Dec. 15, 1970 I. C. POGONOWSKI 3,546,885

THREADED PILE FOR MARINE STRUCTURE

Filed Sept. 30, 1968 2 Sheets-Sheet 1

Fig. 1.

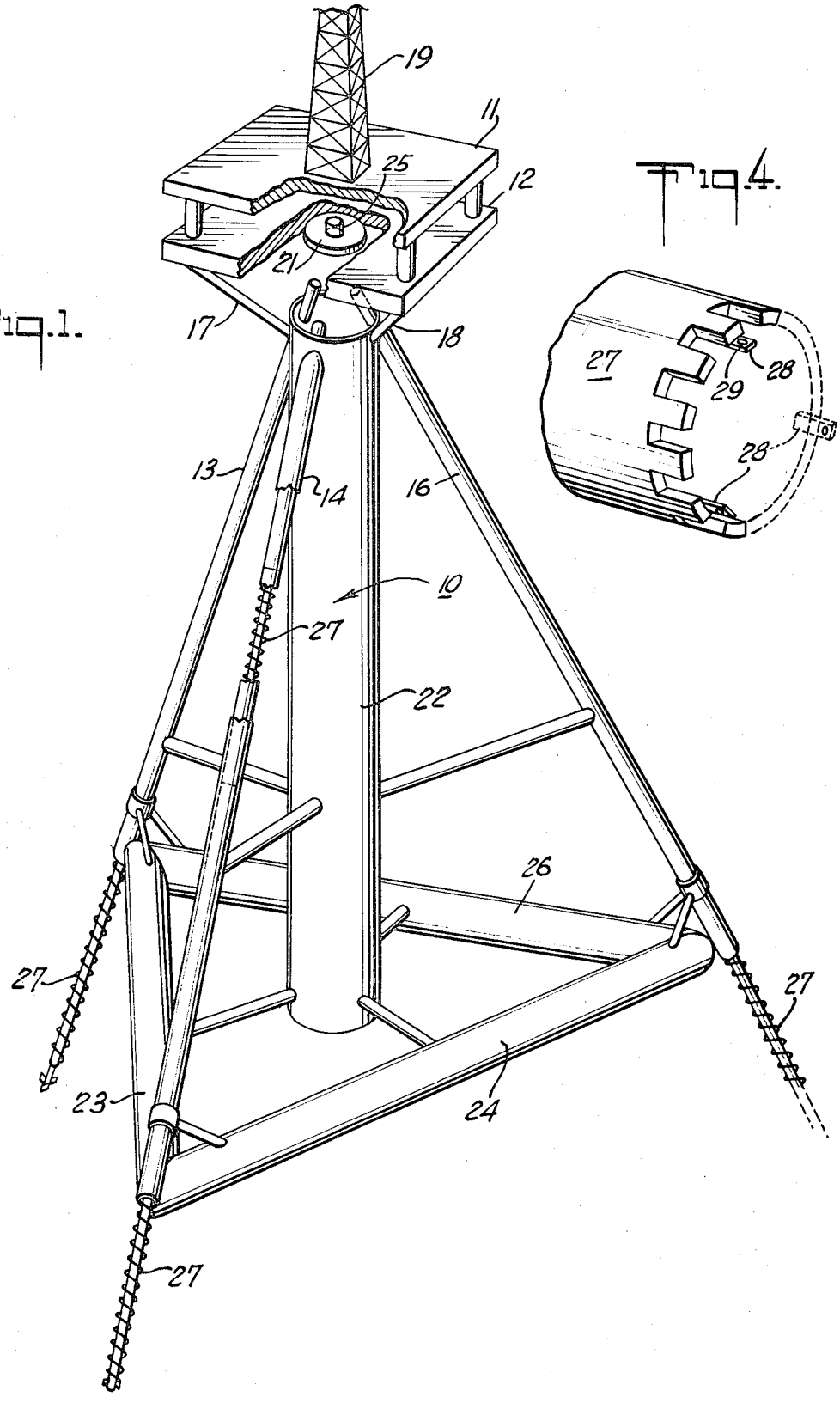


Fig. 4.

