

May 1, 1951

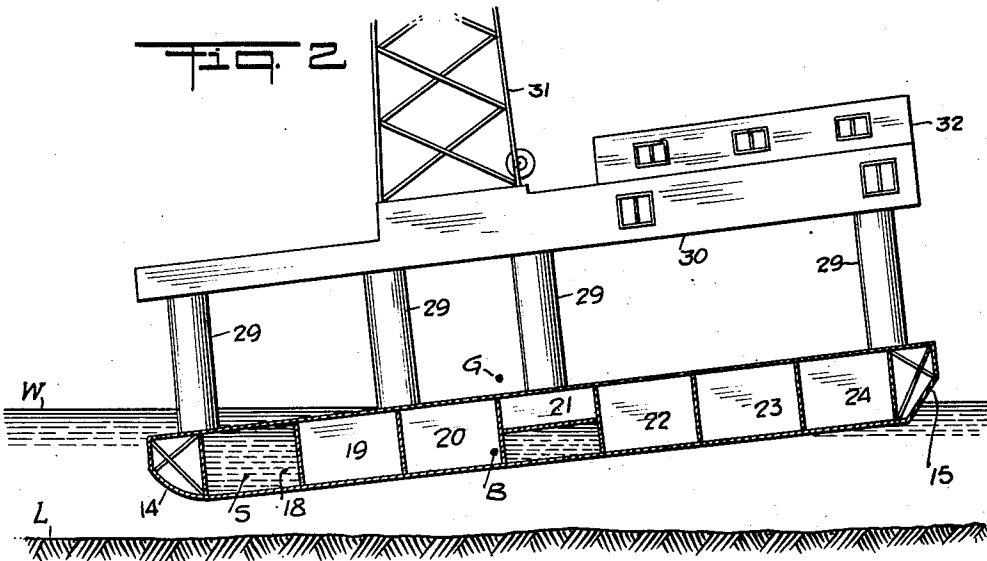
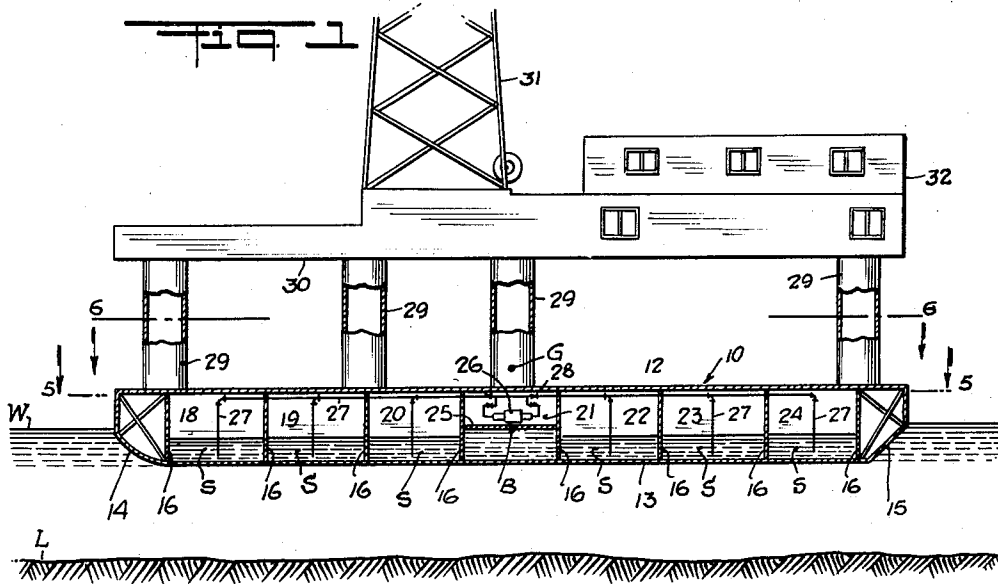
J. T. HAYWARD

