July 11, 1967 J. R. DOZIER 3,330,338

ANCHOR AND METHOD OF INSTALLING

Filed Dec. 31, 1963

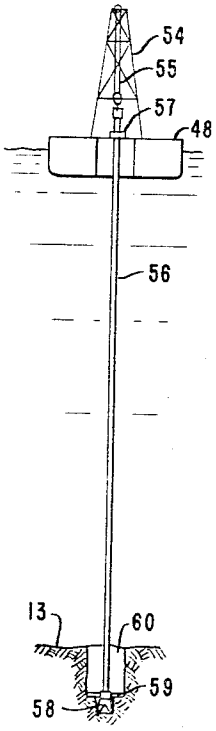

FIG. 2

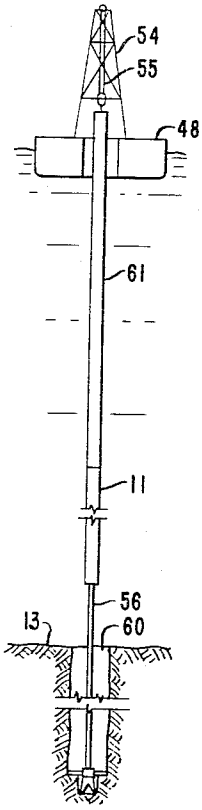

FIG. 3

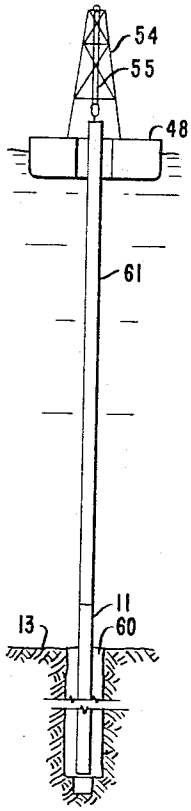

FIG. 4

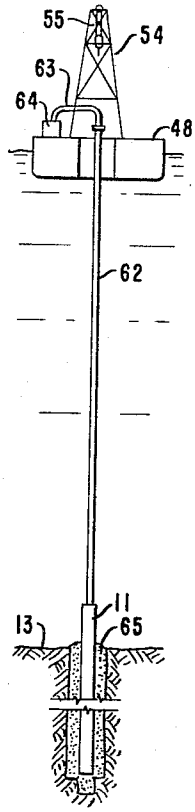

FIG. 5

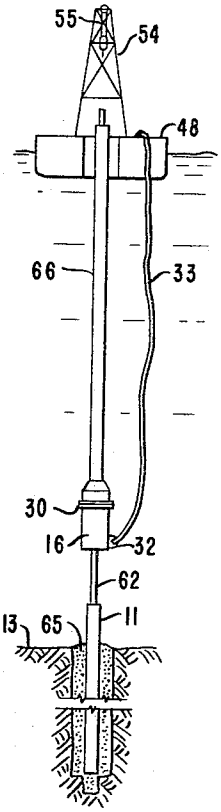

FIG. 6

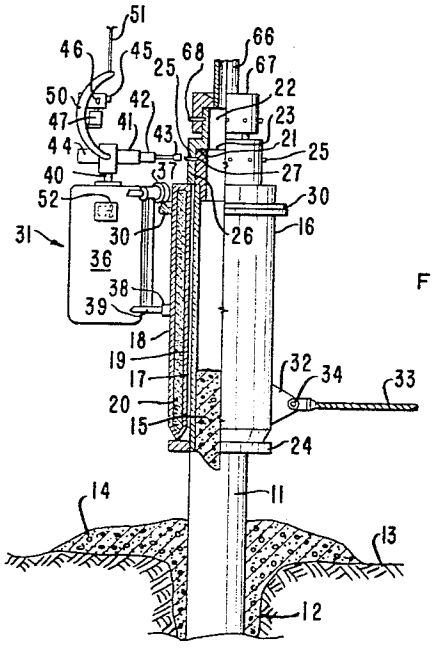

FIG. 1

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HIS AGENT

United States Patent Office 3,330,338 Patented July 11, 1967

3,330,338

ANCHOR AND METHOD OF INSTALLING

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Filed Dec. 31, 1963, Ser. No. 334,812
17 Claims. (Cl. 166—.5)

The present application is a continuation-in-part application of copending patent application Serial No. 157,654 which was filed on December 7, 1961, and is now Patent No. 3,221,816.

