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(54) METHOD OF ERECTING OFFSHORE STRUCTURES AND OFFSHORE TOWER CONSTRUCTION THEREFOR

(71) We, RAYMOND INTERNATIONAL INC., a Corporation organised and existing under the laws of the State of New Jersey, United States of America, of 2801 South Post Oak Road, Houston, State of Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the erection of offshore structures and more particularly it concerns the construction of offshore towers and platforms such as are used in exploration and recovery of resources such as oil from beneath the sea bed.

Offshore towers and platforms of the type to which the present invention pertains are shown in United States Patent No. 3,857,247 to Lindsey J. Phares and in United States Patent No. 3,876,181 to Joseph E. Lucas. In both these patents there is described a two component system comprising a support structure or tower and a platform or deck, which are separately floated or carried by barge out to a desired offshore location. When the support structure arrives on location it is affixed in upright or vertical position to the sea bed with its legs extending up well beyond the water surface. The deck or platform is then positioned between the legs and is jacked up along the legs so that it is clear of the water surface and of all wave action. The platform is then pinned to the support structure and drilling and production operations are then carried out from the stably mounted, elevated platform.

Both the Phares and Lucas patents show arrangements for mounting jacking legs to be suspended from the upper ends of the support structure legs so they extend down alongside the legs to the platform. Jacking mechanisms are provided on the platform to grip the jacking legs and pull the platfor up via the jacking legs to the top of the support structure legs. After the elevated platform is secured to the support structure the jacks and jacking legs may be removed for use in the erection of another offshore tower.

The present invention provides improvements to the above described offshore tower erection techniques. More specifically, the present invention permits a more efficient and lower cost platform structure than has heretofore been necessary. That is, the platform structure may be of lighter weight and less rigid construction than previous platforms. In addition, with the present invention, a platform, once-positioned adjacent the support structure, is made ready for a jacking up operation in a much shorter time than has heretofore been necessary. This is important because during the time the platform is riding on the water adjacent the support structure legs it is subject to the action of the sea and is vulnerable to damage should the sea conditions become severe.

According to one aspect of the present invention there is provided a method of erecting an offshore tower, said method comprising the steps of positioning a support structure, having a plurality of spaced apart vertical legs, on a sea floor so that said vertical legs extend up above the sea level, said support structure being provided with at least one open framework bridge beam connected to and extending between the upper ends of at least two of said vertical legs, floating a platform out to the thus positioned support structure, interconnecting jacking units, each comprising a jacking leg means and a jacking mechanism means operative to undergo longitudinal movement with respect to said jacking leg means, between the or each said bridge beam and said platform so that one of said means is connected to the bridge beam or one of the bridge beams and the other of said means is connected to said platform and operating said jacking mechanism means to raise said platform clear of the water.

According to another aspect of the present invention, there is provided an offshore tower construction comprising a support structure anchored to a sea floor, said

support structure including a plurality of spaced apart vertical legs which extend out above the surface of the sea, an open framework bridge beam member extending across and interconnecting at least two of said legs near their upper end above the sea surface, a platform member positioned adjacent said legs under said bridge beam member, jacking mechanisms mounted on one of said members and elongated jacking legs extending from said jacking mechanisms to the other member and connected thereto, whereby operation of said jacking mechanisms will in use, pull on said jacking legs and raise said platform clear of the water.

There follows a detailed description of examples of the invention, which refer to the accompanying drawings, in which:—

Fig. 1 is an elevated view of an offshore tower structure in which the present invention is embodied;

Fig. 2 is a top plan view of the offshore tower structure of Fig. 1;

Fig. 3 is a side elevational view showing the placement of a support structure of the offshore tower of Fig. 1 as a first step in the erection of the tower;

Fig. 4 is a view similar to Fig. 3 but showing the positioning of a platform at the support structure as a second step in the erection of the offshore tower of Fig. 1;

Fig. 5 is a top plan view illustrating the platform and support structure of Fig. 4;

Fig. 6 is a view similar to Fig. 4 but showing the platform fully positioned at the support structure and ready to be raised thereon;

Fig. 7 is a section view taken along line 7—7 of Fig. 6;

Fig. 8 is an enlarged fragmentary diagrammatic view, taken along line 8—8 of Fig. 7;

Fig. 9 is a view similar to Fig. 7 but showing the platform in fully raised condition;

Fig. 10 is a view similar to Fig. 4 but showing the positioning of a barge mounted platform positioned at the support structure;

Fig. 11 is a view similar to Fig. 7 but showing a barge mounted platform;

Fig. 12 is a view similar to Fig. 11 but showing a raised barge mounted platform;

Fig. 13 illustrates a modified arrangement whereby a bridge beam is mounted atop a previously installed support structure; and

Fig. 14 illustrates a modified arrangement wherein a tilt-up type support structure is installed.