2,551,375

SUBMERGIBLE DRILLING BARGE AND METHOD OF OPERATION

Filed Dec. 15, 1948

3 Sheets-Sheet 1



INVENTOR.
J. T. Hayward
BY
R. W. Wee
ATTORNEY

May 1, 1951

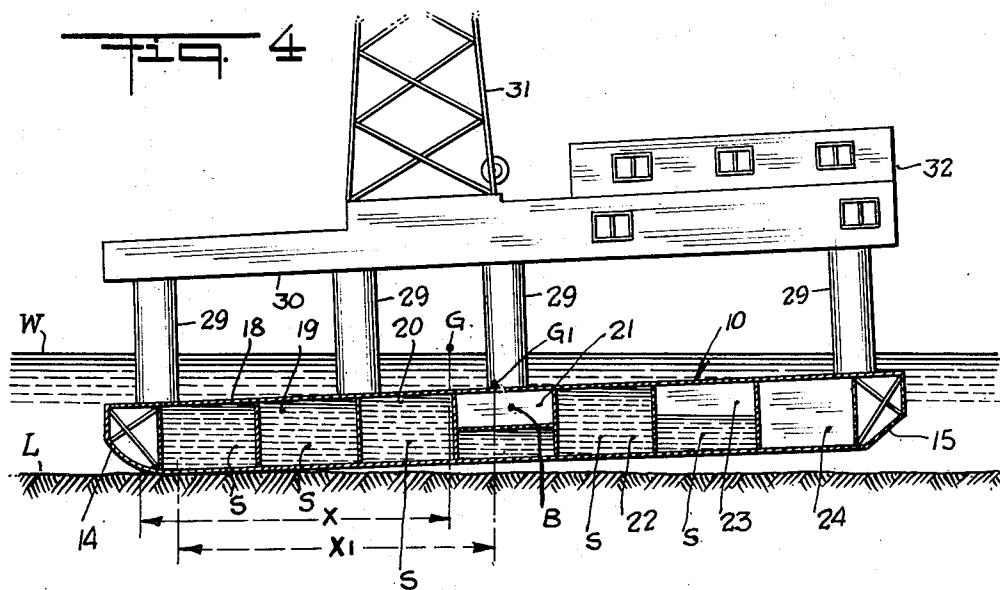
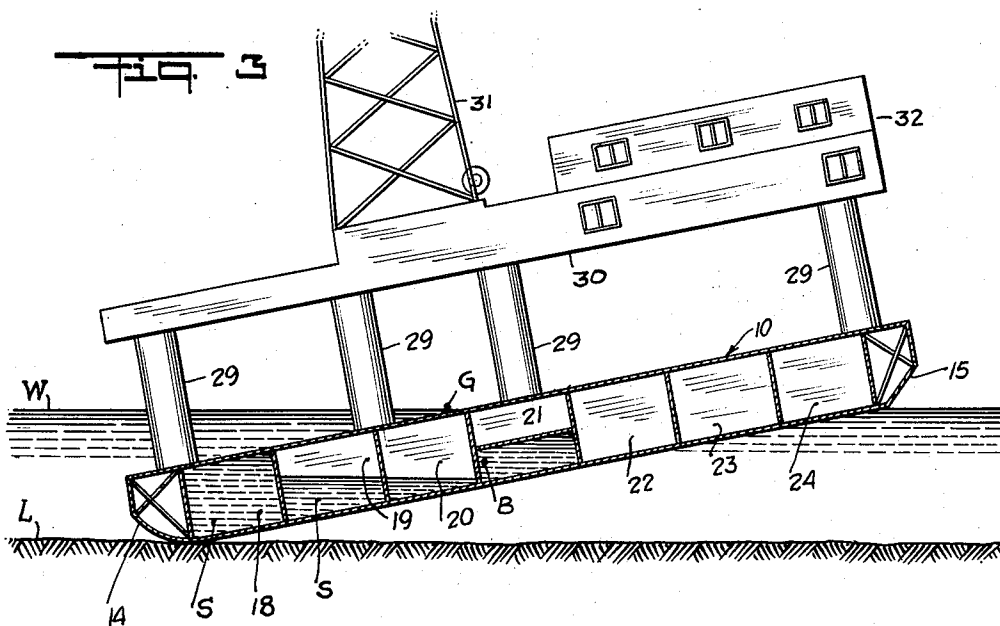
J. T. HAYWARD

