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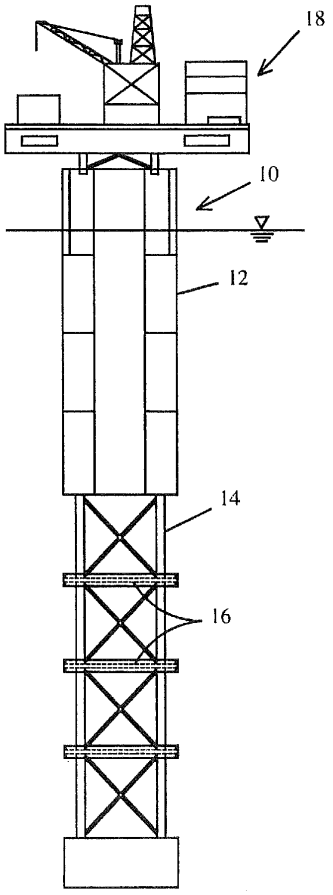
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(54) Improved heave plate on floating offshore structure

(57) A floating offshore structure having a buoyant hull with an open truss frame having heave plates vertically spaced along the truss frame. One or more of the heave plates include a skirt plate that is attached around the outer perimeter of the heave plate and increases the effectiveness of the heave plate at trapping water mass between the heave plates for reducing heave motions of the floating offshore structure. A skirt plate is attached to one or more heave plates at substantially a right angle to the heave plate. The skirt plate may extend beyond the upper and lower surfaces of the heave plate or be positioned so as to be flush with the one surface of the heave plate and extend only beyond the opposite surface of the heave plate.

FIG. 1



EP 2 239 191 A2

Description

FIELD AND BACKGROUND

[0001] The present invention is generally related to floating offshore structures and, more particularly but not exclusively, to floating offshore structures with heave plates.

[0002] In the offshore oil and gas industry some floating structures such as the spar structure described in U.S. Patent 5,558,467 use an open truss frame below the buoyant main hull to reduce the cross sectional area subject to environmental forces of waves and currents. This reduces drag and the effect of these forces on the structure. These structures also incorporate the use of heave plates spaced vertically in the truss frame to function as water mass entrapment plates during vertical motion of the structure. During vertical motion of the structure, the effect of the water mass trapped between the plates serves to reduce the heave motions of the structure caused by waves. The reduction of heave motions is caused by the heave natural period of the structure to be longer than the period of the highest waves with greatest wave energy.

[0003] The use of heave plates has proven to be effective for the desired function. However, there are situations that may require the use of larger or smaller heave plates that are not easily or efficiently dealt with through simple modification of the floating structure or the heave plates themselves.

[0004] Increasing the span of the heave plates outside the perimeter of the offshore structure and the truss frame presents additional difficulties in construction and transport of the structure. The spar hull and truss structures with heave plates are constructed in a horizontal position and skidded to a barge for transportation. Thus, the excessive extension of the heave plates outside the perimeter of the truss frame presents difficulties during construction since the extended heave plates may not be permitted because of the dimension constraints of the support structure. The ineffective solution is to add the extended portion of the heave plates once the structure is floating at the offshore site where it is to be installed for its normal operation. This is not acceptable due to the increased difficulty and expense required for such fabrication while offshore in conditions where the structure is unstable due to the effect of waves, wind, and currents.

[0005] The structures are typically built in fabrication yards that are long distances from the site where they will be installed offshore for production of oil and gas. Because towing of the floating structure must be done at a very slow rate to prevent damage to, or sinking of, the structure they are loaded in the horizontal position onto a heavy lift vessel and then transported to a nearby port where the structure is floated off for final fitting of a limited number of items and then towed a relatively short distance to the installation site. As mentioned above, the over-extended heave plate beyond the truss frame may not fit the supports while lying on its side either in a fabrication yard or on a heavy lift vessel.

[0006] There are also situations that may require modification of the designed effectiveness of the heave plate after a structure has been built. These include use of the structure in a location where conditions are not as originally predicted or use of the structure in a different location from what it was originally designed for.