Dec. 15, 1970 I. C. POGONOWSKI 3,546,885

THREADED PILE FOR MARINE STRUCTURE

Filed Sept. 30, 1968 2 Sheets-Sheet 2

Fig. 2.

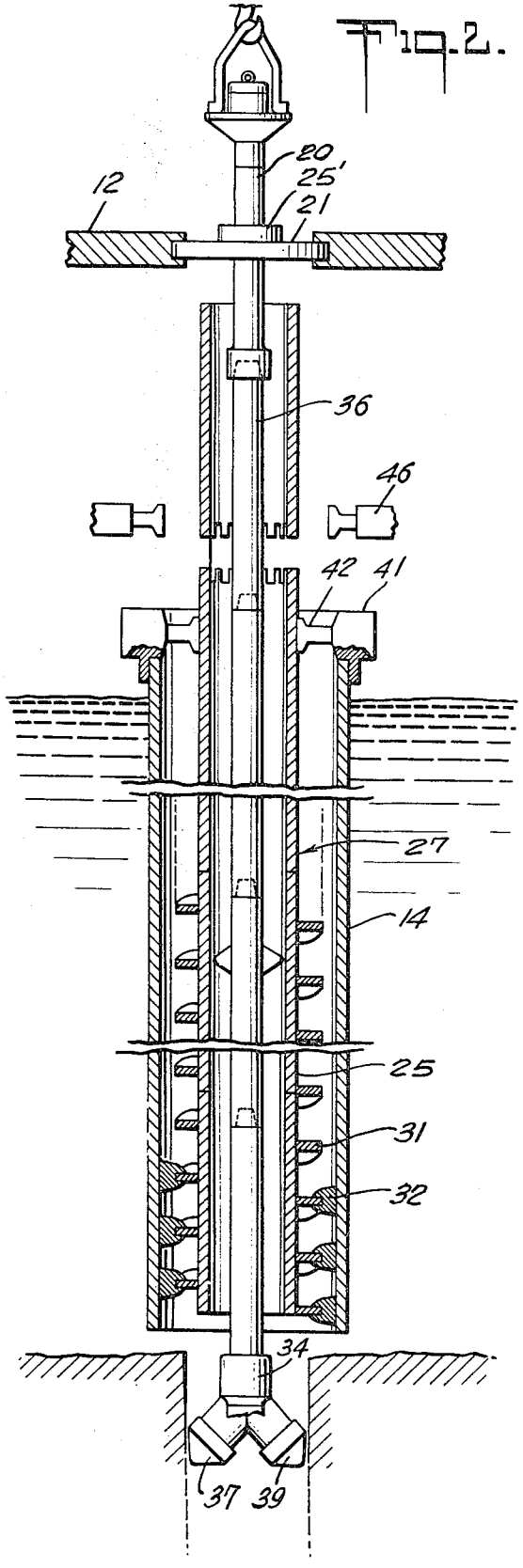
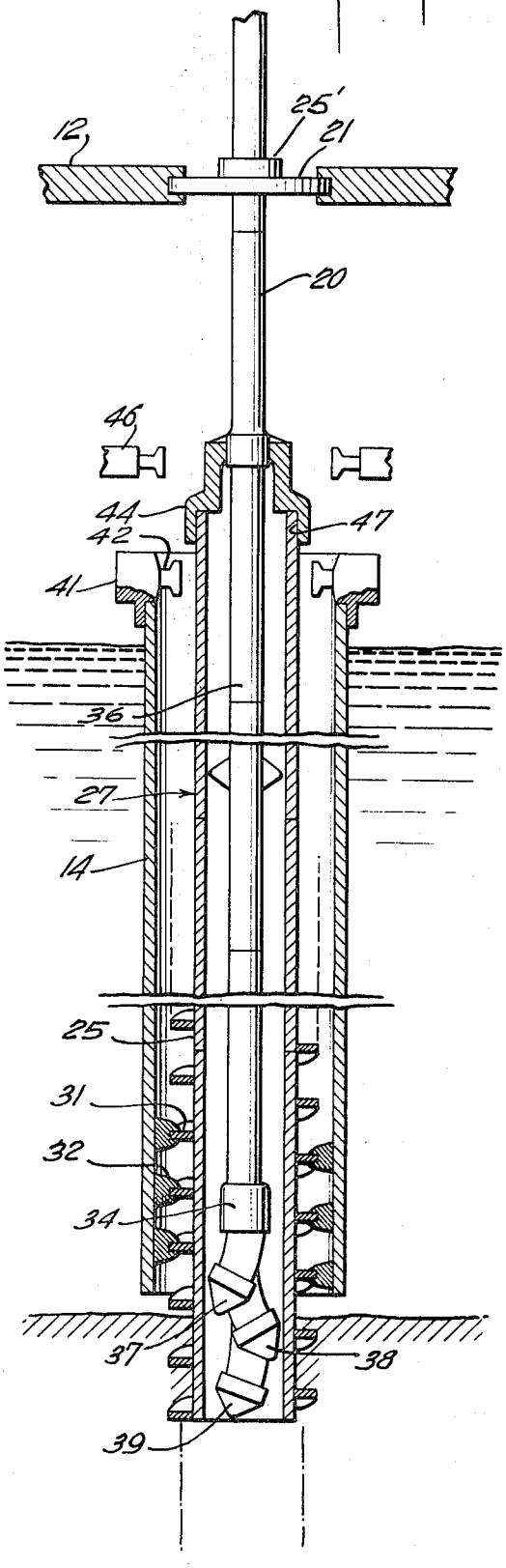


