer 60, and the bearing assembly 40 to another vessel, where the bearing assembly 40 can be replaced or repaired.

[0026] After the bearing assembly 40 has been replaced or repaired, the process may be performed in reverse to install the bearing assembly 40 in the buoy 100.

[0027] In another embodiment, the step of lifting the turret 20 relative to the buoyant body 10 may be omitted. Elevation of the turret 20 may be performed to facilitate reinstallation of the bearing assembly 40, and thus, is not a requisite step during the removal process. Therefore, after attaching the connector stand 65 of the bearing retainer 60 to the support bracket 26 of the turret 20, the inner and outer bolts 31, 32 may be removed to disconnect the inner and outer rings 41, 42 of the bearing assembly 40 from the turret 20 and the buoyant body 10. The bearing assembly 40 is then attached to the adapter beam of the bearing retainer 60. Then, the connector stand 65 is disconnected from the support bracket 26. The bearing retainer 60 and the bearing assembly 40 are lifted toward and attached to the cover 55 for transport to another vessel.

[0028] In another embodiment, the buoy 100 may be configured in other suitable ways to facilitate removal of the bearing assembly 40 from the buoy 100. For example, instead of the detachable cover 55, the buoy 100 may be equipped with a side door sufficiently sized to allow removal of the bearing assembly 40. In another example, the deckhouse 50 may have one or more removable walls. In yet another example, the deckhouse 50 may be releasably connected to the buoyant body 10. During operation, the deckhouse 50 may be removed to allow transport of the bearing retainer 60 and the bearing assembly 40.

[0029] In yet another embodiment, a plurality of guides may be provided on the deckhouse 50 to facilitate alignment of the cover 55 to the deckhouse 50 during re-installation. For example, cone shaped guides may be placed around the deckhouse 50 to help center the cover 55 to the deckhouse 50.

[0030] In one embodiment, a method of removing a bearing assembly from a buoy, wherein the buoy includes a buoyant body rotatably coupled to a turret; the method include providing a bearing retainer configured to retain the bearing assembly and to releasably attach to the turret; attaching the bearing retainer to the turret; coupling the bearing retainer to the bearing assembly; releasing the bearing assembly from the buoyant body and the turret; and removing the bearing retainer and the bearing assembly from the buoy.

[0031] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. A method of removing a bearing assembly from a buoy, the buoy having a buoyant body rotatably coupled to a turret, the method comprising:
 - providing a bearing retainer configured to retain the bearing assembly and to releasably attach to the turret;
 - attaching the bearing retainer to the turret;
 - coupling the bearing retainer to the bearing assembly;
 - releasing the bearing assembly from the buoyant body and the turret; and
 - removing the bearing retainer and the bearing assembly from the buoy.
2. The method of claim 1, further comprising lifting the turret relative to the buoyant body.
3. The method of claim 2, wherein the bearing assembly is lifted along with the turret.
4. The method of claim 3, wherein an outer ring of the bearing assembly is loosened from the buoyant body.
5. The method of claim 2, wherein the turret is lifted using a hydraulic jack, a mechanical jack, buoyancy, and combinations thereof.
6. The method of claim 5, further comprising locking the turret to the buoyant body.
7. The method of claim 2, further comprising locking the turret to the buoyant body.

8. The method of claim 7, wherein locking the turret comprises inserting a locking member through the turret and the buoyant body.
9. The method of claim 1, wherein releasably attaching the bearing retainer to the turret comprises attaching the bearing retainer to the support bracket in the turret.
10. The method of claim 2, further comprising coupling the bearing retainer and the bearing assembly to a cover of the buoy.
11. The method of claim 10, wherein removing the bearing retainer and the bearing assembly comprises removing the bearing retainer, the cover, and the bearing assembly together.
12. The method of claim 10, further comprising removing the deckhouse.
13. The method of claim 2, wherein the bearing retainer comprises an adapter beam having at least two ends configured to attach to the bearing assembly.
14. The method of claim 2, wherein the bearing retainer comprises a ring.
15. A buoy, comprising:
 - a turret coupled to a buoyant body using a bearing assembly;
 - a deckhouse disposed on the buoyant body; and
 - a bearing retainer configured to retain the bearing assembly for transport and to releasably attach to the turret.
16. The buoy of claim 15, further comprising a support bracket on the turret for attachment with the bearing retainer.

17. The buoy of claim 16, further comprising a locking mechanism for rotationally and axially locking the turret to the buoyant body.
18. The buoy of claim 17, wherein the locking mechanism includes:
an inner opening in the turret;
an outer opening in the buoyant body; and
a locking member configured for insertion through the inner and outer openings.
19. The buoy of claim 18, wherein the inner opening is out of alignment with the outer opening during operation of the buoy.
20. The buoy of claim 15, wherein the bearing retainer comprises an adapter beam having at least two ends configured to attach to the bearing assembly.
21. The buoy of claim 20, further comprising a detachable cover on the deckhouse, the cover configured to attach to the bearing retainer.
22. The buoy of claim 15, wherein the deckhouse is detachable from the buoyant body to allow for removal of the bearing retainer and the bearing assembly.