June 1, 1965 R. L. GEER ETAL 3,186,487

UNDERWATER WELL GUIDE SYSTEM

Filed Nov. 6, 1961 2 Sheets-Sheet 1

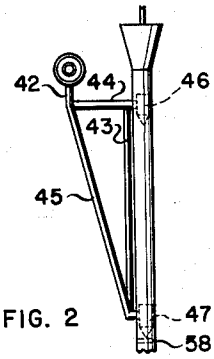


FIG. 2

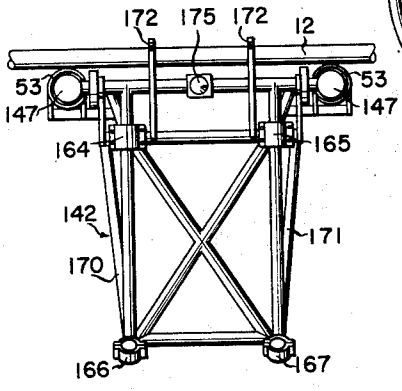


FIG. 5

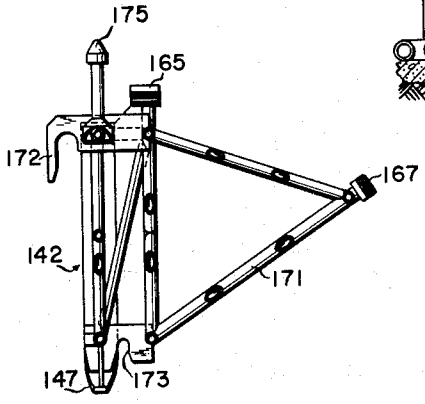


FIG. 6

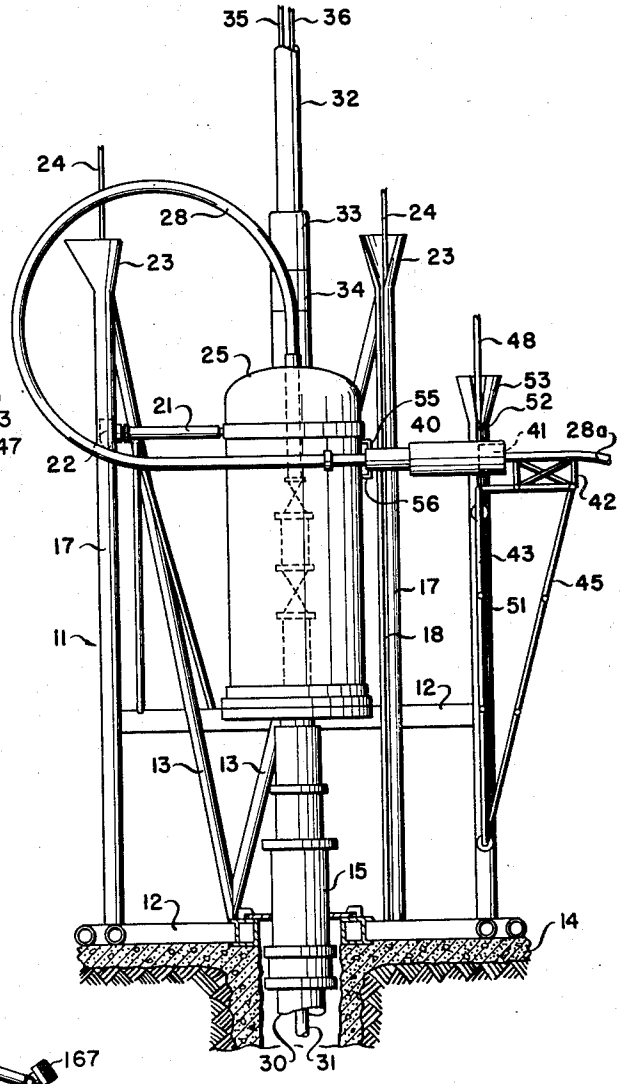


FIG. 1

INVENTORS:
R. L. GEER
L. G. OTTEMAN
BY: A. H. McCarthy
THEIR AGENT

June 1, 1965 R. L. GEER ETAL 3,186,487

UNDERWATER WELL GUIDE SYSTEM

Filed Nov. 6, 1961 2 Sheets-Sheet 2

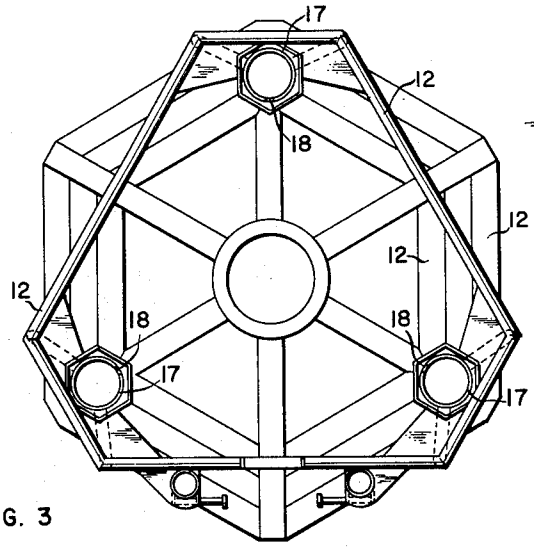


FIG. 3

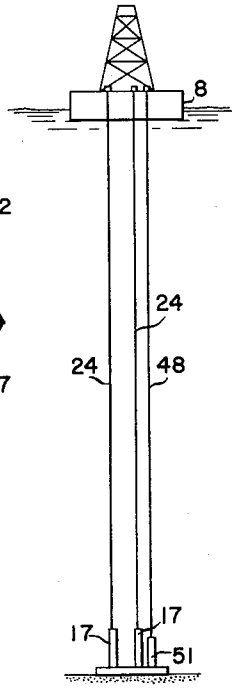


FIG. 7

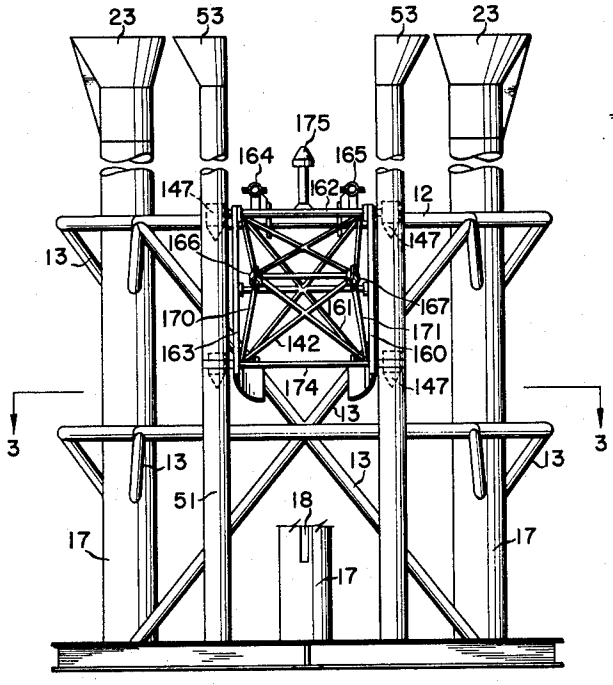


FIG. 4

INVENTORS:
R. L. GEER
L. G. OTTEMAN
BY: A. H. McCarthy
THEIR AGENT

United States Patent Office

3,186,487

Patented June 1, 1965

3,186,487

UNDERWATER WELL GUIDE SYSTEM

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

Filed Nov. 6, 1961, Ser. No. 150,429
5 Claims. (Cl. 166—66.5)

This invention relates to apparatus for use at offshore well installations and pertains more particularly to a guide system adapted to extend from an operational base above the surface of a body of water to a wellhead support structure which is located underwater and preferably on the ocean floor. The present apparatus further pertains to a guide system for guiding various wellhead components, fitting or devices down to a wellhead structure on the ocean floor and into accurate alignment with other wellhead fittings already positioned on a wellhead support base.