Fig. 3.



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THREADED PILE FOR MARINE STRUCTURE

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U.S. Cl. 61—46.5 10 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to a deep water drilling platform for use in offshore or inland waters, which platform embodies one or more support legs extending downward toward the ocean floor. The platform is maintained relatively stationary with respect to the ocean surface and floor by anchoring into the ocean substratum with piles that depend from the lower ends of one or more of the support legs. The respective piles are provided with an externally positioned, upstanding helical member which permits a pile to be rotatably driven into the anchoring medium by activation of the pile through rotary motor means at the water surface.

BACKGROUND OF THE INVENTION

The customary means for anchoring stationary marine platforms of the type contemplated is by use of piling driven into the ocean substream and connected to the marine platform. The piling normally used for such operations takes the form of relatively heavy walled steel tubing of an appropriate diameter between about 16 to 48 inches. The piles are normally assembled to a desired length from shorter tube sections in accordance with the depth of water, the number of piles required and other factors. For convenience, anchoring piles are frequently guided into place through platform support legs or other platform members. The necessity for pile guiding during most offshore driving operations stems from the depth of water in which such platforms operate which usually requires that the piling be relatively long, and consequently of decreasing rigidity in proportion to increased length.

In the instance of relatively deep water it is understandable that when a pile is impact driven from a power source such as a pile driver, at the water surface, the pile will of necessity be of a greater length than the water depth. Further, the mass of the pile will tend to absorb at least part of the impact energy delivered by the pile hammer. The amount of such energy absorption will increase as the pile length increases until a condition is realized where it becomes impractical or virtually impossible to drive the pile solely by impact witth any reasonable degree of effectiveness.

As a matter of economic practicality, marine type offshore platforms are built for use at multiple drilling locations and to facilitate movement of the platform between such locations. This desirable feature however prompts the necessity for rapid anchoring of the platform after it has been floated to a new location. The practice generally followed is that once the platform has been transported to a desired position, anchoring piles are driven into the subterranean floor by a pile driving apparatus usually mounted on a barge or similar vessel placed adjacent to the platform itself. As a consequence, the anchoring operation often becomes contingent on weather conditions which in turn determines water turbulence. When the latter becomes excessively agitated, the pile driving operation is deferred until more favorable conditions prevail.

As a matter of drilling economics then, the anchoring of an offshore platform might be delayed days or even

weeks. Such a delay can result in a loss of thousands of dollars due not only to lost production days but also to the added cost for capital equipment tie-up such as pile driving barge rental and the like.