[0007] Recently, some of the engineering and construction companies around the world have also been considering the use of heave plates in conjunction with semi-submersible structures. The same issues faced with spar type structures also apply to semi-submersibles.

[0008] While the heave plate has proven itself to be useful in reducing heave motions of floating offshore structures, it can be seen that there are physical and operation constraints on the maximum size of heave plates. Thus, there are instances where an improvement is needed.

SUMMARY

[0009] Viewed from a first aspect, the present invention can provide a floating offshore structure having a buoyant hull with an open truss frame having horizontally oriented heave plates vertically spaced apart along the truss frame. The heave plates can include a skirt plate attached around the outer perimeter of the heave plate and increases the effectiveness of the heave plate at trapping water mass between the heave plates for reducing heave motion of the floating offshore structure. A skirt plate can be attached to one or more heave plates at substantially a right angle to the heave plate. The skirt plate may extend beyond the upper and lower surfaces of the heave plate or be positioned so as to be flush with one surface of the heave plate and extend only beyond the opposite surface of the heave plate.

[0010] The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming part of this disclosure. For a better understanding of the present invention, and the operating advantages attained by its use, reference is made to the accompanying drawings and descriptive matter, forming a part of this disclosure, in which illustrative embodiments are presented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In the accompanying drawings, forming a part of this specification, and in which reference numerals shown in the drawings designate like or corresponding parts throughout the same:

[0012] FIG. 1 is a side view of a spar type structure.

[0013] FIG. 2 is a side view of a semi-submersible structure that includes an open truss frame.

[0014] FIG. 3 is an isometric view that illustrates a skirt installed on a heave plate from the floating structures.

[0015] FIG. 4 is an isometric view that illustrates an alternative arrangemrnt of a skirt installed on a heave plate from the floating structures.

[0016] FIG. 5 is a graph that illustrates the effectiveness of the skirt.

DETAILED DESCRIPTION

[0017] Fig. 1 illustrates a spar type floating structure 10 that includes a buoyant hull 12, an open truss frame 14, and a plurality of horizontally oriented heave plates 16 spaced vertically apart along the open truss frame 14. The topsides structure 18 is supported on the hull 12 and includes the drilling and/or production equipment and working/living space for the crew. Fig. 2 illustrates a semi-submersible floating structure that includes the upper buoyant hull 22, an open truss frame 24, and horizontally oriented heave plates 16 spaced vertically apart along the open truss frame 24. The topside structure 28 for drilling and/or production equipment and working/living space for the crew is supported on the upper portion of the hull 22. The approach described in the present disclosure is applicable to all floating offshore structures that use an open truss frame and heave plates to reduce the heave motions of the structure in response to the environmental forces of waves and currents.

[0018] As shown in Fig. 3, a skirt plate 30 is rigidly attached to one or more heave plates 16. The skirt plate 30 is attached to the outer perimeter of the heave plate 16. In the present example, the skirt plate 30 is attached to the outer perimeter of the heave plate 16 at a ninety degree angle thereto such that the skirt plate 30 is substantially vertical when the floating structure is in its installed, normal operational position. Other examples may use alternative attachment angles. The skirt plate 30 of the present example extends around the entire perimeter of the heave plate 16 to maximize the water mass entrapped by the combined heave plate 16 and skirt plate 30. However, in other examples the skirt plate 30 may be designed to extend around less than the full perimeter of the heave plate 16 if wave conditions or other design parameters dictate such an arrangement.

[0019] While the skirt plate 30 is illustrated in Fig. 3 as being attached to the heave plate 16 in a position such that the skirt plate 30 extends above the upper surface of the heave plate 16 and below the lower surface of the heave plate 16, it should be understood that different arrangements are possible. As seen in Fig. 4, the skirt plate 30 may be attached to the heave plate 16 such that the skirt plate 30 extends beyond one surface of the heave plate 16 but is flush with the opposite surface of the heave plate 16. Positioning of the heave plate and skirt plate as seen in Fig. 4 where the skirt plate extends upward from the heave plate 16 would be most effective. It is believed, when located as the lowest heave plate on a floating structure for interacting with the next higher heave plate and skirt plate to entrap water mass. The heave plate 16 and skirt plate 30 may also be positioned such that the skirt plate 30 extends downward. This arrangement of the heave plate and skirt plate would be most effective, it is believed, when located as the highest heave plate on the floating structure for interacting with the next lower heave plate and skirt plate to entrap water mass.

