Aug. 21, 1962 B. N. OUTWIN ET AL 3,050,138

GUIDE SYSTEM FOR UNDERWATER WELLS

Filed July 8, 1960

2 Sheets-Sheet 1

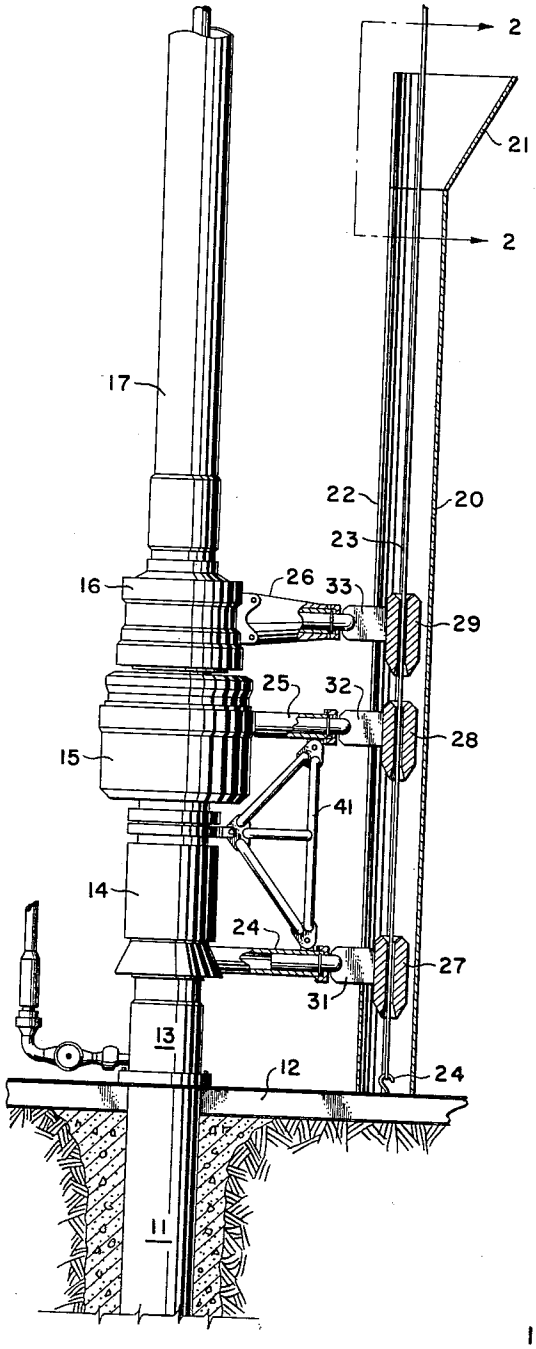


FIG. 1

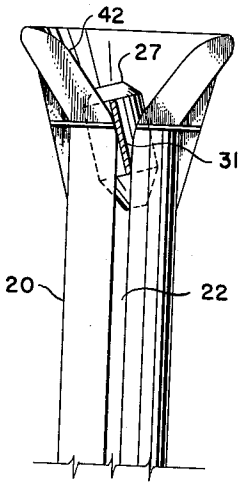


FIG. 2

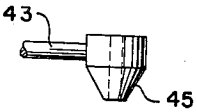


FIG. 5

INVENTORS:
B. N. OUTWIN
L. G. OTTEMAN
BY: J. H. McCarthy
THEIR AGENT

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2 Sheets-Sheet 2

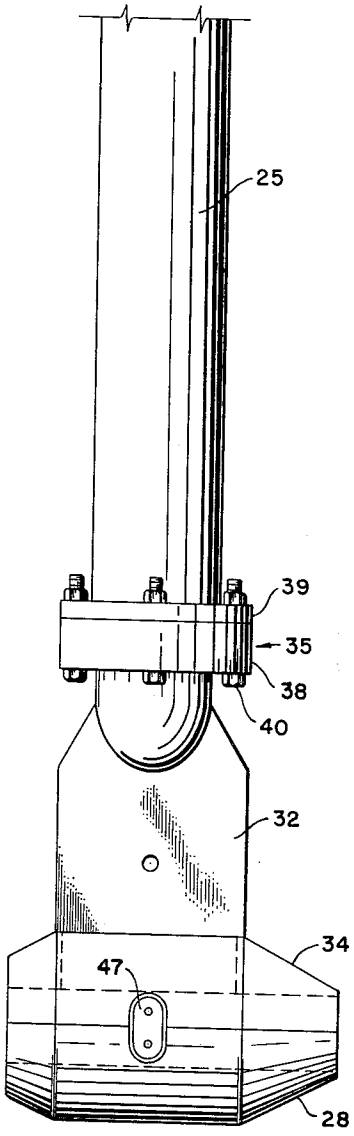


FIG. 3

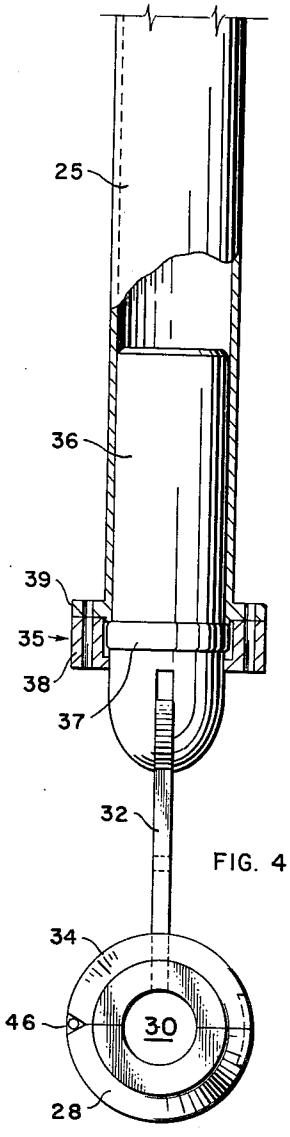


FIG. 4

INVENTORS:
B. N. OUTWIN
L. G. OTTEMAN
BY: A. H. McCarthy
THEIR AGENT

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GUIDE SYSTEM FOR UNDERWATER WELLS

Bertram N. Outwin and Lloyd G. Otteman, Houston, Tex., assignors to Shell Oil Company, New York, N.Y., a corporation of Delaware

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This invention relates to the drilling of offshore wells and pertains more particularly to apparatus for guiding and aligning various pieces of equipment into place at the top of a well wherein all of the operations are carried out underwater.

At present, offshore wells are drilled either from stationary platforms anchored to the ocean floor, movable barges temporarily positioned on the ocean floor, or from movable barges floating on a body of water on which drilling operations are to be carried out. Regardless of the manner in which the wells are drilled, most wells are completed in a manner such that the outermost tubular member of the well extends upwardly from the ocean floor to above the surface of the water where a wellhead or Christmas tree is mounted thereon for controlling the production of the well.

Wellheads extending above the surface of the water constitute a hazard to navigation of vessels in the area as well as constituting a structure which is readily attacked by the wave action, it being well known that the corrosive nature of the seawater and the air readily attack the normal steel platforms unless they are protected in a suitable manner by corrosive-resistant material.

