Offshore platform and method of constructing, erecting and dismantling same.

An offshore structure is provided which is adapted to be fabricated on shore as independent base and deck modules (11) and (12), respectively. The base module (11) includes at least one buoyant section (20). The buoyant section or sections provide buoyancy to the base module during water transport and are flooded to sink and stabilize the base module on the water bottom at a desired offshore location. The base module (11) includes three or more support columns (24, 25, 26, and 27) extending upwardly to adjacent the water surface (13). The deck module (12) is affixed to the base module (11) and is supported by the base module above the water surface (13).
FIELD OF THE INVENTION

This invention pertains to the drilling of offshore hydrocarbon wells and to the production of hydrocarbons from such wells. More particularly, it pertains to economical structures and systems for drilling and producing hydrocarbons in the offshore environment.

BACKGROUND OF THE INVENTION

Review of the Prior Art

Offshore oil drilling and production structures as presently developed and installed at offshore locations are basically either of the submersible jacket type or the jack-up type. Jacket type platforms are characterised by a rigid structure which mounts a drilling platform; the structure is fabricated as a unit in a fabricating yard and is towed buoyantly in a buoyant condition or on a barge to the desired offshore location where the
structure is up-ended and sunk into position to rest on the ocean floor. When the structure is in place the drilling platform is supported a desired distance above the water surface and at that point can be outfitted with drilling or production equipment and other required facilities. Jack-up structures have a buoyant platform component equipped with a complete drilling rig facility to which are mounted several jackable legs or piles. The structure is towed, with the legs retracted, to the desired offshore location where the legs are extended to engage the ocean bottom. Continued jacking causes the platform to be raised above the water surface. Both submersible and jack-up structures must be towed as a unit from the place of fabrication to the offshore site to minimize the weight and transient difficulties with these types of unitary structures. It is frequently necessary that the construction of drilling rig facilities on both types must be completed at sea, necessitating use of heavy duty crane barges. Because submersible and jack-up structures must be moved as a unit, subsequent workover of a submerged well from such structures is complicated. Such structures are usually extremely large and precise placement of such structures is accomplished only with great difficulty.

One suggestion for obviating the inherent limitations on unitary drilling structures is shown in U. S. Patent No. 3,528,254 issued September 15, 1970, and entitled "Offshore Platform Structure and Construction Method". This patent shows the use of a separate base templet and platform superstructure. In the patented system, the base structure is set in the ocean bottom forming no more than a resting pad or templet for a substantially unitary
tower and platform unit. This unitary unit is towed to position and by various guide means positioned over and engaged with the preset base member. One of the objectives of the structure as illustrated in the patent is to permit the removal of the principal tower and platform member without necessitating the removal of the base structure.
SUMMARY OF THE INVENTION

The present invention involves an offshore platform structure composed of two separate components: a buoyant base structure and a platform or deck structure. Each of the components of the platform may be separately manufactured in facilities having differing capabilities.

The base module is adapted to rest on the bottom of the body of water and extend upwardly therefrom to a level adjacent to and preferably above the surface of the water body. To accomplish this objective, the base module includes a water buoyancy chamber which adapts the base to be transported to a desired location in a buoyant condition and to be flooded at the location to a condition of negative buoyancy so as to sink and ultimately rest on the bottom. In addition to the buoyancy structure, the base includes at least three columns extending from the buoyancy chamber upwardly to adjacent to, and preferably above, the water surface.

An independent deck structure, which is conveniently constructed in a fabricating yard, is adapted to separately be transported by barge and positioned in engagement with the upper ends of the base legs. The deck structure includes jacking means for lifting the deck a desired distance above the water surface after engagement thereof with the base legs. The unique features and advantages of the platform structure as herein described include the fact that the deck module can be separately manufactured in a fabricating yard which has facilities and technology for installation of drilling rigs and production equipment and the like and in this regard is possessed of capabilities different from the normal shipyard. At the same time, the base structure by reason of its separation from the more sophisticated deck structure adapts itself to
simple box beam construction easily within the
construction capability of the normal shipyard.

Installation of the completely outfitted deck after
the base has been installed makes it possible to float
the base structure to the location in a vertical position
and ballast it down without paying an excessive penalty
to achieve stability. In other words, if the operation
were attempted with the deck installed on the base, the
center of gravity of the combined deck and base would be
so far above the center of buoyancy that the column
diameters would have to be substantially increased in
order to provide stability to the structure or conversely
additional weight would have to be added to the lower
portion of the base to achieve stability. The entire
concept of the buoyant base and separate deck structure
engaging base legs penetrating the water surface enables,
the minimization of the weight of the platform and the
cost and complexity of manufacturing. This enables this
unit to be used and reused minimizing cost not only of
fabrication, but of installation. This meets the long
standing objective for a less costly platform structure
for the development of what are now considered marginal
gas and oil fields, marginal because of the enormous cost
of installation of the more conventional drilling and
production platforms.

Once the platform is installed and the base buoyancy
chamber or chambers have served their purpose for
transport or erection as described, they may be then
used alternatively for oil storage.