It is known that as a platform is transferred from one well site to an alternate drilling site, variations in the ocean floor consistency are expected. It is common for example that such offshore platforms are required for use, and are floated to parts of the world separated by thousands of miles. The platform therefore will experience diverse ocean floor conditions between the extremes of a readily penetrable muddy consistency, to a relatively dense floor which would require excessive drilling or other probing before piles are successfully imbedded.

It is therefore an object of the invention to provide an offshore platform so constructed to overcome the above mentioned structural as well as anchoring problems. A further object is to provide an offshore platform adapted to be readily transferred from one well position, to an alternate drilling location where it may be again anchored. A still further object is to provide a novel platform anchoring device adapted for insertion into an ocean substratum to rigidly hold a drilling platform in a fixed position. Still another object is to provide a marine platform of the type described including anchoring means in the form of rotatably driven, threaded piles which are adapted for imbedment in the ocean floor. Yet another object is to provide a marine platform of the type contemplated which incorporates threaded anchoring piles adapted for rotatable insertion into the ocean substratum from a power source on the platform itself.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric elevation view of an offshore type drilling platform incorporating the novel pile structure as an anchoring device. FIG. 2 is an enlarged segmentary view in partial cross-section of a section of the platform lower leg showing the drill head in an advanced position from the pile lower end. FIG. 3 is a view similar to that shown in FIG. 2 with the drill illustrated in the retracted position and, FIG. 4 is a segmentary view on an enlarged scale showing the end face of a pile section.

The invention in brief contemplates a stationary offshore marine drilling and/or production platform having one or more working decks raised above the water's surface and adapted to accommodate the normal drilling and production equipment characteristic to such platforms. The decks are elevated above the water by at least one, and preferably by a plurality of support legs which extend toward the ocean floor. While the actual number of support legs required in any particular unit is determined by the platform's capabilities, by the water depth, and by other considerations, the hereinafter described unit is shown with three legs to illustrate at least one embodiment into which the anchoring piles might be incorporated.

The respective support legs are preferably cylindrical in cross-section and define a guide means to accommodate one or more anchoring piles coaxial of the leg longitudinal axis. An expansive base assembly connects to, and rigidizes the legs into a composite structure at the leg lower ends. Said base, may comprise a framework of structural elements, and preferably incorporates bouyancy tanks operable to assist in manipulating the platform during moving and placing.

The novel anchoring piles are characterized by an externally carried helically formed member which upstands from the pile surface. The helical member is of such a disposition and configuration, that the pile, when positioned

at the ocean bottom and rotated at the upper end, will tend to draw itself into a firmly imbedded position within the ocean substratum. The anchoring operation, by the rotary movement particularly in a relatively hard substratum, is facilitated through a drill operably carried within the pile and adapted to advance forward of the latter to form an elongated cavity into which the pile might be readily threaded.

Referring to the FIG. 1, an embodiment of a submersible marine platform **10** is shown which comprises one or more parallel and vertically spaced decks **11** and **12**. Both decks are positioned a distance above the ocean surface to be beyond the reach of waves generated through weather conditions or through the normal ocean environment. A plurality of elongated legs **13**, **14**, and **16** depend downwardly from the decks and are fixed or operably connected to the latter. In the instance of jack-up type legs each leg is adjustable to be raised or lowered in accordance with the depth of water in which the platform is anchored. In either instance however, the legs collectively support deck **12**, as the braces **17** and **18**, in a manner that both decks are at least 50 to 60 feet beyond the ocean surface.

Decks **11** and **12** accommodate such drilling equipment as a drill derrick **19**, rotary table **21**, together with rotary drive, cranes, oil storage facilities and living quarters. The latter are not presently shown, but are however familiar members to offshore platforms. A typical support leg in its simplest form comprises essentially an elongated, heavy walled cylindrical member formed of a plurality of end welded incremental tubular sections. The legs are hollow when formed into an assembled length, and may, although not necessarily, constitute at least in part, a water tight or controlled buoyancy structure. The number of legs employed for a particular platform design is commensurate on the water depth in which the platform is fixed, the weight of the equipment carried, and other considerations including necessary leg cross bracing.