The offshore tower structure of Fig. 1 comprises a platform 20 which is held, by means of a support structure 22, in stationary position up above a sea surface 24 so as to be free of waves and sea currents.

The support structure 22 comprises forward and rearward pairs of vertical legs 26 and 28 which extend up from a base 30. The base 30, in turn, comprises a base plate 32 which is pinned, as by anchor piles 34, to a sea bed 35, and a cluster of tubular elements 36 which extend upwardly from the plate 32 to surround the lower portion of the vertical legs 26 and 28.

Forward and rearward bridge beams 38 and 40, of trusslike open framework construction, extend across and span the distance between the upper ends of the forward and rearward legs respectively. These bridge beams are secured to pedestals 42 and 44 on top of the legs 26 and 28.

As shown in Figs. 1 and 2, the platform 20 is of expansive, generally flat configuration; and in plan view it is shaped as a T, with a base portion 46 and a cross portion 48. The base portion 46 of the T shaped platform extends lengthwise between and beyond the forward and rearward pairs of legs 26 and 28 and in its widthwise direction is extends the full distance between the corresponding legs of each pair. The cross portion 48 of the T shaped platform extends out forwardly and laterally beyond the forward legs 26.

The platform 20 is secured to the bridge beams 38 and 40 along their length; and consequently it is stiffened and strengthened by them. Because of this, the platform although expansive in size, may be made of lighter construction that would have been necessary if the platform had to bridge the entire distance between the legs without external bracing.

The offshore tower structure shown in Figs. 1 and 2 is arranged for oil well drilling. As can be seen in Fig. 2, the forward bridge beam 38 is formed to define a grid like array of drilling locations 50 and to support a drilling tower 52 above different ones of those locations for exploratory drilling. The forward bridge beam 38 also supports a tower crane 54 which is used to position additional lengths of drill pipe in the tower 52.

Although the basic operative elements, i.e. the drilling tower 52 and the tower crane 54, are supported on the bridge beam 38, the platform 20 is required to support personnel, auxiliary equipment and supplies. Thus, as can be seen in Figs. 1 and 2, there is provided a crew quarters 56 at the outer end of the platform base portion 46, and a helicopter landing platform 58 atop the rearward bridge beam 48. Power generating and control equipment 60 is arranged on the platform cross portion 48 and a drill pipe storage ledge 62 is constructed thereabove. A supply hoist 64 is also mounted along the forward edge of the platform cross portion 48 for bringing supplies and equipment up from ship or barges moored to the support structure. A tower and crane positioning ledge 66 is constructed on the plat-

form 20 just behind the forward bridge beam 38. This ledge accommodates the drilling tower 52 and the tower crane 54 when the platform 20 is being moved into position on the support structure or when it is being dismantled from the structure.

Figs. 3—9 illustrate the manner of erecting the above described offshore tower at a desired location in the sea. As can be seen in the phantom outline portion of Fig. 3 the support structure 22 is towed, while floating, to a desired location; and it is then sunk to the sea bed 35 when it has arrived at this location. The flotation control of the support structure 22 can be carried out by external means (not shown) attached to it, or the legs 26 and 28, and the tubular elements 36 may be hollow and selectively floodable. After the support structure has been sunk to the sea bottom, it is secured there by installation of the anchor piles 34.

It will be noted from Fig. 3 that the pedestals 42 and 44 and the bridge beams 38 and 40 are pre-assembled to the upper ends of the legs 26 and 28 before the support structure is towed out to its desired location. Since the bridge beams 38 and 40 are of open framework construction they are relatively light in weight and are of minimum bulk. Therefore they do not offer appreciable resistance to towing nor do they substantially affect balance or buoyancy of the support structure during the towing operation. In fact, the bridge beams 38 and 40 actually brace the upper ends of the legs so that it can better withstand the rigors of sea and wind action during the towing operation. On the other hand, if the support structure 22 were towed with the platform 20 attached, the platform would be subject to wind and/or sea action, which would overstress the structure. Moreover, the structure would not be stable in floating condition and would be likely to capsize.