Some ways of carrying out the present invention
in both its apparatus and method aspects will now be
described by way of example and not by way of limitation
with reference to drawings.
BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of one embodiment of assembled platform structure of the invention;

FIG. 2 is a schematic view showing the construction of a portion of the base module;

FIG. 3 shows a second step in the construction of the base module;

FIG. 4 is a third step in constructing the base module;

FIG. 5 is a schematic illustration showing the base structure being towed to the desired location;

FIG. 6 shows the base structure anchored in the ocean bottom;

FIG. 7 is a schematic illustration of the fabrication of the deck module;

FIG. 8 shows the deck module supported by a barge and being aligned with the preset base structure;

FIG. 9 shows schematically the assembled platform structure;

FIG. 10 is an isometric view of an alternative embodiment of the invention;

FIGS. 11a through 11g show the sequence of steps in constructing and erecting the embodiment of FIG. 10;

FIG. 12 shows a further modification of the embodiment of FIG. 10;

FIG. 13 is a fragmentary side view of a base module resting on the ocean bottom;

FIG. 14 is a fragmentary top view of a marginal portion of the base module of FIG. 13;

FIG. 15 is a fragmentary perspective view of the base module marginal portion shown in FIG. 13;
FIG. 16 is an enlarged fragmentary elevation view, partly in cross-section, of a preferred embodiment of a deck module leg end configuration and base module column top configuration;

FIG. 17 is a simplified side elevation view of a deck module supported for transport on a vessel.

FIG. 18 is a fragmentary top plan view of the vessel of FIG. 17 showing mechanisms on its deck useful for supporting a deck module during transport to an offshore location;

FIG. 19 is a side elevation view showing a deck module supported on a transport vessel and in position for supportive registry of the deck module legs with the support columns of a base module;

FIG. 20 is an enlarged fragmentary elevation view, similar to FIG. 16, showing a preferred mode of engaging and securing a deck module leg to a base module column;

FIG. 21 is a simplified top plan view of a base module platform showing the preferred position of the center of gravity of the platform relative to the position of the deck module legs; and

FIG. 22 is an enlarged fragmentary elevation view of a deck module leg engaged in a recess at the top of a base module support column and showing apparatus for use in disengaging the leg from the support column.
FIG. 1 illustrates one embodiment of the invention in an assembled condition. The platform is resting on the ocean bottom 10 and includes a base module 11 and a deck module 12, the latter being supported by the base module above the water level 13. As illustrated, the deck module 12 is fabricated as a non-buoyant structure and supports conventional drilling equipment 14, crane 15, housing 16, and other facilities conventional to this type of operation. If desired, the deck module can be buoyant. The deck module includes jackable legs 18 which are designed to engage with support columns forming part of the base module and by use of conventional jacking means lift the deck 12 a predetermined distance above the water surface 13.

The base module 11 includes a lower buoyant chamber 20 of box girder construction forming the entire periphery of the base. In the particular embodiment shown, another buoyant section 21 is supported above the buoyant section 20 by support beams 22 provided in acceptable quantity and specifications to comply with good engineering practice. The support beams 22 are designed and fabricated to provide a hydrodynamically stabilizing water plane during ballasting and launching. The second buoyant chamber 21 included within this illustrative embodiment has the advantage of forming a further water plane at this level which, as will be later shown, facilitates the further fabrication of the base. Completing the base module are four vertical columns 24, 25, 26, and 27 extending upwardly from the buoyant chamber 21 to extend through the water surface 13 and, in the manner described above, to support the independent deck module 12. Although a base module having
four columns is preferred and illustrated, configurations with three or five or more columns are contemplated.

The base module 11 may rest on the ocean bottom as shown and may be fastened thereto by anchor piles drilled or driven into and through the plurality of pile guides 30 spaced around the periphery of the lower buoyant chamber 20. The base structure may also be designed to rest at a level attitude on an uneven bottom by an addition of pads (not shown) affixed below the box girders at selected points of contact; specifically, these are those points which transmit the column loads to the sea floor and may be selected in such a way that the natural period of the structure can be optimized for earthquakes.

The sequence of fabrication of the platform structure of FIG. 1 and its erection at an offshore site is shown in FIGS. 2 through 9. The portion of the base structure not including the vertically extending columns is shown in FIG. 2 as being constructed in a normal shipyard facility illustrated schematically by a walking bridge or gantry crane 40. In the shipyard facility, the box beam buoyant chambers 20 and 21 are fabricated and interconnected with the beams 22. At this point, the partially completed base module is launched in normal fashion as shown in FIG. 3 with buoyancy being provided entirely by the lower buoyancy chamber 20. The buoyancy is then adjusted to submerge the partially completed module to float with the water plane or second buoyant chamber 21 at the water level 13. In this relatively stable position, the columns 24, 25, 26, and 27 (columns 26 and 27 are not shown in FIG. 4) may be affixed to the partially completed base module by a crane barge 42. As shown in FIG. 5, the now completed base module may
be towed in a buoyant condition again with the upper buoyant chamber 22 forming a water plane 21 to the offshore location. As illustrated in FIG. 6, at the offshore location the buoyant chamber of the base modules is flooded to produce a controlled negative buoyancy sinking the base to rest on the ocean bottom 10 at which point anchoring piles may be driven through the pile guides 30 with conventional underwater pile-driving equipment.

FIG. 7 shows schematically the fabrication of the deck module 12 in a fabrication yard which may be more suitably adapted to such fabrication than the normal shipyard and in which the deck is totally outfitted with the drilling tower 19 as shown and any other equipment that may be required. When completed, the deck module is loaded on a barge 44 and, as shown in FIG. 8, is transported in this fashion to the location of the base module 12 previously set as described.