Referring to FIGS. 1 and 2, rotary table **21** comprises a mechanism known in the well drilling art including essentially a bearing mounted rotatable table which cooperates with a split collar or kelly drive bushing **25**. A power train including a drive such as a diesel or steam engine together with suitable gear reduction units connects to the table for rotating the same through a clutch mechanism. Bushing **25** includes separable halves, which, when assembled, define a center square hole adapted to slidably receive the square center shank or kelly **20**.

As in normal operation, the lower end of kelly **20** threadably engages the upper end of pipe string **36** supporting the drilling head **34**. The kelly upper end is attached to a rotatable swivel and to the crown block within the derrick structure neither of which members are presently shown but which are familiar to the drilling art. A source of drilling mud also connects to the kelly upper end to provide a forced stream of said mud through the drill string and to the drilling head in accordance with known practice.

In an instance where the threaded pile is rotatably driven by rotary table **21** together with the sliding kelly **20**, the respective platform support legs are expeditiously disposed such that the longitudinal axes thereof terminate at a position in the vicinity of the rotary table center. Thus as shown, the three legs have their upper ends spaced downwardly from lower deck **12**, and the respective axes thereof, when extended form a juncture in the vicinity of the rotary table **21**.

The anchoring piles connect to a platform member whether to the platform base, legs, or other part. Expediency therefore often dictates whether the piles be guidably supported through the downwardly directed legs, or through separate members adapted to the purpose. While the hereinafter described threaded piles might be urged into the ocean substratum in a variety of positions,

to facilitate the description, the respective piles **27** are shown and described as being guidably positioned within, and extending from the lower ends of the respective support legs **13**, **14** and **16**.

Platform **10**, to facilitate the boring or drilling of a plurality of wells, is provided with an elongated center column **22** which extends from lower deck **12** to the ocean floor. Column **22** is not primarily by function a structural member but acts rather to protect well conductors, tanks and similar equipment. Platform **10** is further provided at its lower end with the herein mentioned stabilizing base including structural members **23**, **24** and **26**, end welded to form a triangular configuration at column **22** lower end. The base members are provided with internal controllable buoyant elements such as flotation chambers, thereby to controllably regulate the attitude of the platform during transporting and positioning operations. Further, elongated center column **22** normally housing up to 30 or 40 well conductors, might further be provided with buoyancy elements such as storage tanks and the like which are likewise regulatable to adjust the platform buoyancy.

Referring again to FIG. 1, elongated legs **13**, **14** and **16** extend from a junction of adjacent members of the base assembly, to a position at the upper end of center column **22**, each of which legs includes an axial pile guide passage. Each leg, **13** for example, encloses an elongated pile **27** which is guidably retained therein. In the position shown, the piles extend from the leg upper end, and through the axial guide passage, from which the pile lower end extends and is imbedded in the ocean substratum.

As seen in FIGS. 2 and 3, each pile **27** is formed of a plurality of end welded cylindrical segments of relatively short length which are added to the pile upper end during a driving operation as the pile is progressively and rotatably driven into the ocean floor. Thus the respective pile segments may be formed as shown in FIG. 4, with mating, castellated end surfaces which engage to form a tight joint, which in turn may be welded to unitize the respective units. The joint structure provides a maximum degree of shear strength to resist the torsional force applied to the pile end by the rotary unit **21**. This construction also facilitates disassembly of a pile for salvage purposes when the platform is to be moved.

Each pile joint may be further provided with locking means such as peripherally arranged upstanding lugs **28** and **29** having one or more locking holes which engage corresponding openings in an adjacent segment whereby the two might be readily fastened together. The two end abutting cylindrical sections are thus rigidly locked.

Referring to FIG. 2, the lower end of pile **27** is provided with an upstanding, helically configured member **31** characterized by a relatively constant pitch. The latter in one embodiment is formed by a relatively thin, although strong, continuous ribbon-like metal strip which is welded along its inner edge to the pile exterior surface. The structure thereby provides in effect an upstanding, helically disposed external thread.