It will also be noted in Fig. 3 that there are provided within each of the bridge beams 38 and 40, a plurality of jacking mechanisms 68 and associated rigid tubular jacking legs 70. The bridge beams 38 and 40 thus serve as mounting members on the support structure 22 for the jacking mechanisms 68. This arrangement of jacking mechanisms and jacking tubes permits rapid and convenient interconnection between the support structure and platform for lifting of the platform to its proper height, as will be explained more fully hereinafter.

After the support structure 22 has been secured to the sea bed 35, the platform 20 is towed in a floating condition, as shown in Fig. 4, to the structure. The platform 20, may be fully constructed at a shore location and there outfitted with the crew quarters 56, the power generating and control equipment 60, the drill pipe storage ledge 62 and the tower and crane positioning ledge 66 with the drilling tower and tower crane 52 and 54 mounted hereon. As shown in Fig. 5, the platform is directed so that its base portion 46 first enters the region between the forward legs 26 and then continues on between and beyond the rearward legs 28 until the platform cross portion 48 nearly abuts the forward legs 26. The platform 20 is provided with jacking leg slips 72 which become aligned with the jacking legs 70 on the bridge beams 38 and 40 when the platform is floated into position. These slips are designed to allow the jacking legs to move freely through them longitudinally in one direction but to grip the legs and prevent relative movement in the opposite direction. As shown in Fig. 6, the jacking mechanisms 68 are then operated to lower the jacking legs 70 until they enter their corresponding jacking leg slips 72 on the platform 22 and thereby provide an interconnection between the platform and the bridge beams 38 and 40 extending across the tops of the legs 26 and 28.

As can be seen in Fig. 8 the jacking mechanisms 68 each comprise upper and lower holder assemblies 74 and 76 with the lower holder assembly 76 mounted on a portion of one of the bridge beams 38 and 40. Hydraulic piston and cylinder assemblies 78 are driven and controlled by external means (not shown) to move the holder assemblies 74 and 76 toward and away from each other. Slips 80 on the holder assemblies 74 and 76 are controlled to grip and release the jacking leg 70 in alternate sequence as the holder assemblies are moved toward and away from each other respectively. Thus, in order to lower the jacking leg 70 the slip 80 on the lower holder assemblies 76 are released while those on the upper holder assemblies 74 are engaged when the assemblies are moved toward each other and vice versa when they are moved away from each other. In order to raise the jacking leg, the slip engagement and release sequence is reversed. This is shown diagrammatically in Fig. 8 by leaf type springs 81 which are held by pins 81*a* and 81*b* to bias either the upper or lower portion of the slips 80 against the jacking leg 70.

When the jacking legs 70 engage the slips 72 on the platform 20 they become secured to the platform in a manner which allows upward but not downward movement of the platform with respect to the jacking legs. That is, the slips 72 allow relative movement of the jacking legs 70 with respect to the slips which coincides with movement of the platform and bridge beam toward each other, but they prevent relative movement in the reverse direction. Thus, should the platform begin to rise as a result of wave or tide action, the slips 72 will allow the platform

to move up on the jacking legs. However, the slips 72 act to prevent reverse movement. Thus, wave action is utilized in raising of the platform in a manner similar to that described in U.S. Patent No. 3,876,181 to Joseph E . Lucas.

After the jacking legs 70 have engaged their respective jacking tube slips in the platform 20 the jacking mechanisms 68 are operated to lift the jacking legs and the platform 20 along with them to raise the platform up to the bridge beams 38 and 40 as shown in Fig. 9. When the platform is fully raised, it is secured to the bridge beams along their length, as by welding. The jacking mechanisms and jacking legs may then be removed for use in the erection of other offshore tower structures. Because of the truss-like open framework configuration of the bridge beams 38 and 40 they provide a skeletal type support which strengthens and rigifies the platform when it has been raised and secured to the bridge beams. Also, since the bridge beams span the distance between the legs the platform may be of much lighter and less rigid construction than would have been necessary if the platform had to span the legs on its own.

Figs. 10—12 show a modified arrangement wherein the platform 20 is carried out on a barge 82 to the support structure 22. This designed without regard to buoyancy or ability to withstand the stresses of sea action. As shown in Fig. 11 the jacking legs 70 are engaged in the jacking tube slips 72 on the platform while it is supported by the barge 82; and as shown in Fig. 12 the jacking mechanisms 68 operate to lift the platform up off the barge to the bridge beams 38 and 40 for subsequent attachment thereto. The jacking mechanism and jacking legs 68 and 70 may then be disconnected and lowered back down to the barge for use in the erection of another offshore tower structure.

