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| [72] | Inventor | Homayoun J. Meheen
6464 West 14th Ave., Denver, Colo. 80214 |
| [21] | Appl. No. | 867,848 |
| [22] | Filed | Oct. 20, 1969 |
| [45] | Patented | Nov. 30, 1971 |

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Primary Examiner—David J. Williamowsky

Assistant Examiner—David H. Corbin

Attorney—Van Valkenburgh and Lowe

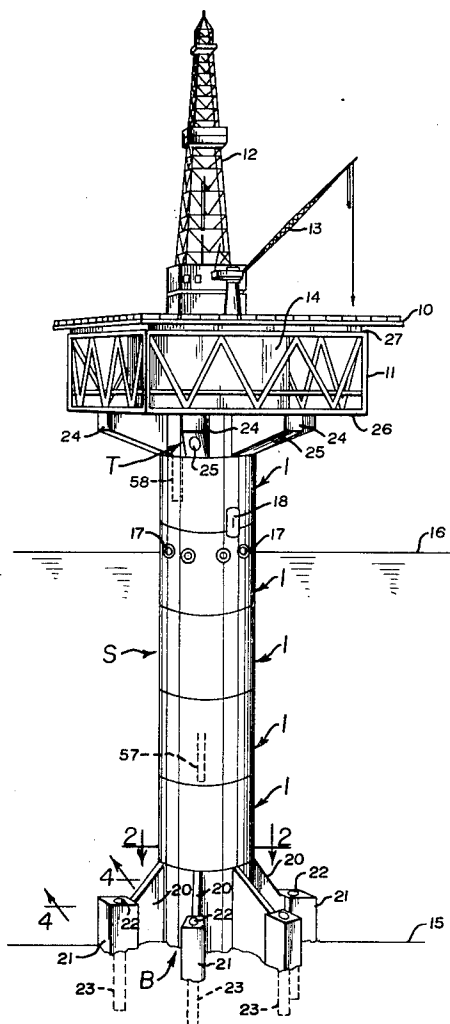
- [54] OFFSHORE PLATFORM SUPPORT**
11 Claims, 13 Drawing Figs.

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| [52] | U.S. Cl. | 61/46,
61/56 |
| [51] | Int. Cl. | E02b17/02,
E02d 5/30 |
| [50] | Field of Search | 61/46, 46.5,
56; 52/651, 721, 20 |

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ABSTRACT: A column formed of annular segments made of reinforced concrete, having longitudinal holes therethrough in which prestressing tendons are installed, is utilized to support an offshore-drilling platform. Holes in outwardly extending ribs or wings of the top and bottom segments guide the piles into the sea floor, while being driven. The piles are cut off at the top of the outwardly radial ribs of the lower segment. In the larger sizes, the bottom segment is provided with a floor having holes with removable plugs, for inflow of sea water to sink the column at the installation site. Holes provided with removable plugs adjacent the bottom of the column permit the column to be used for separating a mixture of oil and sea water and sand. Such columns may also be used for oil storage purposes. Larger platforms, such as consisting of a number of similar platform components, may be supported by two or more columns.



