This invention relates to marine drilling structures and particularly to drilling structures adapted for drilling wells in offshore locations, the structures being of the type which are maintained in the "aftloat-condition" during drilling and is a continuation-in-part of our copending application Serial No. 816,155, filed May 27, 1959, now Patent No. 3,097,495. The term "aftloat-condition" applies to the condition under which drilling operations are conducted in subastra land from a drill-supporting structure which is maintained in aftloat-condition in the overlying water body throughout the drilling operations. In the aforementioned application there is disclosed one embodiment of an aftloat-condition drilling base comprising a generally V-shaped hull surrounded by a working deck or platform, the working deck being supported from the lower hull by a plurality of hollow columns and cross-bracing elements which are provided with annular enlargements intermediate the hull and working platform to define auxiliary buoyancy chambers positioned to be at the level of the water surface when the base has been submerged to working level. These auxiliary chambers have a total buoyancy to provide a substantial increase in the tons-per-inch immersion sufficient to prevent substantial vertical movement of the base under varying live loads. In this earlier form of invention, the structure between the hull and the deck included cross-bracing which, while kept to a minimum, nevertheless substantially reduced the working capacity of the structure.

The present invention has for its principal object improvements in the earlier structure to provide for a greater degree of wave-transparency and a higher degree of stability under all wind and wave conditions, as well as varying load conditions, which may be anticipated in operation of the structure.

A further object is to provide a structural design employing a minimum number of structural units but possessing maximum strength and stability characteristics both during movement from place to place and during drilling.

Another important feature in accordance with this invention is the provision of specialized elements in the base structure by which a high degree of vertical stability is assured under varying loads applied during drilling and to assure maximum righting moments in the structure.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIG. 1 is a front elevational view, in perspective, showing the structure asof on the surface of the water body;

FIG. 2 is a view similar to FIG. 1, showing the structure submerged to working level;

FIG. 3 is a plan view of the deck frame with most of the deck covering removed;

FIG. 4 is a horizontal, cross-sectional view taken generally along line 4--4 of FIG. 1; and

FIG. 5 is a diagrammatic, partly sectional view illustrating the bullasting gear for some of the structural elements of the base.

Referring to the drawing, the base comprises a generally V-shaped hull, designated generally by the numeral 10, a deck or working platform, designated generally by the numeral 11, having substantially the same configuration as the hull and supported in elevated parallel relation thereto by an intervening wave-transparent superstructure, designated generally by the numeral 12. The height of superstructure 12 is generally such that the deck will be elevated above the hull a distance sufficient to position the deck well above the tops of any waves which might be encountered when the base has been submerged to its normal working level.

Hull 10 is composed of a pair of generally triangularly shaped wing sections formed by outer and inner side elements 13 and 14, respectively, which converge at one end to form the apex portions 15 at the outer ends of the sections and are connected to a common base element 16 at the opposite ends. The hull also includes a central apex section of a regular triangular shape formed by side elements 17-17 converging to the apex 19, the base element being defined by the common base element 16 of the wing sections. The apex section is symmetrically divided longitudinally by an element 18 extending between apex 19 and the center of base element 16. Inner elements 14-14 of the wing sections are joined to base element 16 at an angle which may be any suitable angle less than 150°. Ordinarily, angle ω will be 90° or somewhat less, as illustrated.

Each of the several elements comprising the hull sections are preferably constructed of hollow cylindrical steel shells and will be sized so that the overall displacement of the hull will be sufficient to support the entire base and the deck superstructure in the aftloat condition, as well as in partly submerged condition as may be required during operation. The hull elements will be suitably compartmented as by means of bulkheads 24 (FIG. 5). It will be noted that no cross-bracing is employed between the several main hull elements other than those main elements illustrated and described, and the configuration employed thus provides a comparatively simple, yet strong, frame-work having the high degree of rigidity and strength to resist the varying stresses to which such structures are subject in normal use.

Deck 11 may be of any suitable frame design and, as illustrated, comprises a pair of wing members 20-20 connected at an angle, as previously noted, to provide a configuration generally corresponding to that of the hull. The wing members comprise brusses defined by side stringers 21-22 which converge at their outer ends to define the V-shaped configuration and cross-bracing members 22a. Deck 20 may be covered in whole or in part with suitable deck plates 23 or other covering and has mounted thereon the structures S to house living quarters for the crew and machinery employed in connection with the well drilling operations as well as operating and control equipment of the base. A drilling platform D is mounted within the angular area a between the deck wing members, being positioned so that the center of the drill, indicated at C, will be generally on a line intersecting the angle between the hull and deck sections. A drilling derrick R is mounted on the drilling platform in the conventional manner for conducting drilling operations from the platform through the water body and the underlying land.