Recently, methods and apparatus have been developed for drilling and completing a well entirely underwater with the wellhead assembly preferably being positioned on the ocean floor or at least well below the surface of the water. A method of accomplishing this operation is described in copending application, Serial No. 830,538, filed July 30, 1959, to J. A. Haeber et al., and entitled "Underwater Well Completion Method."

One of the major problems encountered in the drilling and completing of wells underwater is that of guiding and aligning equipment into place on the ocean floor. While suitable guide systems have been known for other purposes, there has been no satisfactory guiding and aligning system for guiding equipment into place over flexible cables that are not always vertically aligned, as those which extend from a base on the ocean floor to a floating vessel or other structure having an operational platform positioned above the surface of the water. Since various pieces of equipment used in offshore well operations are quite heavy, i.e., several hundred pounds in weight, such equipment has a tendency to hang-up on a receiving base positioned on the ocean floor in the event that the guiding cables are not positioned vertically in the water.

It is therefore a primary object of the present invention to provide an apparatus adapted to guide equipment from a vessel on the surface of the water down to the ocean floor and align it accurately on other equipment positioned there.

A further object of the present invention is to provide apparatus for accurately aligning equipment with regard to other equipment on the ocean floor without the guided equipment hanging-up at its destination in the event that the guide cables are not exactly vertically-positioned in the water.

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 portion of a receiving base or wellhead support frame positioned on the ocean floor with several pieces of equipment illustrated as being guided into position at the top of a wellhead;

FIGURE 2 is a diagrammatic view of the upper end of a guide column taken along the line 2—2 of FIGURE 1 at the time a guide cone is being positioned therein;

FIGURES 3 and 4 are side and plan views in an enlarged detail of an arm and guide cone of the present invention; and,

FIGURE 5 is a view of another form of a cone and arm.