2,551,375

SUBMERGIBLE DRILLING BARGE AND METHOD OF OPERATION

Filed Dec. 15, 1948

3 Sheets-Sheet 2



INVENTOR.
J. T. Hayward
BY
[Signature]
ATTORNEY

May 1, 1951

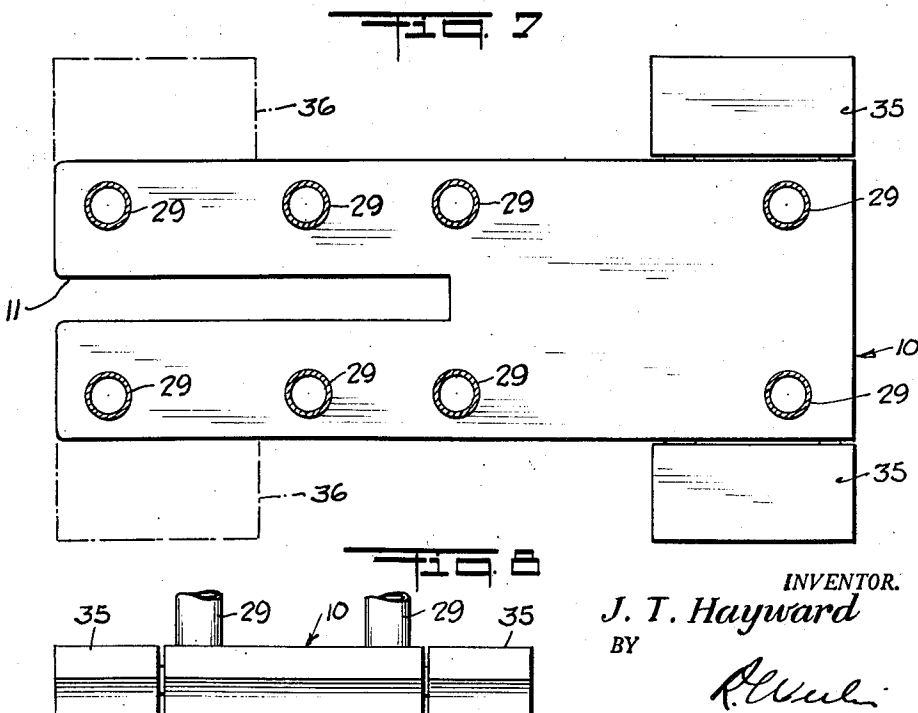
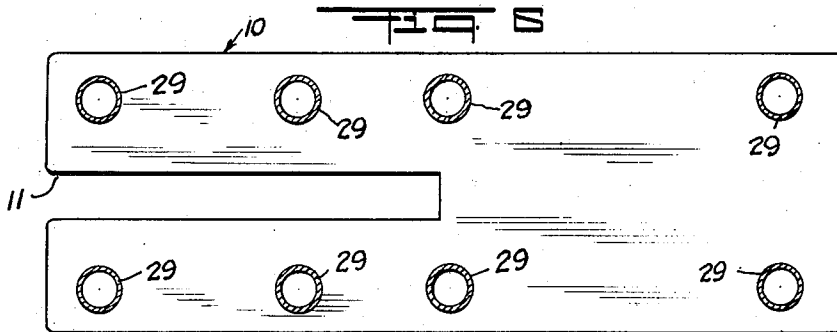
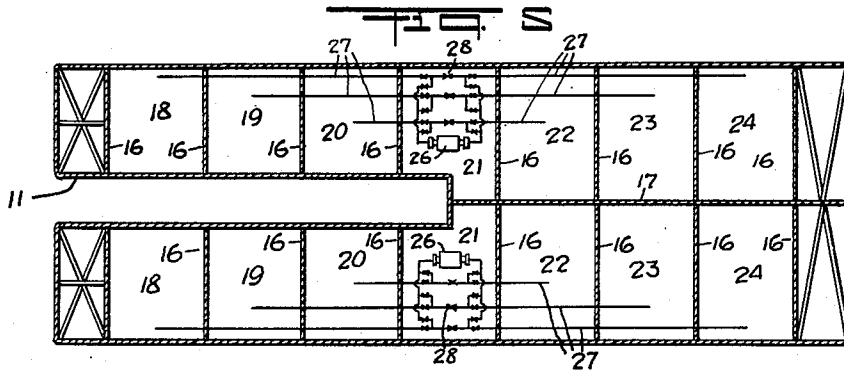
J. T. HAYWARD

2,551,375

SUBMERGIBLE DRILLING BARGE AND METHOD OF OPERATION

Filed Dec. 15, 1948

3 Sheets-Sheet 3



INVENTOR.
J. T. Hayward
BY

Attorney
ATTORNEY

UNITED STATES PATENT OFFICE

2,551,375

SUBMERGIBLE DRILLING BARGE AND
METHOD OF OPERATION

John T. Hayward, Tulsa, Okla.