In an attempt to locate new oil fields, an increasing amount of well drilling has been conducted at offshore locations, such for example, as off the coast of Louisiana, Texas, and California. As a general rule, the strings of casing in a well, together with the tubing string or strings, extend to a point well above the surface of the water where they are closed in the conventional manner that is used on land wells, with a conventional wellhead assembly being attached to the top of the casing. Attempts have been made recently to provide methods and apparatus for drilling and completing a well within both the well casinghead and subsequently the wellhead assembly and the casinghead closure device are located underwater at a depth sufficient to allow ships to pass over them. Preferably, the casinghead and wellhead closure assemblies and other related wellhead equipment are located close to the ocean floor. In order to install equipment of this type underwater in depths greater than the shallow depth at which a diver can easily operate, it has been necessary to design entirely new equipment for this purpose. One such piece of equipment is described in co-pending application, Serial No. 835,930, filed August 25, 1959, and entitled "Underwater Wellhead With Remotely Detachable Flowline," now U.S. Patent No. 3,052,299, of which this application is a continuation-in-part. In the above identified patent application, an underwater wellhead assembly is provided with a flowline connector and auxiliary equipment whereby the wellhead and its flowline may be independently installed at their location on the ocean floor.

It is therefore an object of the present invention to provide apparatus whereby heavy and cumbersome pieces of well drilling equipment or well production equipment may be lowered to or retrieved from a wellhead at the ocean floor.

Another object of the present invention is to provide apparatus whereby a wellhead fitting being lowered into place on an underground wellhead structure will be accurately aligned with a cooperating fitting or other piece of equipment so that it may be readily connected thereto from a remote location, such for example, as from a drilling barge or platform positioned above the surface of a body of water.

A further object of the present invention is to provide a guide system permitting simultaneously installation of two pieces of wellhead equipment arranged in side-by-side relationship while subsequently permitting independent removal of either piece of equipment.

Another object of the present invention is to provide a guide system for permitting accurate placement of a piece of equipment to one side of an underwater wellhead structure in accurate alignment with a selected fitting thereof.

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 schematic view illustrating a wellhead assembly positioned on the ocean floor and being provided with a guide system in accordance with the present invention;

FIGURE 2 is a side view of a pipeline coupling lowering mechanism or an equipment lowering carriage shown;

FIGURES 3 and 4 are plan and side views, respectively, of the wellhead support structure of FIGURE 1;

FIGURES 5 and 6 are plan and side views of the equipment lowering carriage shown positioned on the wellhead support structure of FIGURE 4; and

FIGURE 7 is a diagrammatic view illustrating a floating barge positioned above an underwater support structure of the present invention.

Referring to FIGURE 1 of the drawing, a wellhead support structure **11** is shown as comprising a series of interconnected girders **12** and cross-bracing members **13**. The bottom-most girders **12** may rest on a cement pad **14** which may be poured on the ocean floor. A casinghead **15** is fixedly secured to the wellhead support structure **11** and is preferably installed therewith at the time the wellhead support structure is positioned over the well to be drilled.

Suitable apparatus is provided for guiding well equipment into place upon the casinghead **15**, both during and after drilling operations. In the particular apparatus illustrated in FIGURE 1, the vertical members **17** of the wellhead support structure comprise vertical guide tubes **17** each having vertical slot **18** cut through the wall thereof. Preferably, the guide tubes are arranged on opposite sides of, or form a geometrical pattern around the center line of the well. Each piece of equipment to be lowered into place on the well casinghead **16** may be provided with two or more guide arms **21** adapted to extend through the guide slot **18** of two or more guide tubes **17** where they are connected to guide cones **22**. The guide cones are of a diameter slightly less than the inner diameter of the guide tubes **17** and preferably have a lower portion that tapers downwardly.

Preferably, each of the guide tubes **17** has a cone-shaped flange **23** attached to its upper end which serves to align the guide cones **22** as they move downwardly into the guide tubes **17**. Each of the guide cones **22** is provided with a vertical hole therethrough of a diameter slightly larger than the guiding cables **24** which are secured at their ends to the wellhead support structure within the bottom of the guide tubes **17** and extend upwardly to the surface where they are suspended, preferably by constant tension means, from a drilling vessel or barge **8** (FIGURE 7) from which operations are being carried out.