Referring to FIGURE 1 of the drawing, a string of well casing or a conductor pipe **11** is illustrated as being fixedly secured to a base member **12** of a wellhead support frame. A casing head **13** is in turn fixedly secured to the upper end of the conductor pipe **11**, the upper end of the casinghead being of a size and design to receive and have secured thereto various pieces of equipment.

In the event that a well is being drilled, the casinghead may have temporarily secured to its upper end a sealing and lock-down head **14** having flanged to its upper end a blow-out preventer **15**. At one stage in the operation a landing head **16** attached to the lower end of a marine conductor pipe **17** may have been run into position and temporarily secured to the top of the blow-out preventer **15**. In the event that the well had been completed and was in production a suitable production assembly control unit would have been run down into place and secured to the casinghead **13** in place of the equipment **14**, **15**, **16** and **17** illustrated. In normal practice, the conductor pipe **11** is cemented in the well.

The wellhead support frame may take any form but consists of at least a base member **12** to which a plurality of guide columns **20** are fixedly secured, as by welding. The guide columns **20** are vertically positioned with regard to the horizontal base **12** with the upper ends of the columns being open and preferably flared, as at **21**, to form a cone-shaped guide flange. The guide tubes **20** are fixedly secured to the support frame in equi-spaced relationship to each other and to the axis of the conductor pipe **11**. As shown in FIGURE 2, each guide tube is provided with a longitudinal slot **22** through the side wall which extends from the open top of the tube downwardly a sufficient distance so that equipment can be positioned on the casinghead **13**. The top of each slot **22** preferably has a large V-shaped opening, as shown in FIGURE 2.

Disposed axially within each of the guide tubes **20** is a guide cable **23** having its lower end fixedly anchored to any suitable means, such as an anchoring ring or hook **24**. The cable extends upwardly from its anchor bolt or ring **24** to the vessel or operating platform (not shown) above the surface of the water where it is secured. Preferably, the upper end of each cable is secured to a constant tension winch which provides a pulling force of say, 3,000 to 5,000 pounds, to maintain the cable taut.

Each piece of equipment to be lowered into place within the wellhead support frame is provided with means for guiding it down the guide cables **23**. Thus, the sealing and lock-down head **14**, the blow-out preventer **15** and the landing head **16** are provided with horizontally extending arms **24**, **25** and **26**, respectively, which extend through the slots **22** in the guide columns **20**. The outwardly-extending ends of the arms **24**, **25** and **26** are provided with cylindrical members having frusto-conical end portions, commonly known as guide cones **27**, **28** and **29** which are mounted for sliding movement on the guide cable **23**. Each of the guide cones **27**, **28** and **29** is provided with an axial bore therethrough while the cones are fixedly secured to portions of the arms in the form of plate elements **31**, **32** and **33** having a thickness slightly less than the slot **22** in the guide tube **20**.

A guide cone **28** and its arm **25—32** is shown in enlarged detail in FIGURES 3 and 4. The axial bore **30** in the guide cone **28** is slightly larger in diameter than the cable **20** along which it slides. The lower end of the guide cone **28** is preferably downwardly and inwardly beveled or tapered, as at **34**.

Intermediate the ends of the arm **25—32**, a swivel joint **35** is provided to permit the outwardly-extending portion **32** of the arm and its guide cone **28** to at least partially rotate around a line through the axis of the arm **25**. Any suitable type of rugged swivel joint can be employed which has sufficient strength to support the weight of the equipment being lowered into place. In the particular swivel joint **35** illustrated, the joint comprises a cylindrical member **36** extending into the tubular arm **25** from the outer end thereof. A shoulder **37** is provided or formed on the outer surface of the cylindrical member **36** whereby the cylindrical member can be anchored against axial movement within the tubular arm **25** by means of flange **38** secured to flange **39** on the outer end of the arm **25** by means of bolts **40**.

