Jack-up type offshore platform apparatus has "multiple-stage" feature permitting use in water depths greater than 300 feet, e.g. 600 feet or more, under 100-year storm conditions. Either a mobile type rig or a self-erecting permanent type platform structure is provided. Apparatus includes a floatable upper or working platform to be jacked out of water, one or more lower support platforms each functioning as a weight support and as a lateral bracketing structure when the apparatus is erected, a plurality (three or more) of 300 feet long upper support legs permanently attached at their lower ends to each lower platform and whose upper ends are slidable through, but attachable to the next platform thereabove, and a plurality of independently movable lower support legs whose upper ends are slidable, but attachable to the lowermost platform and whose lower ends rest on the sea bottom. Lower stages widen progressively for increased stability. Stages telescope, the lower platforms nesting with the upper platform, and all support legs projecting above water level, when rig is collapsed and floating. Buoyancy tanks on lowermost legs permit use of winch and cable devices or low-powered jacks for raising and lowering same, and buoyancy tanks in each lower platform permit use of low-powered jacks for raising and lowering platforms, including upper platforms. Telescopic air or compressed gas operated jack, 145 feet long and having expansible movement of 105 feet, is attached at lower end of each lower support leg in one embodiment, and is also useful on modified form of jack-up offshore platform for intermediate depths.
This invention relates to offshore platform structures of the type from which operations, such as oil-well drilling operations, are conducted in coastal waters and other sea areas. More particularly, the invention relates to such platform apparatus as is of a self-erecting, so-called "jack-up" type and which is floated to an offshore site and set by hoisting its operations platform to a height above the level of the water after its support legs have been lowered to rest on the sea bottom.

BACKGROUND OF THE INVENTION AND THE PRIOR ART

It is currently believed that the depths of water in which such jack-up rigs may be positioned and used are limited to about 300 feet and that, when drilling is to be conducted in deeper waters, especially in hurricane-prone locations such as the Gulf of Mexico and in other locations such as the North Sea where severe wave and wind action may be expected, either a so-called "semi-submersible" type platform, or a floating type platform such as a drillship or barge, must be used. However, jack-up type platforms have certain advantages over semi-submersible or ship type platforms, which could be utilized if jack-ups could be safely positioned and used in the deeper water. For example, drilling operations may be conducted from a jack-up rig virtually continuously as compared with operations from a semi-submersible or a floating type platform, both of which are more susceptible to severe wind and wave action caused by storms and the like. Thus, downtime is minimized, resulting in lower average costs of drilling operations. Moreover, the initial cost of a jack-up type platform is far less than that of a semi-submersible rig, which is considered to be the next best type of platform, but the most expensive, from which to conduct deepwater operations.

Although semi-submersibles are used in depths up to about 1,000 feet and drillships can be used in even deeper waters, when on site ready for drilling, semi-submersible platforms and drillships are subject to considerable rolling, heaving and pivoting motion, and to drifting off location due to winds, tides, currents and the like. Both must rely upon heavy anchors and/or electronically controlled thruster devices to keep them accurately in position over the hole being drilled in the sea bottom. Downtime, when it is not possible to drill because of sea conditions, may average from 12 to 25 percent of the time. Moreover, semi-submersibles require frequent adjustment of ballast due to displacement differentials resulting from changes in equipment and consumables, and are more limited with respect to the amount of consumables they can carry as compared with drillships and jack-up platforms.

Considering that the working platform is positioned some fifty or sixty feet above the water when the structure is erected, existing mobile jack-up rigs usable in depths up to about 300 feet of water have support legs, extending from the sea bottom to the elevated platform, which may be almost 400 feet long. Such length is considered a maximum due to the higher bending moments generated by increased length when the structure is supported on the sea bottom, and due to stability problems when the rig is floating as are attributable to the upward projection of the raised legs some 350 feet and the resulting dynamic forces created when the rig rolls in a seaway.

Moreover, although self-erecting platforms may have been installed as permanent platforms in shallow water, it has been believed that such floatable jack-up type apparatus cannot be successfully employed for providing a self-erecting, permanent platform or template in deep water of 300 feet or more for reasons including those for which mobile jack-up type rigs have not been used in working such depths. Thus, it has been believed necessary to build such structures in place by floating either the prefabricated template or its separate components, such as its extremely long support legs, to the drill site in horizontal position and then, by appropriate ballasting and flooding, to tip the template or leg to a vertical position and sink it to the ocean floor. Conventional piling is driven using additional special equipment brought to the site, and a working platform is built on the support at the appropriate elevation above sea level. It is apparent that such known technique for erecting a permanent platform in deep water is a very costly and time-consuming procedure.

Jack-up type offshore platform structures and supporting leg assemblies as are known are, for one reason or another, inadequate to provide either a mobile or permanent type offshore platform from which underwater drilling operations can be conducted in waters deeper than about 300 feet. The striking evidence of this is that, insofar as is known, no jack-up type rig is presently used in such circumstances. Of the known jack-up rig arrangements, some provide underwater bracing which, when the rig is erected, extends laterally because their support legs at a depth corresponding approximately to the midpoint of their lengths, with or without additional similar lateral bracing adjacent the sea bottom. In this regard, U.S. Pat. Nos. to Sudorow 3,013,396, Rechlin 2,771,747, and Samuelson 2,589,146 are probably most pertinent. However, the support legs which are braced by the usually unattached lateral bracing extend continuously from the upper or working platform to the sea bottom and are therefore subject to the aforementioned length limitation, or are telescopic leg or piling arrangements which are inadequate to provide the required stability for operation in depths greater than 300 feet. For example, in the aforementioned Sedorow patent the submerged lateral bracing structure which is provided is in effect, "sling" below the upper platform, and is not intended to itself contribute to the support of the weight of the overall structure. It is not apparent from this or any prior concepts that, by rearrangement of the lateral bracing structure with respect to the leg structure extending thereafterabove and therebelow, the bracing can additionally serve as a major point of weight support of the erected structure as a whole, which can then have at least twice the height of known structures of the type. Nor is it apparent that greater height can be provided by additional tiers of such support bracing structure is erected.

Moreover, although the disposition of buoyancy tanks on the support legs of such structures is known, as described for example in Sudorow U.S. Pat. No. 3,980,446 and Rybicki U.S. Pat. No. 3,367,119, it has not been appreciated how such feature, or the additional disposition of buoyancy tanks on such rearranged lateral bracing structure itself, can contribute to the capability of these structures of being placed in...
3,797,256

depths of water over 300 feet, as well as to the stability of the rig when floating. The referred to Suderow and Rybicki patents also generally disclose so-called “wave-transparent” constructions for such support legs, as is also a feature of the apparatus to be described herein.

Similarly, and although the leg assemblies for such jack-up structures have been previously made in the form of telescopic columns which are extended and retracted by internal or external jack mechanisms such as described for example in Suderow U.S. Pat. No. 2,984,075 and Suderow U.S. Pat. No. 2,961,837, it has not been apparent that such support legs can incorporate as a part of their overall length a very elongated pair of telescoping cylinders which function in uncomplicated manner as pneumatic jacks for equalizing the support provided by each leg and consequently the level disposition of the working platform, and for lifting the entire structure, including the working platform, after the legs have been positioned on the sea bottom.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is intended by the present invention to provide a floatable jack-up type offshore platform apparatus having a plurality of support legs, each of length within the aforementioned maximum limitation of about 400 feet, which can be safely towed or self-propelled at sea to a drill site, and set on the sea bottom and operated safely in water depths significantly greater than 300 feet, e.g. in water depths of 600 feet or more, under extreme conditions of wind and sea, such as so-called 100-year storm conditions and the like.

Although the invention was made in connection with efforts to improve mobile-type offshore platforms which are positioned temporarily for relatively short periods of, say, several months and then refloated and moved to another location, in a modified form the invention also appears well-suited for use as a permanent-type offshore platform structure which would be intended for installation at a particular site for a relatively long period of perhaps more than 10 years, but which is not self-propelling. Such permanent offshore platforms are utilized as drilling and production platforms for gas and oil wells which have been located previously by exploration drilling operations conducted from mobile jack-up or floating type platforms. These permanent drilling and production platforms, called templates, are normally of heavier construction because they will remain on site for such considerable periods of time, and are usually pinned to the ocean floor by means of piles. To avoid the very high costs, and to shorten the erecting time involved in the building of such permanent platforms, it is intended by the present invention to provide a permanent type offshore platform structure which is of the self-erecting type, yet which can be placed safely in deep water for such long periods of time. Thus, the self-erecting permanent type platform can be towed to the site with all equipment aboard, including fuel, drilling mud, drill pipe, casings and the like, as well as the equipment required for the self-erecting of the unit, and fully erected within a comparatively short time of a week or so as compared to several months for a built-in-place structure.

More particularly, and whether the jack-up type apparatus is of the mobile or permanent type, it is intended that it be seaworthy and capable, in its erected condition, of withstanding the most severe wind, wave and ocean current conditions as are experienced in the North Sea and the Gulf of Mexico. That is, it is believed that apparatus in accordance with the invention can safely experience winds up to 120 knots, waves as high as 100 feet, and currents in excess of 4 knots on the surface as would be created by 120 knot wind, as occur in the North Sea. Since hurricane conditions are less severe, the apparatus should also operate safely in the Gulf of Mexico.

It is further intended by the present invention to provide features in jack-up type offshore platforms which will reduce the power requirements for raising and lowering the platform support legs, lateral bracing, and perhaps of the working platform itself. Thus, a winch and cable arrangement, rather than conventional but more expensive hydraulic or mechanical jacks, can be used, or the sizes and therefore the costs of the conventional type jacks can be reduced.

Moreover, certain of the inventive features may be utilized to provide a jack-up type offshore platform especially adapted for use in intermediate water depths in the range of from about 300–450 feet under normally anticipated wind and sea conditions, and possibly as deep as 500 feet in relatively calm waters when severe storms are not anticipated. These platform structures might also be either of the mobile or permanent platform type.