This invention relates to an anchor adapted to secure an anchor line at or near the ocean floor, and pertains more particularly to an anchor adapted to be sunk in the ocean floor and left there in the event that it is necessary to disconnect the anchor line and move an anchored vessel or other structure to another location.

To date, oil and gas wells have been drilled at offshore locations from fixed platforms or from floating or submersible barges. At the conclusion of the well drilling operations, the well equipment and the Christmas tree attached to the top thereof extends above the surface of the water where it was common to surround it by a platform which would be fixedly supported from the ocean floor. In remote locations, the production facilities, such as an oil and metering and storage tanks, were mounted on the platform at the well and the production fluid from the well was run into these lines. In highly developed fields, a centralized production facility for handling a number of wells would be constructed on piles sunk in the ocean floor at a centrally-located position among the wells. Individual production flowlines would then be run from the individual wells to extend to the centralized production facility where the production fluid would be gathered, separated and metered prior to transporting it to shore by means of tankers or through a pipeline.

While installation of the above-described types were satisfactory for oil fields located in shallow water, the same types of installations are impossible to construct or may be constructed only at excessive cost for deep water fields. This is especially true where the oil and gas production fluid is coming from underwater wells, that is, wells wherein the wellhead facilities are positioned underwater or close to the ocean floor. One form of a production facility adapted to be used for a deep water oil field is in the form of a vessel floating on the surface of the ocean while being relatively fixedly anchored in one position relative to the producing wells to which it is connected. Another form of oil-gathering and storage installation for handling a plurality of deep-water wells comprises a buoyant structure anchored below the ocean surface, say at a depth of from 60 to 100 feet, being held at this point by means of anchor lines so that it is outside the zone of greatest wave action.

In the event that one of the above-described types of oil gathering installations or vessels should move off of location, it would probably cause the rupture of one or more production flowlines extending between the vessel and the underwater wells. Many of the presently known types of anchors are unsuitable for anchoring the above-described oil-gathering vessels in that they are subject to being dragged along the ocean floor during heavy storms. It is therefore a primary object of the present invention to provide an ocean floor anchor adapted to be secured to the end of an anchor line and to the ocean floor in a manner such that there is no possibility of the anchor moving from its installed position.

A further object of the present invention is to provide an ocean-floor anchor fixedly secured to the ocean floor while at the same time being readily disconnectible from the end of an anchor line so that in the event that the anchor line becomes worn, the anchor line between the anchor and the vessel can be replaced.

Another object of the present invention is to provide a method of installing and fixedly positioning in the ocean floor an anchor in a manner such that the operation can be carried out at deep water locations without the aid of a diver.

A still further object of the present invention is to provide a method and apparatus whereby an anchor line may be disconnected from an anchor on the ocean floor and replaced by remotely-operated equipment without the use of a diver.

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 taken in partial longitudinal section of one form of an anchoring device in accordance with the present invention;

FIGURES 2, 3, 4, 5 and 6 are schematic views taken in partial longitudinal section illustrating the sequential steps of drilling a hole in the ocean floor, stripping an anchor post and a running string down over the drill string, lowering the anchor post in the hole drilled in the ocean floor, cementing the anchor post in the ocean floor, and subsequently installing replaceable connector means at the top of the anchor post while at the same time lowering the anchor line into place while it is attached to the connector.

Referring to FIGURE 1 of the drawing, an anchor post **11** is illustrated as being positioned in a well or hole **12** drilled or formed in the ocean floor **13** in any suitable manner well known to the art. The anchor post **11** is preferably fixedly secured in the well **12** by means of cement **14**. Cement **15** may also fill the major portion of the anchor post **11**. In order to form the cement **14** around the anchor post **11**, it is essential that the anchor post **11** be in the form of a tubular pipe or casing section having openings at both ends.