The barge is adapted to locate the deck module 12 over the base module so as to engage the jackable legs 18 of the deck with the base columns 24, 25, 26, and 27. To accomplish this, the legs of the deck are jacked down to engage the base columns. This engagement is purposely designed as a "sloppy" fit to allow some motion between the deck legs and base columns. The transporting barge is then ballasted down and the weight of the deck is transferred to the base. Conventional jacking mechanisms (not shown) are then adjusted to jack the deck upwardly a desired distance above the water surface. The jacking means may also be employed to free the deck from the barge.
A second embodiment of the invention particularly adapted to shallower water and to installation at pre-existing drill sites for workover or production is illustrated in FIG. 10. The embodiment of FIG. 10 also includes a base module 50 and a deck module 52. The deck module 52 has legs 53 engaged with and supported by base columns 54, 55, 56, and 57 which, as in the prior embodiment, extend upwardly through the water surface when the base is resting on the ocean bottom. In this embodiment, the base comprises a single pad type buoyant chamber 58 which serves as a large surface upon which the structure may rest on the ocean bottom and which supports, as illustrated, the base columns 54, 55, 56, and 57. In this structure, the buoyant pad 58 has an indent section 60 which is adapted by careful placement of the platform to circumscribe a pre-existing wellhead installation (not shown). In a platform structure for this use, a drilling or production rig 61 may be mounted on the deck 52 so as to overlie a wellhead installation lying within the indent section 60.

FIGS. 11a through 11g illustrate schematically the construction and erection of the platform embodiment shown in FIG. 10. In FIG. 11a, the base member 50 is shown being erected on land. After erection, it is launched and, as shown in FIG. 11b, is towed in a buoyant condition to the location shown in FIG. 11c. At this point, the buoyancy chamber 58 is flooded and the base module then rests on the bottom 62 of the ocean with the columns 54, 55, and columns 56 and 57 (not shown) projecting above the water surface 63.
FIG. 11d shows the deck module 52 also being constructed on land. Although not illustrated in these schematic drawings of FIG. 11, the deck would normally be outfitted while still in the fabrication yard with drilling rig, heliport, cranes, and other normal equipment for drilling and production platforms. Deck 52 is carried from the point of fabrication as shown in FIG. 11e on a barge 64 and is brought in this fashion into engagement with the present base module 50. When in position, the barge 64 is ballasted downwardly to permit deck legs 53 to engage legs 54, 55, 56, and 57 of the base module or the deck legs may be jacked down to engage the base legs. The barge is then removed and the deck 52 is jacked-up by conventional means to the position shown in FIG. 11g.

As mentioned above, this embodiment of the modular platform is particularly adapted to location over or adjacent existing well site because of the structure of the bottom buoyant pad and, to this end, it is important to be able to locate the platform with considerable accuracy. A modification of the base module for this purpose is shown in perspective in FIG. 12. In FIG. 12, a buoyant pad member 70 is, as in the prior embodiment, provided with columns 71, 72, 73, 74 extending from the buoyancy tank 70 through the water surface 76. The pad rests on the ocean bottom 77 and is provided with guides 78 for piles to be drilled or driven in to stabilize the base structure. The pad 70 also has an inset or recess section 80 which is adapted to engage around an existing wellhead installation. Although not shown, a deck to be superimposed on the base module would have an appropriate drill or production rig mounted so as to overlay the recess portion 80.
To achieve precise control of the location of the base module so that the recess portion 80 will, in fact, coincide with a pre-existing installation, winches 82, 83, 84, and 85 are mounted on top of each of the columns 71, 72, 73 and 74, respectively, and mooring lines 86 are fair-leded through sheaves 87 to preset anchors (not shown) so that position control is quite precise as the base nears the sea floor.

The base, and independent deck platform concept herein described, is developed to minimize on-site installations and hookup costs. The concept is simple; the base structure is towed to the site in an upright position and set on the sea floor using its own ballasting system. The completely outfitted deck, which is an independent structure, is brought to the site on the deck of a barge and positioned over the base. The barge is then ballasted down and the deck is transferred to the base columns. The deck is then raised to the design elevation by means of conventional and removable jacks. Once in place, the deck is normally permanently affixed to the base legs.

FIGS. 13-15 illustrate an "anti-scour skirt" 98 for preventing erosion of the ocean bottom due to water action beneath a base module 90. It is important to prevent such erosion so that the base, and thus the entire offshore platform structure, will remain stable once it has been set in position at the desired offshore location.

The "anti-scour skirt" is fixed to the sides of the base module before it is sunk into place on the ocean floor.
Referring particularly to FIG. 13, the base module 90 is shown in place on the ocean bottom 92. The base module of this embodiment comprises a buoyancy chamber 94 and four support columns 96 connected to the buoyancy chamber and extending vertically upwardly therefrom. Only two of the support columns are shown. Further, the base module 90 has the anti-scour skirt 98 connected to its sides.

For purposes of exposition herein, the base module 90 is generally rectangular in horizontal cross-section with each of its sides having a configuration similar to the side shown in FIG. 13. Anti-scour skirts can also be provided on base modules having different configurations than the base module shown in FIG. 13. This can be accomplished by designing the anti-scour skirt to accommodate the design of the particular base module on which it is to be attached.

Anti-scour skirt 98 comprises a plurality of horizontally spaced, adjacent, upwardly and downwardly open receptacles 100 and includes a skirt element 102 mounted in each such receptacle. The receptacles are shown in FIG. 14 without the skirt elements installed and additionally two empty receptacles are shown in FIG. 15 to clearly illustrate the configuration of the receptacles.