Briefly describing the floatable jack-up type offshore apparatus which is provided by the invention, the apparatus may be characterized as having a plurality of “stages,” in vertical tandem arrangement, each supported on another when the rig is fully erected on the sea bottom and arranged for telescopic collapse with the other stages when the rig is in floating condition. In the erected condition, the uppermost stage supports an upper platform at an elevation of about 50 or 60 feet above the water level from which work operations, such as oil-well drilling operations, are conducted. The upper platform is buoyant for floating the entire apparatus.

In addition to the floatable upper or working platform, the apparatus includes one or more so-called lower platforms, each preferably having only a truss-like construction for carrying out its function as both a structural support and a lateral bracing structure when the apparatus has been erected. A plurality of three or more so-called upper support legs are permanently attached at their lower ends to project upwardly from each of the lower platforms, their upper ends being slidable through, but attachable to the next platform thereabove. In addition, a plurality of three of more independently movable, so-called lower support legs for directly supporting the structure on the sea bottom are mounted on the lowermost of the platforms, their upper ends being slidable through, but attachable to the platform, and their lower ends resting on or penetrating the sea bottom when the structure is erected.

The stages are arranged for telescopic movement with respect to each other such that the lower platforms nest against each other and against the underside of the upper platform when the rig is floating, all of the support legs then projecting above the water level. It is contemplated that each of the support legs in each series of upper support legs and in the group of lower sup-
port legs will be at least 250 feet long, or perhaps as long as the present state of the art will permit in such floatable rigs, and thus the rig will be capable of being placed in depths corresponding to multiples of such length. The support legs, as well as the lower platforms, are all of essentially open latticework construction, such that they may be characterized as “wave-transparent” and thus minimize wave forces thereon.

Although each of the lower platforms to which the referred to support legs are attached may have entirely rigid construction, in one embodiment limited vertical movement of the leg structure at each corner of the platform, with respect to the platform itself, is afforded by an associated vertically slidable portion of the platform to which the leg structure is attached. This limited movement is to provide leveling adjustment at the platform to compensate for irregularities of elevation of the sea bottom as might otherwise cause the referred to lower platform to have a canted rather than level disposition, as where one or more legs would be disposed at a higher or lower elevation than intended. The movement of each movable portion is independent of any movement of the others and is powered by hydraulic jack actuators, disposed between the movable portion and the main body of the platform, and controlled from the upper or working platform.

In the preferred embodiment, each of the lower platforms is provided with buoyancy tanks, so that it is at least partially buoyant at all times for the purpose of reducing its effective weight, and therefore the power required to submerge and raise it. These buoyancy tanks are effectively provided at the lower ends of the aforementioned upper support legs which are permanently attached to the platform. Additional buoyancy tanks can be provided to render each lower platform floatable so as to reduce the displacement requirements of the floatable upper platform when the rig is floating, these additional buoyancy tanks being floodable to assist in submerging the platform.

Buoyancy tanks are also provided on the lower ends of the lower support legs, and preferably also on their upper ends, to render each leg partially buoyant and thereby reduce the power requirements for submerging and raising the leg. Thus, less expensive and more dependable winch and cables can be used to raise and lower each of these independently movable lower support legs. Alternatively, remotely controlled, low-powered, underwater-jack-type jacks can be used, these being situated on the lower platform on which the lower legs are mounted.

If jacks are mounted on the lower platform to raise and lower the lower legs, they may instead be high-powered so that, after the lower legs are set on the sea bottom, they can be operated in unison to raise the lower platform on the lower support legs, thus lifting the upper platform attached to the upper support legs, to the desired elevation above the water surface.

In a modified embodiment, each lower support leg is furnished with a pneumatic or compressed gas operated jack by telescoping cylinder portions of the leg, preferably at its lower end. These leg jacks are similarly used to set the lower legs and jack up the entire structure to position its upper platform above the water level. Devices are provided for locking the telescoping cylinders together in their several relative positions, and compressed air or gas inlet means, and a valve opening for flooding the cylinders at appropriate times, are provided. One of the locking devices provides a plurality of annularly spaced apart, radially outward projecting ratchet paws on the inner cylinder for engaging respective ratchet pins on the interior wall of the outer cylinder to prevent the lower inner cylinder from moving upwardly with respect to the outer cylinder, and respective, radially outward slidable wedges on the inner cylinder associated with each of the ratchet paws to engage respective stops on the outer cylinder to concurrently prevent movement of the cylinders in opposite direction. Different arrangements of such elongated, air-jack type support legs in the overall structure are contemplated.

The invention may be adapted for use as a permanently installed type of platform structure, but which may be fully assembled and loaded with equipment in advance, and towed to the site where it is easily self-erected in the same manner as a mobile type jack-up rig. In such embodiment, all of the components are of more rugged or durable construction, and the referred to lower legs preferably have hollow cylindrical, rather than open latticework construction, and are adapted for driving self-contained piles into the sea bottom from its lower end. As in the previous embodiment, the lower ends of these lower support legs are provided with buoyancy tanks to assist in floating the apparatus, but these tanks are flooded for improvement of the stability of the permanent installation after the leg is lowered to the sea bottom. Each hollow cylindrical leg is also at least partially filled with concrete in order to further increase its stability, and to permanently set the driven piles which pin it to the sea bottom.

DETAILED DESCRIPTION OF THE INVENTION

These and other objects, features and advantages of the invention will be more fully apparent from the following detailed description thereof, when taken in conjunction with the accompanying drawings in which:

FIG. 1 is an elevational showing, partially in cross-section, of a mobile jack-up type offshore platform apparatus in accordance with the invention, the rig being shown in floating condition;

FIG. 2 is a top plan view of the apparatus of FIG. 1, with certain features removed for clarity;

FIG. 3 is an illustration, also partially in cross-section, of the mobile jack-up type drilling rig apparatus of FIG. 1 in its “jacked-up” condition, supported on the sea bottom ready for drilling, but with drilling equipment and the like removed for clarity;

FIG. 4 is a further illustration of the apparatus of FIG. 1, also partially in cross-section, showing the apparatus as it would appear during an intermediate stage of the self-erecting procedure;

FIG. 5 is a sectional plan view, as seen from lines 5—5 in FIG. 4, illustrating the lower platform structure of the apparatus of FIG. 1;

FIGS. 6, 7 and 8 are diagrammatic side-sectional illustrations of the lower platform structure of FIG. 5, showing several possible conditions of the structure during the self-erecting procedure;

FIG. 9 is an enlarged fragmentary plan view, partially in cross-section, of only one corner of the lower platform structure of FIG. 5, to illustrate its operation;

FIG. 10 is a similarly enlarged fragmentary elevational view as seen from lines 10—10 in FIG. 9;

FIG. 11 is an elevational showing, partially in cross-section, of a modified form of mobile, jack-up type off-
shore platform apparatus in accordance with the invention, the rig being shown in floating condition;

FIG. 12 is an illustration, also partially in cross-section, of the mobile jack-up type drilling rig apparatus of FIG. 11 in its "jacked-up" condition supported on the sea bottom ready for drilling, but with drilling equipment and the like removed for clarity;

FIGS. 13–17 are enlarged elevational and fragmentary sections of the cross-section, of the lowermost support legs of the apparatus of FIG. 11, to illustrate the various conditions thereof during the self-erecting and refloating procedures, certain features of the support leg being removed for clarity;

FIG. 18 is a further enlarged and fragmentary elevational showing, in cross-section, of the lowermost support legs of the apparatus of FIG. 11 to illustrate a step in the refloating procedure, certain features of the support leg being removed for clarity;

FIGS. 19–22 are still further enlarged and fragmentary, cross-sectional illustrations of the lowermost support legs of the apparatus of FIG. 11 to illustrate the means by which the movable parts thereof are located in position; FIG. 19 being an elevational showing; FIG. 20 being a sectional plan view as seen from lines 20–20 in FIG. 19; FIG. 21 being a fragmentary sectional plan view as seen from lines 21–21 in FIG. 19; and FIG. 22 being a fragmentary side-sectional elevation as seen from lines 22–22 in FIG. 19;

FIG. 23 is an elevational showing, partially in cross-section, of a modified form of mobile, jack-up type offshore platform apparatus, the rig being in floating condition;

FIGS. 24 and 25 illustrate the offshore platform apparatus of FIG. 23 in several stages of the self-erecting procedure;

FIG. 26 is an elevational showing, partially in cross-section, of another modified form of jack-up type offshore platform apparatus in accordance with the invention, but intended for substantially permanent installation at an offshore site, the rig being shown in floating condition;

FIG. 27 is an illustration, also partially in cross-section, of the jack-up type offshore platform apparatus of FIG. 26 in its "jacked-up" condition, supported on the sea bottom but only partially readied for drilling, with drilling equipment and the like removed for clarity;

FIG. 28 is a further but fragmentary illustration of the apparatus of FIG. 26, also partially in cross-section, showing the apparatus as it would appear during an intermediate stage of the self-erecting procedure;

FIG. 29 is an enlarged, fragmentary and sectional plan view as seen from lines 29–29 in FIG. 27, to illustrate the construction and features of the lower support platform structure of the apparatus of FIG. 26;

FIG. 30 is an enlarged fragmentary side-elevational showing, in cross-section, of only one corner of the apparatus of FIG. 26 to illustrate certain of its features, the apparatus being in floating condition;

FIG. 31 is a fragmentary cross-sectional elevation, to a slightly reduced scale as compared with FIG. 30, showing the same corner of the apparatus at an advanced stage of the self-erecting and positioning procedure;

FIG. 32 is an enlarged plan view in cross-section as seen from lines 32–32 in FIG. 31;

FIG. 33 is a greatly enlarged and fragmentary elevational view, in cross-section, as seen from lines 33–33 in FIG. 32;

FIG. 34 is a view similar to FIG. 33, but showing the apparatus as it appears when finally positioned on the sea bottom; and FIG. 35 is a diagrammatic side-sectional elevation, to a reduced scale, illustrating a further modified form of jack-up offshore platform apparatus in accordance with the invention, in which the apparatus has three stages.

