



(11) **EP 2 364 909 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.09.2011 Bulletin 2011/37

(51) Int Cl.:
B63B 35/44^(2006.01) B63B 9/06^(2006.01)

(21) Application number: **11157703.7**

(22) Date of filing: **10.03.2011**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME

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(30) Priority: **11.03.2010 US 721681**

(54) **Deep Water Offshore Apparatus and Assembly Method**

(57) A truss type spar (10) that eliminates the need for the more complex and critical attachment of the buoyant hull to the truss section at a fabrication site/yard that is remote from the fabrication yard where the buoyant hull and truss sections were originally built. The buoyant hull (12) and initial truss sections (14) are constructed at the fabrication yard of choice, joined together, and transported to a dock or fabrication yard (a second location) that is as close as possible to the final offshore installation site. Transport of such completed structures, either separately or together, is normally done on a heavy lift vessel to reduce transport time and prevent damage to the buoyant hull and truss sections. Once at the fabrication yard/dock, the joined buoyant hull (12) and initial truss section (14) are floated off the heavy lift vessel and the draft adjusted to a position suitable for joining additional truss sections. One or more additional truss sections (16,18) can be attached to the initial section, and the completed buoyant hull and truss is then towed to the final offshore installation site.

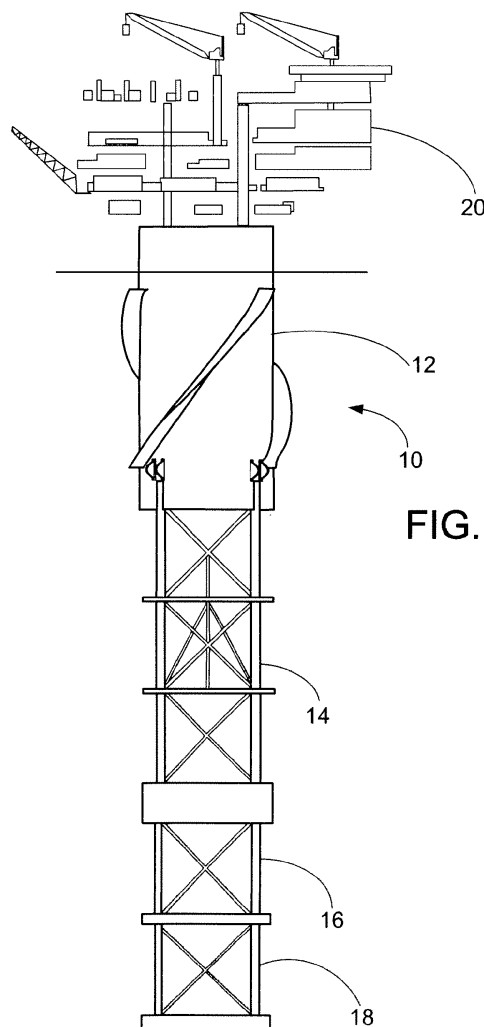


FIG. 1

Description

Field and Background

[0001] The invention is generally related to floating offshore structures and more particularly but not exclusively to a spar type structure with a jacket/truss section.

[0002] As now known in the offshore oil and gas industry, the spar type structure with a jacket/truss extending from the buoyant hull, such as that described in U.S. Patent 5,558,467, provides a number of advantages over other floating structures such as a traditional spar type structure or a TLP (Tension Leg Platform) that makes it desirable, especially for use in deep water. Versions of the spar can be designed for environment specific locations around the world.

[0003] Environmental conditions such as waves, winds, and currents are directly related to the length of the structure required for acceptable motions such as heave, pitch, and yaw. More extreme environmental conditions require longer buoyant hull and truss sections in order to provide acceptable motions. One of the main advantages of the spar is that it can support a type of riser called a top tensioned riser. The riser is the main line that lifts hydrocarbons from subsea reservoirs. The top tensioned riser is supported by the spar using a tensioning device mounted on the production deck at the top of the riser. Recently the industry is moving to a new method of tensioning using hydraulic/pneumatic tensioners. This method of tensioning can cause an increase in the spar heave motions. The solution to overcome this effect of the tensioner is to increase the length of the spar and add a longer truss with more heave plates.

