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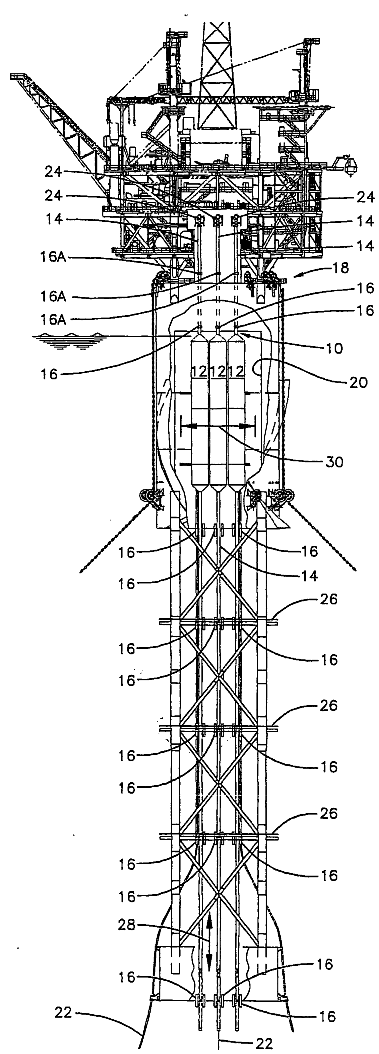
(54) Compliant buoyancy cans and guides for stem pipe of risers

(57) A compliant response stem buoyancy can and guide (10) for a floating offshore structure or vessel (18) includes a buoyancy can (12) supported at the upper stop and the various heave plates (26) by a slip ring (16) that allows axial displacement but constrains any radial motion. The buoyancy can (12) behaves as a compliant response beam with a dynamic response like a spring/mass/damper. The stiffness and mass act to govern the amplitude and frequency of the motion. The water in the well bay reacts to the relative speed of the vessel motion and the buoyancy can (12). The water thus acts as a damper. The vessel (18), stem (14) and buoyancy can (12) are designed so that clearance between the can (12) and hull is larger than the maximum amplitude of the oscillation. Therefore, the can (12) will not impact the hull. The kinetic energy is dissipated by the compliant response of the buoyancy can (12) and stem (14) structure. Because the buoyancy can (12) never hits the hull there are no impact loads or fatigue associated with impacts.



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Description

[0001] This invention generally relates to offshore floating structures, and more particularly to buoyancy cans and guides for risers in such structures.

[0002] In offshore floating structures or vessels used to drill for and produce oil and gas, such as spar type structures and tension leg platforms (TLPs), buoyancy cans are used to support the weight of drilling and production risers. Buoyancy can guides are placed in the body of the vessel. Environmental forces such as wind, waves, and currents cause the buoyancy cans to move and impact wear plates against the guides in the hull. Two design approaches have typically been followed to address the wear associated with the impacts. One approach involves compliant guides. In this approach an elastic material such as rubber that deforms under load is used to absorb the impact energy. This approach does not present a long-term solution because the rubber guides are unable to withstand the loads over a long period of repeated impacts before they fall apart. A second approach is to provide a near zero gap between the buoyancy guides and the vessel. In this approach the tolerances are kept to a minimum to impede the acceleration of the buoyancy can, therefore reducing the impact load. The hull and buoyancy cans are designed to withstand the impact loads. The problem with this approach is that construction tolerances make it very difficult to achieve the small gaps that are required to impede the acceleration of the buoyancy can to an acceptable level.

[0003] The invention addresses the above needs, and provides a compliant stem buoyancy can and guide in a floating offshore structure having a centre well and a riser received in the centre well, the buoyancy can and guide comprising:

> a buoyancy can attached to the upper portion of the riser, said buoyancy can having a predetermined compliant dynamic radial response to environmental forces;
> a stem attached to said buoyancy can and extending through the offshore structure, said stem receiving the riser inside the stem and having a predetermined compliant dynamic radial response to environmental forces; and
> a plurality of slip rings attached along the length of said stem to the offshore structure, said slip rings closely receiving said stem and allowing vertical movement of said stem and the riser.

[0004] In a preferred embodiment of the invention, the buoyancy can is supported at the upper stop and the various heave plates by a slip ring that allows axial displacement but constrains any radial motion. The buoyancy can behaves as a compliant beam with a dynamic response like a spring/mass/damper. The stiffness and mass acts to govern the amplitude and frequency of the motion. The water in the well bay reacts to the relative speed of the vessel motion and the buoyancy can. The water thus acts as a damper. The apparatus is designed so that clearance between the buoyancy can and hull is larger than the maximum amplitude of the oscillation. Therefore, the can will not impact the hull. The kinetic energy is dissipated by the compliant response to the buoyancy can and stem structure. Because the buoyancy can never hits the hull there are no impact loads and no fatigue associated with impacts.

[0005] For a further understanding of the nature of the present invention reference should be made to the following description, taken in conjunction with the accompanying drawing in which like parts are given like reference numerals, and which shows a side section view of an embodiment of the invention in a spar type structure.

[0006] Referring to the drawing, a compliant stem buoyancy can and guide 10 comprises a buoyancy can 12, a stem 14, and a plurality of slip rings 16.