In FIGURE 1 the guide arms **21** are shown as being connected to a container **25** which may be employed to surround the wellhead assembly or production control unit of the well. For purposes of simplifying the drawing and description thereof, the wellhead assembly of the present invention is shown as comprising a pair of control valves **26** and **27** which are positioned in the production flow line **28** coming from the well. Although the well is illustrated as having a single string of well casing **30** and a single string of production tubing **31** extending downwardly into the well, it is to be understood that the present wellhead apparatus could be employed with wells having multiple strings of casing and tubing. Normally, the production control unit or wellhead assembly enclosed within the container **25** comprises the necessary piping, valves, chokes, and other equipment normally connected together and mounted on the top of a well, and known as a "Christmas tree," together with the necessary

hydraulic or electrical systems including pumps, reservoirs, motors, etc., to operate the valves at the head of the well from a remote location.

The container 25 and the wellhead assembly contained therein are normally lowered into place by means of a string of pipe 32 known as a "running string" which has a running head 33 attached to the lower end thereof which may be connected to the top of container 25 or to its lubricator 34. The lubricator or wellhead closure 34 may be of any desired type suitable for use in offshore underwater wellhead assemblies. The wellhead closure is preferably of the type which permits re-entry into the well for well control or work-over purposes. During normal production of a well the running string 32, running head 33 and any pressure tubing strings 35 and 36 which may be contained herein, are discconected from the wellhead assembly and drawn to the surface. When not in use the guide cables 24 are either retrieved or dropped to the ocean floor where they may later be retrieved by grappling hooks or other suitable means when it is desired to use them again to lower equipment to the wellhead. During work-over or other operations on the well, the running string 32 and the running head 33 may be replaced by a marine conductor pipe string and a landing head or seal (not shown).

The production flow line 28 as it leaves the top of the wellhead assembly or the container 25 is preferably, though not necessarily, curved in an arc of substantial radius so that various tools, instruments, or other devices may be circulated through the production flow line and down into the well. As the flow line 28 passes horizontally by the container 28 it is preferably rigidly affixed thereto as by welding, clamping, bolting, etc.

A pipeline coupling or a pipeline connector consisting of a female portion 40 and a male portion 41 is installed in the production flow line 28 at a point close to the wellhead assembly or its container 25. Preferably, the male portion 41 of the coupling is fixedly mounted on a carriage 42 which is, in turn, fixedly secured by means of suitable braces 43, 44 and 45 (FIGURE 2) to one or more guide cones 46 and 47. The guide cones 46 and 47 are slidably mounted on an auxiliary guide cable 48 which passes downwardly through an auxiliary vertical guide tube 51 which is similar in design to guide tubes 17 and is provided with a slot 52 therein and a cone-shaped flange 53 on the top thereof. A suitable stop member 58 is provided in the guide tube 51 so as to limit the downward movement of the cones 46 and 47 within the guide tube 51 so that the carriage 42, at the end of its travel, is positioned with the male portion 41 of the coupling on a level with the female portion 40. Instead of employing a stop member within the guide tube 51, the slot 52 therein may be terminated at some point above the bottom of the tube 51 so as to limit the downward travel of the lower guide cone 47.

The precise placement of the slot 52 in the guide tube 51 serves as aligning means between the carrier 42 and the cable 48 to position the male portion 41 of the coupling in substantially coaxial register and spaced relationship with the female portion 40 of the coupling. In some installations it may be found more advantageous to lower the male portion 41 of the coupling on a carriage 142 that is suspended between two parallel guide cables 48 which terminate in two parallel auxiliary guide tubes 51 (FIGURE 4), positioned to one side of the primary guide tubes 17. The portion 28*a* of the production flow line extending from the male portion 41 of the coupling is preferably flexible, but may also be a preformed rigid section, to facilitate positioning it on the ocean floor and attaching it to the female portion 40 of the coupling. In the event that the well has two or more production flow lines, then the wellhead assembly would be provided with two or more couplings.