As can best be seen by referring to FIG. 13, the skirt elements 102 extend below the bottom of the base module and into the sea floor when the base module is in position at the offshore location. (The sea floor is cut away in the figure so that the bottoms of the skirt elements can be seen). The anti-scour skirt
inhibits water from flowing under the base module and consequently inhibits erosion of the sea bottom under the module. Additionally, the skirt inhibits horizontal motion of the installed offshore platform. Thus, by providing such an anti-scour skirt, the stability of the offshore platform is enhanced.

In the illustrated embodiment, the receptacles 100 are provided by connecting a steel plate 104 to each side of the buoyancy chamber 94. A plurality of steel braces 106 are initially welded to the back of the steel plate in horizontally spaced apart relation to each other. The height of the braces can, as shown, be the same as the height of the steel plate or can be shorter if desired. After the braces are in place on the plate, the other end of each brace is welded to the bulkhead of the buoyancy chamber for connecting the plate to the base module. A steel plate 104 extends along the length of each side of the base module at its base, but preferably does not extend below the bottom of the base. The plate and braces, therefore, do not interfere with floatation of the base module at its construction site.

Each horizontally spaced receptacle 100 is defined at its back by the buoyancy chamber bulkhead, at its front by the back wall of the steel plate, and at its sides by adjacent steel braces 106. The spacing of the braces and the distance from the buoyancy chamber bulkhead to the plate can be as desired to provide a skirt receptacle capable of accommodating skirt elements having a preferred thickness and width. Regardless of the dimensions of the receptacles, they can accommodate skirt elements having any desired length.
The skirt elements 102 are preferably pre-cast concrete members which are individually mounted in each receptacle. The top of each skirt element is preferably provided with a lip 108 which extends over, and is supported by, the top edge of the steel plate 104. One or more steel retainers 110 are provided to hold the skirt element from vertical upward movement in the receptacle. The retainers are of sufficient strength to maintain the skirt in the receptacle when the base module bottoms on the sea floor. Preferably, the retainer is a brace having two legs, one of which is welded to the buoyancy chamber wall, with the other leg extending horizontally across the top of the skirt element.

In one exemplary embodiment of construction of the anti-scour skirt 98, the open receptacles are constructed on the base module 90 before the base module is floated from its place of construction. This enhances the ease and hence the economics of construction of the receptacles. Since each such skirt element extends a desired distance below the bottom of the base module, the skirt elements can interfere with the floatation of the base module if they are installed prior to floatation. Preferably, therefore, the skirt elements are not installed until after the base module is floated. This is particularly important when the base module is constructed and launched from a shipyard way.

Skirt elements can be provided in different lengths to extend any desired distance below the bottom of the base module when they are in place in the receptacle. The desired length of the skirt
elements is determined by the type of sea bottom and by the nature of the sea floor currents at the location at which the base module is to be used. For instance, longer skirt elements may be desired where the bottom is loosely packed mud or the like and shorter skirt elements may be desired where the bottom is more solid.

Therefore, a plurality of identical base modules, each having the same scour skirt receptacle configuration, can be floated before the skirt elements are installed therein. Then, after the base modules are floated, they can be independently outfitted with skirt elements specifically designed for use at any desired offshore location. This enhances the economics of construction of the base modules.

Also, if desired, a base module can be refloated from its original sea bed location after it has served its purpose so that it can be used again at another location. Thus, the originally installed skirt elements can be removed and new skirt elements specifically designed for use at the next location can be readily installed.

FIG. 16 illustrates details of the construction of the upper end 112 of a preferred embodiment of a support column 114 and the lower end 116 of a preferred embodiment of a deck module leg 118 which facilitates engagement of a deck module to a base module. Only one such support column and deck module leg is shown and described below since the lower end of each such leg is preferably identical to the lower end of each other leg and the upper ends of the support columns are also preferably identical to each other.
In the illustrated embodiment, a "pin and socket" arrangement is used for mating and fixing the deck module to the base module. In this instance, the deck module legs are the "pins" and the lower end 116 of each such deck leg or pin is inserted into a "socket" or recess at the top of a respective support column.

In this embodiment, the support column 114 has an upwardly open, vertically elongate recess 120 in its top. The recess 120 is aligned parallel to the axis of the column and preferably is coaxial with the column. The lower end 116 of the deck module leg 118 is configured so that it can be readily inserted into the recess. Preferably, both the recess in the base column and the lower end of the deck leg are cylindrical with the outside diameter of the lower end of the leg being smaller than the inside diameter of the recess. When the lower end of the leg is in the recess, an annulus is defined between the leg and the recess.

Just above the lower end 116 of the leg, the leg tapers to a larger diameter. The length of the lower end of the leg is such that before it bottoms in the recess, the taper 122 at its top engages the inside of the recess and centers the leg lower end in the recess; compare FIG. 20.

If desired, a layer of sand (not shown) or other suitable energy-absorbing material can be placed into the bottom of such a recess 120 to distribute the impact loads evenly when the leg grounds in the recess; in this instance, when the leg grounds on the sand layer in the recess. Although sand layers having any desired thickness can be provided, it is thought that a sand layer two to four feet thick is sufficient to protect the column from damage when the weight of the
A deck module is being transferred from the barge to the base module.

When a sand layer 156 is in the recess (see FIG. 20), the height of the sand layer is considered when designing the length of the lower portion 116 of the leg. Preferably, the lower portion of the leg 116 has a length for providing that the taper 122 at its top engages the inside of the recess before the bottom of the leg grounds on the sand layer. This ensures that the leg is centered in the recess upon engagement.