Referring first to the embodiment of the invention as illustrated in FIGS. 1–10, a two-stage mobile, jack-up type offshore platform apparatus in accordance with the invention is generally indicated by reference numeral 50, and includes a floatable working or upper platform 51 on which oil-well drilling apparatus (generally indicated by reference numeral 52) is mounted. FIG. 3 shows the platform 51 disposed some 50 to 60 feet above sea level S when the rig 50 is in erected condition at an offshore drilling site. The platform measures about 210 feet by 170 feet, and may also include a helicopter landing deck measuring some 75 feet by 60 feet, as indicated by reference numeral 53. Other conventional features and equipment (not shown) may be disposed on the platform 51 for conducting drilling operations. In addition to the platform 51 (which will also be referred to herein as the "upper" platform) the apparatus 50 includes four laterally spaced apart, vertically extending, upper support legs generally indicated by numeral 54, a horizontal lower support platform structure generally indicated by numeral 55, and four laterally spaced apart, vertically extending, lower support legs, generally indicated by numeral 56. Although the apparatus 50 is shown as having four upper support legs 54 and four lower support legs 56, and only one lower support platform 55, it will be understood that the apparatus might be provided with only three, or more than four, upper support legs, and three, or more than four, lower support legs, and that the number of upper legs and lower legs need not be equal.

In addition, and as generally illustrated by FIG. 35, the apparatus may include more than the two stages illustrated in the FIGS. 1–10 embodiment, considering that each additional stage would comprise a plurality of upper support legs such as the legs 54 of FIGS. 1–10, attached to another lower support platform such as the structure 55. Of course, the platforms 51 and 55 need not have rectangular configuration and, if square or polygonal, need not have their respective corners in vertical alignment. As indicated in FIG. 2, the lower support platform 55 preferably is larger in length and width than the upper platform 51.

The lower support platform structure 55 is nestable at the underside of the upper platform 51 when the apparatus or rig is in floating condition, a portion of the lower platform structure fitting within an appropriately recessed structure of the upper platform, as generally indicated by reference numeral 55a. Any additional lower support platform structures below the platform 55 (as illustrated in FIG. 35) would similarly be nestable at the underside of the platform 55. Alternatively, and as is also considered a nestable arrangement, progressively larger dimensioned and floatable lower support platform structures might be disposed in concentrically surrounding relation to the upper platform when the rig is floating. In any event, the nestable relationship between the upper platform and the one or
more lower support platform structures of the rig provides a shallower draft for the floating rig as a whole, and improves its movement characteristics as it is either self-propelled or towed through the water.

Referring briefly to FIG. 4 as compared with FIGS. 1 and 3, it will be understood that each of the lower support legs 56 is vertically movable with respect to the lower support platform 55, independently of each other leg 56. Each is slidable through a vertical guide structure 57 of the platform 55, one of the guide structures 57 being disposed at each of the four corners of the structure 55 in the embodiment shown. When positioned either in its fully raised position or in any lowered position with respect to the platform structure 55, each lower support leg 56 can be rigidly locked in position by suitable locking devices which are only diagrammatically illustrated at reference numbers 57a in FIGS. 2, 5 and 9, these locking means being mounted on the respective guide structures 57.

However, each of the upper support legs 54 is rigidly and permanently attached at its lower end 54a to the lower support platform 55 and, at its upper end, is slidable through the upper platform 51. Each may be securely locked in any vertical position, as by a locking device as ordinarily incorporated in the associated jack assembly 58 which is used to raise and lower the leg from the upper platform 51. Thus, the upper support legs 54 are structurally in fixed relation to the lower support platform 55 and when the apparatus is fully erected at a drill site, they are also in structurally fixed relation to the working platform 51, and therefore are subjected to much smaller bending moments than would be the case were the legs, though in fixed relation to the working platform, pin-ended at the sea bottom. Lighter upper support legs can therefore be incorporated in the structure of the present invention, such as might also be smaller in section to absorb lesser forces from the action of waves and undersea currents.

The length of each support leg 54, 56 can be from about 250 feet to the maximum permitted by the state of the art, i.e., presently about 400 feet. It will be noted that the lower support platform 55 functions not only as a direct support for the weight of the leg and platform structure thereabre, but also as a lateral bracing structure for the upper and lower support legs of the apparatus when in erected condition.

Although as previously indicated the lower platform or lateral bracing structure 55 to which the upper support legs 54 are attached may be rigid throughout its area, as will be especially apparent from FIGS. 6-10 provision may be made for limited vertical slidable movement of each of its corner portions at which the upper and lower legs are connected. These vertically slidable corner portions are generally indicated by reference numeral 59, and are movable within a limited range from about 15 feet above their laterally aligned location with respect to the central area 60 of the structure to about 15 feet therebelow, thus permitting accommodation for differences in penetration of the lower support legs 56 in the sea bottom.

For the purpose of adding buoyancy to the rig when in floating condition as illustrated in FIG. 1 as well as for providing effectively lighter weight when submerged, the platform structure may be provided with respective pairs of buoyancy tanks 61 and 62 at each of its corner portions, as perhaps best understood by reference to FIGS. 5 and 9. Each buoyancy tank 61 is attached to the lower end of an upper support leg 54, and each buoyancy tank 62 is formed in surrounding relation to one of the aforementioned vertical guide structures 57 through which a lower leg 56 is slidable. Referring particularly to FIG. 9, each set of buoyancy tanks 61 and 62 form a part of a vertically movable corner portion 59 of the structure 55, the corner portion 59 being vertically slidable with respect to the central area or frame portion 60 by means of the four vertical slides 63. In addition, means (not shown) are provided for alternate flooding and emptying of buoyancy tanks 62 when submerging and raising the platform 55, and for flooding and emptying buoyancy tanks 61 to preload the structure during the setting operation.

In an alternative arrangement (not shown) only the buoyancy tanks 62 might be vertically slidable with respect to the central area frame 60, the buoyancy tanks 61 and upper legs 54 then being rigidly attached to the central area frame 60. Of course, as is still another alternative, depending upon particular design conditions either the tanks 61 or the tanks 62, or both sets of tanks, may be eliminated.

Lacking of one or more of the vertically movable corner portion 59 is controlled by conventional hydraulic jacking actuators 65 at either side thereof which, together with the vertical guides 63, form the connection between each movable corner 59 and the central area frame 60 of the structure 55.

Referring again to FIGS. 1, 3 and 4, each lower support leg 56 has a buoyancy tank 70 at its lower end and, preferably, a second buoyancy tank 71 at its upper end. As will be best understood from FIG. 3, the upper buoyancy tank 71 has the effect of stiffening the lower support leg along the portion thereof which is joined to the lower platform or structure 55 when the leg is in its lowered position. The lower buoyancy tanks 70, together with the buoyancy tanks 71, if included, have a size such that each leg is virtually weightless when submerged as shown in FIGS. 3 and 4. Thus, ordinary winch and cable arrangements 72, mounted atop the upper legs 54 but controllable by winches 72a on the upper platform 51, can be utilized in raising and lowering the independently movable lower support legs 56, thus eliminating very expensive hydraulic or mechanical jacks at each leg as would otherwise be required. Alternatively, smaller sized hydraulic powered jacks may be used, although the winch and cable arrangement is capable of faster operation.

It will further be noted that the lower platform or lateral bracing structure 55 is formed as a truss by open latticework construction excepting, of course, for the buoyancy tank structures 61 and 62. Similarly, the upper and lower support legs 54 and 56 are preferably formed by open latticework construction. Thus, all of the submerged portions of the offshore platform structure are characterized as having "wave-transparent" construction to minimize inertial effects of waves and the drag effects of subsurface currents. As a result, the forces acting upon the structure are reduced, either when standing on the sea bottom, or when floating with the lower legs and perhaps the upper legs in a downwardly extending condition. The reduction in such forces on the structure reduces the bending moment in each support leg when extending downwardly from the floating structure, and reduces the overturning moment on the structure as a whole when it is standing on the
The apparatus 50 is floated in the condition shown in FIG. 1 to an offshore drill site location, its lower legs 56 being pinned or locked by locking device 57a in their upper positions as shown, and its lower platform structure 55 being in floating or buoyant condition, nested against the underside of the floating platform 51. In this condition the buoyant tanks 62 as well as the buoyant tanks 61 are empty, so that the structure 55 does not detract from, but may add to the buoyancy of the apparatus as a whole. Contributing buoyancy is also furnished by the buoyancy tanks 70 at the lower ends of the lower legs 56. Rather than locking the lower legs 56 in their upper positions, they may be supported therein by the winch and cable arrangements 72.

Referring now to FIG. 4, when the floating unit arrives on site, the general contour of the hard sea bottom 80 on which its lowered legs will rest is first determined using conventional sonar devices or the like. It will be noted that, under usual circumstances, the legs may also be expected to pass through a relatively soft silt bottom 81 before engaging on the hard bottom 80. Lower legs 56 are then lowered from the still raised or floating structure 55 using the respective winch and cable arrangements 72. Each leg 56 is lowered independently of each other and to an extent such that, together, their lower ends generally conform to the contour of the hard sea bottom 80, whereupon each is pinned or locked to the structure 55 using the locking devices 57a. Buoyancy tanks 70 may be partially or fully flooded as the legs 56 are lowered. Alternatively, they may remain empty, unless they are of such size as to render the legs floatable such that the winches and cables 72 could not be used.

As previously noted, the lower ends 54a of the upper legs 54 are rigidly attached to the lower platform structure 55, so that the structure 55 together with the upper legs 54 can now be lowered with respect to the still floating upper platform 51, by conventional hydraulic or rack and pinion type jacks 55 mounted on the latter. At this time the buoyancy tanks 62 and 70 are at least partially flooded, making the structure 55 and the lower legs 56 virtually weightless when submerged. Thus, the lower legs 56, lower platform structure 55, and upper legs 54 are lowered as a unit until the lower legs 56 are in contact with the sea bottom. The operation of the jacks 58 is continued, thereby driving the lower legs 56 downwardly through the silt bottom 81 into engagement with the hard bottom 80, and thereafter jacking the upper platform 51 out of the water, on the upper legs 54, to the desired height above sea level.

