Dec. 16, 1969 P. W. MARSHALL 3,483,708

METHOD OF ANCHORING MARINE STRUCTURES

Filed Dec. 28, 1967

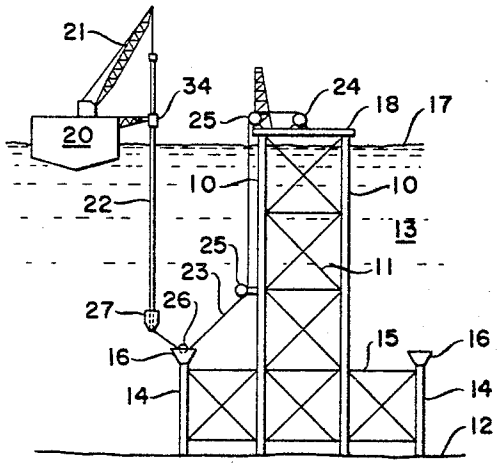



FIG. 1

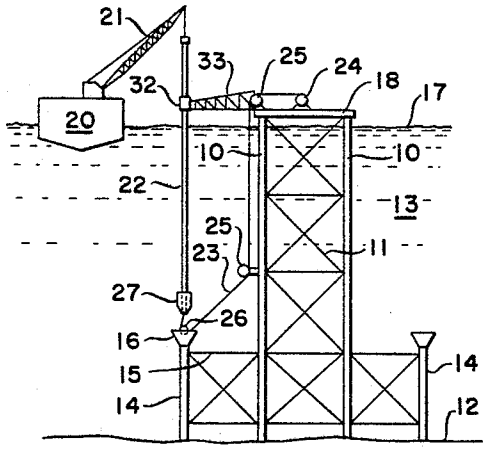



FIG. 2

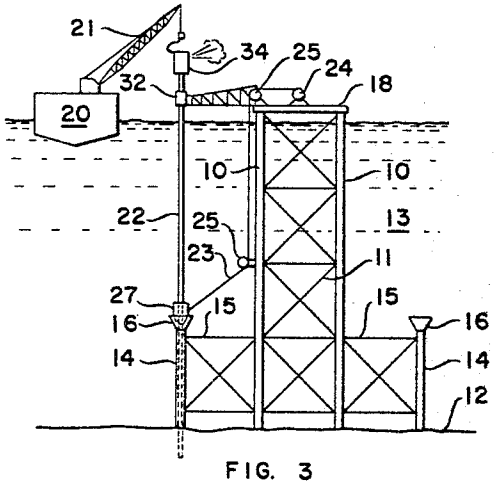



FIG. 3

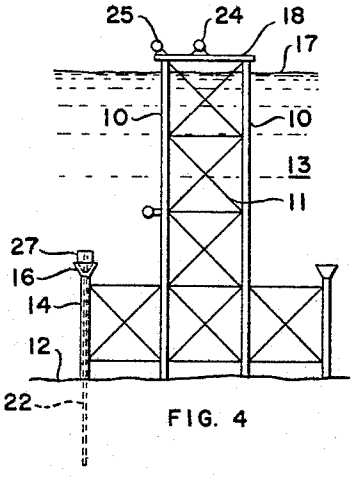



FIG. 4

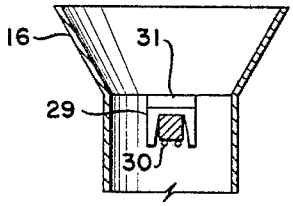



FIG. 6

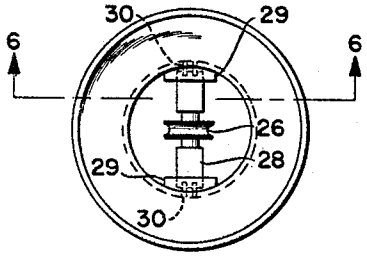



FIG. 5

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# METHOD OF ANCHORING MARINE STRUCTURES

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U.S. Cl. 61—46.5 11 Claims

## ABSTRACT OF THE DISCLOSURE

A method of installing a marine structure offshore wherein a marine structure with pile guides carried on the lower end is positioned on the floor of a body of water and a pile is lowered into axial alignment with one of the guides by pulling the lower end of the pile from a point on the guide; after which the pile is driven into the water floor through the guide to thereby anchor the structure.