Application December 15, 1948, Serial No. 65,475

10 Claims. (Cl. 61-46)

1

This invention relates to a submergible foundation for a drilling rig for the drilling of wells at water locations and particularly to a submergible barge for use in drilling in open sea areas.

The drilling of oil wells in off-shore locations, such as on the continental shelves along the coasts of the United States in water depths greater than about 15 feet, is increasing greatly in importance and creates many new and serious problems in providing both economical and firm and safe support for the heavy drilling rigs employed. Since such locations may be many miles from the shore, open ocean conditions will normally prevail, including often severe wind and wave conditions, which make for great expense and difficulty in transporting and erecting conventional drilling rig foundations which are adequate to meet the conditions encountered.

Drilling barges have heretofore been employed with considerable success for drilling at water locations where water depths are generally substantially less than about fifteen feet, that is, depths which are sufficiently shallow so that the barge hull need be only partially submerged to bring it to rest upon the bottom. At greater water depths, such barges would present large surfaces which would be subjected to such buffeting by the winds and waves prevailing in open ocean areas as to cause shifting of the barge over the water bottom, and serious damage to the barge and the equipment mounted thereon.

Accordingly, the present invention has for its principal objects the provision of a novel form of submerged foundation for drilling rigs, and the method of operating the same, which is particularly adapted for use in off-shore waters of greater depth than heretofore considered feasible or practical for the employment of conventional drilling barges.

In accordance with one embodiment of this invention, a form of barge structure is provided which is adapted to be completely submerged beneath the surface of the water in open ocean areas. The barge is provided with a superstructure adapted to extend above the water surface when the barge is on bottom and constructed so as to present a minimum amount of solid area to the buffeting action of wind and wave normally prevailing in such areas. The superstructure has mounted thereon above the normal wave level, the usual drilling derrick and its necessary appurtenances and may also have quarters for housing the operating crew. Because of the relatively great height and mass of the structure superimposed on the barge hull,

2

which create serious problems of maintaining stability of the structure particularly during submergence and raising of the structure, the barge structure in accordance with this invention employs novel features of construction and a novel method of submergence and re-floating by which completely safe stability is assured throughout the submergence and re-floating operations, and which also provides a stable drilling foundation when at rest on the land bottom underlying the water body.

Other and more specific objects and advantages of this invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate useful embodiments in accordance with this invention.

In the drawings:

Fig. 1 is a side elevation of a barge structure in accordance with one embodiment of this invention having some of the parts thereof broken away for purposes of better illustration and showing the barge structure in normal floating position;

Figs. 2, 3 and 4, are views similar to Fig. 1 showing several stages during submergence of the barge structure;

Fig. 5 is a sectional plan view of the interior of the barge generally along line 5-5 of Fig. 1;

Fig. 6 is a plan view looking downwardly generally along line 6-6 of Fig. 1;

Fig. 7 is a plan view similar to Fig. 6 of another embodiment in accordance with this invention; and

Fig. 8 is an aft end elevational view of the embodiment of Fig. 7.

Referring first to Figs. 1, 5 and 6, the barge structure comprises a generally rectangular hollow hull, indicated generally by the numeral 10, provided with a conventional drilling slot 11 extending from one end of the hull to the midship portion thereof, generally along the longitudinal axis of the hull. The slotted end of the hull will hereinafter be referred to as the forward end or bow of the hull, the other end being termed the aft end or stern. The hull is of more or less generally box-like shape having an upper deck 12 and a generally flat bottom 13 spaced therefrom. At one end of the hull, which may be the bow end, bottom 13 curves upwardly at 14 in a smooth arc, of relatively large radius, this shape at an end of the hull bottom having an important function as will be described in greater detail hereinafter. The opposite end of the hull may be provided with an angular rake

3

15 or this may be square or of any other shape desired. A plurality of transverse bulkheads 16 and longitudinal bulkheads 17 extend through the interior of the hull to form a suitable number of water-tight compartments adapted, through the introduction or removal of ballast, such as water, to provide the required degree of control of the buoyancy of the barge structure in a manner to be described hereinafter. For purposes of this description the corresponding compartments in each of the rows extending through the hull are designated by the numerals 18, 19, 20, 21, 22, 23, and 24 from the forward end. It will be understood that the number of compartments shown in the drawings is selected merely for purposes of illustration and that a greater or lesser degree of compartmentation may be employed depending upon the size of the barge and the degree of buoyancy control which it may be desired to exercise.