To accommodate for differences in penetration of the legs in the sea bottom, and ensure disposition of the lower support structure 55 in horizontal position, the appropriate jacking actuators 65 (FIGS. 9 and 10) are actuated together with and for the same distance as the conventional hydraulic jacks located on the upper platform 51, to vertically move the associated corner portion 59 of the structure 55, together with the upper and lower legs attached thereto, upwardly or downwardly to the extent required to compensate for any difference in leg penetration from that which was anticipated. Of course, the upper leg 54 is detached from, and is slideable through the upper platform 51 during this operation, and it is therefore apparent that such vertical compensating movement of each support leg unit must be performed independently of any other such unit.

Referring now particularly to FIGS. 6, 7 and 8, it will be noted that, were there any difference in penetration between the respective legs from that which was anticipated by measurement of the contour of the hard sea bottom 80, all of the vertically slidable corner portions 59 of the structure 55 would remain and be locked in position with respect to the central area 60 in their laterally aligned positions as illustrated in FIG. 6, yet the anticipated penetration of one leg might be less than that required to drive the leg to refusal. Its associated movable corner portion 59a of structure 55, as shown in FIG. 7, would then be moved downwardly, appropriately to adjust the penetration of the leg to support the required load. A maximum distance of downward adjustment movement of fifteen feet is contemplated. Alternatively, and as illustrated in the left hand portion of FIG. 8, if refusal at one leg is reached before the anticipated depth of penetration, the pertinent slidable corner portion 59b may be raised, with respect to the central area 60 of the structure 55, a maximum of 15 feet to accommodate the lesser than anticipated penetration, thus permitting the central area frame 60 to assume a level condition. Where differences both upwardly and downwardly from anticipated penetration must be accommodated, and as illustrated both in FIG. 8 and in FIG. 3, any other lower leg may be concurrently jacked downwardly a compensating distance as much as fifteen feet, using the appropriate jacks 58 located on the upper platform 51. Upon completion of such levelling operations, the upper legs 54 are locked in their positions with respect to the platform 51 using locking devices which are ordinarily a part of the jacking devices 58 or using separate locking devices.

For preloading of the legs as is a normal procedure before conducting operations, or to resist overturning of the platform during storms, any or all of the buoyancy tanks 70, 71, 61 and 62 may be completely flooded with sea water using conventional flooding valves (not shown) operated from the upper platform 51. Of course, provision such as conventional water distributors or the like (not shown), would be made for emptying these tanks when the rig is to be raised. In addition, it will be noted that each of the lower legs 56 is provided with a dish-shaped footing 56a and, to aid in eliminating suction as would otherwise prevent raising of the lower legs from the sea bottom, conventional water lines and pumping means (not shown) would be provided to pump water below the bottoms of the footings 54a and around the top of the same. Of course, when restoring apparatus 50 to floating condition, the movable corner portions 59 of the structure 55 would be returned to their laterally aligned positions, as shown in FIG. 6, just prior to the nesting of the structure 55 at the underside of the floating platform 51.

It will be noted that the necessary movements of the upper legs 54 and lower legs 56 are imparted by conventional jacks or winches operated on the upper platform 51, and that all other equipment, such as that used for flooding and emptying any buoyancy tanks, relieving suction at the bottom legs, etc., is also operated from the upper platform 51. Pulleys 72b, atop legs 54, are removable.

However, and as previously indicated, the apparatus 50 may be modified by eliminating the movable corner
portions 59 of the lower platform structure 55, thus providing a unitary structure to which the upper support legs 54 are attached, and through which the lower support legs 56 are vertically slideable. The lower support legs may be raised and lowered preferably by respective hydraulic jacks (not shown) mounted on the lower platform structure 55, the jacks being of a type operable underwater, or alternatively by winches and cables on the upper platform 51. Because of the buoyancy provided by the tanks 61 and the buoyancy of the lower legs 56, the lower support platform, together with the upper legs, could be raised and lowered by winches and cables on the upper platform or, preferably, by respective, relatively small size hydraulic jacks situated on the upper platform 51.

In positioning this alternative form of the apparatus, the lower support legs 56 would first be lowered to about their midlength position with respect to the lower platform 55, by means of the aforementioned hydraulic jacks mounted on the latter. Next, the lower platform 55 together with the upper and lower support legs would be lowered by means of the aforementioned hydraulic jacks mounted on the upper platform, this jacking down operation being continued until the upper legs are completely extended. The upper legs are then pinned or locked to the upper platform by suitable locking devices, such as those which are integral with the jacks 58 of the FIG. 1 embodiment. Using the hydraulic jacks mounted on the lower platform, the lower support legs are then lowered into engagement with the hard sea bottom 80. At this time the jacks are operated independently of each other to assure equal loading on the four lower legs, thus keeping both the upper and the lower platforms level. However, the same hydraulic jacks are then operated in unison to jack-up the lower platform on the now lower legs, thus also raising the upper platform out of the water to the desired height above sea level. Buoyancy tanks located at the base of the upper legs, as well as buoyancy tanks at the base of the lower legs, would then be flooded to enhance stability and prevent overturning of the structure under storm conditions. To remove the platform from the sea bottom, the hydraulic jacks mounted on the lower platform would first be operated in unison to lower the upper platform to its floating condition on the surface of the water, and thereafter independently of each other to lift the lower legs off the sea bottom, appropriate water jet apparatus being operated to relieve mud suction at the bottoms of the lower legs during the latter operation. The upper legs would then be disconnected from the floating upper platform, and the hydraulic jacks located on the upper platform would be operated to raise the upper legs, the lower platform and the lower legs as a unit, until the lower platform is in nested relation at the underside of the floating upper platform. The lower legs would then be raised individually, such that the lower end of each leg is laterally aligned with the underside of the nested lower platform.

Referring now to FIGS. 11 and 12, a modified form of mobile, jack-up type offshore platform in accordance with the invention is generally indicated by reference numeral 100 and is shown both in its floating position (FIG. 11) and in its self-erected condition (FIG. 12) at an offshore location. The apparatus 100 has a buoyant upper platform 101 and a partially buoyant or floatable lower support platform or structure 102 which, in the floating condition of the rig, is nestable at the underside of the upper platform 101, as indicated in FIG. 11. The apparatus 100 also has four upper support legs 103, each of which is rigidly attached at its lower end to the lower platform 102, and is slidable through appropriate vertical guides 104 in the upper platform 101. Mounted for vertical slidable movement through appropriate vertical guides 105 in the lower platform 102, are respective lower support legs generally indicated by reference numeral 106, four lower legs being provided. As in the previously described embodiments, the lower support platform 102 may be formed essentially of open latticework, truss-type construction, in which case its primary buoyancy will be imparted by its rigidly attached buoyancy tanks 107, to which the lower ends of the upper legs 103 are attached, in turn.

In the embodiment of FIGS. 11 and 12, the lower half of each lower leg 106 is formed by an elongated, pneumatic or compressed gas operated jack, generally indicated by reference numeral 106a, the upper length portion 106b of the leg having open lattice construction as shown. The jack 106a comprises a pair of telescoping upper and lower cylinders 109 and 110, respectively, which are vertically slideable one within the other. Although each of the cylinders 109, 110 is essentially empty, each lower cylinder 110 carries a buoyancy tank 110a at its lower end, the bottom of the buoyancy tank being provided with an inverted dish-shaped footing 110b. The upper end 109a of the upper cylinder 109 is closed, and is preferably dome-shaped as shown, whereas the upper end of the lower cylinder 110 is open so that both cylinders are floodable concurrently. The cylinder 109 is attached at its upper end to the remaining upper length portion 106b of the lower support leg 106. The slideable fit 109b between the cylinders need not be watertight, and preferably is not watertight to eliminate excessive pressure differential between the air pressure in the tank and the outside water pressure.

As in the previously described embodiment the lower support legs 106 are slidable through their respective guides 105 independently of each other. As shown, each of the upper support legs 103 has latticework construction so that it is wave-transparent, for reasons as previously noted. A removable winch and cable arrangement, generally indicated by reference numeral 111, is mounted on the upper end of each upper support leg 103 for use in raising and lowering the respective lower support legs 106. Mechanical locking devices, diagrammatically indicated by reference numeral 112 in FIG. 12, are provided on the lower support platform 102 for pinning the lower support legs 106 in their downwardly extending, as well as in their raised, positions as indicated in FIGS. 12 and 11, respectively.

The telescoping jacks 106a are preferably pneumatically operated by air compressors A situated on the upper platform 101, the air being admitted to, and reeasable from the upper cylinder 109 as by an air line 113. Alternatively, tanks of compressed gas such as carbon dioxide, also indicated by reference letter A, could be used to expand the cylinders via lines 113, which could provide more rapid operation. The jacks might be hydraulically operated using sea water although, in such case, the slideable fit 109b between the telescoping sections would be watertight. In the illustrated embodiment the overall height of each leg 106
is 300 feet, the length of cylinder 109 being about 145 feet. The range of expansible movement of the jack 106a is about 105 feet, so that the maximum length of the leg 106 is about 400 feet. The diameter of the outer cylinder 109 is about 26 feet, and the outside diameter of the inner cylinder 110 is about 24 feet 8 inches. Of course, it will be understood that the length of the jack 106a might be as short as about 40 feet affording a range of expansible movement up to about 30 feet, or as long as the leg 106 itself, so as to afford a much greater range of telescopic movement.

As most clearly seen in Figs. 13-17, immediately above its buoyancy tank 110a each lower cylinder 110 has a sea water inlet and drain opening 115 having a remotely controlled shutoff valve 116, the opening and closing of the valve 116 being controlled from the upper platform 101. In addition, a locking device 117 is provided for locking the upper and lower cylinders 109, 110 together when in their telescoped relation as shown in Fig. 13.