[0004] Because of the specialty facilities required in the fabrication yards to construct the spar, there are a limited number available worldwide. Consequently, when the location at which the spar will be installed is not near the construction site, the spar must be loaded onto a heavy transport vessel and transported to a site near the location of the final installation. The world wide number of transport vessels available for this operation is very limited because of the required size of the transport vessel. Also, these vessels have limitations on the weight and length of the spar that can be transported.

[0005] Typical construction of the truss type spar has consisted of building the buoyant hull and truss sections separately and then joining them together on land at a fabrication yard when the total length and weight of the joined buoyant hull and truss sections are within the range that can be transported on a heavy lift transportation vessel. When the combined length of the buoyant hull and truss is too long or too heavy for the transport vessel, the buoyant hull and the truss are transported separately to a fabrication site near the final installation location. When the truss and buoyant hull are transported as separate pieces, they are offloaded from the transport vessel by floating the two pieces and joining them while they are floating near a dockside. It is more difficult to

make the connection in this manner than to make the connection on land. When possible, making this connection on land is the preferred method.

[0006] The connection between the truss and buoyant hull is extremely critical because if the truss separates from the buoyant hull it becomes unstable and can capsize. High stress areas in the connection that can result in its failure can be caused by misalignments and other dimensional tolerances that are difficult to comply with when the connection is made with the buoyant hull and truss section floating near a dockside. It is practical in almost all cases to make the main connection between the truss and buoyant hull on land and to attach an initial truss of sufficient length to keep the spar stable even if the additional truss section separates after the hull is installed. Because this main connection is made on land, the connection between the additional truss sections and the initial truss section is less critical when making the connection dockside with the spar and additional truss sections floating. Typically the joining operation has been carried out in a fabrication or ship yard that is closer to the final offshore installation site than the original construction yards. Performing this construction in this way can present special challenges in the form of extra time, costs, and potential alignment issues.

[0007] A typical truss spar for the Gulf of Mexico has a buoyant hull and truss section that is approximately 550 feet long. This is close to the maximum length that can be transported as a single unit by available transport units. Some areas of the world such as the North Sea with more extreme environmental conditions require longer buoyant hulls and truss sections. The difficulties of joining the truss section to the buoyant hull are increased with the longer buoyant hulls and truss sections. Another critical limitation is that there are only a few fabrication/ship yards around the world with the capability to receive and join these two longer sections.

Summary

[0008] The present disclosure arises from work carried out in the knowledge of shortcomings and issues in the known art.

[0009] Viewed from a first aspect, there can be provided a truss type spar that allows the extension of the truss to complete the total required length and eliminates the need for the more critical and complex attachment of the buoyant hull to the truss section to be made with these two structural components in a floating condition. Additional truss sections supporting heave plates can be added to the initial truss section at a fabrication site/yard that is remote from the site/yard where the buoyant hull and truss sections were originally built. The extension is completed by adding sections to the initial truss after transport. The buoyant hull and initial truss sections are constructed at the fabrication yard of choice, joined together, and transported to a dockside location or fabrication yard that is as close as possible to the final offshore installation

site. Transport of such completed structures is normally done on a heavy lift vessel to reduce transport time and prevent damage to the buoyant hull and truss sections. Once at the fabrication yard/dock, the buoyant hull and initial truss section already connected to the buoyant hull are floated off the heavy lift vessel and the draft adjusted to a position suitable for joining additional truss sections. One or more additional truss sections can be attached to the initial truss section, after which the completed buoyant hull and truss is towed to the final offshore installation site.

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

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 illustrates a completed structure in the upright installed position.

[0013] FIG. 2 illustrates a joined buoyant hull and initial truss section placed on a heavy lift vessel for transport.

