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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Marine Structures

We, LITTON INDUSTRIES INC., a corporation organised and existing under the laws of the State of Delaware, United States of America, of 336 North Foothill Road, Beverly Hills, California 90213, 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 marine structures and is particularly suitable for providing the stable marine platforms required in the drilling of oil and gas wells in deep water.

In accordance with one aspect of the invention there is provided a marine structure including hollow columns supporting a platform able to be carried by the columns above water level, the columns being capable of being at least partially flooded for changing the position of the structure with respect to the water level and the structure being such that it can be maintained selectively (A) in a floating position substantially entirely on the surface of a body of water to permit horizontal displacement by towing, (B) in a semisubmerged position in which the columns are partly submerged and (C) in a bottom-sitting positions in waters sufficiently shallow to permit the platform to remain above water level when the structure is in the bottom-sitting position, there being spuds downwardly displaceable for use in the bottom-sitting position and upwardly retractable into a position where they do not interfere with operation of the structure when in either of the other two positions, and the spuds being provided with heave damping members.

As described and claimed in the specification of our copending Application No. 50621/68 (Serial No. 1153653), each of the columns may be supported at its base by a substantially hollow footing capable of being at least partially flooded for operation of the structure in the semi-submerged position and in the bottom-sitting position, the footings having a boat-shaped contour and being orientated to facilitate horizontal displacement of the structure by towing with the orientation defining a center line in the direction in which towing meets least resistance, and wherein those footings which support the stern columns are toed-in with respect to the center line.

One illustrative embodiment of the invention employs a substantially A-shaped watertight superstructure resting on three hollow columns or columnar floats. At the base of each column a buoyant footicg is provided. Each of the footings is boat-shaped and as a flared cut-away bow to enable towing at comparatively high speeds. By partially or totally flooding the footings and columns, the structure is adapted to be maintained semisubmerged or sunk so that it comes to rest on the bottom in a bottom-sitting mode of operation. While the structure is transparent to wave action, swells may cause heaving. To obviate this problem, heave damping means are provided. To further stabilize the platform, a spud is provided at each column to stabilize the structure in position while operating in the bottom-sitting mode. Additional heave dampers are provided on each spud, extendible when operating in the floating mode. If one of the columns were to be damaged, destroying its watertight condition, there would be danger of capsizing. However, the superstructure is watertight, enabling the structure to remain afloat even if one of the columns is holed and flooded. Since only three columns are required and the remaining understructure is quite simple, there is a high degree of wave transparency, assuring independence from any normal surface conditions. Stability in swells is provided by the heave damping means.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made by way of example, to the accompanying drawings, in which:

[Price 4s. 6d.]

Figure 1 is a side elevation of a marine structure;

Figure 2 is a top view of the structure of Figure 1;

Figure 3 is a top view of one of the footings;

Figure 4 is an elevation of one of the footings;

Figure 5 is a front view of one of the footings;

Figure 6 is a cross-sectional view of one of the spuds illustrating suitable means for extending and retracting the heave dampers placed thereon; and

Figure 7 is a cross section of the spud taken along the line 7—7 of Figure 6, illustrating the extended heave dampers.

Referring now to the drawings, and particularly to Figures 1 and 2, a watertight superstructure 11, having a generally A-shaped configuration in plan view, is covered by a substantially triangular working platform 12. As employed for drilling, the working platform 12 supports a drilling derrick 13, cranes such as 14, pipe racks 15, a deck house 16 providing crew quarters, and a helicopter landing platform 17. Additional equipment carried on working platform 12 may include winches 21 and tanks 22 for storing drilling mud and cement.

Ballast pumps, mud pumps, engine driven generators, air conditioning machinery, supplies, etc., are carried within watertight superstructure 11. Engine exhaust and intake air and ventilation is provided to the interior of watertight superstructure 11 by gooseneck ventilators 18, having closeable watertight doors (not shown). Access to the interior of watertight superstructure 11 is provided by watertight hatches 19, Figure 2. A control room 20 is suspended beneath deck 12, wherein drilling operations may be viewed and controlled.

