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METHOD OF ANCHORING OFFSHORE STRUCTURES

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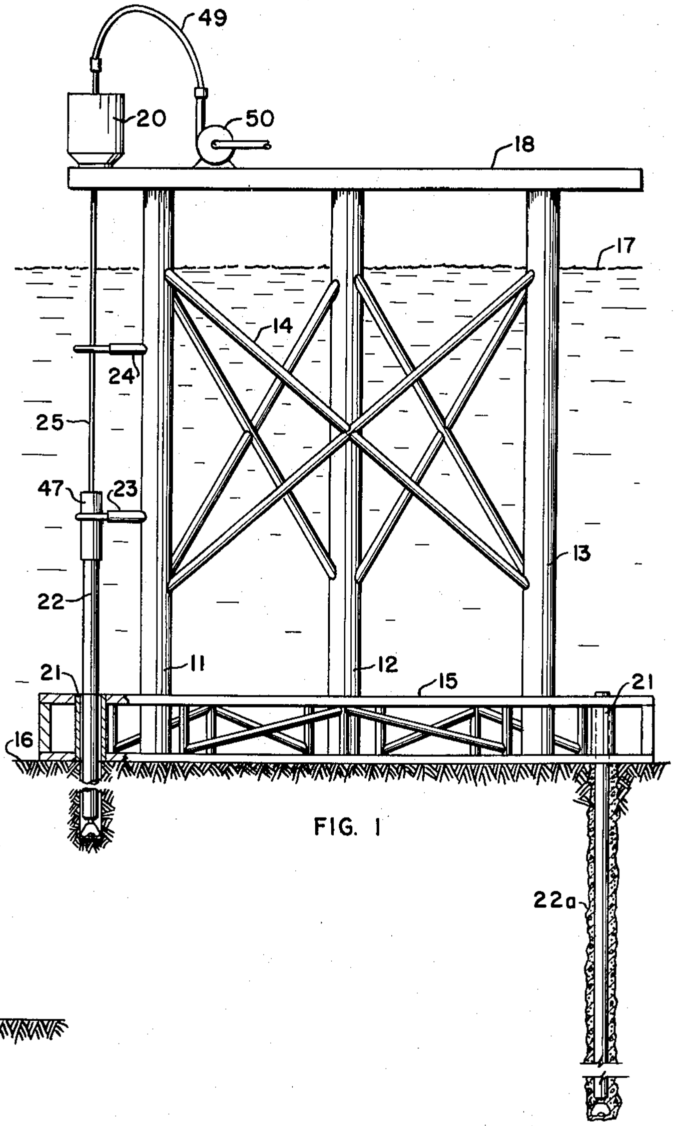

FIG. 1

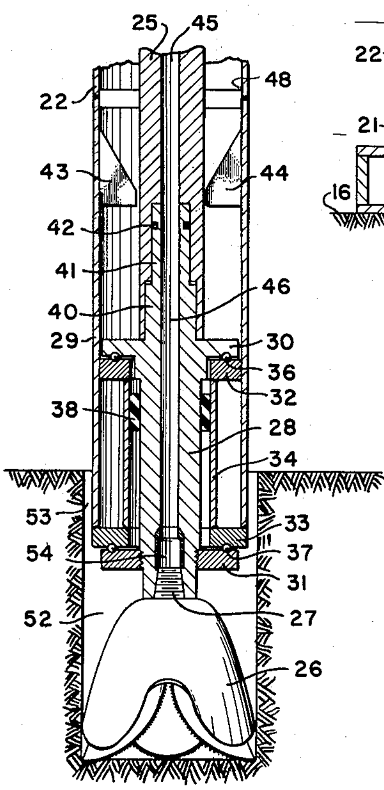

FIG. 2

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METHOD OF ANCHORING OFFSHORE STRUCTURES

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This invention relates to the anchoring of offshore structures of various types to the ocean floor and pertains more particularly to a method whereby structures such as an oil well drilling platform or production platform may be secured to the ocean floor with relatively simple and inexpensive equipment.