The base column 114, the recess 120, and the deck module leg 118 are preferably constructed of steel. The recess 120 of this embodiment comprises a circular steel plate 124 which is welded around the inner periphery of the base column across the opening of the column. An open section of steel pipe 126, preferably having an outer diameter about the same as the outer diameter of the base column, is then welded to the plate. The steel pipe forms the sides of the upwardly open recess. The recess bottom plate 124 and the pipe which forms its sides are of suitable strength to withstand design impact loads of a deck module leg as it bottoms in the recess. As described above, a layer of sand or other energy-absorbing material can be positioned at the bottom of the recess to distribute the impact loads.

FIGS. 17-21 illustrate details of a preferred method of transporting a deck module and of engaging the deck module on a base module already in place on the sea floor.

Referring particularly to FIGS. 17-19, a deck module 130 is shown being transported on a vessel 132,
such as a barge, to a desired offshore location for
engagement with and erection on a base module 134.
The base module 134 is in place on the sea floor 136.
The deck module 130 comprises a generally horizontally
extending platform 136 which is of rectangular planform
configuration. A plurality of horizontally spaced
apart, vertically disposed legs 138 are mounted to the
platform 136 for movement vertically relative to the
platform.

The number of deck module legs provided is equal
to the number of base module support columns carried
by the base module on which the deck module is to be
mounted. In a preferred embodiment, the base module
134 carries four support columns 140 and, therefore,
the deck module 130 has four legs 138. The deck legs
138 are near the corners of the deck module and the
support columns 140 are near the corners of the base
module. In FIGS. 17 and 19, only two of the legs and
support columns can be seen.

In a preferred embodiment, which can best be
understood by referring to FIG. 21, the deck module
130 has a center of gravity 154 located about equi-
distant from first and second legs 138a and 138b,
respectively. The distance from the center of gravity
to the legs 138a and 138b is less than the distance
from the center of gravity to the remaining legs 138c
and 138d. When operations equipment is mounted on the
platform before the deck module is engaged to the base
module, it is arranged to provide this location of the
deck module center of gravity relative to the module
legs.

Referring again to FIGS. 17-19, the lower end of
each leg 138 and the upper end of each base module
support column 140 preferably have the same configuration as the leg and support column illustrated in FIG. 16.

As can best be seen in FIG. 19, the legs 138 are arranged at their lower ends 142 for supportive registry within a cylindrical recess 144 of a corresponding base module support column when the deck module is in position above the base module.

Jacks 146 are provided on the deck module platform. The jacks are operable for driving the platform along the legs 138 so that the platform can be elevated above the water surface on the legs following supportive registry of the legs with the base module 134. Preferably, the jacks are operable for positively driving the legs both upwardly and downwardly relative to the deck module platform. It is particularly important that the legs can be positively driven upwardly relative to the platform for disengagement of the deck module from the base module after the offshore platform is no longer needed at the offshore location. A preferred method of disengaging the deck module from the base module is described in greater detail below.

In a preferred embodiment of this invention, the deck module platform 136 is supported on the vessel 132 by quick-retracting supports 246 which are mounted on the vessel deck and are engageable with the platform. The supports are operable for quickly removing support of the deck module by the vessel for transferring the load of the deck module from the vessel to the base module when the deck module legs are in the support column recesses.

In an exemplary embodiment, the quick-retracting supports comprise movable walls 148 which are movable
into and out of cooperative relation with each other. The vessel 132 is shown in FIG. 18 without the deck module mounted on it so that the quick-retracting supports of this embodiment can be more clearly seen.

When the movable walls 148 are in cooperative relation with each other, they define an enclosure open at its top. If desired, end walls can also be provided so that the enclosure is closed on all four sides. Further, although only two quick-retracting supports 146 are shown, one support or more than two supports can be used if desired. In this embodiment, the walls 148 are boards, but metal plates or walls of other suitable materials can also be used.

The supports 246 each additionally comprise a quantity of sand 150 in each respective enclosure. The top of the sand extends above the enclosure and is in supportive engagement with the deck module platform 136 for supporting the deck module on the vessel. Each such support mechanism 246 also comprises quick-acting hydraulic cylinders 152 that are operable for holding the sides of the enclosures, i.e., the boards, in cooperative engagement. The cylinders also afford quick movement of the boards out of cooperative engagement at a desired time.

If desired, means other than hydraulic cylinders can be provided for holding the walls 148 in cooperative relation with each other and for allowing quick movement of the walls out of such engagement. For example, the walls can be held in position by one or more cables extending between facing walls. The cables can be provided with explosive devices which, when detonated, sever the cables, thereby allowing the boards or walls to fall away quickly out of cooperative
relation to each other. Further, the piles of sand can be contained in an enclosure defined by fall-away walls hinged to the vessel deck around a hopper which can be opened at the same time as the walls are released to fall to horizontal positions, these very quickly removing support of the deck module by the vessel and provide the desired clearance between the deck module platform and the vessel.

If desired, in addition to the supports 246 used for supporting the deck module on the vessel, cables and the like can be secured from the vessel to the deck module to hold it in place while the deck module is being transported to the offshore location.

Referring again to FIG. 19, the deck module 130 is shown in position directly above the base module 134 prior to its engagement with the base module. In a preferred embodiment, the tops of the support columns extend slightly above the water surface. A layer of sand is in each such recess at its bottom. Although not shown, an anti-scour skirt, as described above and illustrated in FIG. 13, is around the periphery of the base module 134 at its bottom.