Superstructure 11 is carried on three substantially cylindrical hollow columns or columnar floats 23, 24 and 25. Tubular brace members 26 are provided between columns 23, 24, and 25 and superstructure 11. At the base of columns 23, 24 and 25 are footings 27, 31 and 32, respectively. Footing 31, at the base of column 24, is illustrated in detail in Figures 3, 4 and 5, by way of example. The basic structure of all footings 27, 31, and 32 is a modified right elliptical cylinder. The bow is cut-away in a "dutch shoe" configuration and a flare having the same volume as the cut-away portion is added to the upper bow. Each of the footings is hollow, and the interior is partitioned by watertight bulkheads such as 33, and 34. The spaces formed by the bulkheads may be employed as ballast tanks and to store liquids such as diesel fuel. On the other hand, these spaces may be at least partially flooded for operation in the semisubmerged or bottom-sitting mode.

Conventional anchor racks 35 and 36 are provided for anchors 38 and 39 suspended by anchor cables such as 38A on the outside of footings 27, 31, and 32. Substantially surrounding the base of each footing is a heave damping fin or plate 37. The portion of heave damping plate 37 in way of the bow of each of the footings is cut-away at 37A to reduce towing resistance, as illustrated in Figures 3 and 4. An additional heave damping plate 41, illustrated in retracted position adjacent plate 37 in Figures 4 and 5, may be extended below footing 31 during the floating mode of operation in order to provide additional damping in long swells. Damping plate 41 is illustrated in the extended position in Figure 1. It is to be understood, and as can be seen from Figures 1 and 2, each of the footings is provided with heave damping arrangements 37, 37A, 41.

As illustrated in Figure 2, stern footings 31 and 32 are toed-in approximately five degrees with respect to the center line, defining the direction of motion, to facilitate towing. As will be apparent, a yaw in platform 11 due to wind or current displacing the stern to starboard will tend to place footing 31 in a straight ahead position and footing 32 at a considerably greater toed-in position with respect to the direction of movement. Footing 32 will, therefore, have a considerably increased drag, tending to force the structure back into the straight ahead position. A yaw to port will increase the drag of footing 31.

All the foregoing description with reference to Figures 1—5 is similar to that of the marine structure described and claimed in the specification of our copending application No. 50621/68 (Serial No. 1153653).

Spuds 42, 43 and 44 associated with columns 23, 24, and 25, respectively, are provided to stabilize the structure in position while in the bottom-sitting mode. As illustrated in Figure 1, the spud 42 is held to superstructure 11 by upper guide bracket 45. Spud 42 passes through a guide in footing 27 and in the bottom-sitting mode it will be forced into the bottom to assist in anchoring the structure. While operating in the towing mode, the spuds are raised so that each of the bottom ends of the spuds is enclosed within a footing. A rack on the spud and a motor driven pinion enclosed within bracket 45 may be conveniently employed for extending and retracting spud 42. The other spuds 43 and 44 are mounted in an identical manner. Near the bottom of spud 42 are shown heave damping members 46 and 47. As illustrated in Figures 6 and 7, these are a plurality of petal-shaped plates 47A, which may be retracted flush to the sides of spud 42. Hydraulic jack 51, operating rod 52, raises hinged links 53 to open petals 47A. Protective collars 54 and 55 placed adacent the top and bottom of retracted petal-shaped heave dampers 46 and 47 protect the heave dampers in the retracted position when the spud 42 is raised through footing 27 or is

forced into the bottom. Spud 43 is illustrated in Figure 1 in the retracted position, as it would be when the structure of the present invention is being towed. The other spuds 43 and 44 are also provided with heave damping members.

As discussed hereinabove, the structure of the present invention may readily be towed to a desired position. Boatshaped footings 27, 31 and 32 are provided with flared cut-away bows, enabling towing with relatively little resistance, and toed-in stern footings 31 and 32 provide natural towing stability. Heave damping plates 41, and spuds 42, 43 and 44 are retracted when under tow. Upon attaining the desired position, the structure may be placed on the bottom if the water is shallow, or anchored in the floating mode if the water is deep. In the bottom-sitting mode, heave dampers 41, 46, and 47 remain retracted. To reduce buoyancy, the tanks in the footings are flooded as well as portions of columnar floats 23, 24 and 25. If the bottom is relatively soft, spuds 42, 43 and 44 are forced into the bottom to provide a firm anchorage.