Referring now particularly to Figs. 19 and 20, a locking device, generally indicated by reference numeral 120 and carrying a plurality of ratchet elements 121, is attached atop the lower cylinders 110 for locking the upper and lower cylinders 109, 110 in any one of several vertically expanded positions relative to each other. Each ratchet pawl 121a is pivotable on a horizontal pivot shaft 120a and is adapted as by the semi-circular end portion 121b at its outer or free end, to engage one of the plurality of vertically spaced aprt, horizontal ratchet pins 122 which are attached, as by welding, adjacent to the interior side wall of the upper cylinder 109. The ratchet pins 122 extend between respective pairs of vertical stiffeners 123, which also serve to laterally guide the ratchet pins 121 as to maintain the annular alignment of the upper and lower cylinders 109, 110 by preventing relative rotation between them. Vertically spaced, cylindrical-shaped stiffeners 124 are also provided within the upper cylinder 109, these extending arcuately between the vertical stiffeners 123, and functioning as guides for the vertical movement of the inner, lower cylinder 110. The lower cylinder 110 also has stiffened,conciliation, as indicated by reference numeral 119 in Fig. 19.

The ratchet pawls 121a are advanced and retracted in the radial direction of the lower cylinder in response to pivotal action in the horizontal plane, of a center mounted cam disc 125 on the fixed, criss-cross pattern, box girder structure 126 to which the ratchets 121 are attached, as best seen in Fig. 20. The box-girder construction 126 adds rigidity, yet permits the top of the cylinder 110 to remain open to the passage of water, for operational purposes as will be described. The ratchet pawls 121a are normally retained in their outwardly extended positions as shown in Fig. 19 by the tension springs 127 (see Fig. 20) which are mounted on the box-girder structure 126 and normally urge the disc 125 in counter-clockwise direction, as shown, to press on the ratchet control rods 128. The rods 128 extend between the respective ratchet pawls 121a and the disc 125, the rods being pivotally attached eccentrically with respect to the center of the disc as shown, to hold the ratchet pawls 121a in their outwardly extended positions engaging the respective pins 122 of the upper cylinder, which are respectively positioned adjacent the four, annularly spaced apart locations of the ratchets. Hydraulic cylinders 129 are provided between the box-girder structure 126 and the outer periphery of the disc 125 for disengaging the ratchet pawls 121a at appropriate times, as will be explained. The hydraulic cylinders 129 are operated by control means (not shown) located on the upper platform 101 and act, via their control rods 130, to pivot the disc 125 in clockwise direction as shown, i.e., in direction reverse to that of the bias of springs 127, as will be apparent. As will be noted, the ratchets 121 are intended to operate simultaneously.

Referring now to Figs. 19 and 21, the locking device 120 also carries a pair of wedge-shaped locking bars 131 mounted for slidable movement below their respectively associated pair of ratchets 121a as will be understood from a comparison of Figs. 19 and 21. The locking bars 131 are slidable in radial direction within respective guides 132 formed in the structure 126 as seen in Fig. 19. When in their simultaneously locked positions the locking bars 131 project beyond the outer periphery of the lower cylinder 110 to respectively engage the stops as are provided by the upper surfaces of a pair of the pins 122, located below those engaged by the ratchets 121a, as also indicated in Fig. 19. Locking engagement of the locking bars with their associated pins 122 is effected and maintained by pivoting of a horizontal arm 133 which is also centrally mounted on the box-girder structure 126. For this purpose, control rods 134 are pivotally attached at their respective ends to the bars 131 and to the outer ends of the arm 133, as shown in Fig. 21. Springs 134a, forming part of each control rod 134, exert radially outward bias to ensure that the locking bars 131 are urged outwardly their full distances to wedge over their associated pins 122.

Movement of the slidable locking bars into and out of their locking positions is effected by actuation of conventional two-way hydraulic cylinders 135, which extend between the girder structure 126 and the respective outer ends of the pivotable arm 133 as shown, and which are remotely controlled from the upper or working platform 101.

The pneumatic jacks 106a which form the lowermost halves of the respective lower support legs 106 are utilized both to raise the upper platform 101 to its desired elevation on the upper support legs 103 some 50 feet above the water, and to individually project lengths of each lower leg 106 to achieve a firm setting on the hard sea bottom 80 and as may involve some penetration thereof. That is, assuming that the rig is initially in floating condition over a drill site as shown in Fig. 11, at which time the lower cylinders 110 are fully retracted and locked by the locking pins 117 within the upper cylinders 109, and the lower support legs 106 themselves are locked by locking devices 112 in their raised positions, the procedure for self-erecting the apparatus 100 is as follows:

Referring to any particular lower support leg as illustrated in Fig. 13 and considering that all of the lower support legs 106 are operated in the same manner, the mechanical locking devices 112 are first unlocked to release the connections between the respective lower legs 106 and the lower platform 102, and the respective valves 116 are opened to admit sea water to the lower cylinders 110. The sea water flows upwardly between the cylinders through the sliding fit 109b, and thence through the sea water inlet opening 115. At this time the locking device 117 is unlocked so that the telescoped cylinders are free to expand relative to each
other. However, buoyancy tank 110a is sufficiently buoyant to retain the lower cylinder 110 in floating condition within the upper cylinder 109, although its buoyancy is insufficient to prevent the entire lower leg 106 from submerging as the water is admitted. Displaced air from the interior of the cylinders is permitted to escape through air line 113, and the independent downward movement of each leg 106 is effected and controlled by one of the winch and cable arrangements 111. Of course, lowering of the legs might alternatively be effected by respective hydraulic or mechanical jacks mounted on the lower platform 102, which would engage each leg 106. In any event, when in their lowered positions, the legs 106 are rigidly attached to the lower support platform structure 102 by means of mechanical locking devices 112, the structure 102 still being in its floating or raised position.

At this time, the hydraulic or other type jacks 140 on the upper platform 101 which respectively engage each of the upper support legs 103 are unlocked and utilized to jack-down all of the upper legs 103 with respect to the floating platform 101, the jacking being continued until the attached lower platform 102 has descended below the still floating upper platform 101 to a depth corresponding to the full length of the upper support legs 103, a depth of about 300 feet. The interior of the still telescoped cylinders is at this time filled with water as indicated in FIG. 14, and the remotely controlled valves 116 are then closed.

With both its lower support legs 106 and upper support legs 103 in their fully lowered condition, it can be assumed that the lower ends of the still telescoping lower legs are at or near the sea bottom 80, at a depth of about 650 feet, further assuming that the height of each of the platforms 101, 102 is 50 feet, the elevation of the underside of the platform 101 above sea level 8 will be 50 feet, and the length of each leg 103, 104 is 400 feet.

Compressed air or gas can now be admitted through the air line 113 to force the lower cylinders 110 down onto the sea bottom 80 and to then lift the upper platform 101 out of the water to its desired elevation as shown in FIG. 16, all of the jacks 106a being operated concurrently after each of the respective lower cylinders 110 have been firmly set in the sea bottom 80. Of course, at this time the internal locking devices of the jacking assemblies 140 on the upper platform 101 are in locked condition with respect to all of the upper legs 103, and it will be understood that the upward jacking movement of the pneumatic jacks 106a lifts the upper platform 101, the upper support legs 103, the lower platform 102, and the upper ends 106b of the lower legs 106, contemporaneously. The elevation differential between the upper end 110c of the lower cylinder and the lower end 109b of the upper cylinder is sufficient to seal the air within the cylinders and to exert the required force to raise the structure thereabove. As the cylinders expand telescopically, the ratchet pawls 121a of the cylinder locking devices 120 respectively engage the pins 122, to prevent downward movement of the upper cylinders 109 with respect to their associated lower cylinders 110.

With the upper platform 101 has been levelling at its proper height, the compressed air in the upper cylinders 109 is permitted to escape through the air lines 113, so that the cylinders fill with sea water, admitted through the respective slide fits 109b between the cylinders and the openings 115, so that each leg is then in condition as shown in FIG. 17. It will be noted that the entire weight of the apparatus 100 is then transmitted to the sea bottom through the ratchet locking devices 120. However, in any of the cylinders 109 the displacement of the air by sea water could cause the leg to settle somewhat, such that all of the legs might settle unevenly. In such instances, it may be necessary to pneumatically recharge one or more of the tanks 109 to the extent necessary to level the platform 101.

After the apparatus 100 has been properly set on the sea bottom as shown in FIG. 12 the slideable locking bars 131 of the locking devices 120 (FIG. 19) are extended radially, by pivoting the arm 133 as previously explained, so that each of the bars 131 engages the upper surface of its then associated ratchet pin 122 of the outer cylinder of the pair, thus locking the cylinders 109, 110 securely together and preventing any upward movement of the upper cylinders 109 relative to the lower cylinders 110.

When refloating the platform, the locking bars 131 are first retracted, from their wedged condition, over the ratchet pins 122, by means of the hydraulic cylinders 135 (FIG. 21) which are controlled from the upper platform 101. Compressed air is then admitted to the upper cylinders 109 via the compressed air lines 113, thus relieving the weight load from the ratchet locking devices 120. The ratchet pawls 121a are then retracted utilizing the hydraulic cylinders 129 as shown and described in connection with FIG. 20.

After the cylinder locking devices 120 are disengaged, the air is released from the pneumatic cylinders 109, permitting the leg portions 106b and the cylinders 109 of the lower legs 106 to settle downwardly, thus lowering all of the structure thereabove, and refloating the upper platform 101. The pneumatic jacks 106a are then telescoped and filled with water.

The hydraulic jacks 140 on the upper platform 101 are then simultaneously actuated to raise all of the upper legs 103 and, thus, the structure 102 and lower legs 106 therebelow. Referring to FIG. 18, each of the pneumatic jacks 106a is equipped with a suction relieving device, generally indicated by reference numeral 141, for relieving any suction below and surrounding its footing 110b. The suction relieving device 140 is a water jetting arrangement comprising a water supply line 142 which extends from the upper platform 101 through the upper end 109c of the upper cylinder 109, and a coiled spring supported hose 142a for connecting the water path to the water supply line 143 attached within the lower cylinder 110, as shown. The water supply line 143 extends downwardly through the buoyancy tank 110a, at the lower end of which it has lateral branches 143a which distribute the jetting water over a plurality of jet orifices 143b through which the water appears at the underside of the dish-shaped footing 110b. Additional water jet orifices 143c also distribute the water jetting action to the exterior of the cylinder 110 as it rests within the sea bottom 80. Thus, any natural suction, as would otherwise prevent raising of any lower leg 106, can be relieved.