[0020] Fig. 5 is a graph that illustrates the calculated effectiveness of the use of such heave plate skirts at increasing the water mass effectively entrapped due to heave motions of the floating structure. The graph illustrates that a skirt plate that is eight feet tall increases the effective heave added mass of the entrapped water by ten percent over the use of a heave plate alone.

[0021] It will be understood that use of a heave plate skirt may provide advantageous performance relative to the use of heave plates alone.

[0022] The heave plate skirt provides a means for the heave plates to trap more water mass without exceeding the size limits of the heave plate on a particular structure.

[0023] The heave plate skirt provides flexibilities for adjusting the trapped mass by changing the skirt height without the need to change the heave plate itself, which should result in having minimal negative impact on the project during the design phase.

[0024] The heave plate skirt is useful for supporting riser porches on the edge of the heave plate if riser porches are to be used on the structure.

[0025] The calculated effectiveness of the skirt plate in entrapment of additional water mass as compared to the same size heave plate alone outweighs a potential disadvantage of the increased surface area exposed to currents.

[0026] Specific aspects of the present disclosure are set out in detail in the following numbered clauses:

1. In a floating offshore structure having a buoyant hull, an open truss frame rigidly attached to and extending below the hull, and at least two horizontally oriented heave plates attached to and spaced vertically apart along the length of the open truss frame, a skirt plate rigidly attached to the outer edge of at least one heave plate at substantially a right angle to the heave plate and extending beyond at least one surface of the heave plate.

2. The skirt plate of clause 1, wherein the skirt plate is attached around the full perimeter of the heave plate.

3. The skirt plate of clause 1 or 2, wherein at least one skirt plate is flush with the one surface of the heave plate and extends beyond the opposite surface of the heave plate.

4. In a floating offshore structure having a buoyant hull, an open truss frame rigidly attached to and extending below the hull, and at least two horizontal heave plates attached to and spaced vertically along

the length of the open truss frame, a skirt plate rigidly attached to the outer edge of at least one heave plate at substantially a right angle to the heave plate and extending beyond at least one surface of the heave plate, with the skirt plate attached around the full perimeter of the heave plate.

5. A floating offshore structure having a buoyant hull with an open truss frame having heave plates vertically spaced along the truss frame. One or more of the heave plates include a skirt plate that is attached around the outer perimeter of the heave plate and increases the effectiveness of the heave plate at trapping water mass between the heave plates for reducing heave motions of the floating offshore structure. A skirt plate is attached to one or more heave plates at substantially a right angle to the heave plate. The skirt plate may extend beyond the upper and lower surfaces of the heave plate or be positioned so as to be flush with the one surface of the heave plate and extend only beyond the opposite surface of the heave plate.

[0027] While specific embodiments and/or details of the invention have been shown and described above to illustrate the application of the principles of the invention, it is understood that this invention may be embodied as more fully described in the claims, or as otherwise known by those skilled in the art (including any and all equivalents), without departing from such principles.

Claims

1. A skirt plate configured to be rigidly attached to the outer edge of a heave plate of an open truss frame of a floatable offshore structure at substantially a right angle to the heave plate and extending beyond at least one surface of the heave plate.

2. The skirt plate of claim 1, wherein the skirt plate is configured to be attached around the full perimeter of the heave plate.

3. The skirt plate of claim 1 or 2, wherein the skirt plate is configured to be attached flush with one surface of the heave plate and extends beyond the opposite surface of the heave plate.

4. A heave plate for an open truss frame of a floatable offshore structure comprising a skirt plate of any of claims 1 to 3 rigidly attached thereto.