However, in the event that the water in the area where it is desired to drill is too deep for bottom-sitting, the structure is partially flooded to float in a semisubmerged position, with the waterline for example at the level indicated in Figure 1. Heave dampers 41 are lowered. Spuds 42, 43, and 44 are lowered and spud heave dampers such as 46 and 47 are extended. The anchors such as 38 and 39 are carried out a distance from the structure by accompanying work boats and lowered to the bottom to prevent drift from the desired position.

Since the structure is inherently transparent to wave action, it will be little affected thereby. The up and down motion, resulting from long swells, will be reduced to a negligible amount by heave dampers 41, 46, and 47. After work in the desired site has been completed, the structure may be placed in towing position by retrieving the anchors, retracting the spud heave dampers such as 46 and 47, retracting spuds 42, 43, and 44, and the heave damping plates such as 41. Footings and columns are pumped out, and as a result, footings 27, 31 and 32 again float the structure at the water surface, which may then be readily towed to another location.

WHAT WE CLAIM IS:—

1. A marine structure including hollow columns supporting a platform able to be carried by the columns above water level, the columns being capable of being at least partially flooded for changing the position of the structure with respect to the water level and the structure being such that it can be maintained selectively (A) in a floating position substantially entirely on the surface of a body of water to permit horizontal displacement by towing, (B) in a semisubmerged position in which the columns are partly submerged and (C) in a bottom-sitting position in waters sufficiently shallow to permit the platform to remain above water level when the structure is in the bottom-sitting position, there being spuds downwardly displaceable for use in the bottom-sitting position and upwardly retractable into a position where they do not interfere with operation of the structure when in either of the other two positions, and the spuds being provided with heave damping members.

2. A marine structure according to claim 1, wherein the heave damping members are blades hinged to the spuds so that they may assume, selectively, an extended, operating position when the marine structure is in the semisubmerged position and a retracted position when the spuds are upwardly retracted.

3. A marine structure according to claim 1 or 2, wherein each of the columns is supported at its base by a substantially hollow footing capable of being at least partially flooded for operation of the structure in the semisubmerged position and in the bottom-sitting position, the footings having a boat-shaped contour and being orientated to facilitate horizontal displacement of the structure by towing with the orientation defining a center line in the direction in which towing meets least resistance, and wherein those footings which support the stern columns are toed-in with respect to the center line.

4. Marine structure according to claim 3, wherein the stern footings are toed-in by approximately five degrees.

5. A marine structure according to claim 3 or 4, wherein the interior of each of the footings is subdivided by bulk-heads to permit partial flooding of the footing.

6. A marine structure according to claim 5, wherein the footings can also be totally flooded.

7. A marine structure according to any one of claims 3 to 6, wherein a heave damping plate is provided below and extends beyond the periphery of the base of each footing.

8. A marine structure according to claim 7, wherein an additional heave damping plate is arranged below each first-mentioned heave damping plate and can be lowered into an extended position at a distance below the associated first-mentioned heave damping plate to give increased heave damping action.

9. A marine structure according to claim 7 or claim 8, wherein any of said heave damping plates which extend below the bow area of its footing is provided with an aperture in the bow area to reduce towing resistance.

10. A marine structure according to claim 7, 8 or 9, wherein there are cutouts in the heave damping plates providing passages for lowering and lifting anchors alongside the footings.

11. A marine structure according to claim 10, wherein there is one of said cutouts in the

forced into the bottom. Spud 43 is illustrated in Figure 1 in the retracted position, as it would be when the structure of the present invention is being towed. The other spuds 43 and 44 are also provided with heave damping members.

As discussed hereinabove, the structure of the present invention may readily be towed to a desired position. Boatshaped footings 27, 31 and 32 are provided with flared cut-away bows, enabling towing with relatively little resistance, and toed-in stern footings 31 and 32 provide natural towing stability. Heave damping plates 41, and spuds 42, 43 and 44 are retracted when under tow. Upon attaining the desired position, the structure may be placed on the bottom if the water is shallow, or anchored in the floating mode if the water is deep. In the bottom-sitting mode, heave dampers 41, 46, and 47 remain retracted. To reduce buoyancy, the tanks in the footings are flooded as well as portions of columnar floats 23, 24 and 25. If the bottom is relatively soft, spuds 42, 43 and 44 are forced into the bottom to provide a firm anchorage.