In that the consistency of the ocean substratum at most drilling locations might be predetermined to at least a limited degree prior to a drilling operation, the number of piles and the depth to which each pile must be imbedded can normally be programmed ahead. It is thus feasible, in most instances, through a knowledge of the substratum composition, to predetermine the actual length of threaded section which is required on any pile. Further, the number of such piles which might satisfactorily anchor a particular platform in a position may be determined.

Such preliminary groundwork however is rather expensive and time consuming. The normal procedure is to obtain core samples and seismic readings of the substratum at a proposed drilling location. These samples, by analysis together with seismic readings suggest the characteristics of the anchoring medium as to consistency, composition as well as proposed value of the site as an oil producing facility.

Referring to FIGS. 2 and 3, to guidably position the respective piles **27** during rotation, and to control the rate of penetration both before and while entering into the ocean substratum, the pile guide inner wall of leg **14** is provided with a guide track such as a spirally formed channel **32** at the leg **14**, having a pitch corresponding to the pitch of the pile helical thread. As pile **27** and the guide channel **32** are aligned in sliding engagement, rotation of pile **27** will automatically cause the latter to advance itself along the guide channel and urge itself into the ocean floor. The guide channel **32** may comprise a continuous member or may be discontinuous. Its primary functions however are to guide the pile during relative movement therebetween and to maintain the two in a controlled axial relationship.

Referring to FIGS. 2 and 3, to achieve the needed versatility of operation in all varieties of ocean floors, each threaded pile **27** is provided with a rotatable drilling device **33** adapted to predrill a cavity of suitable size, into which pile **27** might be threaded or rotatably inserted. Each drill includes a lower positioned drilling head **34**, carried on an extensible drill string **36** which terminates at an upper engaging end. In a preferred embodiment of drill head **34**, the latter is retractably actuated to a disengaged position within the lower end of pile casing **25**, and expandable when advanced from the lower end. Drill head **34** other than being retractable to disengage itself, is of a type normally utilized for drilling such wells. The drill head in essence comprises a plurality of conical drill elements **37**, **38** and **39** cooperatively arranged to be mutually engaged and having cutting edges to break away the substratum as drill string **36** is rotated. The form of drill string **36** comprises a plurality of end threaded pipes adapted at the upper end to receive an engaging socket of drill kelly **20**.

As mentioned drill head **34** is of the retractable type wherein the three conical drill elements are adapted to be actuated to a withdrawn position in the pile **27** lower end. During a drilling step however, conical elements **37**, **38** and **39** are urged from the pile lower end, to expand laterally at a position forward of the pile, to a diameter larger than the diameter of pile body **25**. As the drill string is rotated, head **34** advances into the substratum, to form a cavity of a diameter less than that of the upstanding thread member **30**. yet greater than the diameter of the pile tubular body **25**.

Following standard drilling practice, the drill head conical elements **37**, **38** and **39** are replaced periodically for sharpening or replacement as needed. For example the pile unit is adapted to readily penetrate a hard surface such as one made up primarily of a rock composition or the like, but is likewise adapted for insertion into a yieldable or muddy substratum.

Referring again to FIGS. 2 and 3, to facilitate insertion of a threaded pile **27** into the ocean floor at a drilling site, platform legs **13**, **14** and **16** include means to support the pile and the drill unit in a manner to allow a proper sequence of actuation. Each leg, **14** for example, is provided with a pile clamping mechanism including a fixed peripheral ring **41** disposed externally of the leg outer surface. The ring supports an inner, segmented ring **42** comprising a plurality of shoes having an engaging face. Expanding means connecting the respective outer ring **41** and inner segmented ring **42** shoes, permits the engaging face of the latter to be forcibly urged inwardly against the pile external wall, there to firmly lock the latter against movement with respect to the leg **14**. While not shown in detail, the respective clamping rings surrounding the leg, threaded pile and drill are powered and actuated hydraulically by a suitable mechanism.

Referring again to FIGS. 2 and 3, during a drilling operation, the upper pipe segment of drill string **36**, threadably connects to the socket at the lower end of kelly **20**. The latter, in the usual manner slidably registers in the square center opening of split kelly bushing **25** on rotary table **21**. The upper end of kelly **20** is in turn rotatably supported by the swivel and crown block suspended from derrick **19**.