One or more of the compartments, preferably those in the midship portion of the hull, such as compartments 21, may be provided with intermediate liquid-tight decks 25, the portions below the decks being employed for storage of fuel oil, fresh water or other liquids, while the portions above the decks may be employed to house pumps 26 and other machinery employed particularly for regulating the buoyancy of the hull. Each of the compartments is provided with suitable filling and emptying pipes 27 for handling liquid ballast, such as sea water, in passage to and from the compartments and these pipes are connected to a suitably valved manifold 28, which is connected to pumps 26 by which such ballast may be supplied to or removed from the several compartments or transferred from one to the other as may be required for controlling the buoyancy of the hull in any desired manner. It will be understood that the piping arrangement is merely illustrative, such ballast handling systems being of widely varying form well known to those skilled in the art. The specific details of ballast handling systems do not, therefore, form an essential part of this invention.

Rigidly mounted on hull 10 and extending upwardly therefrom are a number of cylindrical steel pillars 29 of suitable length such that when hull 10 is at rest on the bottom underlying a water body, the upper ends of pillars 29 will extend to such a height as to be above the crests of the waves which may normally be anticipated in the area in which the barge structure is to be operated. Such pillars will normally be more or less symmetrically disposed over the area of the barge surface and will be the minimum number required to safely support the superimposed load of the drilling derrick and all its appurtenances while at the same time providing an open superstructure which will present a minimum amount of resistance to the free passage of the waves therethrough. In general, the pillars will be so spaced as to provide the maximum moments of inertia of their water planes relative to the longitudinal and transverse axes of the hull consistent with the load supporting requirements of the pillars. In the illustrative embodiment two rows of four longitudinally spaced pillars 29 are arranged in parallel along opposite sides of the barge hull, the mid-ship pairs being somewhat more closely grouped to provide strong structural support for a derrick or other relatively concentrated load. It will be understood that other arrangements as well as a greater or lesser number of such pillars may be

4

employed consistent with the above-mentioned objectives for any particular size of barge structure and the load to be imposed thereon. The cylindrical shape is found to be particularly advantageous in resisting the impact of the waves. Moreover this type of construction permits the elimination of the large number of relatively slender columns and cross bracing elements more commonly used in off-shore foundations of this general type, which have been found to be easily subject to smashing or tearing out, particularly in heavy weather when they are often subjected not only to the impact of great waves but also the battering action of various kinds of flotsam frequently borne by the waves. Additionally, the pillars, which will ordinarily be made 6 to 8 feet in diameter, may be made hollow to provide communication with adjacent compartments so that they may be employed as trunks to house and protect the various pipes, wires and other control and communication elements which must be passed between the hull compartments and the drilling and operating platforms carried on the pillars, and to provide access thereto by operating personnel. The large cross section and position of the pillars also contribute materially to the maintenance of the longitudinal and transverse stability of the structure during submerging operations in a manner to be described hereinafter.

A suitable working platform 30 is mounted on the upper ends of pillars 29 and a drilling derrick 31 of conventional size and shape is mounted on platform 30 in suitable alignment with drilling slot 11. A housing 32 is mounted on platform 30 aft of derrick 31 and is adapted to enclose the engines and other machinery employed in connection with the drilling operations and to provide housing quarters for the drilling and operating personnel.

The structure is operated in the following manner, reference being first made to Fig. 1 in which the barge structure is shown in what may be considered to be the normal towing or floating position on the surface of a water body W. It will be seen that in this position the compartments are only partially filled with ballast S which will be fairly evenly distributed among the several compartments in order to maintain the hull in buoyant condition on a level keel and at the proper draft for effective stability during towing. In this condition the barge structure will be fully stable and may be safely towed to the desired off-shore location at which drilling operations are to be conducted, and submerging operations will then be begun.