This invention relates generally to the anchoring of structures of various types to the floor of a body of water and more particularly to the method of anchoring marine structures of the type having a base with a plurality of skirt pile sleeves for receiving concentric stub-piles therethrough.

## BACKGROUND OF THE INVENTION

In drilling and producing wells at offshore locations large marine structures are employed which are positioned on the floor of a body of water and extend upwardly above the water surface. These structures or so-called "platforms" generally comprise a lower base element including a plurality of substantially vertical legs which extend above the surface of the water and an operating deck secured to the upper end of the legs above the water surface. If the platform is to be used for the 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 oil and gas production purposes, various manifolding equipment, storage tanks, meters and treating apparatus are generally mounted on the platform deck.

After a marine structure or platform of the above-described type has been built on land, transported to a desired offshore location and positioned on the floor of a body of water, it is the general practice to anchor the structure to the water 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 these 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. In addition, it is also a practice at times to install stub-piles through suitable sleeves or guide means attached to the lower end of the marine structure to further anchor the structure to the water floor. Stub-piles are piles that do not extend to the surface of the water and usually only extend up to the top of the sleeve or guide attached to the base of the marine structure, thereby providing support for the structure without causing an obstruction to wave action or impairing access to the platform deck.

In relatively shallow water stub-piles may be satisfactorily located in sleeves or guides attached to the lower end of the structure and then driven into the floor of the body of water by employing conventional methods. However, in deep water in the order of hundreds of feet in depth, the problem of aligning the piling in the sleeve or guide becomes increasingly difficult if not impossible,



especially at depths exceeding deep sea diver capabilities. Accordingly, there was a need for a method of anchoring marine structures in relatively deep water by remotely locating a stub-pile in a sleeve or guide attached to the lower end of the marine structure which method could be performed entirely from the water surface without the need of employing deep sea divers and it is to this end that the subject invention is directed.

## SUMMARY OF THE INVENTION

In view of the above, it is a primary object of the present invention to provide a method of installing a sub-pile to anchor a marine structure which method can be performed entirely from the water surface.

It is another object of the present invention to provide a method of locating and aligning a stub-pile and a guide or sleeve attached to the lower end of the marine structure and outboard thereof by suspending the pile in the water in the vicinity of the sleeve and moving the pile laterally into axial alignment with the sleeve by pulling the lower end of the pile from a point on the sleeve or guide.

Still another object of the present invention is to provide a method of the subject type in which the lower end of the pile is pulled into registry with the upper end of the sleeve or guide.

A further object of the present invention is to provide a method of locating and aligning a stub-pile and a guide or sleeve attached to the lower end of the marine structure by connecting a drawline to the lower end of the pile and extending the drawline past and in sliding contact with the sleeve or guide and then extending the drawline up to the water surface where the drawline is tensioned to thereby pull the pile into aligned registry with the sleeve or guide.

These and other objects of this invention will become apparent from a reading of the ensuing description of the invention taken in conjunction with the drawings.

In summary, the present invention provides a method of installing a marine structure at an offshore location by means of stub-piles which are lowered in a substantially vertical position in the vicinity of skirt pile sleeves or guides attached to the lower end of the marine structure adjacent the water floor, moving the pile laterally into substantial axial alignment and registry with the sleeve by pulling the lower end of the pile from a point on the sleeve, lowering the pile through the sleeve into engagement with the water floor and finally driving the pile into the water floor through the sleeve.

The pile is preferably anchored to the sleeve after it is driven into the water floor. The pile may be pulled into alignment with the sleeve by connecting a drawline to the lower end of the pile, extending it past and in sliding contact with the sleeve and continuing to extend the drawline up to the water surface where it may there be tensioned to pull the pile into axial alignment with the sleeve and preferably into registry with the upper end thereof.