5. A floatable offshore structure having a buoyant hull, an open truss frame rigidly attached to and extending below the hull, and at least two heave plates, oriented to be substantially horizontal when the structure is floating, attached to and spaced vertically apart along the length of the open truss frame, wherein at least one heave plate comprises a skirt plate according to any of claims 1 to 3 rigidly attached to the outer edge thereof.

6. A method of providing additional stability for a floatable offshore structure having a buoyant hull, an open truss frame rigidly attached to and extending below the hull, and at least two horizontally oriented heave plates attached to and spaced vertically apart along the length of the open truss frame, the method comprising:

   providing a skirt plate rigidly attached to the outer edge of at least one heave plate and extending substantially perpendicularly to the heave plate beyond at least one surface of the heave plate.

7. The method of claim 6, wherein the wherein the skirt plate is attached around the full perimeter of the heave plate.

8. The method of claim 6 or 7, wherein the skirt plate is attached flush with one surface of the heave plate and extends beyond the opposite surface of the heave plate.

FIG. 1

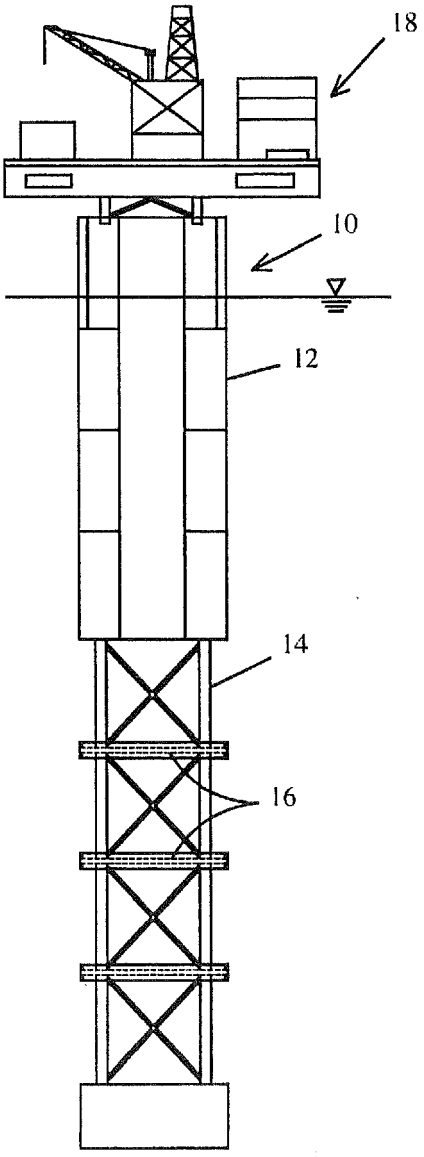


FIG. 2

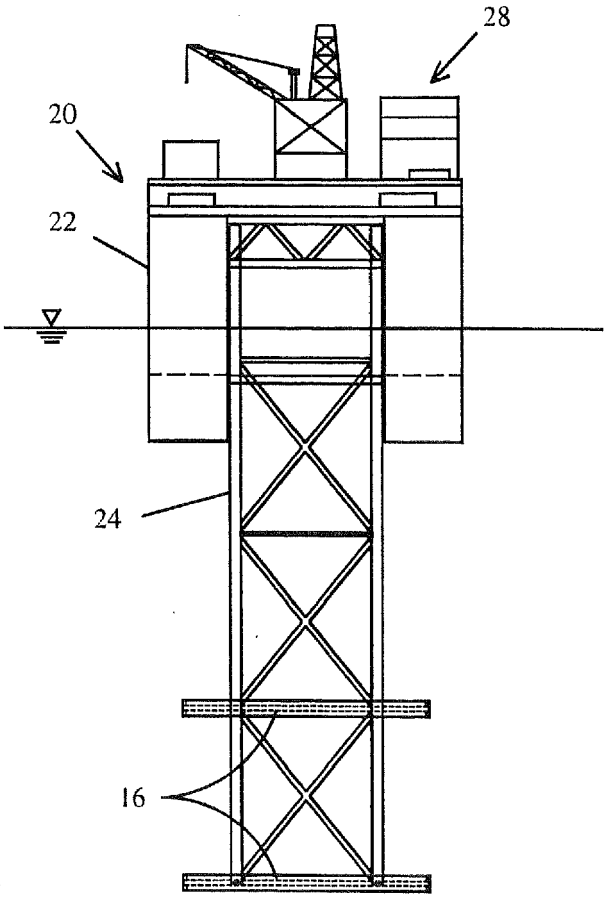


FIG. 3

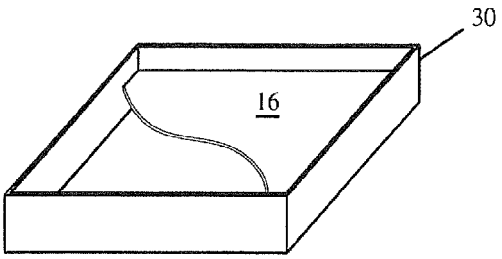


FIG. 4

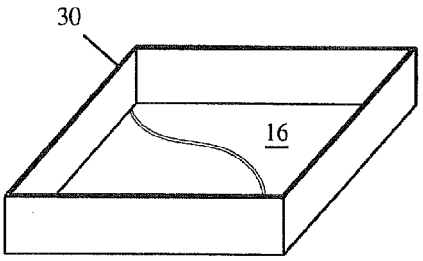
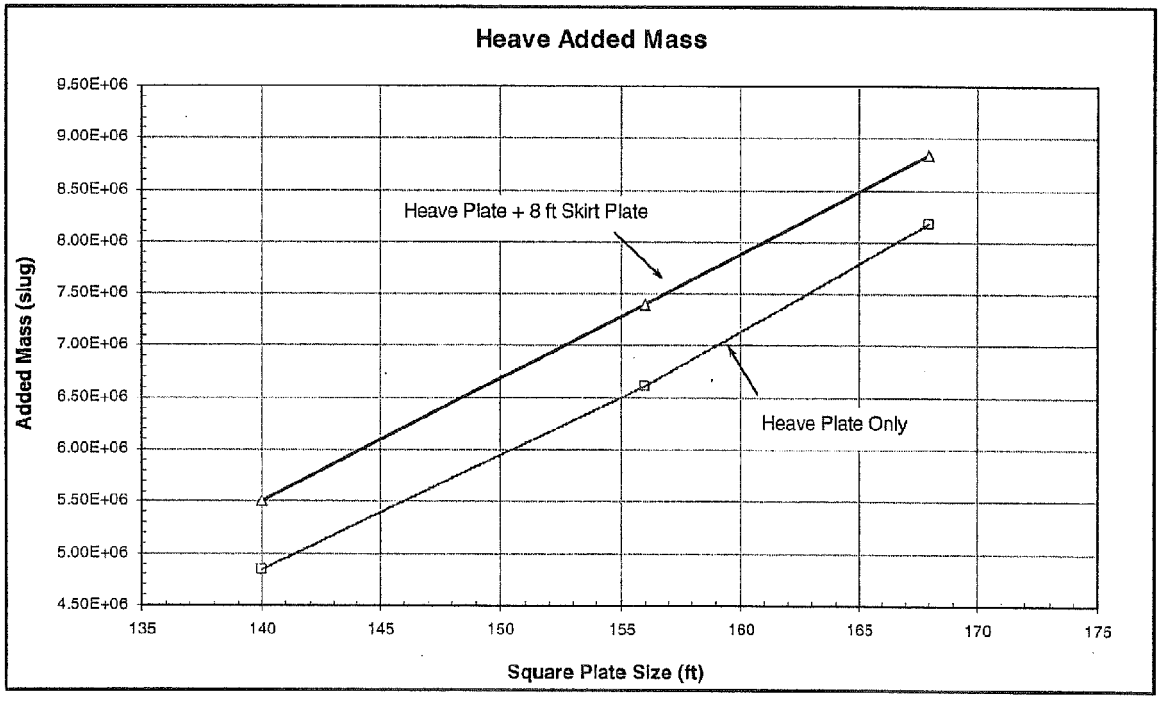


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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