Fig. 2 illustrates the next stage of operations. Compartments 18 will be filled with ballast while the other compartments are emptied, either by discharging them to the exterior of the hull or by transferring their ballast to compartments 18. The lower part of compartments 21 containing fuel oil, for example, may remain full without seriously affecting the submerging operations, but these compartments also may be filled or emptied as may be required for proper control of the submergence operations. Filling of compartments 18 with contemporaneous emptying of the other compartments will cause the whole barge structure to trim by the head, that is, the forward deck of hull 10 will, as illustrated, sink beneath the water surface although its bottom will not yet have contacted the land bottom L, while the aft portions of the hull will rise and remain well afloat. In this condition,

the center of buoyancy of the hull, indicated by the point B, will necessarily fall vertically below the center of gravity of the structure, indicated by the point G, and the structure will be stable and in no danger of capsizing. The forward pillars 29, because of their appreciable displacement and relatively great distance from the longitudinal and transverse axis through the center of buoyancy, will contribute to both the transverse and longitudinal stability of the structure at this stage of the operations.

Fig. 3 illustrates the next stage of operation. Compartments 18 having already been filled with ballast, additional ballast will now be introduced into compartments 19 (and successively in the next succeeding compartments as may be necessary) to further depress the bow of the hull until its underside contacts land bottom L, as illustrated. It will be understood that the interior of the bow portion will be suitably structurally reinforced so as to safely support the loads which are necessarily imposed on it by this type of operation. Since one end of the barge hull now rests upon the land bottom, the normal condition that the center of buoyancy must be vertically in line with the center of gravity for a stable floating body is no longer essential because some of the weight is now resting on the land bottom. The addition of ballast to the forward compartments will, in fact, move the center of gravity forward, as illustrated, without affecting the position of the center of buoyancy. Accordingly, in this stage, the barge structure will still be in completely stable condition with one end resting on bottom and the other still buoyant and extending above the water surface.

Reference will now be made to Fig. 4. In the stage here illustrated, with the bow of the hull resting on the land bottom, ballast will be progressively admitted to the succeeding compartments in the aft direction. This will cause the hull to pivot downwardly about the curved bow portion 14, which is in contact with the land bottom, so that the after part of the hull will also sink below the water surface. The final submergence of the after part of the hull is the most critical stage in the submergence operation and it is in connection with this stage of operations that the curved bow portion 14 of the hull and the hollow construction of the aft group of pillars 29 serve very useful functions. It is known that any hollow object, once it is completely submerged, tends to sink faster and faster because it collapses slightly due to increasing external pressure, thus its displacement is reduced while its weight remains constant. In addition, because the center of gravity is considerably above the bottom upon which the bow rests, a lever arm is formed having a length X corresponding to the distance between a fulcrum, represented by the point of contact of the bow with the bottom, and a point on a perpendicular to the center of gravity G. If the fulcrum is fixed, as would be the case if the bow portion was square or sharply pointed, this lever arm would tend to lengthen as the stern of the hull moves downwardly and the center of gravity correspondingly moves in the aft direction to the position G₁. However, because of the curved formation of bow portion 14, the fulcrum or point of contact of the bow portion with the land bottom will also move in the aft direction as the stern of the hull descends, and the new lever arm X₁ increases in length only very

slightly, if at all, thus making the intermediate submergence conditions relatively longitudinally stable and preventing runaway sinking. Runaway sinking is additionally prevented by the position and appreciable cross-section of the group of pillars 29 on the after part of the hull. It will be seen that as the barge hull submerges, these pillars will necessarily displace increasing volumes and, therefore, a corresponding amount of ballast must be admitted to the after compartments to overcome the buoyant effect of these pillars, thereby again tending to stabilize longitudinally the intermediate submergence conditions and requiring definite additions of ballast to cause the hull to move down from stage to stage.

During the final stage of the sinking, lateral stability is obtained partially due to the transverse moments of inertia of the water planes of the columns about the longitudinal axis and partially by the rounded bow ends resting firmly on the bottom. Since the sea bottom at the majority of drilling sites is soft mud, then in order that the lateral support contributed by the bottom be a maximum, the bow must be of such a shape that it will continually form a good seat in the soft mud as the sinking barge pivots around this contact. For this reason the vertical profile of the bow is a convex curve with large radii of curvature in contrast to the angular shape of the rake of drilling barges heretofore employed.