In drilling and producing wells at offshore locations, large structures are employed which are positioned on the ocean floor and extend upwardly above the surface of the water sometimes to a distance equal to the maximum wave height to be encountered in that area. An offshore structure generally comprises a footing or base element, which may be in the form of a framework or a pontoon which rests on the ocean floor, with a plurality of vertical legs extending upwardly above the surface of the water where an operating platform is secured thereto for supporting various pieces of equipment. If the platform is to be used for drilling of wells, drilling equipment including a drill rig and auxiliary equipment as well as living quarters for the crew and storage facilities are usually mounted on top of the platform. If the platform is to be used for production purposes various manifolding equipment, storage tanks, meters and treating apparatus are generally mounted on the platform. Platforms of this type are relatively large in size and may range up to 300 feet in length. A typical platform for use in the drilling of wells may have a hull that is 80 feet wide, 140 feet long and 15 feet high.

After an offshore structure of the above-described type has been positioned on the ocean floor, it is the general practice to anchor the structure to the floor by driving piles down through the vertical legs of the structure so that they penetrate up to 300 feet or more in the ocean floor. In general, the depth to which the piles are sunk depends on the nature of the soil on the ocean floor. Thus, the harder the formation beneath the structure the shorter the piles that are used. While some of the piles that are driven through the legs of the structure are cut off at the level of the top of the legs of the structure and then welded or otherwise connected to the leg, it is also a practice at times to install stub piles in the bottoms of the legs and through the footing of the structure. Stub piles are piles that do not extend to the surface of the water. Usually they only extend up to the top of the footing of the offshore structure, thereby providing support for the structure without causing an obstruction to wave action.

In shallow water piles may be satisfactorily driven into the ocean floor with conventional tools employed, such as with a pile driver. However, in deep water, as the mass and unsupported length of a pile increases, the efficiency of a driving hammer is reduced. In driving a stub pile into the ocean floor it is necessary to install a follower pipe or section of pile which extends from the top of the stub pile to above the surface of the water so that it can be contacted by a driving hammer. The driving hammers now being employed are large and expensive and considerable improvement in their operation may be needed to drive piles in deep water, say, 100 feet or more in depth. It has been suggested that in order to increase the efficiency of a hammer driving stub piles, the hammer could be designed to operate underwater. When an underwater pile driving hammer is developed, the follower pile above a stub pile can be eliminated since the hammer would remain on the top of the pile until it was driven to its final elevation. To date, however, such a hammer has not been developed.

It is therefore an object of the present invention to provide a method of installing stub piles through a footing or base of an offshore structure without employing a follower pile or a pile driving apparatus.

A further object of the present invention is to provide a method of anchoring an offshore structure with piles in deep water to a fairly solid ocean floor without the necessity of employing pile driving equipment.

Another object of the present invention is to provide a method whereby an offshore structure may be simply and inexpensively anchored to the ocean floor.

Still another object of the present invention is to provide a method whereby an offshore structure having a plurality of legs may be anchored to the ocean floor without installing piles in the legs, so that the legs may be employed more efficiently, such as: to form fluidtight chambers which aid in floating the structure to its location, or serve as housing means for various service lines or pipes for flooding or evacuating a floatable base secured to the bottom of the structure.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a diagrammatic view illustrating a platform structure positioned on the ocean floor and anchored thereto by means of piles; and,

FIGURE 2 is a diagrammatic view taken in longitudinal cross-section of one form of a drilling head to be mounted at the bottom of each of the piles prior to installing them into the ocean floor.

Referring to FIGURE 1 of the drawing, an offshore structure is shown as comprising a plurality of support members or legs **11**, **12** and **13** interconnected by means of bracing members **14** and fixedly secured to a base member **15** which rests on the ocean floor **16**. While a three-legged structure is shown for ease of illustration, it is to be understood that the structure could employ any number of legs which are usually arranged in a configuration having a closed perimeter. The legs **11**, **12** and **13** are generally tubular, being legs of large diameter pipe. However, in some circumstances they may be solid members, such as I-beams. The base member **15** is shown as being a unitary structure comprising a series of interconnecting members so as to reinforce it. In some structures the base member **15** may be covered to form a buoyancy tank adapted to be flooded or evacuated so as to form a float by which the entire structure may be raised or lowered. Mounted on the top of the legs **11**, **12** and **13**, at a suitable distance above the surface of the water **17**, is an operating platform or deck **18**. Element **20** represents a readily movable drilling apparatus which is moved from one position to another along the edge of the deck **18**. While the base member **15** is illustrated as a unitary structure having an area substantially equal to that of the deck **18**, it is to be understood that a much smaller base member could be secured to the bottom of each of the supporting legs **11**, **12** and **13**.