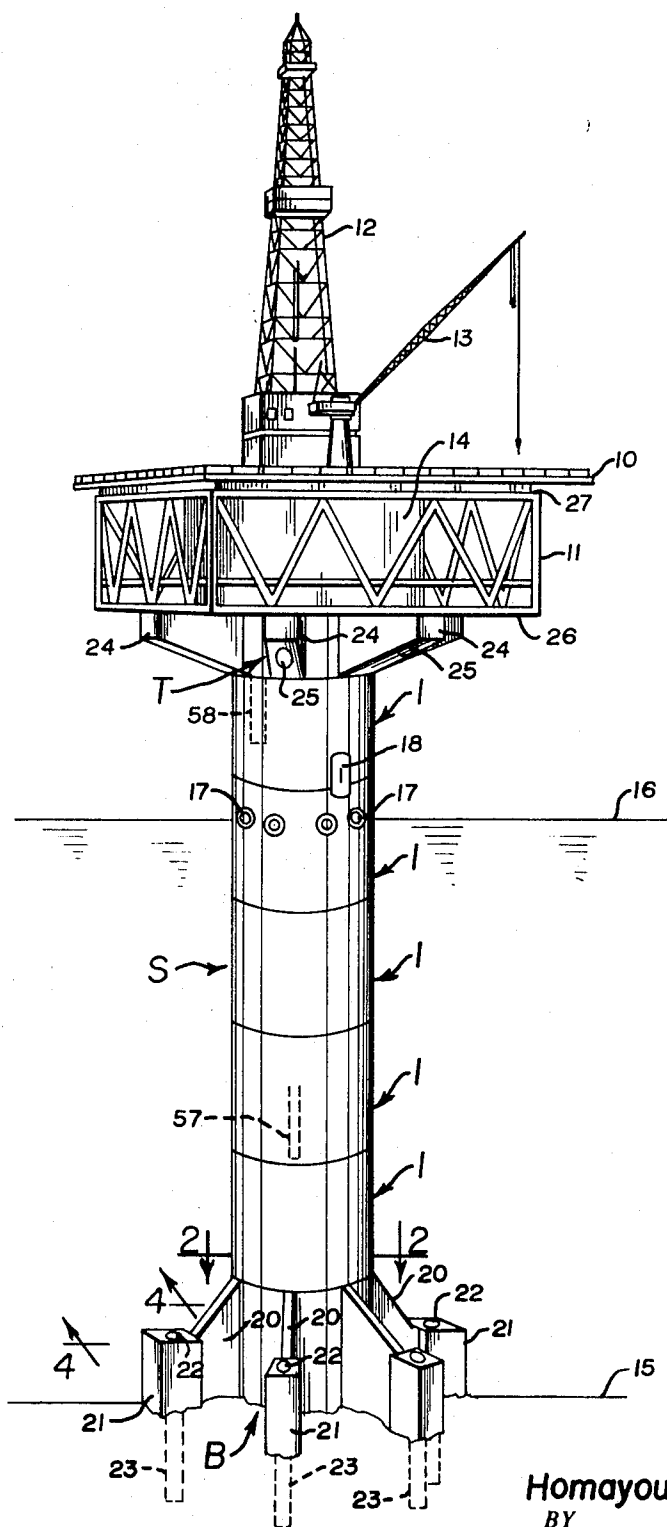


Fig. 1

INVENTOR.
Homayoun J. Meheen
 BY
Van Valkenburgh & Lauer
 ATTORNEYS

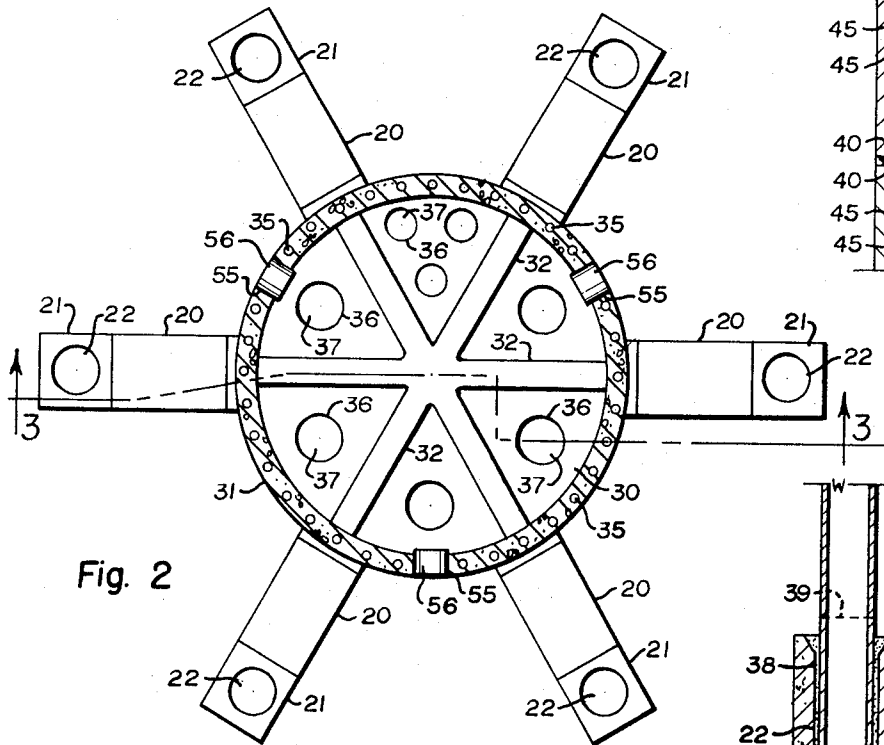


Fig. 2

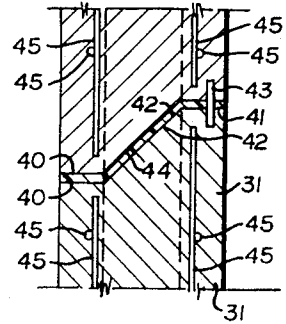


Fig. 6

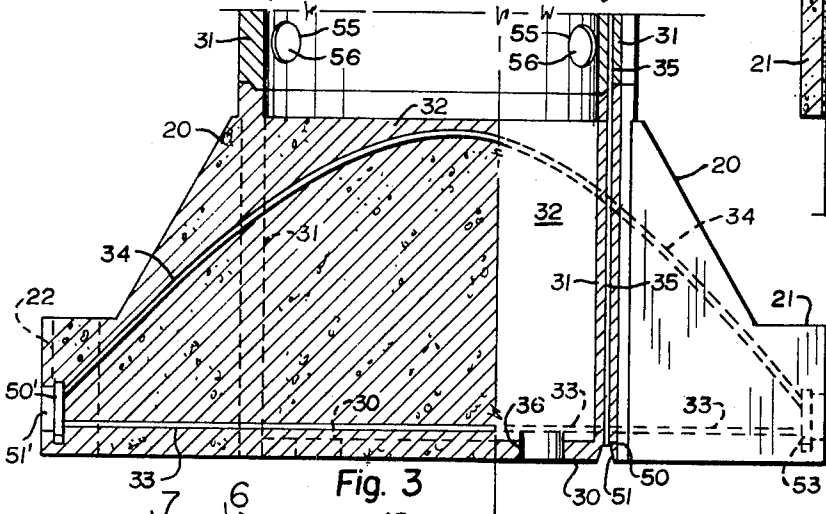


Fig. 3

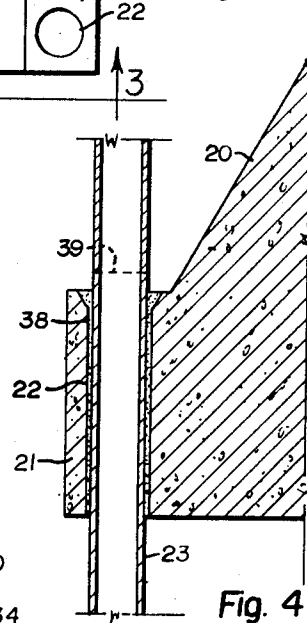


Fig. 4



Fig. 5

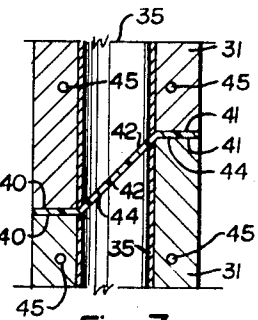


Fig. 7

INVENTOR.
Homayoun J. Meheen

BY

Van Valkenburgh & Lowe

ATTORNEYS

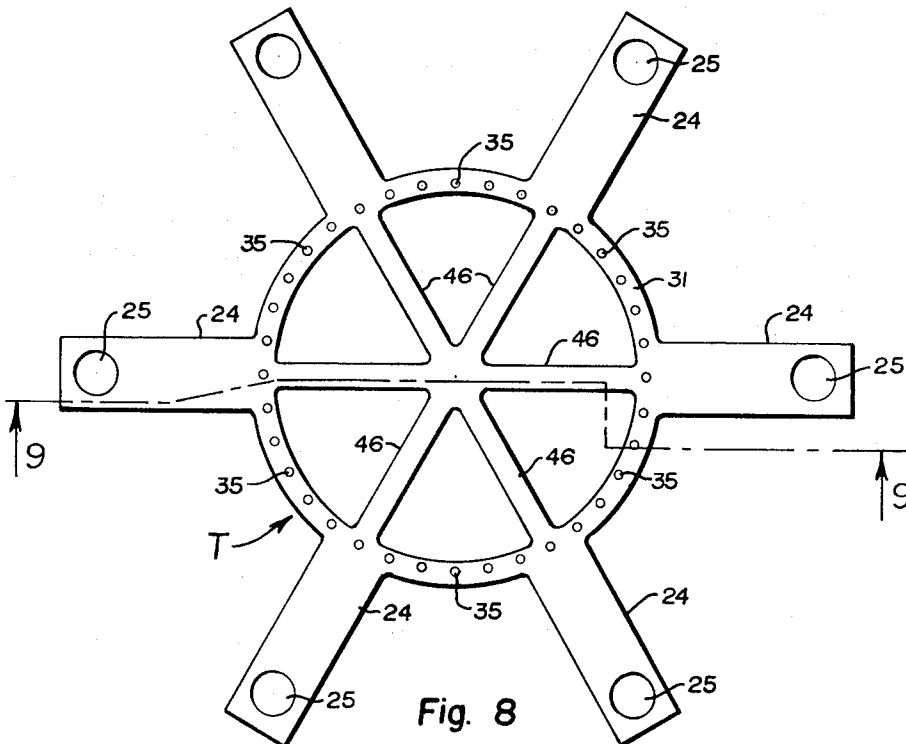


Fig. 8

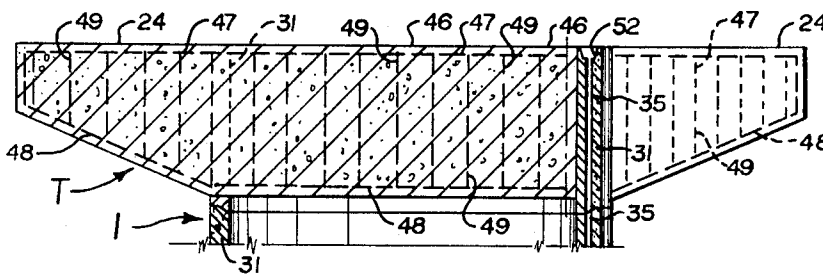


Fig. 9

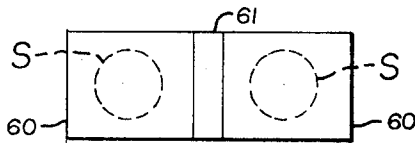


Fig. 10

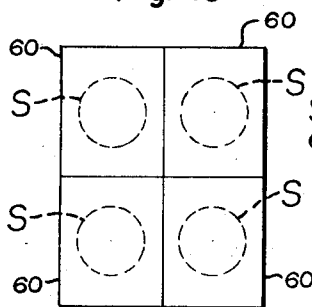


Fig. 12

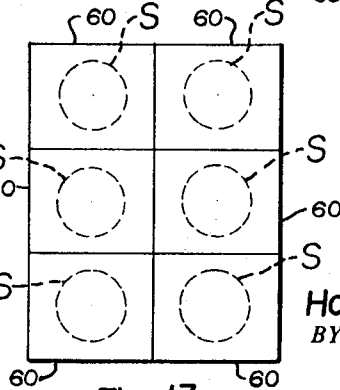


Fig. 13

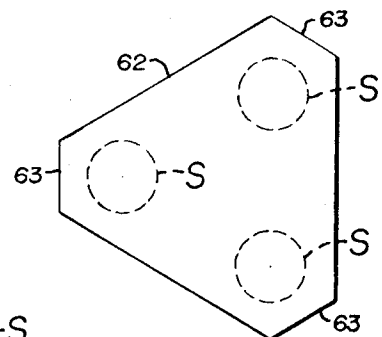


Fig. 11

INVENTOR.

Homayoun J. Meheen

BY

Van Vleet, Bengt & Lowe

ATTORNEYS

OFFSHORE PLATFORM SUPPORT

This invention relates to supports for offshore platforms useful in the drilling of oil or gas wells, and the like, and particularly offshore platform supports which are formed partially or primarily of prestressed concrete and the like.

Numerous problems are encountered in the erection or installation and use of offshore-drilling platforms, including the accurate location of the platform, the transportation of a platform support or parts thereof to the installation site, the