[0007] The drawing generally illustrates a floating offshore structure 18, such as a spar type structure, that is provided with a centre well 20 sized to receive drilling and/or production risers 22.

[0008] The buoyancy can 12 is attached to the upper portion of the stem 14 and provides buoyant support to the stem 14 and risers 22. The stem 14 extends upward from the buoyancy can 12 to controls 24 on the top of the offshore structure 18.

[0009] A plurality of slip rings 16 are sized to closely receive the stem 14 and are spaced along the length of the stem 14. One slip ring 16A is preferably positioned around each stem 14 at the upper end of the offshore structure 18. The remaining slip rings 16 are positioned below the buoyancy can 12 and are attached at the lower end of the centre well 20 and to heave plates 26 that are attached to the offshore structure 18.

[0010] The stiffness of the buoyancy can 12, stem 14, and riser 22 are designed to work in conjunction with the slip rings 16 to prevent the buoyancy can 12 from contacting the offshore structure 18 during normal movement in response to environmental forces.

[0011] The stiffness of the buoyancy can, stem 14, and riser 22 is selected to control the compliant dynamic response of these structures. The slip rings 16 closely receive the stem 14 and riser 22 to allow vertical movement as indicated by arrows 28 but limit radial movement.

[0012] The combination of the slip rings 16 and the predetermined compliant dynamic response limit the radial movement of the buoyancy can 12 to a range that is less than the inner diameter of the centre well 20, as indicated by arrows 30. Thus, the buoyancy can 12 behaves as a compliant beam with a dynamic response like a spring/mass/damper system. The stiffness and mass of the configuration governs the amplitude and frequency of the motion. The water in the centre well 20 reacts to the relative speed of the offshore structure and the can, thus acting as a damper. The drag of the buoyancy can 12 is a function of V^2 (velocity squared). Also, the acceleration of the water in the centre well 20 induces buoyancy that damps the motion. The configuration is designed so that the clearance between the buoyancy can 12 and inner wall of the centre well 20 is larger than the maximum amplitude of the oscillation of the buoyancy can 12. Therefore, the buoyancy can 12 will not impact the hull of the offshore structure. The kinetic energy is dissipated by the compliant response of the buoyancy can 12 and stem structure.

[0013] The configuration will depend upon a variety of factors. These factors include the depth of the structure 18, the minimum natural period of the structure 18 and the buoyancy can 12, the buoyancy required, the diameter of the centre well 20, the diameter of the buoyancy can 12, the diameter of the stem 14, and the diameter of the riser 22. An example of one possible configuration follows. The controls 24, buoyancy can 12 and stem 14 that run through a spar structure 18 such as that described in US Patent No. US-A-5 558 467 may have a total length of approximately 754 ft (230 m). The controls 24 and stem 14 would extend approximately 168 ft (51.2 m) above the normal water line. The buoyancy can 12 would begin at approximately 5 ft (1.52 m) below the normal water line and extend downward to approximately 163 ft (49.7 m) below the normal water line. The stem 14 extends the remainder of the distance through the structure 18 and the riser 22 extends beyond the keel of the structure 18 to the sea floor. For such a structure having a centre well 20 with a diameter of 13 ft (4.0 m), a required tension (buoyancy) of 1,000 kip (4.5×10^6N) is preferred for a water depth of approximately 5,610 ft (1,710 m). Seven slip rings 16, as indicated, would be spaced along the length of the centre well 20. An example of one spacing arrangement is as follows. The slip rings 16 may be placed at intervals of 50 ft (15.2 m) and 21 ft (6.40 m) above the mean water level, and at levels of 5 ft (1.52 m), 205 ft (62.5 m), 262 ft (79.9 m), 340 ft (104 m), 418 ft (127 m) and 536 ft (163 m) below the mean water level. It is preferable that a slip ring 16 be positioned at or near the keel joint of the offshore structure 18.