## DESCRIPTION OF THE DRAWINGS

FIGURES 1 through 4 are elevational views of a typical marine structure to which the subject invention may be adapted and sequentially illustrate the subject method;

More specifically, FIGURE 1 is an elevational view showing a stubpile being lowered into the water in the vicinity of a skirt pile sleeve attached to the marine structure;

FIGURE 2 is the same elevational view showing the pile pulled into alignment with the skirt pile sleeve;

FIGURE 3 is the same elevational view showing the pile being driven into the water floor;

FIGURE 4 is the same elevational view showing the completed installation with the pile driven into the water floor to thereby anchor the marine structure;

FIGURE 5 is a plain view of the upper end of one of the skirt pile sleeves; and

FIGURE 6 is a cross-sectional view of a skirt pile sleeve taken along the lines 6—6 to FIGURE 5.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGURE 1 of the drawing, a marine structure is shown as comprising a plurality of support members or legs **10** interconnected by suitable bracing **11** and positioned on the floor **12** of the body of water **13**. It will be understood for the purposes of this invention that the structure could employ any number of legs which are usually arranged in a configuration having a closed perimeter or it could even be a single leg structure. The legs **10** are generally tubular and constructed of large-diameter pipe but may also be solid members such as I-beams. A plurality of skirt pile sleeves **14** are attached to the lower ends of the legs **10** and carried outboard thereof by means of suitable bracing **15**. Each skirt pile sleeve **14** is a tubular structure open at each end with the upper end having a flared mouth portion **16** for receiving a pile. The lower end of the sleeve **14** is adapted to rest against the floor **12** of the body of water **13**. Mounted on top of the legs **10** at a suitable distance from the surface **17** of the body of water **13** is an operating platform or deck **18** which carries suitable well drilling or servicing equipment, or alternately, platform **18** may be a temporary platform carrying construction equipment. Although the skirt pile sleeves **14** are shown as continuous tubular members it will be understood for the purposes of this invention that any form of guide means for guiding the pile may be employed, for example, vertically spaced rings attached to the marine structure of a sufficient size to allow a pile to pass therethrough.

A barge **20** positioned on the surface **17** of the body of water **13** adjacent the marine structure includes a deck-mounted derrick **21** which serves to lower a pile **22** in a substantially vertical position into the water **13** near one of the skirt pile sleeves **14**. A drawline **23** extending from a winch **24** located on the operating deck **18** passes over suitable pulleys **25** carried on the deck on leg **10**, past pulley **26** carried by the skirt pile sleeve **14** and then to the pile **22** where it is connected in a manner to be hereinafter described.

It is preferable for the purpose of this invention that the drawline **23** be positioned over the pulleys **25** and **26** prior to locating the offshore structure on the floor **12** of the body of water **13**. Accordingly, when the marine structure is sunk and positioned in its desired location the drawline **23** would not be connected to the pile **26** as shown but rather would extend back up to the water surface where it would be suitably tied off on the operating deck **18**. Thus, when the structure has been positioned on the water floor and it is desired to drive a pile through the skirt pile sleeve **14** the free end of the drawline **23** would be transferred to the barge **20** where it would be attached to the lower end of the pile **22** at the water surface. The pile **22** may be fabricated by adding lengths to the upper end of the pile and successively lowering it to the position shown in FIGURE 1. The drawline **23** is preferably connected to the lower end of the pile **22** by means of a pulling ring **27** attached to the pile **22** in a manner that the pulling ring will release from the pile under impact and yet is capable of withstanding the pulling force exerted by drawline **23**. For example, the pulling ring may surround the pile **22** and be attached thereto by any suitable tangible means such as shear pins.

Referring now to FIGURES 5 and 6 one suitable arrangement for mounting the pulleys **26** employed at the skirt pile sleeve **14** is shown in greater detail. The pulley



**26** is carried on a shaft **28** which is retained in the interior wall of the skirt pile sleeve **14** by means of inverted U-shaped brackets **29** which are rigidly attached to the inner wall of the sleeve **14**. The brackets **29** prevent the shaft **28** from moving upwardly when the drawline **23** is tensioned. After the shaft **28** is positioned in the brackets **29** shear pins **30** are inserted through suitable holes in the sleeve **14** to thereby prevent downward movement of the shaft **28**. The upper surface **31** of the brackets **29** is tapered so that when the pile **22** is lowered into the sleeve **14** the pile will be guided and centered between the brackets **29**. It will be apparent that the diameter of the pile **22**, the interior diameter of the skirt pile sleeve and the thickness of the brackets **29** must be selected to provide sufficient clearance to permit the pile **22** to pass between the brackets **29**.