When the barge structure has thus been submerged and landed on bottom, the weight of the ballast and the weight carried by the superstructure will prevent its movement over the land bottom and provide a firm safe foundation for conduct of the desired drilling operations.

When drilling operations have been completed, the barge structure may be re-floated by reversing the procedure described previously. That is, the ballast will be removed from the aft compartments allowing the stern portion to rise to the surface while the bow portion remains in contact with the land bottom. With the stern afloat and the bow on bottom, the structure will be entirely stable, and as the forward compartments are emptied of ballast in progression from stern to bow, the bow portion will be allowed to rise until the whole structure is again afloat in the position illustrated in Fig. 1. It will be understood that as the hull rises the ballast will be suitably trimmed in the several compartments to bring the structure to an even keel when fully afloat.

With the hull fully submerged, as described, the open construction of the superstructure, as formed by the relatively few widely spaced cylindrical pillars 29, will allow free passage of the waves through the structure below the elevated platform and thus eliminate or greatly obviate the dangers normally inherent in presenting flat solid surfaces to the waves and winds prevailing in the open ocean. Furthermore, owing to the relatively small, area of the water plane of pillars 29 at the water line, changes in sea level, such as those due to waves and tides, will have very little effect upon the displacement and will not tend to lift the barge during high water or place excessive load on the bottom when the water line drops.

From the foregoing description it will be evident that this invention provides a novel form of barge structure which can be safely and efficiently submerged to form a stable drilling foundation; which can be safely employed in open ocean areas

7

and which may be raised and moved to other locations all with a minimum of expense and effort.

Barge structures in accordance with the above-described embodiment may be employed with complete safety in water depths up to at least one-half the width of the barge. The forward tilt of the structure during submergence and raising is only a minor factor for consideration in the use of this invention. It will readily be seen that if a barge 160 feet long and 60 feet wide, a conservative size for drilling platforms, having a hull 15 feet in depth and a normal draft of 5 feet when afloat, is employed in water 30 feet deep, the maximum tilt of the structure will be approximately 8 degrees, an angle which is entirely safe for structures of the kind described.

In water depths greater than about 30 feet, the necessarily increased over-all height of the superstructure and its super-imposed drilling derrick and other equipment may so increase the total height of the structure that the structure may become transversely unstable when resting on a very soft bottom, although entirely stable while afloat.

Figs. 7 and 8 illustrate another embodiment designed to meet such a contingency. In this embodiment a pair of hull sections 35 are built onto opposite sides of the after end of hull 10. These sections are designed to form lateral extensions of this portion of the hull which, when on bottom, will serve to increase the normal area and width of the hull and thereby improve the on-bottom stability of the structure. These sections 35 will also assist in the submerging operation by increasing both the longitudinal and lateral stability because they remain above water with the rest of the after end until the forward end has come to rest firmly on bottom. It will be understood that hull sections 35 may be suitably compartmented and provided with suitable ballast-supplying and emptying gear so that they may be operated as an integral part of the after end of hull 10 during submerging and raising operations. If necessary or desirable, a similar pair of sections 36, shown in broken lines in Fig. 7, may be similarly built onto opposite sides of the forward end of hull 10 to increase its lateral width and supporting area at that end. The added sections 35 and 36 may be made detachable in order that they may be removed when necessary to permit the barge structure to traverse narrow water which will not accommodate structures having the full width of hull 10 plus the added sections, or to facilitate docking of the structure.

It will be understood that various alterations and modifications may be made in the illustrative embodiments of this invention and in the method of operation herein described without departing from the scope of the appended claims but within the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A submergible drilling barge, comprising, a hull of generally rectangular shape adapted to be completely submerged in a water body, one end of said hull being curved upwardly from the bottom thereof in a convex curve of relatively large radii of curvature, a plurality of generally symmetrically spaced hollow cylindrical pillars extending upwardly from said hull and adapted to form buoyant extensions thereof, the length of said pillars being such as to extend substantially above the normal surface level of said water body when

8

said hull is resting on the bottom thereof, a platform structure mounted on the upper ends of said pillars, and means for controllably regulating the buoyancy of said hull.