Superstructure 12 comprises a plurality of vertical cylindrical columns including end columns 25 connecting apex portions 15 and 19 of the hull with the corresponding portions of the deck sections. End columns 25 are of a relatively large diameter which is uniform from top to bottom, as illustrated. Immediately adjacent end columns 25 and laterally spaced therefrom on outer hull elements 13 and 17 are additional cylindrical columns
3,207,110

26—26, herein termed "stabilizing columns." The latter include a lower portion 27 of relatively large diameter comparable in its dimensions, as illustrated, although a larger number may be provided. Laterally spaced along the several side elements 13 and 14 and base element 16 are a plurality of hollow cylindrical columns 30 which extend between the hull and the deck. Columns 30 are relatively small in diameter as compared with end columns 25 and lower portions 27 of the additional stabilizing columns. Each of the columns 30 is provided intermediate its ends, at approximately the working level of the base, with an annular enlargement 31 of considerably less length than columns 30.

The primary function of enlargements 31 is to increase the water plane area at the working level as compared with the water plane areas of any other level between the hull and the deck. In this way the supporting capacity of the structure at that level is substantially increased, increasing the tons-per-inch immersion factor of the structure to maximum and rendering the structure substantially more stable to vertical movement under the varying loads which occur during drilling, and still maintaining the minimum of the remaining structure for maximum stability and minimum resistance to wave forces. It will be noted that there are no cross-bracing elements of any type between the several vertical columns 25, 26 and 30 and this affords the maximum degree of wave transparency, while providing the desired degree of stability. Columns 25 and the enlarged diameter portions 27 of columns 26, being located at the outer ends and along the outer sides of the hull, serve to increase substantially the righting moments of the structure to additionally assure maximum stability.

The spatial arrangement and size of the enlargements 31 will be selected to provide the minimum water plane-to-displacement ratio which is practically attainable for a structure of the kind herein described, and to locate the horizontal center of flotation of the structure, when at the working level, at a point which will be substantially coincident with the center of the rotary table, indicated at C. By so-locating and arranging the enlargements, not only will the nautical stability of the structure be greatly enhanced, but both vertical movement of the structure and changes in its horizontal attitude under varying loads will be greatly reduced, thereby avoiding any dangerous tilting or other excessive movements of the base.

By placing enlargements 31 at suitable distances with respect to the longitudinal and transverse axes of the base structure and generally symmetrical relative thereto, the moments of inertia of their water planes about these axes will be maximums for the particular shape of the structure, an arrangement which results in maximum righting moments and hence nautical stability. Moreover, as noted, by placing the relatively larger columns 25 at the ends of the hull sections and providing the additional large diameter stabilizing columns 26 immediately adjacent thereto on the outer hull elements, the righting moments will be further increased and the range of stability thereby further improved. As noted, the vertical length of the enlargements 31 will be such as to accommodate a reasonable amount of vertical movement of the base structure under changing loads.

FIG. 5 illustrates, more or less diagrammatically, generally conventional valving and pumping gear by which the compartments in the hull elements 13, 14, 16, 17 and 18 and in at least some of the columns and enlargements 31, may be selectively ballasted and deballasted in order to submerge and refloat the structure. As illustrated, valves 33 are suitably positioned in the various structure elements to admit sea water to the interiors thereof, while a compressor 34 may direct air through a header 35 connected to the various compartments by suitable air lines 36 for blowing or deballasting these compartments. Compressor 34 may be replaced by suitable pumps for introducing and removing ballast. It will be understood that the ballasting and deballasting gear is entirely conventional and the specific details thereof form no part of this invention.

In operation, the hull elements will be deballasted to render them sufficiently buoyant to float the entire structure on the surface of the water body, so that it may be readily moved to a well location (FIG. 1). When positioned over the well location, the hull elements and compartments will be appropriately ballasted to submerge the structure to a depth at which the hull elements will be below any effective wave action thereon (FIG. 2). This degree of submergence will place the base structure at its working level at which the enlargements 31 and the upper ends of enlarged portions 27 of stabilizing columns 26 are located, and will position the working platform at a suitable elevation above the water surface. As noted previously, the distance between deck 11 and the hull elements will be such that when the structure is submerged to the proper depth, the deck will be at a height above the water surfaces such as to effectively clear the tops of any waves which may be anticipated in the areas in which the drilling is conducted.

When in working position, a plurality of anchors, carried at the ends of cables 37 (FIGS. 1 and 2), will be run out from the apex portions of the hull elements in a suitable pattern to limit lateral movements of the base structure to practical minimums under even severe storm conditions.

When the structure has been submerged to its working level and anchored, drilling may be conducted from the drilling platform D in the conventional manner, until a well is completed. When the well has been completed, the base structure will be refloated, the anchors released, and the structure moved away from the well. By locating the drilling station in the angle between the hull elements 14—14, it will be seen that the base structure can be moved away from the well or returned thereto with a minimum of difficulty.