As the pile **22** is lowered to the position as shown in FIGURE 1, the slack in the drawline **23** is taken up by means of the winch **24**. Alternatively, the pile may be first lowered into the vicinity of the sleeve **14** and then tension applied to the drawline. Since the drawline **23** acts around pulley **26** on skirt pile sleeve **14** the pulling ring **27** and hence the pile **22** is actually being pulled from a point on the skirt pile sleeve, i.e., from the pulley **26**. Therefore, continued tension in the drawline **23** serves to pull the pile **22** into axial alignment with the skirt pile sleeve **14** as shown in FIGURE 2. The exact location of the pulley **26** is not critical; however, it is desirable to have the pulley located within the interior of the skirt pile sleeve as shown in FIGURES 5 and 6 so that tension on the drawline **23** will not only serve to slign the pile **22** with the skirt pile sleeve **14** but will also bring the pulling ring **27** into register with the flared upper end **16** of the skirt pile sleeve **14**.

In relatively deep waters the unsupported span of the pile **22** extending between the skirt pile sleeve **14** and the derrick **21** will be quite long and its is therefore desirable to support the pile **22** near its upper end to prevent the pile from buckling. This may be accomplised by employing a suitable pile guide **32** attached to a truss member **33** carried by the operating deck **18** as shown in FIGURES 2 and 3. A similar guide **34** carried by the barge **20** may be used when the pile is first lowered into the water as shown in FIGURE 1. The guide **34** preferably incorporates suitable pipe-holding means, for example, slips, so that the pile may be held stationary when the lift cable of the derrick **21** is removed from the upper end of the pile so that successive lengths can be added to fabricate the pile **22**. The slips may be gimbal-mounted so that wave induced motion of the pile can be accommodated. Alternately, the barge mounted guide **34** may be used throughout the pile installation procedure, in which case the barge's anchor system must provide adequate lateral support for the top of the pile, in addition to holding the barge on location.

After the pulling ring **27** is positioned in the flared upper end **16** of the sleeve **14**, the pile may then be lowered into the top of the sleeve **16** by any suitable means, for example, a steam pile driver **34** as shown in FIGURE 3, or by force of the weight and mass of the pile. When the pile is driven pulling ring **27** releases from the pile **22** and the pile is driven against shaft **28** causing shear pins **30** which hold the pulley shaft **28** in place to break thereby permitting the pile to pass through the sleeve **14**. The shaft **28** and pulley **26**, having served their function are expendable and merely fall to the bottom of the sleeve **14**. Although in the arrangement disclosed the pulley **26** is located in the interior of the sleeve **14**, it will be appreciated that the pulley **26** could be attached to any portion of the sleeve **14** or flared mouth **16** without departing from the scope of the invention. For example, the pulley **26** could be attached to a bracket affixed to the upper edge of the flared mouth **16**. However, it is preferable to locate the pulley edge of the flared mouth **16**. However, it is preferable to locate

the pulley interiorly since this location assures better axial alignment between the pile **22** and the sleeve **14**.

The piling may then be driven through the sleeve **14** to a desired depth in the floor **12** of the body of water, which may typically be in the order of several hundred feet. After driving the piling is cut off just above the flared mouth **16** by underwater divers or by a pipe-cutting tool of any suitable type and the piling suitably secured to the sleeve **14** by suitable means well known in the art. Typically, the pile is secured by filling the annulus between the pile **22** and the sleeve **14** with cement.