Positioned adjacent each of the legs of the structure and preferably near the outer edge of the base member **15** are pile guide sleeves **21** which have an internal diameter slightly larger than the diameter of the pile **22** or **22***a* which is to be positioned therein. If desired, each leg **11** may be provided with one or more guide arms **23** and **24** which aid in supporting the pile **22** or a drive shaft **25** which is operatively connected to the drilling unit **20**.

Prior to installing pile through the base member **15** into the ocean floor **16**, a drill bit is secured to the lower end of the pile in a manner shown in FIGURE 2 of the drawing. The drill bit 26 is threadedly connected as at 27 to a short shaft 28 which is provided with a sealed bearing unit. One such unit would be formed by radially-extending flanges 30 and 31 which are fixedly secured to the shaft 28. A cooperating bearing unit is formed at the bottom of the pile 22 on the inner wall thereof and takes the form of a pair of inwardly-extending flanges 32 and 33 which are fixedly secured to the inner wall of the pile 22 and are welded to a support tube 34 which is slightly larger in diameter than the diameter of the shaft 28 extending therethrough. Ball or other suitable types of bearings are employed, as at 36 and 37 to facilitate rotation of the flanges 30 and 31, 32 and 33. A seal 38 is inserted between the shaft 28 and the surrounding tube 34 to prevent fluid entry into the pile during its installation.

Formed at the top of the shaft 28 is a polygonal (such as a square) driving head 40, which in this embodiment, extends upwardly with a reduced diameter, as at 41, and is provided with a seal 42. Guide fins 43 and 44 are secured, as by welding, to the inner wall of the pile or bit housing 29 for guiding the lower end of the drive shaft 25 down into position on the square driving head 40. It is necessary of course that the lower end of the drive shaft 25 be provided with a polygonal recess for receiving the mating driving head 40 therein. Additionally, the drive shaft 25 and the short shaft 28 to which the bit 26 is connected, are provided with flow passages 45 and 46, respectively, for circulating a fluid therethrough. It is to be understood that the bit 26 is provided with fluid discharge ports in a manner normal to drill bits. If desired, a seal or slip joint 47 which may contain an annular packer member between the drive shaft 25 and the inside of the pile 22 may be employed to form a substantially fluid-tight seal or stabilizer as the top of the pile moves downwardly with the drive shaft 25.

In anchoring an offshore structure in accordance with the method of the present invention, the structure is first transported to the desired offshore location on barges or is floated into position. A floated barge is then sunk to the ocean floor at the desired location. If the structure is carried to the location by barges, large cranes are normally employed to lift the structure off the barge or barges and lower it to the ocean floor.

With the structure seated on the ocean floor as illustrated in FIGURE 1 of the drawing, a tubular steel pile 22 is selected and the bit housing 29 (FIGURE 2), including the bit 26 and shaft 28, is attached to the lower end of the pile 22. The pile 22 is then lowered down through guides 23 and 24 and through the pile guide sleeve 21 which extends vertically through the footing 15. The lower end of the drive shaft 25 is then passed down through the pile 22 and rotated slightly until the recessed lower end thereof engages the driving head 40 at the top of the short shaft 28 carried in the bit housing 29. The upper end of the drive shaft 25 is then passed through and operatively connected to any suitable type of mechanism 20 for rotating the shaft. If desired, the top of the tubular drive shaft 25 may be connected by means of a conduit 49 to a mud pump 50 for circulating a drilling fluid down through the drive shaft 25 and the bit 26 as the pile 22 and the bit 26 are being drilled into the ocean floor 16.

It may be seen that in drilling pile 22 into the ocean floor in the manner described hereinabove, a relatively light drive shaft 25 and a relatively small driving mechanism 20 may be employed. The present method differs from normal drilling operations in that the weight on the bit 26, and hence the weight bearing against the bottom of the borehole 51 (FIGURE 2), is not entirely dependent upon the weight of the drill string or drive shaft 25 above the bit 26. In the present method of drilling piles into the ocean floor, the weight of the pile 22 is applied to the bit 26 and constitutes in most cases the main force for driving the bit 26 into the formation. However, because

of the unique arrangement of the bit 26 and its shaft 28 which rotate at the bottom of the pile 22 independently thereof, it is not necessary to employ a large or expensive drive mechanism 20 capable of rotating large diameter and heavy pile. For example, the pile 22 may be a piece of steel pipe 30 or 33 inches in diameter.