At a time prior to engaging the deck module to the base module, the maximum acceptable dynamic load which can be applied by a leg 138 to a support column 140 in the course of disposing the leg in registry with the recess is ascertained. The velocity of the leg productive of such maximum dynamic load is then determined. By use of accelerometers or the like located on the vessel, the vertical velocity of the legs 138 due to wave action at the offshore location is then measured. Preferably, when the sea state is such that it imparts a vertical velocity to the legs
which is less than that which will produce the maximum acceptable dynamic load, the deck module is engaged to the base module.

In a preferred engagement sequence, the lower ends of the first and second legs 138a and 138b, which are nearest the center of gravity 154 of the platform, are jacked down into the recesses 144 first. The first and second legs can be jacked down separately or together, as desired. Since the first and second legs are nearer the center of gravity of the platform than are the other two legs, stability of the platform is maintained when the legs 138a and 138b are engaged in the recesses. After the first and second legs are bottomed on the sand layer in each respective recess 144, the other two legs are jacked downwardly either one at a time or together into supportive registry in the recesses of the remaining two support columns.

Referring particularly to FIG. 20, one of the legs 138 is shown in supportive registry with a corresponding recess 144 of the support column 140. The lower end 142 of such a leg 138 and the recess 144 are arranged so that when the leg is in the recess, an annular space 160 is between the leg lower end and the wall of the recess.

When the legs 138 of the deck module 130 are each in the recess of a respective support column 140, as is shown in FIG. 20, the vessel support mechanisms 246 are operated to quickly remove support of the deck module by the vessel. Thus, support of the deck module is transferred from the vessel to the base module.

In the illustrated embodiment, the support mechanisms are operated by releasing hydraulic pressure from the hydraulic cylinders 152 which hold the boards 148 vertically in place. The boards quickly fall away
from their vertical position to a near horizontal position level with the deck. This removes lateral support of the sand so that the sand pile quickly falls away from supportive registry with the platform. There is, therefore, by operation of the support mechanism 246, a clearance provided between the vessel deck and the platform. If desired, at the same time that the support mechanisms are operated, the vessel can be ballasted down. This provides an additional clearance. Preferably, the clearance provided upon operation of support mechanisms between the deck module platform and the vessel deck is at least equal to that distance equal to the decrease in draft of the vessel upon removal of the load of the deck module from the vessel plus an additional distance related to vertical motion of the vessel in response to action on the vessel by waves having a height, period, and direction not in excess of a predetermined height, period, and direction. A sufficient clearance is required so that the vessel is not slammed up against the underside of the platform after the weight of the platform is transferred from the vessel to the deck module. In any event, the sand 150 of the support mechanism 246 provides a buffer so that if the barge is moved upwardly against the platform, the sand will prevent metal to metal contact between the vessel deck and the platform.

After the deck module 130 is engaged on the base module and is supported by it, the barge is moved out from beneath the platform. The platform is then jacked to a desired location above the water surface. As described above, once the platform is at a desired elevation above the water surface, the platform can be welded to the base legs and the jacks can be removed.
In a preferred embodiment, the annulus 160 between each leg lower end and the recess wall is filled with a cementitious material such as grout to bond each leg to its respective support column. The annulus 160 can be filled with grout either before or after the platform is jacked to its desired elevation above the sea surface.

To provide for injecting grout into the recess 160, a grout inlet pipe 162 is provided through the wall of the recess extending into annular space 160. Additionally, a return pipe 164 is provided at about the top of the recess for return of grout and for venting the recess.

In some instances, as described above, it can be desirable to reuse the deck module and/or the base module at several different offshore locations. Provision, therefore, may be made in practicing this invention for safe removal of the deck module 130 from the base module 134 after the overall structure has served its function at a particular location.

Referring now particularly to FIG. 22, a deck leg 138 is shown with its lower end 142 in supportive registry with the recess 144 of the base column 140. Grout 170 is in the annulus 160 bonding the lower end of the deck leg to the base column.

Preferably, the deck module is removed from the base module by lowering the platform 136 along its legs 138 so that landing pads 136a on the bottom of the platform are in contact with the upper ends of the base module support columns. Conventional jacking mechanisms 146 used for jacking platform 136 upwardly along legs 138 are essentially uni-directionally operable mechanisms in that they are designed for
lifting a load upwardly along legs 138; they can be used to lower the platform along legs 138 with the assistance of gravity, but they cannot be used to apply substantial upward force on the legs relative to the platform. Therefore, an auxiliary jacking mechanism 175 is provided in association with each conventional jacking mechanism 146 for forcefully jacking legs 138 upwardly relative to platform 136. Auxiliary jacks 175 are operated, after the platform engages columns 140 via pads 136a, to urge the legs upwardly relative to the platform sufficiently to break the bond provided by the grout 170 between each leg and its respective base module support column. This procedure ensures that the legs are free to be raised from the recesses.

The deck module platform 136 is then raised on its legs 138, by use of jacking mechanisms 146, to a selected height above the water surface and a vessel suited for receiving and supporting the deck module via the platform is then moved into position underneath the deck module. The platform is then lowered on its legs into supportive registry of the deck module by the vessel. The legs are then raised relative to the deck module platform, as by use of auxiliary jacking mechanisms 175, thereby raising the leg lower ends 142 out of registry with the recesses 144 at the top of the base module support columns. The vessel carrying the disengaged deck module can then be removed from the vicinity of the base module.