An alternative arrangement which may be used when driving the pile **22** is to employ a follower pile or section or pile which extends from the top of the pile **22** up to the driving equipment on the surface. The so-called "follower" is employed until the pile **22** has been driven to the position as shown in FIGURE 4 after which the follower is removed and brought to the surface. This arrangement eliminates the necessity of employing divers to cut off the pile at the top of the sleeve **14**. 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 has been driven to its final elevation. It will be apparent that in view of the above discussion the particular means employed to drive the pile **22** into the position shown in FIGURE 4 is not essential to nor does it form a part of the present invention. For example, it may even be desirable to eliminate pile driving equipment altogether and drill a hole in the ocean floor for the pile as shown in the U.S. patent to Siebenhausen 3,115,755. The guide **32** and the arrangement of the pulleys **25** while preferably employed as shown in the drawings and as described above may, of course, be altered without departing from the invention. In this regard, it will be noted that the guide **32** might be eliminated provided there is sufficient rigidity or buoyancy in the pile **22** to permit it to be accurately driven from the surface. This, of course, will depend on the size of the pile selected and the depth of the water. Similarly, the arrangement of the pulleys **25** may be varied or they may even be eliminated so that the guide line **23** is pulled directly from the winch **24** without any intermediate pulleys.

In the course of planning for the pile installation described above it is necessary to determine that the pile will not buckle under its own weight plus the installation forces imposed upon it. This determination is made by analyzing the pile as a beam-column, which must be capable of supporting the static weight of the pile itself plus that of the pile driver or other equipment mounted on the pile. Additional installation forces, for example, blows from the ram of the steam pile driver or impulses from a resonant pile driver, may be applied which, although they would exceed the static buckling strength of the pile, do not cause buckling because of their transient nature. These transient forces may be predicted by analyzing the pile as a composite of discrete elastic elements subject to a longitudinal stress wave, and air upper limit on the buckling tendencies of these transient forces, which do not affect the entire pile at once, may be obtained from a beam-column analysis.

Having thus described my invention what I claim is:

**1.** A method of installing at an offshore location a marine structure having a plurality of annular pile guide means attached to the lower end of said structure and outboard thereof for receiving concentric stub-piles therethrough, said method comprising:

positioning said marine structure on the floor of a body of water;

lowering a pile into said water in a substantially vertical position and in the vicinity of one of said pile guide means;



moving said pile laterally into substantial axial alignment with said guide means by pulling the lower end of said pile under tension from a point on said guide means;

laterally restraining said pile near the upper end thereof and outboard of said marine structure;

lowering said pile through said guide means into contact with the floor of said body of water;

driving said pile through said guide means into the floor of said body of water; and

securing said pile to said sleeve.

**2.** The method as defined in claim **1** including the step of cutting off any portion of said pile extending above said guide means after said pile is driven into said floor.

**3.** The method as defined in claim **1** wherein the steps of lowering said pile into said water and moving said pile into alignment with said guide means are performed at substantially the same time.

**4.** The method as defined in claim **1** including the step of pulling said pile into registry with the upper end of said guide means.

**5.** The method as defined in claim **4** wherein said pile is pulled from a point located near the upper end of said guide means.

**6.** The method as defined in claim **5** wherein said point is located interiorly of said guide means.

**7.** A method of installing at an offshore location a marine structure having a plurality of skirt pile sleeves attached to the lower end of said structure and outboard thereof for receiving concentric stub-piles therethrough, said method comprising:

positioning said marine structure on the floor of a body of water;

extending a drawline from the water surface downwardly into contact with the upper end of one of said skirt pile sleeves and back up to the water surface;

connecting one end of said drawline to the lower end of a pile to be driven through one of said skirt pile sleeves;

lowering said pile into said water in a substantially vertical position;

tensioning the other end of said drawline to thereby pull the lower end of said pile into substantial alignment and registry with the upper end of said skirt pile sleeve;

laterally restraining said pile near the upper end thereof and outboard of said marine structure;

lowering said pile through said sleeve into contact with the floor of said body of water;

driving said pile through said skirt pile sleeve into the floor of said body of water; and,

securing said pile to said sleeve.

**8.** The method as defined in claim **7** including the step of cutting off any portion of said pile extending above said sleeve after said pile is driven into said floor.

**9.** The method as defined in claim **7** wherein the steps of lowering said pile into said water and tensioning said drawline are performed at substantially the same time.

**10.** The method as defined in claim **1** wherein said pile is laterally restrained from the upper end of said marine structure.

**11.** The method as defined in claim **7** wherein said pile is laterally restrained from the upper end of said marine structure.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

52—745; 61—53.5; 166—6; 175—7