Drilling is generally continued until the desired length of pile 22 has been drilling into the ocean floor or until the top of the pile *22a* is substantially flush with the top of the base member or footing 15. As the pile 22 enters the ocean floor the drive shaft 25 moves down with it and additional lengths of drive shaft are connected to the upper end thereof, if necessary. After the pile 22 has been drilled to the desired depth, it is generally preferred to cement it in place by circulating a cement slurry by means of a pump down through the drive shaft 25 and through the bit 26, continuing the circulation so that the cement slurry fills the borehole 52 passing up the annular space 53 between the outside of the pile 22 and the formation. The space between the pile 22 and the pile guide sleeve 21 in the footing may also be filled with cement which is allowed to harden and serve, if desired, as a connection between the pile 22 and footing 15.

The cementing operation is carried out in a manner normal to the cementing art, with a cement plug being pumped down after the cement, if desired. The bit shaft 28 is preferably provided with a recessed portion or landing collar 54 in which a pumped-down cementing plug can be seated so as to hold a back pressure on the cement when the drive shaft 25 is pulled free of the square driving head 40 at the top of the bit shaft 28. Thus, when the shaft 25 is pulled to the operating platform 18 again, it is free of cement. While the method of the present invention has been described with regard to anchoring a multi-legged platform to the ocean floor, it is realized that the present method can also be employed to anchor the footing of a single caisson to the ocean floor in a similar manner, the footing being substantially greater in area than the cross-sectional area of the caisson.

I claim as my invention:

1. A method of anchoring an offshore structure positioned on the floor of a body of water, said structure comprising a plurality of vertical support members connected together to outline a geometrical figure having a closed perimeter, said support members terminating in a weight-bearing footing at their lower ends with at last one guide in said footing adjacent each support member, said method comprising the steps of fixedly securing a bit to the bottom of a tubular pile, guiding said pile down through the water outside any vertical support member and into said guide in said footing, installing a drive shaft in the pile to engage the rotatable bit at the bottom thereof, lowering the bit and lower end of the pile through the guide in the footing adjacent the support member, rotating the drive shaft to drill a hole slightly larger than the diameter of the pile and drill the bit and pile into the consolidated formation beneath the footing, continuing drilling until the top of the pile is below the water level and at a predetermined level relative to the top of the footing, discontinuing drilling, cementing the pile and bit to the formation, withdrawing the drive shaft from said pile, and cementing the upper end of the pile to the footing.

2. A method of anchoring an offshore structure positioned on the floor of a body of water, said structure comprising a plurality of vertical support members connected together to outline a geometrical figure having a closed perimeter, said support members terminating in a weight-bearing footing at their lower ends with at least one guide in said footing adjacent each support member, said method comprising the steps of fixedly securing a rotatable bit to the bottom of a tubular pile, guiding said pile down through the water outside any vertical support member and into said guide in said footing, installing a tubular drive shaft in the pile engaging

the rotatable bit at the bottom thereof, lowering the bit and lower end of the pile through the guide in the footing adjacent the support member, rotating the drive shaft to drill a hole slightly larger than the diameter of the pile and drill the bit and pile into the consolidated formation beneath the footing until the top of the pile is substantially level with the top of the footing, discontinuing drilling, pumping a cement slurry down through said drive shaft and bit in a quantity sufficient to fill the annular space outside the pile for cementing the pile to the formation, withdrawing the drive shaft from said pile, and cementing the upper end of the pile to the footing.

3. A method of anchoring an offshore structure positioned on the floor of a body of water, said structure comprising a plurality of vertical support members connected together to outline a geometrical figure having a closed perimeter, said support members terminating in a weight-bearing footing at their lower ends with at least one guide in said footing adjacent each support member, said method comprising the steps of fixedly securing a rotatable bit to the bottom of a tubular pile, positioning said pile alongside one of the support members of the structure, guiding said pile down through the water outside any vertical support member and into said guide in said footing, installing a tubular drive shaft in the pile engaging the rotatable bit at the bottom thereof, lowering the bit and lower end of the pile through the guide in the footing adjacent the support member, rotating the drive shaft from a position above the surface of the water to drill a hole slightly larger than the diameter of the pile and drill the bit and pile into the consolidated formation beneath the footing, circulating a drilling fluid through said drive shaft during the drilling operation, continue drilling until the top of the pile is substantially level with the top of the footing, discontinuing drilling and circulation of drilling fluid, pumping a cement slurry down through said drive shaft and bit in a quantity sufficient to fill the annular space outside the pile for cementing the pile to the formation and the footing of the structure, withdrawing the drive shaft from said pile, connecting the upper end of the pile to the footing, and repeating the steps for installing at least one pile adjacent each of said support members.

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