handling of the platform support or parts thereof during installation and the anchoring of the platform support to the sea floor or sea bottom. Other problems encountered during installation include the expense and difficulty of underwater work, the maintenance of the platform support and parts in an upright position until adequately anchored, the attachment of parts of the platform to each other and the facility with which anchoring piles and the like may be driven. The problems encountered during use of the platform are the ability of the platform support to withstand wave and tide action, the ease and facility with which wells may be drilled from the platform, the facilities for storage of oil produced, the facilities for separation of oil from oil, water and sand mixtures and the protection of crews and equipment during severe storm conditions. Since the wave and tide conditions normally differ in various places, while the maximum expected severity of storm conditions may vary from one location to the other, the requirements for different locations may vary. Also, since some locations are in relatively shallow water, such as a depth of 50 feet or less, or in relatively deep water, such as a depth of on the order of 500 to 2,000 feet, with numerous locations at intermediate depths, the requirements may vary considerably from location to location. Also, the extent or area of the desired platform may vary considerably for any given installation.

Among the objects of this invention are to provide a novel offshore platform support which is particularly adapted for intermediate water depths; to provide such a platform support, two or more of which may be utilized to support platforms of different areas; to provide such a platform support which may be used for oil storage; to provide such a platform support, the interior of which may be utilized to separate oil, water and/or sand mixtures; to provide such a platform support which minimizes the amount of underwater work required during erection or installation; to provide such a platform support which facilitates the drilling of wells from the platform; to provide such a platform support which facilitates the installation of piling for attachment of the platform support to the seabed; to provide such platform supports which may be formed primarily of prestressed concrete and consisting of segments which may be precast and stressed together, or may be made by slip forming, either on shore or off shore; to provide such platform supports which may be made on shore and readily floated to the erection site; and to provide such platform supports which are effective and efficient in use.