To effect a workable connection between the derrick supported elongated kelly **20**, and the upper end of threaded pile **27**, exact alignment of the said two members is preferred though not essential since the swivel from which kelly **20** is suspended will compensate for some degree of misalignment. While a desired arrangement is to utilize the deck mounted rotary table **21**, draw works, and other equipment as the source of rotative movement, other similar power media might be likewise employed to insert the threaded pile. It is appreciated however that use of the rotary table and associated bushing **25** as the torque applying elements obviates the necessity for extra equipment on the platform even on a temporary basis.

To accommodate the inwardly directed platform legs, rotary table **21**, its ancillary power plant and draw works may be adjustable to a canted position with respect to the drill deck to provide the most effective alignment of kelly **20** with the longitudinal axes of the respective legs. The torque applying equipment may also be movably mounted to the platform deck thereby to permit lateral movement for aligning with the pile end.

Pile **27** is so arranged to be rigidly clamped to leg **16** by circular clamp **41**. The latter as mentioned, comprises a plurality of circularly arranged shoes or segments **42** adapted for radial movement whereby the inner engaging faces contact the pile outer wall to support and immobilize the latter. In such condition, the pile is independent of the drill string and ready to form a cavity into which the pile may be inserted. Inner drill string **36** is now rotated, and lowered to extend drill head **34** beyond the lower end of pile casing **25** and to the expanded condition. As the drill is rotated by table **21**, a stream of drilling mud is circulated through drill string **36** to carry away rock, sediment and/or other residual elements from the drill head area in the usual manner.

The combined weight of drill string **36** and pile **27** will often be sufficient, when used in relatively deep waters, to penetrate the substratum merely by its mass. Such penetration however will depend primarily on the consistency of the substratum. Thus, in a relatively muddy or soft ocean floor the pile will tend to sink until resisted by a more firm composition in the substratum. For this initial entry of the pile, it is only necessary to connect additional segments to the pile upper end. Thereafter further pentration is facilitated by sequential drilling and pile rotation until a desired depth is achieved.

After a cavity of suitable depth, usually the length of single casing segment, has been formed in the substratum, drill head **34** is withdrawn to a position wherein the head is in arrears of the pile lower opening. When so withdrawn, drill head elements **37**, **38** and **39** are disassociated and collapsed inwardly to permit said elements to be accommodated within the pile.

The entire pile **27** together with drill string **36** are next rotated to advance the pile further into the performed cavity. This latter step is achieved by disconnecting kelly **20** from the drill string upper end after the drill string has been stabilized in place by a circular clamp. With the kelly raised out of the way, an adapter **44** is next fitted to the pile upper end. Adapter **44** includes a connecter socket **47** that fastens to the upper end of pile **27**. The adapter also connects to the kelly **20** lower end preferably by a quick disconnect coupling whereby both pile and drill string are mutually supported and rotated. Thereafter, rotation of the kelly will cause the pile **34** to be downwardly guided by guide **32**, thereby advancing the pile further into the cavity a predetermined distance.

With both the pile **27** and the drill head **34** lowered into the cavity a maximum depth, each must be lengthened by addition of segments to the upper ends thereof. Such addition is readily achieved in any of several ways, one of which is as follows. In the lowered position, and

surrounded by the cavity, pile 27 is firmly locked by actuation of ring clamp 41 which exerts radial inward pressure against the pile wall. Similarly, drill string 36 is firmly locked in suspended position by clamp ring 46.

With the pile or piles imbedded to a desired length, the platform will in effect be supported through the helical guide 32 at the leg inner wall. The latter member will prevent relatively longitudinal movement between leg and pile. However, a more secure joint between said members is assured by cementing or grouting in the usual manner. This latter step consists of filling the annular space between leg and pile with a quick hardening cement. Usually the grouting material is directed to the joint area in liquid form and then permitted to harden.