However, in the event that the water in the area where it is desired to drill is too deep for bottom-sitting, the structure is partially flooded to float in a semisubmerged position, with the waterline for example at the level indicated in Figure 1. Heave dampers 41 are lowered. Spuds 42, 43, and 44 are lowered and spud heave dampers such as 46 and 47 are extended. The anchors such as 38 and 39 are carried out a distance from the structure by accompanying work boats and lowered to the bottom to prevent drift from the desired position.

Since the structure is inherently transparent to wave action, it will be little affected thereby. The up and down motion, resulting from long swells, will be reduced to a negligible amount by heave dampers 41, 46, and 47. After work in the desired site has been completed, the structure may be placed in towing position by retrieving the anchors, retracting the spud heave dampers such as 46 and 47, retracting spuds 42, 43, and 44, and the heave damping plates such as 41. Footings and columns are pumped out, and as a result, footings 27, 31 and 32 again float the structure at the water surface, which may then be readily towed to another location.

WHAT WE CLAIM IS:—

1. A marine structure including hollow columns supporting a platform able to be carried by the columns above water level, the columns being capable of being at least partially flooded for changing the position of the structure with respect to the water level and the structure being such that it can be maintained selectively (A) in a floating position substantially entirely on the surface of a body of water to permit horizontal displacement by towing, (B) in a semisubmerged position in which the columns are partly submerged and (C) in a bottom-sitting position in waters sufficiently shallow to permit the platform to remain above water level when the structure is in the bottom-sitting position, there being spuds downwardly displaceable for use in the bottom-sitting position and upwardly retractable into a position where they do not interfere with operation of the structure when in either of the other two positions, and the spuds being provided with heave damping members.

2. A marine structure according to claim 1, wherein the heave damping members are blades hinged to the spuds so that they may assume, selectively, an extended, operating position when the marine structure is in the semisubmerged position and a retracted position when the spuds are upwardly retracted.

3. A marine structure according to claim 1 or 2, wherein each of the columns is supported at its base by a substantially hollow footing capable of being at least partially flooded for operation of the structure in the semisubmerged position and in the bottom-sitting position, the footings having a boat-shaped contour and being orientated to facilitate horizontal displacement of the structure by towing with the orientation defining a center line in the direction in which towing meets least resistance, and wherein those footings which support the stern columns are toed-in with respect to the center line.

4. Marine structure according to claim 3, wherein the stern footings are toed-in by approximately five degrees.

5. A marine structure according to claim 3 or 4, wherein the interior of each of the footings is subdivided by bulk-heads to permit partial flooding of the footing.

6. A marine structure according to claim 5, wherein the footings can also be totally flooded.

7. A marine structure according to any one of claims 3 to 6, wherein a heave damping plate is provided below and extends beyond the periphery of the base of each footing.

8. A marine structure according to claim 7, wherein an additional heave damping plate is arranged below each first-mentioned heave damping plate and can be lowered into an extended position at a distance below the associated first-mentioned heave damping plate to give increased heave damping action.

9. A marine structure according to claim 7 or claim 8, wherein any of said heave damping plates which extend below the bow area of its footing is provided with an aperture in the bow area to reduce towing resistance.

10. A marine structure according to claim 7, 8 or 9, wherein there are cutouts in the heave damping plates providing passages for lowering and lifting anchors alongside the footings.

11. A marine structure according to claim 10, wherein there is one of said cutouts in the

first-mentioned heave damping plate of the forward footing, said one cutout being provided in the bow area of the forward footing.

12. A marine structure according to any one of the preceding claims, wherein the platform is provided by a watertight superstructure.

13. A marine structure according to any one of the preceding claims having only three columns.

14. A marine structure according to any one of the preceding claims, carrying offshore drilling equipment.

15. A marine structure substantially as hereinbefore described with reference to the accompanying drawings.

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