Additional objects and the novel features of this invention will become apparent from the description which follows, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of an offshore-drilling platform which includes a platform support constructed in accordance with this invention, particularly for intermediate water depths; FIG. 2 is a horizontal section, on an enlarged scale and taken along line 2—2 of FIG. 1, showing particularly a bottom segment of the platform support;

FIG. 3 is an offset longitudinal or vertical section, taken along line 3—3 of FIG. 2;

FIG. 4 is a vertical sectional detail, on a further enlarged scale and taken along line 4—4 of FIG. 1, showing particularly a pile and a preferred manner of installation thereof;

FIG. 5 is a fragmentary top plan view, on a further enlarged scale, of a portion of a segment of the platform support of FIG. 1;

FIG. 6 is a fragmentary longitudinal section, taken along line 6—6 of FIG. 5 and on a further enlarged scale, showing

particularly the joint between two of the segments of the platform support,

FIG. 7 is a fragmentary vertical section similar to FIG. 6, but taken along line 7—7 of FIG. 5;

FIG. 8 is a top plan view, on an enlarged scale, of a top segment of the platform support of FIG. 1;

FIG. 9 is an offset vertical section, taken along line 9—9 of FIG. 8;

FIG. 10 is a diagram of a platform supported by two platform supports;

FIG. 11 is a diagram of a platform supported by three platform supports;

FIG. 12 is a diagram of a platform supported by four platform supports; and

FIG. 13 is a diagram of a platform supported by six platform supports.

An offshore-drilling platform utilizing a support S constructed in accordance with this invention is illustrated in FIG. 1, a platform 10 being supported by a truss structure 11, in turn mounted on the support S. A derrick 12 and a crane 13, as well as other suitable equipment for drilling and other operations, are mounted on the platform 10. The crew's quarters 14 may also be placed within the truss structure 11, with additional crew's quarters, storage facilities and the like, when desired, being mounted on the platform 10.

In accordance with this invention, the support S comprises a series of superimposed, vertically aligned, connected segments, including a bottom segment B, intermediate segments I and a top segment T. The segments may be of suitable diameter, such as on the order of 21 feet in height and 22 feet in diameter, including a 1-foot wall thickness. The bottom segment B rests on the sea floor or bottom 15, while a sufficient number of segments are provided to elevate the crew's quarters 14 and platform 10 well above, such as on the order of 50 feet, the normal sea level 16, which may be on the order of 80 to 100 feet from the sea floor 15. Additional intermediate segments may be utilized for greater sea depths. A series of bumpers 17 may be installed on the outside of the column adjacent the sea level 16, while a door 18 may be provided for entry of personnel or supplies from small craft.

In accordance with this invention, the bottom segment B is provided with a series of radially extending ribs 20, such as 3, 4, 6 or more in number, terminating at the ends in blocks 21 having vertical holes 22 therein, through which hollow piles 23 may be driven into the sea bottom. The top segment T is provided with a series of radial wings 24, corresponding to the number of ribs 20 and provided with holes 25 in vertical alignment with holes 22, so that the piles may be guided by holes 25, when being driven through bottom holes 22 into the sea bottom. As hereinafter described, after being driven, the piles are cut off at the tops of blocks 21 to produce stub piles, so that there will be no exterior piling above the sea level 16, to reduce resistance to wave action, particularly when 125 mile per hour winds and 51-foot waves are possible, as in the Gulf of Mexico. Ribs 20, as in FIG. 1, may be narrower than blocks 21, or may have the same thickness, as in FIG. 2. The bottom chords of truss structure 11 are supported by wings 24, while a lower deck 26 is suspended from the truss structure and an upper deck 27, on which the platform 10 is mounted, is mounted on the truss structure.

The bottom segment B, as in FIG. 2, is provided with a closed bottom 30, which may be slightly thicker than the sidewall 31, while a series of webs 32, on the inside of the segment, are formed as extensions of the respective outside ribs 20, for placement of lower, diametrical tendon tubes 33 and inverted arcuate, upper tendon tubes 34, a pair of each extending through each pair of aligned ribs 20 and corresponding webs 32. The tendons placed in tubes 33 and 34 are utilized in prestressing the ribs and webs, as in the manner described below, while vertical prestressing of the segments may be accomplished by tendons installed in vertical tendon tubes 35 in wall 31, as in FIGS. 5 and 7. The bottom 30 may be provided with a series of holes 36 for risers and conduits from

the wells, with each hole 36 being closed in any suitable manner, as by a removable plug 37 of FIG. 3, which plug may be removed for use of the respective hole.