Fig. 13 shows another modification wherein the support structure 22 is floated to location and installed there prior to installation of the bridge beams 38 and 40. These beams may then be installed by means of a derrick barge 84. As shown, the jacking mechanisms and jacking legs 68 and 70 may be previously mounted on the bridge beams so that the entire bridge beam and jacking assembly may be positioned on top of the legs 26 and 28. Because the bridge beams are of open framework construction they may be handled by a derrick barge rather easily, as compared to the platform itself.

Fig. 14 shows the installation of a tilt-up type support structure 86 with preassembled bridge beams 88. The basic idea of horizontally floatable support structure which is tilted to upright position by selective flooding is well known and is shown for example, in U.S. Patent No. 2,857,744 to W. F. Swiger, et al. In that patent a temporary truss 22 is shown attached to the upper ends of the legs; however, it is believed that the present invention represents the first time that bridge beams have been used in the lifting and reinforcing of a platform structure.

Reference is made to our co-pending Applications Nos. 25027/76, 33566/77 and 33567/77 (Serial Nos. 1,524,424, 1,524,425 and 1.524,426).

WHAT WE CLAIM IS:—

1. A method of erecting an offshore tower, said method comprising the steps of positioning a support structure having a plurality of spaced apart vertical legs, on a sea floor so that said vertical legs extend up above the sea level, said support structure being provided with at least one open framework bridge beam connected to and extending between the upper ends of at least two of said vertical legs, floating a platform out to the thus positioned support structure, interconnecting packing units, each comprising a jacking leg means and a packing mechanism means operative to undergo longitudinal movement with respect to said jacking leg means, between the or each said bridge beam and said platform so that one of said means is connected to the bridge beam or one of the bridge beams and the other of said means is connected to said platform and operating said jacking mechanism means to raise said platform clear of the water.

2. A method of erecting an offshore tower according to claim 1 wherein said jacking units are interconnected by securing each said packing mechanism means to the bridge beam or one of the bridge beams and by connecting each said jacking leg means to said platform.

3. A method of erecting an offshore tower according to claim 2 wherein said jacking means are moved by their respective jacking mechanism means to enter into and to be engaged by slips in said platform which allow movement of the platform with respect to the jacking leg means therethrough in a direction which corresponds with raising of the platform but not in the reverse direction.

4. A method of erecting an offshore tower according to claim 1 wherein the or each said bridge beam is connected to said legs after said support structure is anchored to the sea floor and before said platform is raised.

5. A method of erecting an offshore tower according to any preceding claim, wherein said platform is secured to said bridge beam after it has been reused.

6. A method of erecting an offshore tower according to claim 5 wherein said

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to move up on the jacking legs. However, the slips 72 act to prevent reverse movement. Thus, wave action is utilized in raising of the platform in a manner similar to that described in U.S. Patent No. 3,876,181 to Joseph E . Lucas.

After the jacking legs 70 have engaged their respective jacking tube slips in the platform 20 the jacking mechanisms 68 are operated to lift the jacking legs and the platform 20 along with them to raise the platform up to the bridge beams 38 and 40 as shown in Fig. 9. When the platform is fully raised, it is secured to the bridge beams along their length, as by welding. The jacking mechanisms and jacking legs may then be removed for use in the erection of other offshore tower structures. Because of the truss-like open framework configuration of the bridge beams 38 and 40 they provide a skeletal type support which strengthens and rigifies the platform when it has been raised and secured to the bridge beams. Also, since the bridge beams span the distance between the legs the platform may be of much lighter and less rigid construction than would have been necessary if the platform had to span the legs on its own.

Figs. 10—12 show a modified arrangement wherein the platform 20 is carried out on a barge 82 to the support structure 22. This designed without regard to buoyancy or ability to withstand the stresses of sea action. As shown in Fig. 11 the jacking legs 70 are engaged in the jacking tube slips 72 on the platform while it is supported by the barge 82; and as shown in Fig. 12 the jacking mechanisms 68 operate to lift the platform up off the barge to the bridge beams 38 and 40 for subsequent attachment thereto. The jacking mechanism and jacking legs 68 and 70 may then be disconnected and lowered back down to the barge for use in the erection of another offshore tower structure.