[0014] FIG. 3 illustrates the joined buoyant hull and initial truss section being floated off of the heavy lift vessel.

[0015] FIG. 4 illustrates the buoyant hull and initial truss section in a floating horizontal position with additional truss sections being moved in for attachment to the initial truss section.

[0016] FIG. 5 illustrates the structure with the additional truss sections attached to the initial truss section.

[0017] While the invention is susceptible to various modifications and alternative forms, specific embodiments are shown by way of example in the drawings and are herein described in detail. It should be understood, however, that drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

Detailed Description

[0018] A completed offshore structure 10 is illustrated in Fig. 1 in the upright installed position. The structure includes a buoyant hull section 12, an initial truss section 14, additional truss sections 16, 18, and a topsides 20.

[0019] The buoyant hull section 12 and initial truss section 14 are preferably constructed at the same location

in the normal manner as well known in the industry. The buoyant hull section 12 and initial truss section 14 are then joined together at the construction location on land and placed on a heavy lift vessel 22 as illustrated in Fig. 2. The joined buoyant hull section 12 and initial truss section 14 are then transported on the heavy lift vessel 22 to a location such as a dock or ship yard that is closer to the final offshore installation site. This minimizes the towing distance of the structure when not on a heavy lift vessel 22.

[0020] After transportation to the dock or fabrication yard (second location) the already joined buoyant hull section 12 and initial truss section 14 are floated off of the heavy lift vessel, usually by ballasting the heavy lift vessel 22 down, as illustrated in Fig. 3, and moving the heavy lift vessel 22 or the buoyant hull section 12 and initial truss section 14. The draft of the buoyant hull section 12 and initial truss section 14 is adjusted to a suitable draft for attaching one or more additional truss sections 16, 18 to the initial truss section 14.

[0021] As seen in Fig. 4, the additional truss sections 16, 18 are floated into position adjacent the end of the initial truss section 14 and rigidly attached to the initial truss section 14. The completed structure of the buoyant hull section 12, initial truss section 14, and additional truss sections 16, 18 is then towed to the final offshore installation site in the horizontal position as seen in Fig. 5 and installed in a manner known in the art whereby the ballast of the structure is adjusted to cause the truss sections to lower into the water such that the entire structure is in a vertical position with a preselected portion of the buoyant hull 12 above the water line. The structure is moored into place and the topsides 20 is installed on the buoyant hull section 12.

[0022] In order to insure that the connection between the buoyant hull 12 and the initial truss section 14 can be made on land in a more controlled and amenable condition and subsequently transported as a single unit to the offloading location, the spar hull is designed to be the maximum allowable combination of buoyant hull 12 and initial truss section 14 that can be transported on a particular vessel. If this renders the truss length too short and the hull requires additional heave plates to meet the prescribed operation, these additional truss sections 16 supporting the heave plates will be added after transportation. This approach facilitates making the most critical connection between the buoyant hull 12 and the initial truss section 14 on land as compared to previous methods which required transporting the buoyant hull and truss separately and making this connection in a floating condition after transportation.

[0023] Therefore, from one viewpoint, there has been disclosed a truss type spar that eliminates the need for the more complex and critical attachment of the buoyant hull to the truss section at a fabrication site/yard that is remote from the fabrication yard where the buoyant hull and truss sections were originally built. The buoyant hull and initial truss sections are constructed at the fabrication

yard of choice, joined together, and transported to a dock or fabrication yard (a second location) that is as close as possible to the final offshore installation site. Transport of such completed structures, either separately or together, is normally done on a heavy lift vessel to reduce transport time and prevent damage to the buoyant hull and truss sections. Once at the fabrication yard/dock, the joined buoyant hull and initial truss section are floated off the heavy lift vessel and the draft adjusted to a position suitable for joining additional truss sections. One or more additional truss sections can be attached to the initial section, and the completed buoyant hull and truss is then towed to the final offshore installation site.

[0024] The structure and method disclosed herein can provide a number of advantages over the state of the art.