The following is a set of data with respect to the dimensions of the base structure and its several elements constructed in accordance with the illustrative embodiment of this invention:

**HULL ELEMENTS**

<table>
<thead>
<tr>
<th>Length:</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sides from apex 15 to apex 19, approx.</td>
<td>360</td>
</tr>
<tr>
<td>Between apexes 15—15, approx.</td>
<td>360</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height:</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between bottom of hull elements and bottom of deck, approx.</td>
<td>120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diameters:</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull elements 13, 14, 16, 17, and 18, approx.</td>
<td>18</td>
</tr>
<tr>
<td>Columns 25</td>
<td>17</td>
</tr>
<tr>
<td>Portions 27 of columns 26</td>
<td>17</td>
</tr>
<tr>
<td>Columns 30 and portion 28 of column 26</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enlargements 31:</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>10</td>
</tr>
<tr>
<td>Diameter</td>
<td>16</td>
</tr>
</tbody>
</table>

From the foregoing, it will be seen that this invention provides a base structure which is fully competent for offshore condition drilling in water depths up to as much as 600 feet; which possesses a high degree of stability under severe weather conditions; in which the center of flotation in drilling position is substantially coincident with the center of the drill; which may be moved from about a well with a minimum of difficulty; and which requires smaller anchors, less steel, and is consequently...
lower in cost than more conventional vessels of the same displacement.

While the above-described drilling rig base is particularly adapted for afloat-condition drilling, being capable of drilling to water depths of up to about 300 feet, the base may also be used as a drilling base while resting on the sea floor in water up to about 90 feet deep. In this position, about 30 feet of clearance will be provided between the water level and the deck, this being ample clearance for the passage of waves of almost any size which might be anticipated. The structure, when fully submerged to rest on the sea bottom, will be fully stable and provide a highly wave-transparent foundation for the platform from which the drilling operation will be conducted.

It will be understood that numerous changes and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims without departing from the spirit of this invention.

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

1. A buoyant drilling rig base for afloat condition drilling, comprising, a hull constructed of horizontally disposed hollow tubular members interconnected to define a generally V-shape, a deck having a configuration corresponding substantially to that of the hull, a wave-transparent structure supporting the deck from said hull and forming with said hull members buoyancy elements having displacement sufficient to support said base in partially submerged floating position in a water body without rigid connection to the underlying land, said wave-transparent structure including:
   (a) vertically disposed hollow end columns extending between the outer ends and apex portions of the hull and the corresponding deck portions, said end columns having a relatively large uniform diameter throughout their length;
   (b) a plurality of vertically disposed hollow intermediate columns laterally spaced along the hull members between said end columns, said intermediate columns being of substantially lesser diameter than said end columns;
   (c) said intermediate columns having annular enlargements of substantially lesser length than said intermediate columns forming auxiliary buoyancy chambers positioned on the columns and having their opposite ends in substantially vertically spaced relation to both the hull and the deck and located to be partially submerged when the base is submerged to its working level in the water body, said auxiliary buoyancy chambers having collective total buoyancy to provide tons-per-inch immersion sufficient to prevent substantial vertical movement of the base under varying live loads;
   (d) the intermediate column disposed next adjacent each of said end columns having a relatively large uniform diameter section extending upwardly from said hull members to about the level of the upper ends of said auxiliary buoyancy chambers on the other intermediate columns, and having a relatively smaller diameter section extending upwardly from said level to the deck;
   (e) the spaces between the several columns being clear of any intervening cross-bracing to provide maximum wave-transparency, and means for ballasting and deballasting the several buoyancy elements whereby to regulate the extent of submergence of said base in the water body.

2. A buoyant drilling rig base for afloat condition drilling, comprising, a hull constructed of horizontally disposed hollow tubular members interconnected to define a generally V-shape, a deck having a configuration corresponding substantially to that of the hull, a drill support mounted centrally of the angular area of the base defined by said V-shape, a wave-transparent structure supporting the deck from said hull and forming with said hull members buoyancy elements having displacement sufficient to support said base in partially submerged floating position in a water body without rigid connection to the underlying land, said wave-transparent structure including:
   (a) vertically disposed hollow end columns extending between the outer ends and apex portions of the hull and the corresponding deck portions, said end columns having a relatively large uniform diameter throughout their length;
   (b) a plurality of vertically disposed hollow intermediate columns laterally spaced along the hull members between said end columns, said intermediate columns being of substantially lesser diameter than said end columns;
   (c) said intermediate columns having annular enlargements of substantially lesser length than said intermediate columns forming auxiliary buoyancy chambers positioned on the columns intermediate the hull and the deck to be partially submerged when the base is submerged to its working level in the water body, said auxiliary buoyancy chambers having a total buoyancy to provide tons-per-inch immersion sufficient to prevent substantial vertical movement of the base under varying live loads;
   (d) the intermediate column disposed next adjacent each of said end columns having a relatively large uniform diameter section extending upwardly from said hull members to about the level of the upper ends of said auxiliary buoyancy chambers on the other intermediate columns, and having a relatively smaller diameter section extending upwardly from said level to the deck;
   (e) the spaces between the several columns being clear of any intervening cross-bracing to provide maximum wave-transparency,
   (f) the spatial arrangement of said enlargement being such that the center of flotation of the water plane area thereof is substantially coincident with said drill support, and
   means for ballasting and deballasting the several buoyancy elements whereby to regulate the extent of submergence of said base in the water body.

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JACOB SHAPIRO, Examiner.