In the event it is desired to reuse the deck and base modules at a different offshore location at a moderately different water depth, no changes need be made to the deck module. It is a simple matter to shorten the base module column height to adjust
for reduced water depth, or to extend the legs a moderate amount consistent with the strength of the base module as initially constructed and consistent with the dynamic loads anticipated at the new offshore location.

This concept allows both the base and the deck to be constructed at the same time and in different locations. The deck equipment can be installed and checked out on shore, thereby eliminating hookup costs. Platforms of this type can be designed to meet a wide range of conditions, from the calm waters of Indonesia to the rough waters of the North Sea. The concept offers great potential savings in those instances where time is at a premium and on-site installation costs are otherwise unduly high.
CLAIMS:

1. An offshore platform for installation and use at a location in a body of water characterised by:
   (a) a unitary base module (11 or 50 or 90) adapted to rest on the bottom of the body of water and extend upwardly therefrom to adjacent the surface of the water body, the base including:
      (i) a buoyancy chamber (20 or 58 or 94) adapted to permit the base to be moved to a desired location in a condition of positive buoyancy and to be flooded at the location to a condition of negative buoyancy so as to sink and rest on the bottom; and
      (ii) at least three columns (24 to 27 or 54 to 57 or 71 to 74 or 96 or 140) extending from the buoyancy chamber upwardly to adjacent the water surface; and
   (b) an independent deck module (12 or 52 or 130) adapted to be separately moved to and positioned in engagement with the upper end of the base columns (24 to 27 or 54 to 57 or 71 to 74 or 96 or 140) and including jack means (146) for lifting the platform a desired distance above the water surface after engagement thereof with the base columns.

2. An offshore platform as claimed in Claim 1 wherein the deck module has legs (18 or 53 or 118 or 138) equal in number and arrangement to the number and arrangement of the base columns and wherein said deck module legs are alignable with the base columns whereby said deck module legs are engageable with and supportable by the columns for permitting the deck to be elevated above the water surface in response to operation of the jack means.

3. An offshore platform as claimed in Claim 2 wherein the support columns are of such length that the top of each
column is disposed above the water surface when the base module is sunk to the bottom at the location, each support column having an upwardly open, vertically elongate recess (120 or 144) in its top, aligned parallel with the axis of the support column, and said legs are deck module mounted to the platform for movement vertically relative to the platform, each leg being arranged at its lower end for supportive registry within the upwardly open recess (120 or 144) of a corresponding support column when the deck module is in position above the base module at the location, and said jack means is operatively co-operative between the platform and the legs and operable for driving the platform relatively along the legs so that the platform can be elevated above the water surface on the legs following supportive registry of the legs with the base module supported on the bottom.

4. An offshore platform as claimed in Claim 3 wherein the recesses and leg lower ends are co-operatively arranged to define an annular space (144) between each leg lower end and the wall of the corresponding recess when the leg is supportively registered in the recess, and means (162, 164) for inserting grout into the annular space.

5. An offshore platform as claimed in any preceding claim wherein the base module additionally comprises an anti-scour skirt (98) fixed to the sides of the buoyancy chamber, the skirt extending around the periphery of the buoyancy chamber and extending therebelow.

6. An offshore platform as claimed in Claim 5 wherein the anti-scour skirt comprises a plurality of upwardly and downwardly open receptacles (100) carried by the base module substantially around the periphery thereof adjacent its lower extent, and a plurality of skirt elements (102)
adapted to be inserted into and be supported in the receptacles in fixed relation to the base module with the lower ends of the skirt elements disposed below the lower extent of the base module.

7. An offshore platform as claimed in Claim 5 or 6 wherein the skirt elements are designed for insertion into the receptacles following construction and floating of the base module.

8. An offshore platform as claimed in any preceding claim wherein the buoyancy chamber (20) is of box beam construction and defines the lower extremity of the base module.

9. An offshore platform as claimed in any preceding claim 1 to 7 wherein the buoyancy chamber (58) is a hollow mat member defining substantially the entire bottom area of the base module.

10. An offshore platform as claimed in claim 9 wherein the hollow mat member has an opening therein between two of the upwardly extending support columns to permit the base module to be installed substantially around an existing sea bottom installation.

11. An offshore platform as claimed in any preceding claim wherein the deck module carries desired operation equipment (14, 15, 61) prior to engagement with the base module.

12. An offshore platform as claimed in any preceding claim wherein the deck module is non-buoyant.

13. An offshore platform as claimed in any preceding
claim wherein the position of the center of gravity (154) of the deck module platform is about equidistant from a first and a second leg (138a and 138b) and the distance from the position of the center of gravity to the first and second legs is less than the distance from the position of the center of gravity to each remaining leg.

14. An offshore platform as claimed in Claim 13 wherein there are four horizontally spaced apart vertically disposed legs mounted to the deck module platform.

15. An offshore platform as claimed in claim 14 wherein the base and deck modules are of generally rectangular planform configuration, and the support columns and the legs are disposed adjacent the corners of the respective module.

16. An offshore platform as claimed in claim 3 or claim 3 and any one of claims 4 to 15 wherein the jack means are operable for positively driving the legs both upwardly and downwardly relative to the deck module platform.

17. An offshore platform as claimed in any preceding claim including a buoyant vessel (44 or 64 or 132) for supporting and transporting the deck module to the location, the vessel including quick-retracting support means (246) engageable with the deck module platform for supporting the platform on the vessel, the support means being operable for quickly removing support of the platform by the vessel and for providing between the platform and the vessel a selected clearance.