The piles 23 are preferably driven prior to the addition of the truss structure 11 and platform 10, as from a suitable barge, each being of sufficient length to be inserted through one of the upper holes 25 and down into the corresponding lower hole 22. After the piles have been driven to a suitable depth, they are grouted to the block 21, as by grout 38 of FIG. 4, which may be placed by scuba divers. The pipe may also be filled with concrete up to the top of block 21 and the pipe then cut off to produce stub piles, as by a shaped explosive charge inside or outside the pipe, along the dotted line 39, at or slightly above the top of block 21.

The joint between each of the segments, as in FIGS. 5-7, is preferably an offset joint, such as comprising a lower, inner land 40, a higher, outer land 41 and a bevel 42 connecting the lands. The edges of the lands 40 and 41 may correspond to the inside and outside edges, respectively, of the tendon tubes 35, while two or more alignment pins 43 may be embedded in one segment and extend into a corresponding hole in the adjacent segment, to insure alignment of tendon tubes 35. When the segments are fitted together, the joints between the segments may be sealed and the segments connected together by a suitable grout 44, such as an epoxy resin. Additional reinforcement may be provided in each of the segments, such as reinforcing bars or rods 45, placed in any suitable vertical and annular arrangement in the wall 31.

The top segment T is provided with a series of radial webs 46 inside wall 31, in alignment with the respective wings 24, as in FIG. 8. A series of upper reinforcing bars 47 and lower reinforcing bars 48, as in FIG. 9, may extend through each aligned pair of webs and wings, with upright stirrups 49 connecting the upper and lower reinforcing bars. The upper and lower reinforcing bars may be curved around the outside of pile holes 25. Connection plates 50 for the prestressing tendons may be cast in the bottom segment B, at the lower ends of tendon tubes 35, as in FIG. 3, with conical recesses 51 provided for access to the tendon connections, and similar plates 50' and recesses 51' at one end of each pair of tendon tubes 33 and 34. Conical recesses 52 may also be provided in the top of top segment T, as in FIG. 9, at the upper end of each tendon tube 35, to receive conical clamping devices, as hereinafter described. A recess 53, for the same purpose, may be provided at the opposite ends of tendon tubes 33 and 34, as in FIG. 3.

The segments of the support S may be precast on shore or on a barge near the site of the tower, as in a form having a configuration corresponding to the segment cast. The intermediate segments I may be cast in an annular form, while special forms may be provided for the bottom segment B and the top segment T, although the same form used for the intermediate segments may be adopted for casting the upper and lower segments, as by slots which may be closed for casting the intermediate segments but to which suitable auxiliary forms may be attached for forming wings 24 on the outside and webs 46 on the inside of the top segment, or ribs 20 and blocks 21 on the outside and webs 31 on the inside of the bottom segment. The bottom segment may be cast in inverted position, for easier casting of the ribs 20. However, when more than one support S is to be made, it may be more convenient to use one form for casting the bottom segment, another form for casting the top segment and still another form for casting each of the intermediate segments. The tendons for prestressing the reinforced concrete may be inserted in the respective tendon tubes at an appropriate time, such as between 2 days and 4 days after the concrete has initially set, depending upon when the concrete reaches a predetermined compressive strength. The prestressing tendons in tubes 35 may be stressed against plates 50 and against plate 51 for the tendon tubes 33 and 34 of the bottom segment, by the use of conical guides and washers, or by a sleeve and split cones, followed by grouting in the tendon tubes, as in the manner described in my copending application Ser. No. 712,187, filed

Mar. 11, 1968, now U.S. Pat. No. 3,483,707. After the tendons are installed, the recesses 51, 51', 52 and 53 are filled with grout.