2. A submergible drilling barge, comprising, a hull of generally rectangular shape adapted to be completely submerged in a water body, one end of said hull being curved upwardly from the bottom thereof in a convex curve of relatively large radii of curvature, a plurality of generally symmetrically spaced hollow cylindrical pillars extending upwardly from said hull and adapted to form buoyant extensions thereof, the length of said pillars being such as to extend substantially above the normal surface level of said water body when said hull is resting on the bottom thereof, a platform structure mounted on the upper ends of said pillars, and means for controllably regulating the buoyancy of said hull, said means comprising a plurality of separate ballast compartments arranged transversely and longitudinally throughout the interior of said hull, and means for transferring liquid ballast to and from selected ones of said compartments.

3. A submergible drilling barge, comprising, a hull of generally rectangular shape adapted to be completely submerged in a water body, said hull having a relatively flat bottom having one end curving upwardly in a convex curve of relatively large radii of curvature, a plurality of generally symmetrically spaced hollow cylindrical pillars extending upwardly from said hull and adapted to form buoyant extensions thereof, the length of said pillars being such as to extend substantially above the normal surface level of said water body when said hull is resting on the bottom thereof, a platform structure having a well drilling rig thereon mounted on the upper ends of said pillars, and means for controllably regulating the buoyancy of said hull, said means comprising a plurality of separate ballast compartments arranged transversely and longitudinally throughout the interior of said hull and means for transferring liquid ballast to and from selected ones of said compartments.

4. A submergible drilling barge, comprising, a hull of generally rectangular shape adapted to be completely submerged in a water body, one end of said hull being curved upwardly from the bottom thereof in a convex curve of relatively large radii of curvature, a plurality of generally symmetrically spaced hollow cylindrical pillars extending upwardly from said hull and adapted to form buoyant extensions thereof, the length of said pillars being such as to extend substantially above the normal surface level of said water body when said hull is resting on the bottom thereof, a platform structure mounted on the upper ends of said pillars, a pair of hull sections of lesser length than said hull affixed to opposite sides of said hull at one end thereof to form lateral extensions thereof, and means for controllably regulating the buoyancy of said hull.

5. A submergible drilling barge, comprising, a hull of generally rectangular shape adapted to be completely submerged in a water body, one end of said hull being curved upwardly from the bottom thereof in a convex curve of relatively large radii of curvature, a plurality of pillars extending upwardly from said hull adapted to form buoyant extensions thereof and suitably spaced relative to the longitudinal and transverse axes thereof to increase the longitudinal and transverse stability of said hull, the length of said

pillars being such as to extend substantially above the normal surface level of said water body when said hull is resting on the bottom thereof, a platform structure mounted on the upper ends of said pillars, and means for controllably regulating the buoyancy of said hull.

6. The method of completely submerging a drilling barge in a water body, comprising, submerging one end of said barge while maintaining the opposite end of said barge in buoyant condition and extending above the surface of said water body until said one end is in contact with the underlying land bottom, and thereafter progressively submerging successive after portions of said barge until the entire barge has been submerged and brought to rest on said land bottom.

7. In the method set forth in claim 6, reversing the sequence of the steps set forth therein in order to re-float said barge.

8. In a drilling barge having a hollow generally rectangular hull divided into a plurality of ballast compartments extending from end-to-end thereof, the method of completely submerging said barge in a water body, comprising, introducing ballast into the compartments in one end of said hull while maintaining the compartments in the opposite end of said hull in buoyant condition and extending above the surface of said water body until said one end has been submerged into contact with the underlying land bottom, and thereafter introducing ballast into succeeding ones of said compartments progressively to-

ward said opposite end of said hull to effect submergence thereof while said one end remains in contact with said land bottom.

9. In the method set forth in claim 8, reversing the sequence of steps set forth therein in order to re-float said barge.

10. In a drilling barge having a hollow hull of generally box-like shape having one end curving upwardly from the bottom thereof in a convex curve of relatively large radii of curvature, the method of completely submerging said hull in a water body, comprising, submerging the curved end of said hull while maintaining the opposite end of said hull in buoyant condition and extending above the surface of said water body until said curved end is in contact with the underlying land bottom, and thereafter progressively submerging successive after portions of said hull to thereby effect downward rotation thereof about said curved end until the entire barge has been submerged and brought to rest upon said land bottom.

JOHN T. HAYWARD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,346,743	Fink	July 13, 1920
1,681,533	Giliasso	Aug. 21, 1928
2,422,168	Kirby	June 10, 1947