A connector housing **16** is shown as being positioned at the top of the anchor post **11**. The connector housing **16** is adapted to fit in sliding axial engagement on the outside of the anchor post and therefore is provided with an upwardly-extending bore **17** therein of an internal diameter sufficient to receive the anchor post **11** therein. As shown in FIGURE 1, the connector housing **16** is preferably in the form of a tubular sleeve which may be of reinforced construction, as one having a pair of concentric wall elements **18** and **19** arranged in spaced relationship with cement filling the space **20** between the wall elements, if desired. The connector housing **16** is provided with an inwardly-extending seating shoulder **21** in the bore **22** thereof which is adapted to seat on top **23** of the anchor post **11**, or on a landing surface formed thereon. Alternatively, instead of the connector housing **16** seating on top of the anchor pile or post **11**, the anchor post **11** may be provided with an outwardly extending flange **24** fixedly secured to the outer surface of the anchor post **11**, as by welding, at a point below the top of the post. Thus, the connector housing **16** would be arranged with its lower edge seated on the top of the flange **24** thereby eliminating the necessity of providing a seating shoulder **21** in the bore of the connector housing. The purpose of the seating shoulder **21** on the connector housing, or the landing flange **24** on the anchor post is to provide accurate alignment, as needed, so that a coupling member carried by the connector housing **16** is brought into accurate register at a designated position on the outer surface of the anchor post **11**. The connector housing **16** is provided with suitable coupling means including elements extending inwardly into the bore of the connector housing a distance sufficient to engage the anchor post **11** so as to

fixedly secure the connector housing **16** to the anchor post **11**. In the one form of coupling means illustrated, the coupling means comprises substantially horizontally-extending locking screws **25** passing through the wall **26** of the connector housing and into the bore thereof so as to engage the outer surface of the anchor post **11**, or an annular groove **27** formed in the outer surface thereof. It is necessary that the head of the screws **25** extend outwardly at all times from the outer surface of the connector housing so as to be engaged by a wrench.

The connector housing **16** of the present invention is provided with suitable landing surface means carried outwardly on the housing for receiving thereon an underwater manipulator. In the arrangement illustrated, the landing surface comprises an outwardly-extending ring element **30** adapted to seat or land a remotely-actuatable underwater manipulator device **31** thereon. Extending outwardly from the connector housing **16** are one or more pad eyes **32** or other suitable means for connecting an anchor line **33** to the pad eye. In this case a bolt **34** is employed to make this connection.

The manipulator device, generally represented by numeral **31**, may be of any suitable type, one of which is shown in U.S. Patent 3,099,316. The manipulator device comprises a body member **36** having means such as wheels **37** for securing it to the anchor post **11**, or the connector housing **16** thereof. In the embodiment illustrated, the wheels **37** are positioned on the ring element or track **30** so that the manipulator is mounted in fixed relationship to the anchor post **11**. Instead of employing wheels on the track **30** it is to be understood that the track **30** could be omitted with the manipulator device being secured to the anchor post **11** or its connector housing **16** by any other suitable connector means such as clamping arms, suction cups, electromagnets, etc. Since the connector means carried by the manipulator do not form part of the present invention, they will not be described in greater detail here. The wheels **37** are preferably actuated by motor means operatively connected to the wheels and positioned inside or outside the body member **36**. Additionally, the body member **36** is preferably provided with a pair of idler rollers **38** mounted on an outwardly-extending frame **39** to contact the outer surface of the connector housing **16**, as shown in FIGURE 1 where the drive wheels **37** are positioned on the track **30**. Alternatively, the rollers **38** could be power-actuated and friction contact with the outer surface of the connector housing **16** to drive the manipulator device **31** around the anchor post **11**.

A portion of the body member **36** is arranged for upward extension therefrom, preferably in the form of a telescoping arm **40**. Mounted on the top of the telescoping arm or body portion **40** in a laterally-extending cylinder **41** having a telescoping arm **42** extendible outwardly therefrom. The arm **42** is provided with a rotatable wrench head **43** that is power operated by suitable motor means mounted in the arm **42** by the cylinder **41**, preferably in the rear portion **44** thereof. A television camera **45** and suitable lights **46** are mounted at the top of the manipulator device on a power-actuated light swivel and tilting mechanism **47**, while the television viewing screen is positioned on a vessel **48** (FIGURE 2) at the surface.