Fig. 13 shows another modification wherein the support structure 22 is floated to location and installed there prior to installation of the bridge beams 38 and 40. These beams may then be installed by means of a derrick barge 84. As shown, the jacking mechanisms and jacking legs 68 and 70 may be previously mounted on the bridge beams so that the entire bridge beam and jacking assembly may be positioned on top of the legs 26 and 28. Because the bridge beams are of open framework construction they may be handled by a derrick barge rather easily, as compared to the platform itself.

Fig. 14 shows the installation of a tilt-up type support structure 86 with preassembled bridge beams 88. The basic idea of horizontally floatable support structure which is tilted to upright position by selective flooding is well known and is shown for example, in U.S. Patent No. 2,857,744 to W. F. Swiger, et al. In that patent a temporary truss 22 is shown attached to the upper ends of the legs; however, it is believed that the present invention represents the first time that bridge beams have been used in the lifting and reinforcing of a platform structure.

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WHAT WE CLAIM IS:—

1. A method of erecting an offshore tower, said method comprising the steps of positioning a support structure having a plurality of spaced apart vertical legs, on a sea floor so that said vertical legs extend up above the sea level, said support structure being provided with at least one open framework bridge beam connected to and extending between the upper ends of at least two of said vertical legs, floating a platform out to the thus positioned support structure, interconnecting packing units, each comprising a jacking leg means and a packing mechanism means operative to undergo longitudinal movement with respect to said jacking leg means, between the or each said bridge beam and said platform so that one of said means is connected to the bridge beam or one of the bridge beams and the other of said means is connected to said platform and operating said jacking mechanism means to raise said platform clear of the water.

2. A method of erecting an offshore tower according to claim 1 wherein said jacking units are interconnected by securing each said packing mechanism means to the bridge beam or one of the bridge beams and by connecting each said jacking leg means to said platform.

3. A method of erecting an offshore tower according to claim 2 wherein said jacking means are moved by their respective jacking mechanism means to enter into and to be engaged by slips in said platform which allow movement of the platform with respect to the jacking leg means therethrough in a direction which corresponds with raising of the platform but not in the reverse direction.

4. A method of erecting an offshore tower according to claim 1 wherein the or each said bridge beam is connected to said legs after said support structure is anchored to the sea floor and before said platform is raised.

5. A method of erecting an offshore tower according to any preceding claim, wherein said platform is secured to said bridge beam after it has been reused.

6. A method of erecting an offshore tower according to claim 5 wherein said

platform is raised by said jacking units up to the or each bridge beam and is then fastened to the or each said bridge beam along its length.

7. A method of erecting an offshore tower according to claim 5 or claim 6 wherein said packing units are disconnected and removed after said platform has been secured to the or each said bridge beam.

8. An offshore tower construction comprising a support structure anchored to a sea floor, said support structure including a plurality of spaced apart vertical legs which extend out above the surface of the sea, an open framework bridge beam member extending across and interconnnecting at least two of said legs near their upper end above the sea surface, a platform member positioned adjacent said legs under said bridge beam member, jacking mechanisms mounted on one of said members and elongated jacking legs extending from said jacking mechanisms to the other member and connected thereto, whereby operation of said jacking mechanisms will in use, pull on said jacking legs and raise said platform clear of the water.

9. An offshore tower construction according to claim 8 wherein said jacking mechanism is mounted on said bridge beam member.

10. An offshore tower construction according to claim 9 wherein said platform is provided with slips which, in use, accommodate said jacking legs and allow relative movement of the platform with respect to said jacking legs in a direction which corresponds to raising of said platform member but prevent relative movement in the reverse direction.

11. An offshore tower construction according to any of claims 8 to 10 wherein a plurality of packing mechanisms are arranged with their associated jacking legs extending alongside each of the support structure legs between said bridge beam member and said platform member.

12. An offshore tower construction according to any of claims 8 to 11 wherein said bridge beam member is constructed to support a drilling tower and to accommodate movement of said drilling tower to different drilling locations along the span of said bridge beam member.

13. An offshore tower construction according to any of claims 8 to 12 wherein said support structure has a pair of forward said legs and a pair of rearward said legs and wherein forward and rearward bridge beam members are mounted to span the spaces between the legs of the forward and rearward pairs respectively.

14. A method of erecting an offshore tower substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

15. An offshore tower construction substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

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