At or about the time when the lower platform structure 102 has reached the underside of the floating upper platform 101, the valves 116 in the lower legs are opened so that the pneumatic jacks 106a will be drained. The jacks 140 are operated until the upper legs 103 and the lower platform 102 are fully raised.
The locking devices 112 on the lower platform 102 are then unlocked, and the respective winches 111 are connected to the lower legs 106, whereupon the legs 106 are raised to their uppermost position as shown in FIG. 11. The locking devices 117 are engaged to lock the cylinders 109, 110 together, and the locking devices 112 are also engaged, to ready the apparatus 100 for towing or self-propulsion to another location.

It will be noted that use of pneumatic or compressed air jacks 106a as in the FIG. 11 embodiment permits the legs 140 on the upper platform 101, which are used to raise the upper support legs 103, to have smaller size and thus lower cost. The pneumatically operated jacks 106a also permit the apparatus to operate in deeper water than otherwise, and are relatively low in cost when compared to the conventional hydraulic jacks as would otherwise be required for their purpose.

Although not illustrated, it is contemplated that the telescopic jacks 106a might be hydraulically operated using sea water rather than air or compressed gas. However, a seal, such as one of a floating labyrinth type, would be provided at the slide fit 109b between the cylinders 109 and 110, to restrict the leakage of water between the two cylindrical sections. Although weight, buoyancy and pressure conditions would be different, the hydraulic jacks would operate essentially in the same manner as has been described.

Of course, the upper platform jacks 140 might be used to jack-up the upper platform 101 on the upper support legs 103 after the lower support legs 106 have been stabilized on the sea bottom 80 and the platform 101 has been leveled by operation of the telescopic air jacks 106a as described. In such alternative arrangement, the adjustable or expansible heights of the air jacks 106a need be only about 30 feet as compared with 105 feet as previously mentioned.

It will be understood from FIGS. 23-25 that elongated, fluid-powered telescopic jacks, as have been described in connection with the FIG. 11 embodiment, may be utilized in a somewhat modified form of jack-up type, offshore platform apparatus, as indicated by reference numeral 150. This rig appears particularly suitable for use in intermediate water depths in the range of 350-450 feet when operating in the Gulf of Mexico during the hurricane season, and possibly in water depths to 500 feet during the nonhurricane season. It has the advantage of lower first cost when compared with the apparatus 50 and 100 as shown in FIGS. 1 and 11, because it is considered less complicated.

Comparing FIGS. 23 and 24, it will be understood that the apparatus 150 has a plurality (three or more) of support legs 151 having a maximum permissible length of about 500 feet, and whose upper ends 152 each have open lattice work, or wave-transparent construction for reasons as previously explained. The lower end lengths of the support legs 151 are formed by elongated pneumatic or compressed gas jacks 153 which are of the telescoping cylindrical type as previously described in connection with FIG. 11. The rig also includes a floatable upper platform 154, and a submersible lower platform or lateral bracing structure 155, which is nestable at the underside of the platform 154 when the rig is in floating condition as illustrated in FIG. 23. The legs 151 are capable of being lowered and raised with respect to the upper or working platform 154, the legs 151 being slidable within respective vertical guides 156 of the upper platform, as indicated.

Also mounted on the upper platform 154 in adjacent relation to each of the legs are conventional hydraulic jacks 157. From FIGS. 24 and 25 it will be more clearly understood that the lateral bracing structure 155 is attached between the outer, upper cylinders 158 of the jacks 153, and that the structure 155 is of wave-transparent construction. Each pneumatic jack 153 has an inner, lower cylinder 159 which has a buoyancy tank 159a and an inverted dish-shaped footing 160 at the lower end thereof, as in the embodiment of FIG. 11.

The inner and outer cylinders 158, 159 are telescopically slidable with respect to each other, and have all of the equipment and features described in connection with FIGS. 11-22. In the embodiment of FIGS. 23-25 the length of the pneumatic jack 153 is about 45 feet, providing an extensible length of about 105 feet.

Self-erecting of the rig from its floating condition as illustrated in FIG. 23 to its jack-up condition as shown in FIG. 25 is conducted by operating the telescopic air jacks 153 in the same manner as described in connection with FIGS. 11-22. That is, the integral locks as are a part of the conventional hydraulic lifting jacks 157 are released, as are the connections (not shown) between the inner and outer cylinders 158, 159, whereupon sea water is permitted to enter the lower cylinders 159 through inlet valves and openings (not shown) similar to valves 116 and openings 115 in the FIG. 11 embodiment. All of the legs 151 are then jacked downwardly using the hydraulic jacks 157. Legs 151, being attached via the truss-like lateral bracing structure 155, move downwardly concurrently to the position shown in FIG. 24, whereupon they are again locked to the upper platform 154 using the locking devices of the jacks 157. It will be noted that the air jacks 153 are at this time filled with sea water, any air therein having been permitted to be expelled via suitable air lines (not shown) such as the air lines 113 of the FIG. 11 embodiment. Compressed air is then admitted to all of the jacks 153 to force their lower cylinders 159 downwardly into engagement with the sea bottom 80.

As described in connection with the embodiment of FIGS. 11-22, the upper platform 154 may then be jacked upwardly out of the water, to the desired elevation of some 40 feet thereafter, by either continuing to operate the hydraulic jacks 153, or by using the conventional hydraulic jacks 157 located on the upper platform. In the latter event, movement of the jacks 153 would be terminated and their cylinders 158, 159 would be locked together as soon as their respective footings 160 have achieved firm engagement with the sea bottom 80. Of course, and as previously explained, where the hydraulic jacks 157 are used to elevate the working platform, the air jacks 153 may have considerably shorter length. The jack cylinders 158, 159 may be locked together using a locking device (not shown) such as the locking device 120 as illustrated in detail and described in connection with FIGS. 19-22. The new expanded telescopic air jacks 153 are filled with water to transfer the weight load from the compressed air to the mechanical locking device between the cylinders, and to increase the stability of the structure to resist overturning forces of wind and sea.

The apparatus 150 is restored to its floating condition in essentially the same manner as explained in connection with the FIG. 11 embodiment. That is, the pneumatic jacks 153 are first purged of water and filled with
air to relieve the load on the mechanical locking devices (not shown) between the cylinders, whereupon the locking devices are disengaged. The air in the jacks 153 is then permitted to escape, causing a lowering of the entire apparatus 150c relative to its lower cylinders 159. The hydraulic jacks 157, on the now floating upper platform 154, are then actuated to simultaneously raise all of the legs 151. During this lifting operation the referred to valves (not shown) in the lower cylinders 159 are opened to permit draining of water from the cylinders, and the legs 151 will achieve their raised positions as shown in FIG. 23. The locking devices in the jacks 157 then lock the legs to the upper platform 154, and the cylinders 158, are again locked together by locking devices (not shown) therebetween.

Referring now to FIGS. 26–29 and the detailed showings of FIGS. 30–34, a floatable, self-erecting but permanent type of offshore platform apparatus in accordance with the invention is generally indicated by reference numeral 200. It may be characterized as a two-stage platform apparatus, and is capable of being safely positioned and used as a permanent oil-well drilling and production platform in waters 450 feet deep, or deeper, such as in the North Sea and Gulf of Mexico. That is, in addition to supporting drilling equipment the large, upper or working platform 201 would also support tanks, pumps, separators, compressors and other equipment as is utilized in the production of oil from an underwater well. This fixed structure, more commonly referred to as a “template,” is intended to remain on site, in the open sea, for a period of 10 or more years, and is normally pinned to the sea floor by means of piles which transmit the load from its support legs to the sea bottom. As illustrated in FIG. 26, the apparatus 200 is towed to the site with all equipment aboard, including that required for erecting the structure in its permanent location, as well as oil-well drilling and production equipment. Of course, the equipment utilized in the erection of the structure, such as portable jacks used in lowering its support legs, pumps, pile drivers, or compressors, concrete mixers, and portable cranes (such as the crane 202 in FIG. 27) will be removed and re-used for similar installations.

In addition to the upper platform 201, the apparatus 200 has six upper support legs 203 arranged in a rectangular pattern, and a similarly arranged plurality of six lower support legs 206 as will be understood from a comparison of FIGS. 26 and 27. The upper support legs 203 are attached, via respective buoyancy tanks 204, to a lower support platform 205 which also functions as a lateral bracing structure, and whose length and width is such as will provide greater lateral spacing between the lower support legs 206, than between the upper support legs 203, as shown. Thus, in its erected condition as shown in FIG. 27, the more widely spaced lower support legs 206 impart greater stability to the structure.

As in the previously described embodiments of FIGS. 1 and 11, each of the lower support legs 206 is mounted with vertical slide 207 on the lower platform 205 for controlled, vertical slideable movement with respect to the latter. Each of the legs 203, 206 may be 300 feet in length or longer, and may have diameter or width of 26 feet or more. As will be noted, the lower legs 206 have cylindrical construction as will afford greater stability, whereas the upper legs 203 are shown as having triangular open latticework construction for presenting less resistance to wave motion and currents as are more prevalent at shallower depths. However, it will be understood that the upper support legs 203 might also have cylindrical construction, if such were desired to provide a more durable permanent structure.

The upper legs 203 are similarly mounted for vertical slideable movement through suitable vertical guides 208 of the upper platform 201, to which the legs 203 will be permanently attached.

Because they will be used only once in setting the permanent structure 200, the apparatus carries only portable jacks 209, 210 (FIG. 26) for lowering the lower support legs 206 and upper support legs 203, respectively, these jacks being removed after the rig has been erected (FIG. 27). In the erected condition as shown in FIG. 27, the apparatus 200 will be pinned to the sea bottom 80 by piles 211 which are driven by a portable, pneumatic pile driver 212, as will be explained. Referring briefly to FIGS. 31 and 32, it will be understood that each lower support leg 206 is interiorly reinforced by a concentric wall 206a, which extends at least part way along its length from its lower end to the wall 206a being spaced inwardly from the outerwall by the radially extending vertical stiffeners 206b which provide respective spaces 215 within which the respective piles 211 are initially disposed, and from which they will be driven, as will be understood from Figs. 33 and 34. The lower ends of the lower support legs 206 are provided with buoyancy tanks 213 to reduce the power requirements of the portable jacks 209, and to facilitate lowering of the legs, as previously explained.