In FIGURE 2, a guide cone **27** is shown at the moment it lands in the top of the guide tube, it being assumed that the barge at the surface is displaced several degrees from a line running vertically from the guide base assembly on the ocean floor so that the guide cable (not shown) extends through the water at the angle taken by arm **24** in FIGURE 2. In the event that no swivel joint **35** (FIGURES 3 and 4) is provided in each arm, the guide cone **27** would hang-up in the manner illustrated with the extending arm **24** becoming wedged in the slot **22** thus preventing the piece of equipment attached to the guide arms and cones from becoming properly seated in place in the wellhead support frame. With the apparatus of the present invention the guide cone **27** (FIGURE 2) rotates slightly and assumes a vertical position within the guide **20** and slot **22** and continues downwardly until a piece of equipment is properly seated in place. In the event that two pieces of equipment, such for example as the sealing and lock-down head **14** and the blow-out preventer **15**, are rigidly connected together when they are lowered into place on the casinghead **13**, it may be found desirable to interconnect the arms **24** and **25** of these respective elements **14** and **15** with suitable bracing **41** in order to get a more accurate alignment. However, if some vertically misalignment of a component, such as a landing head **16**, is desired in order to manipulate it a bit to get it to fit on another component already in place, a single set of arms and guide cones are used, as at **29**, rather than a pair of vertically aligned guide cones, as **27** and **28**, which would restrict any sideways movement. Pieces of equipment can be lowered into place within the wellhead support frame in any suitable manner, as by using the marine conductor pipe **17** or a similar pipe string or suitable cable means.

When lightweight components are to be lowered into place between the guide columns on the ocean floor, the plate elements **31**, **32** and **33** of the horizontally-extending arms may be replaced by rod elements **43** (FIGURE 5) of a diameter less than the width of slot **22** and the swivel joints may be omitted. The guide cones are preferably made of two halves, i.e., vertically split, with recessed hinges **46** (FIGURE 4) on one side and a recessed latch as connector plate **47** on the other side to facilitate connection to a guide cable. Also cylindrical members having frusto-conical end portions, commonly known as guide cones **45** of the shape shown in FIGURE 5 may be found preferable in circumstances where the guide lines are at a substantial angle to the vertical.

We claim as our invention:

1. Apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, said apparatus comprising a wellhead support frame positioned below the surface of water and fixedly secured to the ocean floor,

said support frame including a plurality of vertically-positioned guide tubes fixedly secured to said support frame in spaced relationship to the axis of the well conductor pipe, there being a longitudinal slot through the side wall of each of said guide tubes downwardly from the open top thereof, a guide cable disposed within each of said guide tubes, one end of said cable being fixedly anchored within said guide tube, the cable being adapted to be held in tension from above so as to extend upwardly through the body of water, at least one guide member mounted for sliding movement on each of said guide cables, arm means fixedly secured at one end to each of said guide members and being adapted to extend through the slots in the wall of said guide tubes, the other ends of said arm means being adapted to be fixedly secured to a device to be positioned within said wellhead support frame, and a swivel joint positioned in each of said arm means intermediate the ends thereof for permitting at least partial rotation of the guide member on the axis of said arm means.

2. Apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, said apparatus comprising a well conductor pipe extending into the earth formation below a body of water and cemented therein, a wellhead support frame fixedly secured to said well conductor pipe near the top thereof, said support frame including a plurality of vertically-positioned guide tubes fixedly secured to said support frame in equi-spaced relationship and to the axis of said conductor pipe, there being a longitudinal slot through the side wall of each of said guide tubes downwardly from the open top thereof and at a point closest to the axis of said conductor pipe, a guide cable disposed axially within each of said guide tubes, one end of said cable being fixedly anchored within said guide tube near the lower end thereof, the cable being adapted to be held in tension from above so as to extend upwardly through the body of water, at least one guide member mounted for sliding movement on each of said guide cables, arm means fixedly secured at one end of said guide member and being adapted to extend through the slots in the wall of said guide tubes, the other ends of said arm means being adapted to be fixedly secured to a device to be positioned within said wellhead support frame, and a swivel joint positioned in each of said arm means intermediate the ends thereof for permitting at least partial rotation of the guide member on the axis of said arm means.

3. Apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, said apparatus comprising a wellhead support frame positioned below the surface of water and fixedly secured to the ocean floor, said support frame including a plurality of vertically-positioned guide tubes fixedly secured to said support frame in equi-spaced relationship to the axis of a conductor pipe, there being a longitudinal slot through the side wall of each of said guide tubes downwardly from the open top thereof, a guide cable disposed within each of said guide tubes, one end of said cable being fixedly anchored within said guide tube, the cable being adapted to be held in tension from above so as to extend upwardly through the body of water, at least one guide member mounted for sliding movement on each of said guide cables, and arm means in the form of a small diameter rod fixedly secured at one end to each of said guide members and being adapted to extend through the slots in the wall of said guides tubes, the other ends of said arm means being adapted to be fixedly secured to a device to be positioned within said wellhead support frame.

4. Apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, said apparatus comprising a well conductor pipe extending into the earth formation below a body of water and cemented therein,

a wellhead support frame fixedly secured to said well conductor pipe near the top thereof, said support frame including a plurality of vertically-positioned guide tubes fixedly secured to said support frame in equi-spaced relationship to each other and to the axis of said conductor pipe, there being a longitudinal slot through the side wall of each of said guide tubes downwardly from the open top thereof and at a point closest to the axis of said conductor pipe, the upper ends of said guide tubes being flared outwardly forming cone-shaped guide flanges, a guide cable disposed axially within each of said guide tubes, one end of said cable being fixedly anchored within said guide tube near the lower end thereof, the cable being adapted to extend upwardly through the body of water while having its upper end normally anchored to a structure positioned above said water, at least one guide member mounted for sliding movement on each of said guide cables, arm means in the form of a metal plate fixedly secured at one end to each of said guide members and being adapted to extend through the slots in the wall of said guide tubes, the other ends of said arm means being adapted to be fixedly secured to a device to be positioned within said wellhead support frame coaxial with said conductor pipe, and a swivel joint positioned in each of said arm means intermediate the ends thereof for permitting at least partial rotation of the guide member on the axis of said arm means.

5. Apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, said apparatus comprising a well conductor pipe extending into the earth formation below a body of water and cemented therein, a wellhead support frame fixedly secured to said well conductor pipe near the top thereof, said support frame including a plurality of vertically-positioned guide tubes fixedly secured to said support frame in equi-spaced relationship to each other and to the axis of said conductor pipe, there being a longitudinal slot through the side wall of each of said guide tubes downwardly from the open top thereof and at a point closest to the axis of said conductor pipe, the upper ends of said guide tubes being flared outwardly forming cone-shaped guide flanges, a guide cable disposed axially within each of said guide tubes, one end of said cable being fixedly anchored within said guide tube near the lower end thereof, the cable being adapted to extend upwardly through the body of water while having its upper end normally anchored above said water, at least one guide member mounted for sliding movement on each of said guide cables, the lower end of said guide cone being downwardly and inwardly tapered, said guide member having an axial hole therethrough slightly larger in diameter than the guide cable positioned therein, arm means in the form of a metal plate fixedly secured at one end to each of said guide

members and being adatped to extend through the slots in the wall of said guide tubes, the other ends of said arm means being adapted to be fixedly secured to a device to be positioned within said wellhead support frame coaxial with said conductor pipe, a swivel joint positioned in each of said arm means intermediate the ends thereof for permitting at least partial rotation of the guide member on the axis of said arm means, and means for lowering said device from the surface of the water into place within said wellhead support frame.

6. Apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, said apparatus comprising wellhead support means positioned below the surface of the water and fixedly secured to the ocean floor, said support means including guide tube means fixedly secured to said support means in spaced relationship to the axis of pipe means extending therefrom, there being longitudinal slot means through the side wall of said guide tube means downwardly from the open top thereof, guide cable means disposed within said guide tube means, one end of said cable means being fixedly anchored within said guide tube means, said cable means being adapted to be held in tension from above so as to extend upwardly through the body of water, guide member means mounted for sliding movement on said guide cable means, arm means fixedly secured at one end to said guide member means and being adapted to extend through the slot means in the wall of said guide tube means, the other end of said arm means being adapted to be fixedly secured to a device to be positioned within said wellhead support means, and swivel means in said arm means for permitting at least partial rotation of said guide member means on the axis of said arm means.

7. An apparatus for guiding into an operative position near the ocean floor a device to be used in drilling, completing and servicing an underwater well, an apparatus comprising a device to be positioned near the ocean floor, a plurality of radially-extending arm means fixedly secured at one end to said device, at least one guide member mounted on the other end of the arm means, said guide member adapted to be mounted for sliding movement along a guide cable, and a swivel joint positioned in each of said arm means intermediate the ends thereof for permitting at least partial rotation of the guide member on the axis of said arm means.

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