The manipulator device **31** may be suspended on a hook **50** having a weight-supporting and current-transmitting cable **51** attached to its upper end. Thus, power for operating the manipulator device and its associated equipment is sent down the cable **51** from the vessel **48** while television signals are returned up the cable to the vessel. At the same time, the manipulator device **31** may be lowered from the vessel **11** by means of the cable **51** and its associated hoist (not shown) to any selected level in the water. For moving the manipulator device **31** laterally at the end of the cable **51**, the manipulator device is provided with suitable propulsion means such, for example, as motor-driven propellers **52** which are mounted outboard of the body member **36** on at least two sides thereof. At least a portion of the body member **26** may form a void chamber which may be selectively flooded by controls of the vessel **48** for adjusting the buoyancy of the manipulator device **31**. If additional buoyancy is desired, suitable buoyancy tanks may be secured to the weight supporting cable **51**.

One method of sinking the anchor of the present invention is illustrated in FIGURES 2 through 6. Anchor installing operations may be carried out from any suitable vessel, barge or platform such as the one schematically represented by numeral **48** in FIGURES 2 through 6. The barge is provided with a suitable derrick **54** equipped with conventional fall lines **55** of a hoist system adapted to raise and lower a drill string or other pipe string **56**. In the event that the anchor post **11** (FIGURE 1) is to be drilled into the ocean floor, the barge **48** (FIGURE 2) is provided with a suitable rotary table **57**. It is to be understood that the anchor post of the present invention may be driven into the ocean floor by means of an underwater pile driver or a pile driver operating on the vessel **48** with a driving connection such as a string of pipe extending from the top of the anchor post to the pile driver (not shown) on the vessel. Alternatively, a string of pipe may be lowered from the vessel to the ocean floor and water pumped down the pipe string and jetted into the ocean floor as the pipe string is being lowered, thereby forming a hole in the ocean floor into which the anchor post **11** may be inserted. In this operation, it is preferred that the anchor post **11** would form the lower end of the jetting pipe string and be disconnectible therefrom. Thus, after jetting the anchor post **11** in the ocean floor, cement could be pumped down the pipe string, around the bottom of the anchor post and up the side thereof, with the pipe string extending from the top of the anchor post of the vessel being subsequently disconnected from the anchor post and pulled back to the vessel.

Preferably, however, the pipe string **56** (FIGURE 2) is provided with a drill bit **58** at the bottom thereof and a collapsible expander bit **59** positioned thereabove. An anchor post hole **60** is then formed in the ocean floor **13** by rotating the drill string **56** at the vessel **48**. When the hole **60** has been drilled to its desired depth, a running pipe string **61** (FIGURE 3) having an anchor post **11** secured to the bottom thereof is lowered down over the drill string **56**. While the anchor post **11** (FIGURE 4) may be cemented in place by pumping cement down the drill string **56** and out the bit **58** thereof, with the drill string **56** being later employed to guide the connector housing **16** into place, as shown in FIGURE 6 it is preferred that the drill string and bit be pulled back to the vessel after at least the lower end of the anchor post **11** has entered the hole **60** in the ocean floor **13**.

When the anchor post **11** has been positioned at the desired depth in the hole **60**, a cementing pipe string **62** of a smaller diameter is run down through the running pipe **61** (FIGURE 4) and the running string **61** may then be stripped up to the vessel again. As illustrated in FIGURE 5, the upper end of the cementing pipe string **62** is connected by a conduit **63** to a cement pump and source of cement **64**. The cement passes down the cementing pipe string **62** and through the anchor post **11**, around the bottom thereof and thence upwardly to fill the annular space **65** between the outside of the anchor post **11** and the wall of the halo **60**. After the cement has hardened, the cementing pipe string **62** is used as a guide down along which a connector housing **16** and its running pipe string are lowered until the connector housing **16** is seated on the anchor post **11** in a manner described hereinabove with regard to FIGURE 1. The lower end of the running pipe string **66** may be connected to the top of the connector housing **16** in any suitable manner, as by screw threads, J-latches, etc. In FIGURE 1 the running pipe

string **66** is illustrated as having provided on its lower end a cap **67** equipped with horizontally-extending locking screws **68** which are adapted to disconnect underwater by means of the manipulator device **31** lowered and propelled through the water, as described hereinabove with regard to locking screws **25** at the top of the closure housing **16**.