Referring to FIG 29, it will be understood that the lower platform or bracing structure 205 has truss-like open latticework construction, making it wave-transparent for reasons as previously explained.

When the floating rig 200 as shown in FIG. 26 arrives on site, the portable jacks 209 which have retained the lower support legs 206 in their raised positions as shown, are unlocked and operated to jack the lower support legs 206 downwardly to their lowestmost positions as illustrated in FIG. 28. The lower support legs 26 are then welded or otherwise permanently attached to the lower support platform structure 205, and the portable jacks 209 are removed.

The portable jacks 210 on the floating platform 201 are then unlocked and operated to simultaneously lower all of the upper support legs 203 and the lower support platform 205 until the attached lower support legs 206 come to rest against, and perhaps penetrate, the hard sea bottom 80. The jacks 210 continue to operate, thus lifting the upper platform 201 out of the water and transferring its weight to the support legs 203, the lower support platform 205, and the support legs 206. Of course, such transfer of weight may cause the respective legs to sink lower into the sea bottom, and their respective lengths may therefore require adjustment prior to commencement of the operation, as by first determining the contour and support capability of the sea bottom 80 at the particular locations at which they will rest. The upper platform 201 is then welded or otherwise permanently attached at the upper ends of the upper support legs 203, and the portable jacks 210 are removed. The buoyancy tanks 204 and 213 may be filled with water or concrete to increase the stability of the structure if desired.
Referring now to FIGS. 30-34, it will be understood that each of the referred to pile spaces 215 of each lower support leg 206 is provided with a funnel-shaped pile driver guide 216 which is attached by suitable welded bracing structure (not shown) therein, and that piles 211, which are of a conventional type, are respectively positioned within the pile driver guides 216 in the manner shown in FIG. 30 when the rig 200 is being floated over the drill site. Additional pile guides 218, for guiding the lower ends of the piles 211, extend vertically through each buoyancy tank 213 of the legs 206, as also indicated in FIG. 30. As indicated in FIG. 31, a portable pneumatic pile driver 212 is suspended on a cable 219 which extends downwardly from the floating upper platform 201, and is positioned within, and lowered with one of the lower support legs 206. Suitable air supply hoses and exhausts (not shown) are also previously attached to, and lowered with the pile driver 212. When the lower support leg 206 has been pressed to the maximum possible extent against the sea bottom 80, the pile driver 212 is moved and lowered within one of the pile driver guides 216 and used to drive one of the piles 211. Driving of the piles 211 proceeds sequentially, the repositioning of the pile driver 212 within the respective spaces 215 and guides 216 being facilitated by an underwater television camera and light, as generally indicated by numeral 220, which is also suspended within the leg 206 by the cable 221 from the upper platform 201.

FIGS. 33 and 34 illustrate the vertically spaced apart, polygonally extending stiffeners 222 which are preferably disposed within each of the pile spacings 215, and the plurality of vertically spaced apart bearing rings 223 which are preferably disposed on the upper end of each pile to increase the bearing of the pile in the concrete 224 which, after the pile is driven, is poured within the associated pile space 215. Stiffeners 222 also increase the effectiveness of the concrete 224, in holding each pile 211 in place, as will be understood. Of course, the legs 206 may be entirely filled with concrete, if desired to increase stability.

FIG. 33 also illustrates the contemplated provision of a relatively narrow opening, pile support ring 225, at the lower end of each of the pile guides 216, for supporting the associated pile 211 within the space 215 before the pile is driven. These support rings 225 are made of relatively thin material and the diameter of each is smaller than its associated pile so that, when driven as illustrated in FIG. 43, the pile 211 is forced through the support ring 225.

FIG. 35 shows an alternative arrangement for either a mobile type or permanent type, self-erecting offshore platform apparatus 250, the rig having three stages provided by two submerged lower support platform structures 251, 252 which, when the rig is floating, are nestable against the underside of, or in surrounding relation with respect to, the floatable upper or working platform 253, as in the previous embodiments. The first lower support platform 251 has three or more rigidly attached, upper support legs 254 which project upwardly therefrom and which support the upper platform 253 when connected thereto as in the previous embodiments. The lower ends of these legs 254 are respectively welded to the buoyancy tanks 255 which are, in turn, welded to the platform structure.

The second lower support platform 252 is wider than the first platform 251 and carries a similar plurality of rigidly attached upper support legs 256, the lower ends of which are joined to the platform 252 via the attached buoyancy tanks 257. The legs 256 are initially slidable through the upper platform 251 thereabove, and are attached to the latter when the rig is erected, in manner as described in connection with the previous embodiments. The first lower support platform 251 may be provided with additional, floodable buoyancy tanks 258, preferably in respective surrounding relation with the upper legs 256 projecting from the next lower platform 252 as in the previous embodiments. Platform 252 may also have similar additional, floodable buoyancy tanks 259, as shown.

A similar plurality of lower support legs 260, each of which is initially slidably independently of each other, is carried by the lowest lower support platform 252, and are rigidly attached to that platform when in their downward extending positions, as will be understood. Buoyancy tanks 261 are provided on the lower ends of the lower support legs 260 for previously explained reasons.

As in the previous embodiments, each of the legs 254, 256, and 260 may have length up to 400 feet, and may have wave-transparent construction. It will be understood that the so-called "wedding cake" arrangement shown in FIG. 35, wherein each lower support platform 251, 252 supports all of the structure thereabove, provides an extremely stable structure.

Of course, in all of the embodiments, any of the buoyancy tanks in the lower support legs and/or in the lower support platform structures might be omitted, in which case the respective appropriate jacks for raising and lowering the support legs and platform structures would have to be more powerful. Moreover, it will be noted that any of these buoyancy tanks, when included, may be used for storage of fuel oil, fresh water, and similar supplies when the apparatus has been positioned on the sea bottom.

Thus has been described floatable, jack-up type offshore platform apparatus which achieves all of the objects of the invention.

What is claimed is:
1. Jack-up type offshore platform apparatus comprising a floatable upper platform, at least one horizontal lower support platform structure nestably arranged in substantially surrounding relation with respect to at least a portion of said upper platform and for disposition in vertically spaced tandem relation below said upper platform when said apparatus is in erected condition, each of said lower support platform structures being of substantially open latticework construction and carrying an attached plurality of upwardly projecting, elongated upper support legs in laterally spaced apart relation to each other and respectively engaging the platform structure thereabove for vertical movement with respect thereto, means for attaching each of said upper support legs at locations along their respective lengths to said platform structure which it engages for vertical movement, said upper platform being mounted for vertical movement on, and having means for its attachment to said upper support legs on that lower support platform structure which is disposed immediately below said upper platform when said apparatus is in said erected condition, a plurality of elongated lower support legs respectively mounted in laterally spaced apart relation to each other on the lowermost of said lower support platform structures for vertical
movement independently of each other to project downwardly from the platform when said apparatus is in said erected condition, and means for attaching each of said lower support legs at locations along their respective lengths to said lowermost support platform structure, whereby when said apparatus is in said erected condition, each said lower support platform structure supports and transmits to the support legs therebelow all of the weight of the structure thereabove.

2. Jack-up type offshore platform apparatus according to claim 1 wherein each of said lower support legs has a buoyancy tank attached to the lower end thereof for rendering the leg at least partially buoyant, and wherein said apparatus further comprises winch and cable means operable from said upper platform for raising and lowering at least said lower support legs with respect to said lowermost lower support platform structure.

3. Jack-up type offshore platform apparatus according to claim 2 wherein each of said lower support platform structures has buoyancy tank means rendering the structure at least partially buoyant, and said winch and cable means is further attachable to each of said upper support legs for raising and lowering their associated lower support platform structure with respect to said upper platform.

4. Jack-up type offshore platform apparatus according to claim 2 wherein said winch and cable means includes pulley means temporarily mounted atop said upper support legs on which said upper platform is mounted for vertical movement.

5. Jack-up type offshore platform apparatus according to claim 2 wherein each of said lower support legs further has a buoyancy tank attached near the upper end thereof.

6. Jack-up type offshore platform apparatus according to claim 1 wherein said lateral spacing apart of the legs of each of said pluralities of upper and lower support legs is greater than that of any of said pluralities of legs thereabove when said apparatus is in said erected condition.

7. Jack-up type offshore platform apparatus according to claim 1 wherein each of said lower support legs has a buoyancy tank attached thereto for rendering the leg only partially buoyant, and wherein said apparatus further comprises respective low-powered jacks on the lowermost of said lower support platform structures and engaging each of said lower support legs for raising and lowering the same with respect to said lowermost support platform structure, each of said low-powered jacks having power sufficient to raise its said associated lower support leg only when the leg is rendered partially buoyant by its said attached buoyancy tank.

8. Jack-up type offshore platform apparatus according to claim 6 which further comprises respective high-powered jacks on said lowermost lower support platform structure, and engaging each of said lower support legs, each of said jacks being operable independently of each other for raising and lowering each of said lower support legs with respect to said lowermost support platform structure to position and set the support legs on a sea bottom, and said jacks being operable concurrently for raising and lowering said lowermost support platform structure on said lower support legs when the same are set on said sea bottom to commen- surately raise and lower all of said apparatus thereabove.

9. Jack-up type offshore platform apparatus according to claim 1 wherein each of said upper and lower support legs is at least 250 feet long.