Assuming that the segments are precast on shore, the cast segments are placed on a barge and towed to the erection site, being prestressed during towing. The segments thus are preferably transported in end to end position, so that the tendons in tubes 35 can be inserted through all of the segments. After prestressing and curing, the support S may be lowered by a barge crane in vertical position into the water, or merely slid off one side or from the end of the barge. As the support enters the sea, one or more of the plugs 37 for holes 36 may be removed, or provided with a valve which may be opened, to admit sea water into the interior of the column, to sink it slowly as it is adjusted into position. The area of the ocean floor 15 on which the lower segment is to rest may first be leveled off, as by a clamshell bucket or a pressure hose. If there is any tidal action at the point, an excavation may be made to receive the bottom segment, in order to prevent shifting sand from being removed beneath any portion of the bottom segment, particularly the ribs 20. After the support S has been placed in position, the holes 25 of the top segment being in alignment with the holes 22 in the bottom segment, the piles 23, originally sufficiently long to be driven to depth and still extend above the upper wings 24, are inserted, in turn, through the respective upper hole 25 and bottom hole 22, then driven to the desired depth, after which the piles are grouted and cut off at the tops of blocks 21, as indicated previously. After the piling has been driven and the column secured to the bottom of the sea, any sea water inside the column, used for sinking purposes, may then be pumped out, if necessary. The inside of the column below the lower deck 26 may be used for oil storage purposes, if desired.

In further accordance with this invention, the inside of the column may be used for gravity separation of oil and water mixtures, through the provision of a series of holes 55, as in FIGS. 2 and 3, through the wall of and adjacent the bottom of the lowermost intermediate segment I. Holes 55 are normally closed by removable plugs 56, which may be also constructed as a clapper-type valve, so as to be opened and closed from above through air lines connected to a cylinder and piston connected to the pivoted valve, but conveniently installed after drilling has been completed. The casing for the well drilled from the derrick 12, of course, extends through one of the holes 36, which has been unplugged prior to drilling so that the casing may be lowered therethrough. The casing for the well, of course, extends upwardly to the platform 10, being conventional in nature and therefore not shown. However, when the support column is to be used for separation of oil and water, a waste pipe 57, shown in dotted lines in FIG. 1, is placed inside the column, so as to extend downwardly to a point near the lower end thereof, for introduction into the column of a mixture of oil and sea water and sand, which is to be separated. A draw pipe 58, also shown in dotted lines, is installed to extend downwardly to a point near the top of the column within the area in which oil separating from the water and sand will float on top of the sea water within the column, so as to enable the separated oil and sand to be withdrawn from the column. The separated water and sand, as waste, drains out through the holes 55, since the total height of the water and oil within the column will be above sea level, thus producing sufficient hydrostatic pressure to force separated water and sand out through the holes 55, which may also be opened and closed from above, in accordance with the level of the oil within the column.

A series of two or more supports S, as illustrated diagrammatically in FIGS. 10-13, may be utilized to support platforms of various sizes, the number of supports being more dependent on the depth of the water and the severity of expected storm conditions, than the actual area of the platform. Thus, it will be understood that the platform supported by one or more supports or columns S may vary considerably. However, by using a conveniently sized platform component 60, as in FIG.

10, with a filler deck 61 therebetween, an elongated, rectangular platform can be supported by a pair of supports or columns S. The platform 62 of FIG. 11, mounted atop three supports S, arranged in an equilateral triangular relation, is conveniently triangular in form with blunted apices 63. However, the spacing between the supports S of FIG. 11 is approximately the same as the spacing between the supports S of FIG. 10, such as on the order of 60 feet between centerlines. When the depth of the water or the expected severity of storm conditions require four supports, as in FIG. 12, a series of four platform components 60 may be supported in rectangular relationship by four supports S, as indicated, but spaced somewhat closer together than in FIG. 10 or FIG. 11. As in FIG. 13, six platform components 60 may be supported in a rectangular relationship atop a corresponding series of six supports S. The supports S are preferably constructed as in FIG. 1, although the alternative supports or columns hereinafter described may be utilized for the purpose, depending upon the sea depth. As will be evident, a well may be drilled within any of the supports S or within two or more of the supports S, if spaced sufficiently far apart for the purpose. Also, any of the supports S not used for drilling may be used for oil storage purposes, while one or more, particularly when more than two supports are present, may be utilized for separating oil from water and sand, as in the manner previously described.