[0025] One advantage is it allows the most critical and complex connection between the buoyant hull and the initial truss section to be completed on land in a specialized fabrication yard.

[0026] Another advantage is it broadens the range of vessels capable of transporting the initial spar configuration.

[0027] Still another advantage is that any number of truss and heave plate sections can be added, extending the applicability of the spar to multiple possible deployment sites, making it more competitive in the global market.

[0028] Another advantage is that it minimizes the complexity of attaching the additional truss sections to the hull, resulting in a saving in time and cost.

[0029] While specific examples, embodiments and/or details 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

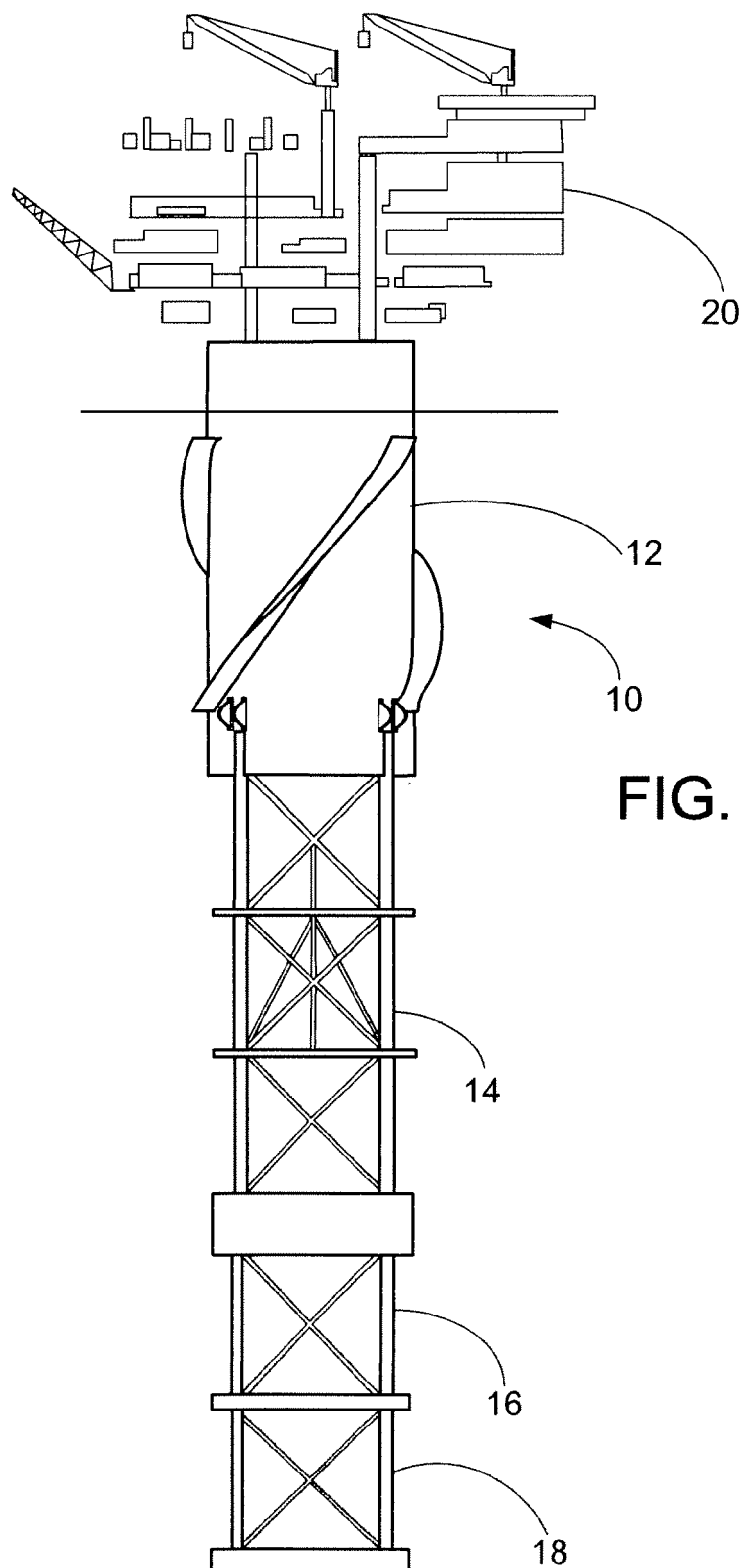
1. A truss spar type structure, comprising:

a buoyant hull section;
 an initial truss section attached to the buoyant hull section at a fabrication yard on land before transport from the fabrication yard, with the size of the attached buoyant hull and initial truss section capable of being transported on a heavy lift vessel; and
 at least one additional truss section attached to the main truss section at a different location from the original fabrication yard for the buoyant hull and main truss sections.

2. The truss spar type structure of claim 1, wherein each additional truss section is shorter than the main truss section.

3. A method for assembling a truss spar type structure, comprising the steps:

constructing a buoyant hull section;
 constructing an initial truss section;
 joining the initial truss section to the buoyant hull section, with the joined buoyant hull section and initial truss section capable of being transported on a heavy lift vessel;
 transporting the joined buoyant hull and truss sections on a heavy lift vessel to a second location; and
 attaching at least one additional truss section to the main truss section.



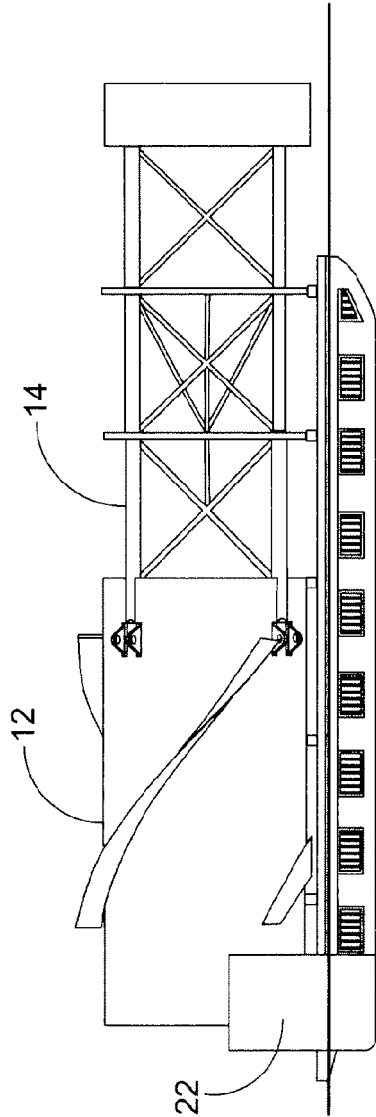


FIG. 2

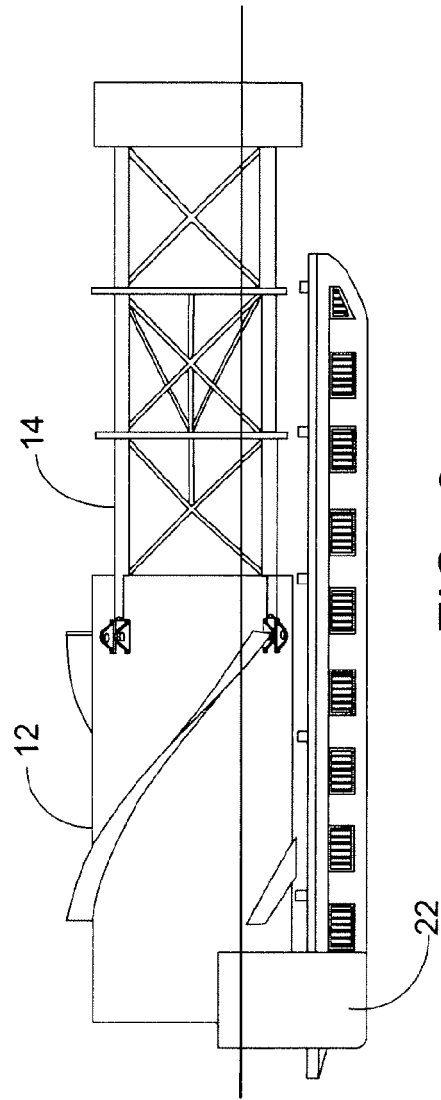


FIG. 3

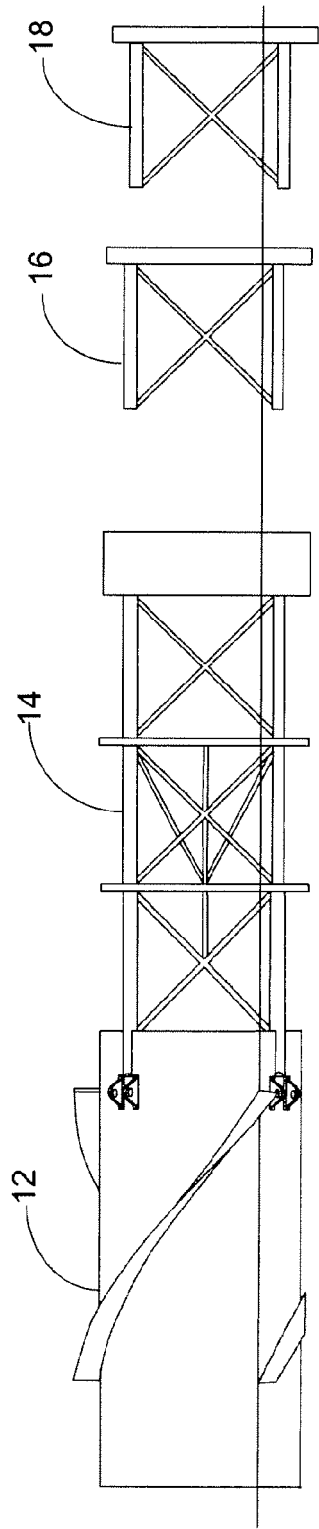


FIG. 4

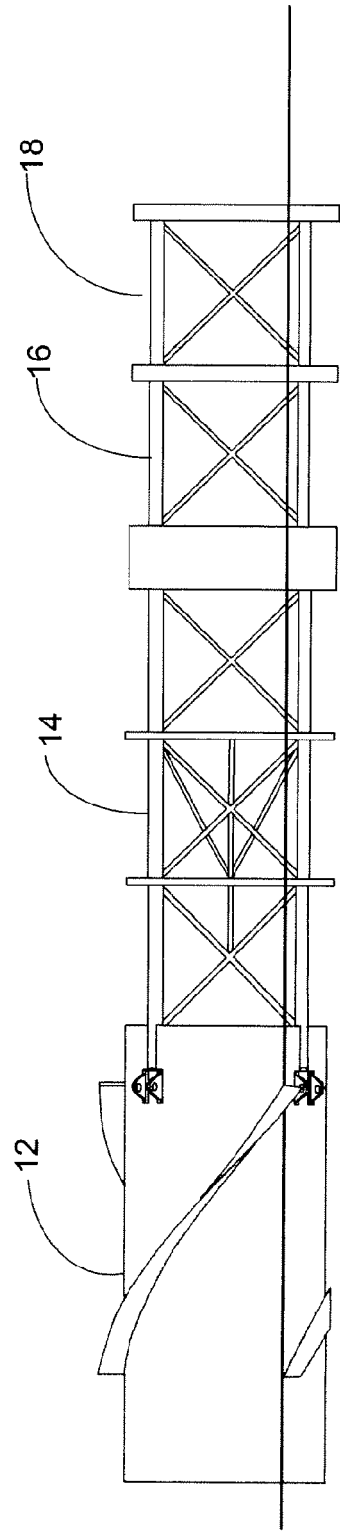


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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