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(54) OFFSHORE TOWER CONSTRUCTION AND ERECTION METHOD

(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 tower constructions and more particularly it concerns novel techniques for 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 platform 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 on a sea floor a support structure having at least one vertical support leg being provided either before or after said positioning step with a mounting member, so that said leg with said mounting member extends up above the sea level, floating a platform member out to the thus positioned support structure, at least one jacking mechanism being secured to one of said members and operative to move an elongated rigid jacking leg in a vertical direction, operating said jacking mechanism to move said jacking leg longitudinally in a direction toward the other member until the end of the leg enters into and is engaged by a slip mechanism in the other member, said slip mechanism being of the one way type to allow free relative movement of said jacking leg into said slip mechanism but not back out, and thereafter operating said jacking mechanism to elevate said platform member clear of the water.

According to another aspect to the invention, there is provided an offshore tower construction comprising a support structure constructed to be anchored to a sea floor, said structure including at least one vertical support leg which extends out above the surface of the sea when said structure is secured to the sea floor, a mounting member

connected to the upper end of the or at least one of said support legs, a platform member constructed to be positioned adjacent said support leg or legs and to be lifted upwardly therealong clear of the water, at least one jacking unit comprising an elongated rigid jacking leg and a jacking mechanism relatively movable along said jacking leg, the or each said jacking unit being mounted so that its jacking leg may extend vertically between said platform member and the or a respective one of said mounting members with its jacking mechanism mounted on one of said members, the jacking mechanism being operable to move its jacking leg longitudinally in a direction toward the other member, a one way slip mechanism being provided on the other member for receiving the end of the jacking leg when moved toward the other member, said slip mechanism being arranged to engage said jacking leg and to allow free movement of said jacking leg in a direction into said slip means but not back out.

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

Fig. 1 is an elevational 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 portion 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 sectional 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 23 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 truss-like 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 it 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 than 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 support 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 helicoptor landing platform 58 atop the rearward bridge beam 40. 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 platform 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 support 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 support 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 thereon. 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.

It will be appreciated that, as an alternative, the jacking mechanisms 68 may be provided on the platform 20 while the slips 72 are provided on bridge means 38 and 40. In this arrangement, the jacking legs are lifted by the jacking mechanisms to engage the slips. Thereafter, the jacking mechanisms 68 are used to elevate the platform 20 upon the jacking legs which are held against downward movement by the slips 72.

Figs. 10—12 show a modified arrangement wherein the platform 20 is carried out on a barge 82 to the support structure 22. This arrangement permits the platform to be 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 mechanisms 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. 12 shows another modification where in 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 it 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. 35026/76, 35027/76 and 33567/77 (Serial Nos. 1,524,423, 1,524,424 and 1,524,426).

WHAT WE CLAIM IS:—

1. A method of erecting an offshore tower, said method comprising the steps of positioning on a sea floor a support structure having at least one vertical support leg being provided either before or after said positioning step with a mounting member, so that said leg with said mounting member extends up above the sea level, floating a platform member out to the thus positioned support structure, at least one jacking mechanism being secured to one of said members and operative to move an elongated rigid jacking leg in a vertical direction, operating said jacking mechanism to move said jacking leg longitudinally in a direction toward the other member until the end of the leg enters into and is engaged by a slip mechanism in the other member, said slip mechanism being of the one way type to allow free relative movement of said jacking leg into said slip mechanism but not back out, and thereafter operating said jacking mechanism to elevate said platform member clear of the water.

2. A method of erecting an offshore tower according to claim 1 wherein said jacking mechanism is secured to said mounting member and wherein said slip mechanism is provided in the platform member.

3. A method of erecting an offshore tower according to claim 1 or claim 2 wherein said platform member is secured to said support structure after it has been raised and wherein said jacking mechanism and jacking leg are thereafter disconnected and removed from said members.

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.

It will be appreciated that, as an alternative, the jacking mechanisms 68 may be provided on the platform 20 while the slips 72 are provided on bridge means 38 and 40. In this arrangement, the jacking legs are lifted by the jacking mechanisms to engage the slips. Thereafter, the jacking mechanisms 68 are used to elevate the platform 20 upon the jacking legs which are held against downward movement by the slips 72.

Figs. 10—12 show a modified arrangement wherein the platform 20 is carried out on a barge 82 to the support structure 22. This arrangement permits the platform to be 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 mechanisms 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. 12 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 it 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 on a sea floor a support structure having at least one vertical support leg being provided either before or after said positioning step with a mounting member, so that said leg with said mounting member extends up above the sea level, floating a platform member out to the thus positioned support structure, at least one jacking mechanism being secured to one of said members and operative to move an elongated rigid jacking leg in a vertical direction, operating said jacking mechanism to move said jacking leg longitudinally in a direction toward the other member until the end of the leg enters into and is engaged by a slip mechanism in the other member, said slip mechanism being of the one way type to allow free relative movement of said jacking leg into said slip mechanism but not back out, and thereafter operating said jacking mechanism to elevate said platform member clear of the water.

2. A method of erecting an offshore tower according to claim 1 wherein said jacking mechanism is secured to said mounting member and wherein said slip mechanism is provided in the platform member.

3. A method of erecting an offshore tower according to claim 1 or claim 2 wherein said platform member is secured to said support structure after it has been raised and wherein said jacking mechanism and jacking leg are thereafter disconnected and removed from said members.

4. An offshore tower construction comprising a support structure constructed to be anchored to a sea floor, said structure including at least one vertical support leg which extends out above the surface of the sea when said structure is secured to the sea floor, a mounting member connected to the upper end of the or at least one of said support legs, a platform member constructed to be positioned adjacent said support leg or legs and to be lifted upwardly therealong clear of the water, at least one jacking unit comprising an elongated rigid jacking leg and a jacking mechanism relatively movable along said jacking leg, the or each said jacking unit being mounted so that its jacking leg may extend vertically between said platform member and the or a respective one of said mounting members with its jacking mechanism mounted on one of said members, the jacking mechanism being operable to move its jacking leg longitudinally in a direction toward the other member, a one way slip mechanism being provided on the other member for receiving the end of the jacking leg when moved toward the other member, said slip mechanism being arranged to engage said jacking leg and to allow free movement of said jacking leg in a direction into said slip means but not back out.

5. An offshore tower construction according to claim 4 wherein the or each jacking mechanism is on the or one of the mounting members and wherein the associated slip mechanism is on said platform member.

6. An offshore tower construction according to claim 4 or claim 5 wherein said template is formed with a plurality of spaced apart vertical template legs and open framework bridge beams spanning the distances between different pairs of said template legs near the upper ends thereof.

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