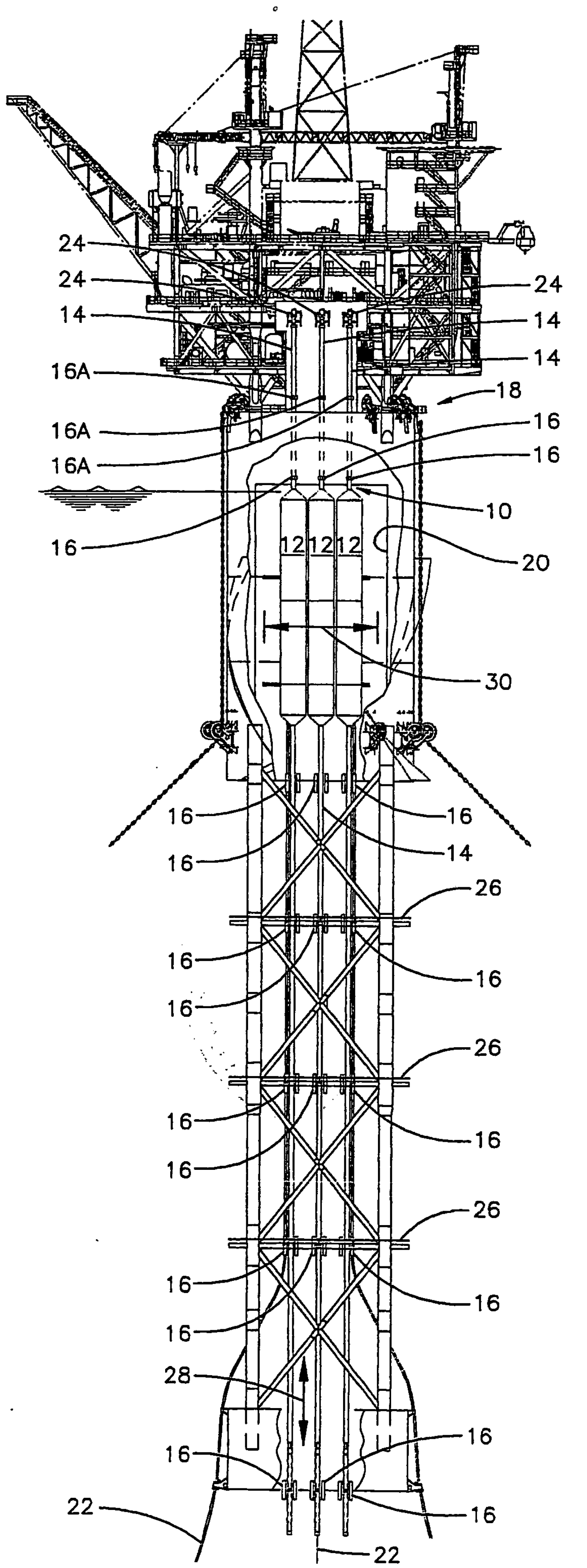
[0014] The preferred embodiment of the invention provides several advantages. There are no impact loads to the walls of the buoyancy can 12. Therefore, the wall thickness and other structural steel can be reduced. This provides a positive cost impact and increases the net buoyancy. The slip rings 16 are placed around the stem 14 and the riser 22 instead of the buoyancy can 12. Because the diameter of the slip ring 16 is substantially smaller than if it were placed around the buoyancy can 12, this allows the use of more sophisticated devices and materials to control the gap and the wear.

[0015] Because many varying and differing embodiments may be made within the scope of the inventive concept herein taught and because many modifications may be made in the embodiment herein detailed, it is to be understood that the description herein is to be interpreted as illustrative and not in a limiting sense.

Claims

1. A compliant stem buoyancy can and guide in a floating offshore structure (18) having a centre well (20) and a riser (22) received in the centre well (20), the buoyancy can and guide comprising:

> a buoyancy can (12) attached to the upper portion of the riser (22), said buoyancy can (12) having a predetermined compliant dynamic radial response to environmental forces;
> a stem (14) attached to said buoyancy can (12) and extending through the offshore structure (18), said stem (14) receiving the riser (22) inside the stem (14) and having a predetermined compliant dynamic radial response to environmental forces; and
> a plurality of slip rings (16) attached along the length of said stem (14) to the offshore structure (18), said slip rings (16) closely receiving said stem (14) and allowing vertical movement of said stem (14) and the riser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EUROPEAN SEARCH REPORT

Application Number
EP 03 25 4719

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 6 176 646 B1 (STANTON PAUL NELSON ET AL) 23 January 2001 (2001-01-23) * figures *	1	B63B22/02 E21B17/01
X	US 6 309 141 B1 (ALLEN DONALD WAYNE ET AL) 30 October 2001 (2001-10-30) * figure 6 *	1	
X	US 6 161 620 A (EKVALL ANDERS G C ET AL) 19 December 2000 (2000-12-19) * figures *	1	
X	WO 01 88324 A (AKER MARITIME INC ;EDO CORP FIBER SCIENCE DIV (US)) 22 November 2001 (2001-11-22) * figures *	1	
Y	WO 01 41549 A (FMC CORP) 14 June 2001 (2001-06-14) * figures *	1	
Y	US 4 634 314 A (PIERCE ROBERT H) 6 January 1987 (1987-01-06) * figures *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7) B63B E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 November 2003	VAN ROOIJ, M

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24-11-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6176646 B1	23-01-2001	BR 9904373 A	12-09-2000
		GB 2342937 A ,B	26-04-2000
		NO 995156 A	25-04-2000
US 6309141 B1	30-10-2001	NONE	
US 6161620 A	19-12-2000	BR 9714110 A	21-03-2000
		WO 9829638 A2	09-07-1998
		GB 2335452 A ,B	22-09-1999
		NO 993186 A	25-06-1999
WO 0188324 A	22-11-2001	US 6488447 B1	03-12-2002
		AU 5975101 A	26-11-2001
		WO 0188324 A1	22-11-2001
WO 0141549 A	14-06-2001	AU 1815601 A	18-06-2001
		GB 2386140 A	10-09-2003
		NO 20022748 A	01-08-2002
		WO 0141549 A2	14-06-2001
		US 2003180097 A1	25-09-2003
US 4634314 A	06-01-1987	NONE	

EPO FORM P0459

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