As illustrated in FIGURE 6, the anchor line **33** is preferably secured to the connected housing **16** before lowering it into place on the anchor post **11**. However, it is to be understood that the anchor line could be subsequently connected to the connector housing **16** by means of a manipulator device **31**. If desired, the manipulator device **31** may be mounted on the ring element or track **30** surrounding the connector housing **16** before it is lowered into place from the vessel down to the anchor post **11** at the ocean floor. Alternatively, the connector housing **16** may be lowered as illustrated in FIGURE 6 into place on the anchor post **11**, with the manipulator device being later lowered through the water down to the connector housing where it would be positioned thereon. As may be seen from FIGURE 1, the telescoping arm **40** of the manipulator device **31** may be raised or lowered to bring the wrench head **43** of the telescoping arm **42** into register with the locking screws **25** so as to run the screws **25** into place and connect the connector housing **16** to the anchor post **11**. Operations are carried out by observing the screws and manipulator wrench head **43** by means of a television camera **45** which may also be employed to locate the anchor post in the first place. After one screw **25** has been run into place, the drive wheels **37** of the manipulator device **31** are energized so that the manipulator device is moved about the track **30** until its wrench head **43** is positioned opposite another screw. This operation is repeated until all the screws have been connected. Subsequently, the telescoping arm **40** would be extended to raise the wrench head **43** opposite the screws **68** which connect the bottom of the running string **66** to the connector housing **16**. After the screws were disconnected, the running pipe string **66** would be pulled back to the vessel. The other end of the anchor line at the vessel would then be moved and connected to the structure being anchored in the ocean. The manipulator device **31** at the end of its operations would be lifted off the track **30** and pulled back to the vessel **48**.

I claim as my invention:

1. An anchor adapted to secure anchor lines to the ocean floor, said anchor comprising

an anchor post sunk in the ocean floor,

connector housing adapted to fit in sliding axial engagement on the outside of said anchor post, said connector housing having a bore therein extending upwardly from the bottom thereof, said bore being of a size to receive said anchor post therein,

coupling means carried by said connector housing, said coupling means including rigid mechanical connector means extending inwardly into the bore of said connector housing and engageable with said anchor post therein, and

an anchor line connector carried outwardly on said connector housing for securing the end of an anchor line thereto, and a substantially laterally extending anchor line extending therefrom.

2. The apparatus of claim **1** including landing surface means carried outwardly by said connector housing for receiving an underwater manipulator thereon.

3. The apparatus of claim **2** wherein said securing means of said coupling means comprises substantially horizontally extending locking screws, the heads of said screws extending outwardly at all times from the outer surface of said connector housing.

4. The apparatus of claim **2** including cement surrounding the anchor post in the ocean floor.

5. The apparatus of claim **2** including an inwardly-extending seating shoulder in the upper end of the bore of said connector housing of a size adapted to engage the upper end of said anchor post.

6. The apparatus of claim **2** wherein said connector housing is a tubular sleeve.

7. The apparatus of claim **6** wherein said landing surface means is an outwardly-extending ring element secured to the outer surface of said connector housing.

8. The apparatus of claim **7** wherein said landing surface ring element is arranged in spaced relationship to said connector housing outer surface.

9. The apparatus of claim **7** wherein the tubular sleeve of said connector housing includes inner and outer concentric wall elements in spaced relationship with each other.

10. The apparatus of claim **9** including cement filling the space between the inner and outer wall elements.

11. A method of setting an anchor line in the ocean floor, said method comprising the steps of

sinking an anchor post into the ocean floor so that the top of the anchor post is near the ocean floor,

maintaining contact between the top of the anchor post and a vessel thereabove on the surface of the ocean,

connecting a laterally extending anchor line to a connector housing,

lowering the connector housing and the end of the anchor line connected thereto from the vessel onto the anchor post sunk in the ocean floor, and

connecting the upper end of the connector housing to said anchor post so that the anchor line extends substantially laterally therefrom.

12. The method of claim **11** including the step of positioning an underwater manipulator adjacent said connector housing for connecting the connector housing to said anchor post.

13. The method of claim **12** including the step of positioning said underwater manipulator on said connector housing prior to lowering said connector housing through the water from said vessel.

14. The method of claim **12** including the step of positioning said underwater manipulator on said connector housing after positioning said connector housing on said anchor post.

15. The method of claim **11** including the step of forming a hole in the ocean floor prior to sinking the anchor post therein.

16. The method of claim **15** including the step of cementing the anchor post in the hole formed in the ocean floor.

17. The method of claim **15** wherein said hole is formed by a drill string and including the step of sliding the anchor post and a running pipe string down the drill string and into the hole.

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