While not presently shown, it is understood that each support leg may include a plurality of, rather than a single pile. The procedure however for imbedding the same will be substantially as described with respect to a single pile as will the pile guide means disposed in each leg.

To remove a platform from a particular location for transfer to another either by floating or by transport, the platform is first disconected from the ocean floor. If the leg-pile joint was originally grouted, explosives would be the most expeditious means for severing the joint. Thereafter, the freed platform could be manipulated by controlled bouyancy.

In the instance of non-grouted leg-pile joints, the threaded piles could be reversibly rotated to dislodged the same from the ocean floor. This method of removal could constitute a reversal of the previously noted imbedding step together with the measures known in the art for assisting in such removal. For example, jetting of a high pressure fluid stream through the pile walls and into the imbedded medium would tend to fluidize the joint and ease removal. Also, control of the pile holding mechanism can be exercised by utilization of the osmosis principle through suitable electrical connection with the pile.

I claim:

1. In a marine platform for an offshore drilling and production installation having a deck holding drilling and production equipment, and including a rotary drive means, at least one leg connected to said deck and extending toward the ocean floor for supporting said deck above the ocean's surface, and a pluraliity of pile guide members connected to said platform and disposed in a substantially upright disposition, each of said pile guide members including:

means forming an elongated guide passage having an opening at the passage lower end,

an externally threaded pile positioned in said means forming said guide passage, said threaded pile including a cylindrical body having opposed lower penetrating ends, and an uppermost engaging end, the latter being adapted for removable connection to said rotary drive means on said deck,

and a drill, reciprocably mounted in said externally threaded pile cylindrical body for movement thereof between extended and retracted positions, said drill being adapted to be rotatably driven and advanced from said pile lower end to form a cavity in the ocean floor.

2. In a marine platform as defined in claim 1 wherein said drill is radially expandable when extended to a position beyond the lower end of said cylindrical pile body to form a cavity upon rotation thereof characterized by diameter larger than the diameter of said cylindrical pile body.

3. In a marine platform as defined in claim 1 wherein said plurality of pile guide members is integral with said at least one leg to form a part of the latter.

4. In a marine platform as defined in claim 1 wherein; said pile is adapted at the upper engaging end thereof for receiving and being joined to additional pile incremental lengths to increase the pile overall length.

5. In a marine platform as defined in claim 1 including; means for independently inducing rotational movement to said respective pile and said drill.

6. In a marine platform as defined in claim 1 including; means for simultaneously rotating the respective pile and drill.

7. In a marine platform as defined in claim 1 including; positioning means disposed in said means forming said pile guide passage, and slidably engaging said externally threaded pile whereby to advance said pile longitudinally through said guide passage as said pile is rotated.

8. In a marine platform as defined in claim 1 wherein, said rotary drive means includes a rotary table adjustably carried on said deck, and a kelly slidably received in said rotary table to be rotated thereby, said kelly being adapted to selectively engage the upper end of the said pile and drill, to sequentially rotate said respective members whereby to form a bore with said drill and to rotatably insert said externally threaded pile into said bore.

9. A soil penetrating anchoring pile including:

an elongated penetrating drill having a cutting head at one end thereof and an actuating end dimetrally opposed to said cutting end,

a hollow pile having an upper end surrounding and spaced outwardly of said penetrating drill to define an annular guide passage for the latter,

said penetrating drill being reciprocably and rotatably disposed in said hollow pile, and being longitudinally movable from a retracted position within the pile, to an extended position beyond the open end thereof,

a helical flute formed on the periphery of said pile and extending for a portion of the length thereof,

a heavy walled cylindrical support member surrounding said hollow pile extending axially thereof,

guide means depending from the inner surface of said heavy wall,

said helical flute on said penetrating drill slidably engaging said guide means, whereby rotational movement of said pile within said support member will displace said pile in a longitudinal direction with respect to said support member.

10. In an anchor defined in claim 9 wherein said guide means includes:

means forming a channel extending along the inner surface of said heavy wall, said helical flute having an outer edge slidably received in said means forming said channel for guiding said flute longitudinally of said support member as said pile is rotated.

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JACOB SHAPIRO, Primary Examiner

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