10. Jack-up type offshore platform apparatus according to claim 1 wherein at least the lower end portion of the length of each of said lower support legs has elongated cylindrical shape, and said apparatus further comprises a floatable buoyancy tank on said lower end of each of said lower support legs, a plurality of annularly spaced apart, tubular pile guides extending vertically through each of said buoyancy tanks, a corresponding plurality of vertically extending pile driver guides attached to the interior of each of said lower end portions and respectively in vertical alignment with said pile guides, and removable pile driver means suspended substantially from said upper platform and positionable within each of said support legs lower end portions for engaging each of said respective pile driver guides for driving a pile positioned within its said associated pile guide, each of said tubular guide means having plate means attached substantially adjacent to its lower end and providing a constricted opening for supporting a pile within the guide, said plate means being rupturable by said pile when the latter is driven.

11. Jack-up type offshore platform apparatus according to claim 1 wherein each of said lower support platform structures has buoyancy tank means rendering the structure at least partially buoyant.

12. Jack-up type offshore platform apparatus comprising a floatable upper platform, at least one horizontal lower support platform structure nestably arranged with respect to said upper platform for disposition in vertically spaced tandem relation below the latter when said apparatus is in erected condition, each of said lower support platform structures carrying an attached plurality of upwardly projecting, elongated upper support legs in laterally spaced apart relation to each other and respectively engaging the platform structure thereabove for vertical movement with respect thereto, means for attaching each of said upper support legs at locations along their respective lengths to said platform structure which it engages for vertical movement, said upper platform being mounted for vertical movement on, and having means for its attachment to said upper support legs on that lower support platform structure which is disposed immediately below said upper platform when said apparatus is in said erected condition, a plurality of elongated lower support legs respectively mounted in laterally spaced apart relation to each other on the lowermost of said lower support platform structures for vertical movement independently of each other to project downwardly from the platform when said apparatus is in said erected condition, and means for attaching each of said lower support legs at locations along their respective lengths to said lowermost support platform structure, whereby when said apparatus is in said erected condition, each said lower support platform structure supports and transmits to the support legs therebelow all of the weight of the structure thereabove, said lateral spacing apart of the legs of each of said pluralities of upper and lower support legs being greater than that of any of said pluralities of legs thereabove when said apparatus is in said erected condition, at least one of said lower support platform structures having a vertically movable portion associated
with each of said attached upper support legs, said upper support legs being respectively attached to said movable portions, and respective connection means between each of said movable portions and the remainder of said one platform structure to provide limited vertical movement of the movable portion from a position above to a position below the elevation of said remainder of the platform structure when said apparatus is in said erected condition.

13. Jack-up type offshore platform apparatus according to claim 12 wherein said other support legs which engage said one platform structure for vertical movement with respect thereto respectively engage said movable portions of the platform structure.

14. Jack-up type offshore platform apparatus according to claim 13 wherein each of said movable portions has a pair of buoyancy tanks, one of said pair of buoyancy tanks being floodable.

15. Jack-up type offshore platform apparatus comprising a floatable upper platform, at least one horizontal lower support platform structure nestably arranged with respect to said upper platform for disposition in vertically spaced tandem relation below the latter when said apparatus is in erected condition, each of said lower support platform structures carrying an attached plurality of upwardly projecting, elongated upper support legs in laterally spaced apart relation to each other and respectively engaging the platform structure thereabove for vertical movement with respect thereto, means for attaching each of said upper support legs at locations along their respective lengths to said platform structure which it engages for vertical movement, said upper platform being mounted for vertical movement on, and having means for its attachment to said upper support legs on that lower support platform structure which is disposed immediately below said upper platform when said apparatus is in said erected condition, a plurality of elongated lower support legs respectively mounted in laterally spaced apart relation to each other on the lowermost of said lower support platform structures for vertical movement independently of each other to project downwardly from the platform when said apparatus is in said erected condition, and means for attaching each of said lower support legs at locations along their respective lengths to said lowermost support platform structure, whereby when said apparatus is in said erected condition, each said lower support platform structure supports and transmits to the support legs therebelow all of the weight of the structure thereabove, each of said lower support legs comprising an independently operated, fluid-powered jack for adjusting its length independently of any other support leg, each of said fluid powered jacks comprising a pair of elongated, substantially empty upper and lower cylinders concentrically arranged for telescoping slidably movement relative to each other and together constituting at least a portion of the length of said associated support leg, said upper cylinder having a closed upper end and an open lower end, and said lower cylinder having a closed lower end and an open upper end, means for introducing fluid under pressure into, and for discharging the same from the interior of said cylinders for inducing said telescoping slidably movement relative to each other, means for admitting and discharging sea water into and from said interior of said cylinders, and means for locking said upper and lower cylinders together at positions along the length of their said relative movement.

16. Jack-up type offshore platform apparatus according to claim 15 wherein said upper and lower cylinders constitute substantially the lower half of the length of said associated support leg.

17. Jack-up type offshore platform apparatus according to claim 16 wherein said means for admitting and discharging sea water into and from said interior spacing between said cylinders comprises means providing avalved opening near the lower end of said lower cylinder.

18. Jack-up type offshore platform apparatus according to claim 16 wherein each of said lower cylinders has a buoyancy tank adjacent to its lower end, said valved opening being disposed for admitting and discharging sea water at a location above said buoyancy tank.

19. Jack-up type offshore platform apparatus according to claim 15 wherein each of said lower support legs is at least 250 feet, and the lengths of each of said cylinders is at least 40 feet.

20. Jack-up type offshore platform apparatus according to claim 15 wherein said fluid under pressure is compressed air.

21. Jack-up type offshore platform apparatus according to claim 15 wherein said fluid under pressure is compressed gas, and said means for introducing said gas comprises compressed gas tanks mounted on said upper platform.

22. Jack-up type offshore platform apparatus according to claim 15 wherein said means for locking said upper and lower cylinders together comprises ratchet pawl means mounted on one of said said cylinders for movement towards and away from the other of said cylinders, ratchet pin means mounted on said other cylinder for engagement by said ratchet pawl means of the first said cylinder to prevent said telescoping movement between said upper and lower cylinders in one direction, radially movable means on one of said cylinders, and stop means on the other of said cylinders for engagement by said radially movable means to prevent said telescoping movement between said upper and lower cylinders in the opposite direction.

23. Jack-up type offshore platform apparatus according to claim 22 wherein said means for locking said upper and lower cylinders together further comprises latch means spaced upwardly from the lower end of said lower cylinder for locking said cylinders in their fully telescoped relation.

24. A support leg for a jack-up type offshore platform apparatus, said leg comprising a pair of elongated, substantially empty upper and lower cylinders concentrically arranged for telescoping slidably movement relative to each other and together constituting at least a portion of the length of said support leg, said upper cylinder having a closed upper end and an open lower end, and said lower cylinder having a closed lower end and an open upper end, means for introducing fluid under pressure into, and for discharging the same from the interior of said cylinders for inducing said telescoping slidably movement relative to each other, means for admitting and discharging sea water into and from said interior of said cylinders, and means for locking said upper and lower cylinders together at positions along the length of their said relative movement.

25. A support leg according to claim 24 wherein said upper and lower cylinders substantially constitute the
lower length portion of said support leg, and said support leg has an upper length portion having wave-transparent construction.

26. A support leg according to claim 25 which further comprises a buoyancy tank within said lower length portion.

27. A support leg according to claim 26 wherein said buoyancy tank forms said closed lower end of said lower cylinder, and which further comprises an inverted-dish shaped footing at the underside of said buoyancy tank, and water jet means for relieving suction forces adjacent to said footing as would otherwise resist the raising of said support leg when resting on a sea bottom.

28. Jack-up type, mobile offshore platform apparatus comprising a floatable upper platform, a first plurality of elongated, substantially vertical upper support legs mounted in laterally spaced apart relation to each other on said upper platform for vertical movement with respect thereto, a horizontal lower support platform structure extending laterally between, and rigidly attached to the lower ends of all of said first plurality of legs, and having buoyancy tank means rendering the platform structure and said upper support legs at least partially buoyant, means on said upper platform for jacking the platform upwardly and downwardly along the lengths of said upper support legs and for attaching the platform to each of said legs at locations along their respective lengths, a plurality of elongated, substantially vertical lower support legs respectively mounted in laterally spaced apart relation to each other on said lower support platform structure for vertical movement with respect thereto independently of each other and independently of said upper platform, a buoyancy tank on the lower end of each of said lower support legs for rendering the same at least partially buoyant, winch and cable means operable from said upper platform and including removable pulley means mounted substantially adjacent to the tops of said upper support legs for raising and lowering said lower support legs with respect to said lower support platform structure, and means for attaching each of said lower support legs to said lower support platform structure at locations along their respective lengths, said upper and lower support legs and said lower support platform having substantially wave-transparent construction, and said lateral spaced apart relation of said lower support legs being wider than that of said upper support legs.

29. Jack-up type offshore platform apparatus comprising a floatable upper platform, a plurality of elongated support legs in laterally spaced apart relation to each other and respectively engaging said upper platform for vertical slidable movement with respect thereto, each of said support legs being at least 250 feet long and having an upper length portion and a lower length portion, said lower length portion of each leg being formed by a pair of substantially empty upper and lower cylinders arranged in telescoping slidable relation with each other, said upper cylinder of each leg being at least 40 feet long and having a closed upper end and an open lower end, and said lower cylinder of each leg being at least 40 feet long and having an open upper end and a buoyancy tank on and closing its lower end, means on each said support leg for introducing fluid under pressure into, and for discharging the same from the interior of its said cylinders for inducing said telescoping slidable movement relative to each other and independently of such movement of said cylinders on any other of said support legs, means on each of said lower cylinders for admitting and discharging sea water into and from the interior thereof, and means for locking together each of said pairs of upper and lower cylinders, respectively, at locations along the lengths of their said relative movement, a horizontal lower support platform structure attached to and extending between said lower ends of all of said upper cylinders whereby said support legs project upwardly and uniformly a height therefrom, and means for attaching said upper platform to said upper length portions of said support legs.

30. Jack-up type offshore platform apparatus according to claim 29 wherein said lower support platform structure and said upper length portions of said support legs have wave-transparent construction, and which further comprises jack means on said upper platform for jacking of the platform upwardly and downwardly along the lengths of said support leg upper length portions.

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