From the foregoing, it will be evident that the requirements and objects hereinbefore set forth are fulfilled to a marked degree. In the embodiment described, the piles are accurately guided, during driving, and are connected to the column in such a way as to firmly affix the column to the sea bed. In the embodiment, the resistance of the column to bending stresses is enhanced by the prestressing tendons which are stressed to a desired degree of tension in the tendon tubes. Thus, forces due to water or wave action which may tend to bend the column must first overcome the compression in the concrete walls of the column caused by tension of the prestressing tendons, before any of the segments are subjected to tension stresses. In the installation of the supports and platforms, the amount of underwater work required is held to a minimum, since no welding or similar time-consuming operations need be carried out at great depths. In the embodiment, the preparation of the sea floor by sluicing hoses does not require the divers to be at the bottom for extended periods of time. Also, the grouting of the individual piles to the ends of the radial ribs shown in FIG. 1 does not require a diver to be at the bottom for an extended length of time, since each pile may be grouted after being driven, and the time required to drive the next pile permits the diver to return to the surface. Also, the piles are accurately guided during driving, although eventually cut off near the bottom. As will be evident, cutoff sections of pile may be welded together to form longer sections for other piles. The segments of the columns are readily cast, with appropriate reinforcement inside the concrete. The column may be used for the storage of oil and also, through drainage holes provided near the base of the column, to separate mixtures of oil and sea water and sand, which are frequently produced from offshore wells. Although reference is made herein to the sea level and sea bottom, it will be understood that the platform supports and platforms of this invention may be installed in fresh water lakes.

Although a preferred embodiment of this invention has been illustrated and described, it will be understood that other embodiments may exist and that various changes may be made, all without departing from the spirit and scope of this invention.

What is claimed is:

1. An offshore-drilling platform support for installation in a body of water, comprising:
 - an upright column including a series of connected, hollow segments, each having a reinforced concrete wall and a series of longitudinal holes in said walls for accommodating prestressing means;

a series of at least three radiating base supports extending radially from the bottom segment and constructed and arranged to engage the floor of said body of water;

a corresponding series of radiating platform supports extending radially from the uppermost segment and constructed and arranged for mounting of a platform thereon; and

said bottom base supports and the corresponding top platform supports being in vertical alignment and having upright, vertically aligned holes for receiving and guiding a plurality of piles to be driven into said floor of said body of water.

2. An offshore drilling platform installed in a body of water and comprising:

a support as defined in claim 1, with said base supports engaging the floor of said body of water and a platform mounted on said upper radiating platform supports; and

a series of stub piles disposed in said holes in said base supports and extending into said floor but each terminating adjacent the upper edges of the corresponding base support.

3. An offshore-drilling platform support, as defined in claim 1, wherein:

abutting segments in said column meet at offset joints.

4. An offshore-drilling platform support, as defined in claim 3, wherein:

said joints comprise a lower, inner, generally horizontal land, a higher, outer, generally horizontal land and a bevel connecting said lands, said bevel extending across said holes for accommodating said prestressing means.

5. An offshore-drilling platform support, as defined in claim 1, wherein:

said series of base supports include at least three outwardly extending ribs which are connected to said wall and having a downwardly extending top;

a block connected to the outer end of each rib and having an upright hole therein to accommodate a pile;

a floor at the bottom of said bottom segment and connected to said wall; and

a series of webs extending inwardly from said wall to the center of said bottom segment and in alignment with said ribs.

6. An offshore-drilling platform support, as defined in claim 5, wherein:

said series of platform supports include outwardly extending wings connected with the wall of said top segment, corresponding in number to the ribs of said bottom segment and vertically aligned therewith, said wings having upright, pile guiding holes adjacent the outer ends thereof in vertical alignment with the pile holes in said blocks of said bottom segment; and

a series of webs connected to said wall and extending inwardly to the center of said top segment, said webs being in alignment with said outer wings.

7. An offshore-drilling platform support, as defined in claim 5, wherein:

said ribs and webs of said bottom segment comprise an even number;

a lower hole extends from the outside of each said block through the corresponding rib and inside web, and the opposite web and rib;

a series of arched, upwardly curved holes extend from the outside of each block adjacent the lower end thereof upwardly through said block and the corresponding rib and into the corresponding web, thence downwardly through the opposite web and rib to the opposite block; and prestressing means are disposed in said holes.

8. An offshore-drilling platform comprising:

a series of two spaced supports, each said support as defined in claim 1; and

a pair of rectangular platform components, each mounted atop one of said supports, and a narrower filler deck between said platform components.

9. An offshore-drilling platform comprising:

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a series of three spaced supports, each said support as defined in claim 1, said supports being disposed in a triangular arrangement; and
a triangular platform having blunted apices and mounted atop said supports.

10. An offshore-drilling platform comprising:

a series of four spaced supports, each said support as defined in claim 1, said supports being disposed in a rectangular arrangement; and
a series of four rectangular platform components disposed

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in a rectangular arrangement and each mounted atop one of said supports.

11. An offshore-drilling platform comprising:

a series of six spaced supports, each said support as defined in claim 1, said supports being disposed in a rectangular arrangement; and

a series of six rectangular platform components disposed in a rectangular arrangement and each mounted atop one of said supports.

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