18. An offshore platform as claimed in claim 17 wherein the selected clearance provided between the deck module platform and the vessel upon operation of the support means is at least equal to that distance equal to the decrease in
draft of the vessel upon removal of the load of the deck module from the vessel plus an additional distance related to motion of the vessel in response to action upon the vessel of waves having a height, period, and direction not in excess of predefined height, period, and direction.

19. An offshore platform as claimed in claim 17 or 18 wherein the quick-retracting support means comprises movable wall means (146) carried by the vessel movable into and out of a co-operative relation in which the wall means define an upwardly open enclosure, a quantity of sand (150) disposed in the enclosure and extending thereabove for supportive engagement with the deck module platform for supporting the deck module on the vessel, and quick-acting means operable for holding the wall means in said co-operative relation and for affording quick movement of the wall means out of said co-operative relation.

20. An offshore platform as claimed in any preceding claim wherein said base includes a second buoyancy chamber structurally supported a predetermined height above the first said buoyancy chamber, the two buoyancy chambers being adapted to permit the base to be floated with a selectable one of the buoyancy chambers adjacent the water line and to be flooded at the location so as to sink so that the lower buoyancy chamber rests on the bottom.

21. A method of constructing and erecting an offshore platform characterised by:

(a) fabricating a buoyant base module having support columns extending upwardly to upper ends located above the bottom of the base by a distance substantially equal to the water depth at an offshore location of the platform;

(b) separately fabricating a deck module;
(c) floating the base module to the offshore location;
(d) rendering the base module non-buoyant to cause it to settle and rest on the bottom with the support columns extending upwardly to adjacent the water surface;
(e) transporting the deck module from its place of fabrication to the offshore location and there disposing it over and in engagement with the base columns; and
(f) elevating the deck module above the water surface.

22. A method as claimed in claim 21 wherein the base module is fabricated in a shipyard and is launched in a positively buoyant and hydrodynamically stable condition.

23. A method as claimed in claim 21 or 22 wherein the base module is floated and towed to the offshore location in a vertical orientation.

24. A method as claimed in claim 21, 22 or 23 wherein the support columns are fabricated to extend upwardly so that the height of the base module from the top of the support columns to the lower extent of the base structure is a small selected amount greater than the water depth at the selected location and so that each support column has an upwardly open, vertically elongate recess at its top aligned parallel with the axis of the support column, the deck module is fabricated so as to comprise a plurality of legs carried by, and vertically movable relative to the platform, the number of legs being equal to the number of base module support columns and arranged at their lower ends for supportive registry with the recesses of the respective base module support columns, the deck module is disposed with the lower ends of the deck module legs in supportive registry with the base module support columns.
via the recesses and the deck module platform is then elevated on the legs to a selected elevation above the water surface.

25. A method as claimed in claim 24 wherein the lower ends of the deck module legs and the base module support column recesses are co-operatively configured to define an annular space around the leg lower ends upon supportive registry of the leg ends in the recesses, and including the further step of filling each annular space with a cementitious material after disposition of the leg lower ends in such supportive registry to bond the legs to the support columns.

26. A method as claimed in claim 24 or 25 including the steps of:

(a) fabricating the deck module so that its center of gravity is located closer to first and second ones of the legs than to each remaining leg; and

(b) disposing the leg lower ends in registry with the base module support column recesses by engaging the lower ends of the first and second ones of the legs in supportive registry with their corresponding recesses before engaging the lower ends of the remaining legs with their corresponding recesses.

27. A method as claimed in claim 24 or 25 including the further steps of ascertaining the maximum dynamic load which can be applied by a leg to a support column in the course of disposing the leg in registry with a support column recess and determining the velocity productive of such maximum dynamic load, and moving the leg lower ends into registry with the support column recesses under conditions in which the downward velocity of the legs is less than the determined velocity.
28. A method as claimed in claim 24 or 25 comprising disposing a quantity of sand in the lower extent of such an elongated recess at the top of each such support column before disposing the leg lower ends in supportive registry with the recesses.

29. A method as claimed in claim 24 or 25 comprising, after floating the base module, installing an anti-scour skirt on the base structure of the base module, said anti-scour skirt extending below the bottom of the base structure substantially around the perimeter thereof.

30. A method as claimed in claim 24 or 25 comprising transporting the deck module to the selected location by supporting the deck module on a floating vessel via support mechanisms which locate the deck module platform a selected distance above the vessel deck and which are quickly operable to remove support of the deck module by the vessel and to provide substantial clearance between the platform and the vessel deck; and after disposition of all legs in supportive registry with the support column recesses, operating the support mechanisms to remove support of the deck module by the vessel.

31. A method as claimed in claim 24 or 25 wherein four horizontally spaced apart vertically extending legs are carried by the deck module platform.

32. A method as claimed in claim 25 comprising removing the deck module from the base module at a desired time by the steps of:
   (a) lowering the deck module platform along its legs into contact of the platform with the upper ends of the base module support columns;
   (b) urging each leg upwardly relative to the
platform sufficiently to break the bond between each leg and its respective base module support column, thereby to ensure that the legs can be raised from the recesses; and thereafter
  
  (c) removing the deck module from the base module.

33. A method as claimed in claim 32 wherein the step of removing the deck module from the base module includes the further steps of:

  (a) raising the deck module platform on its legs to a selected height above the water surface;
  (b) moving into position under the platform a vessel adapted for receiving and supporting the deck module via the platform;
  (c) lowering the platform on its legs into support of the deck module by the vessel; and
  (d) raising the legs relative to the deck module platform to raise the leg lower ends out of registry with the recesses at the tops of the base module support columns.