The equipment lowering carriage illustrated in FIGURES 4, 5 and 6 comprises an arrangement of structural

members 160, 161, 162 and 163, together with any suitable arrangement of cross braces and provided with guide cones 147, of a size to fit between the auxiliary guide tubes 51. The equipment carriage 142 is also provided with suitable connector means 164, 165, 166 and 167, which may be in the form of bolts or clamps, for securing pieces of equipment, such for example, as wellhead flowlines or their fittings, to the carriage. The connector devices 166 and 167 are positioned preferably at the end of outwardly extending side arms 170 and 171. The carriage 142 may also be provided with a latching means in the form of hooks or slotted plates, 172 and 173, which are of a size to hook onto the upper structural member 12 (FIGURE 4) and a horizontally extending bar 174 which extends between the auxiliary guide columns 51. Thus, the hook 172 would be lowered vertically down over the top structural member 12 while the lower hook 173 was lowered down on the support bar 174. If desired, a fishing and lowering head 175 (FIGURE 6) may be secured to the top of the carriage for attaching a wire line (not shown) thereto for lowering. When using an equipment carriage provided with latches or hooks 172, any of the inner connecting girders or the cross-bracing members of the wellhead support structure may be employed as stop means for limiting the vertical movement of the equipment carriage 142 and accurately positioning any equipment carried thereby at a predetermined level above the base structure and in accurate alignment with any wellhead fitting.

It may readily be seen that by employing an auxiliary set of guide cables 48, together with the guide cables 24, two pieces of equipment arranged to be connected and operate in side-by-side relationship may be connected together on a drilling barge and lowered simultaneously into position on a wellhead support structure on the ocean floor. Additionally, by employing a primary guide system and an auxiliary guide system which terminate in fixed spaced relationship on an underwater wellhead structure, various pieces of wellhead equipment or wellhead fittings in the associated equipment may be raised and lowered, selectively or simultaneously, individually or as a combined unit, on the guide system of the present invention. It may also be seen that in the event that the cables to one guide system became entangled or parted under abnormal stresses, suitable equipment could be lowered down the other guide system to make the necessary repairs to the damaged guide system.

We claim as our invention:

1. Apparatus for guiding wellhead equipment from an operational base above the surface of a body of water to a predetermined point below the surface of the water, said apparatus comprising wellhead support structure having a wellhead support base positioned below the surface of the water, a plurality of tubular guide columns with the lower ends thereof being fixedly secured to said support base, a flexible guide line fixedly secured to each of said guide columns and coaxial therewith, said guide lines extending upwardly through said water to said operational base thereabove, means carried on said operational base and operatively connected to said guide lines for supporting the upper ends thereof, each of said tubular guide columns having a longitudinal slot through the wall thereof, substantially adjacent the well axis, said support structure including auxiliary tubular guide column means fixedly secured to said support base at a spaced distance from the axis thereof, and flexible guide line means having the lower end thereof fixedly secured in said auxiliary tubular guide column means, said guide line means extending upwardly through said water to said operational base thereabove.

2. The apparatus of claim 1 wherein said auxiliary guide column means have aligning means adapted to be engaged by at least a cooperating portion of an equipment carriage means.

3. The apparatus of claim 2 including vertical-move-

ment-limiting stop means affixed to said support structure and engageable by the carriage means for fixedly positioning said carriage means at a predetermined level above said support base.

4. Apparatus for guiding wellhead equipment from an operational base above the surface of a body of water to a predetermined point below the surface of the water, said apparatus comprising wellhead support structure having a support base positioned below the surface of the water, a plurality of tubular guide columns with the lower ends thereof being fixedly secured to said support base, a flexible guide line fixedly secured in each of said guide columns and coaxial therewith, said guide lines extending upwardly through said water to said operational base thereabove, means carried on said operational base and operatively connected to said guide lines for supporting the upper ends thereof, tubular guide elements coaxially slidably mounted on said guide lines for movement therealong, a plurality of support arms, one end of each of said arms rigidly positioning a guide element a fixed radial distance from the vertical axis of said hole in said support base, the other ends of said arms being affixed to a wellhead component to be guided into place on the tubular member of said support base, each of said tubular guide columns having a longitudinal slot through the wall thereof substantially adjacent the well axis, said slots being at least slightly wider than the arms that slide therein, said support structure including auxiliary tubular guide column means fixedly secured to said support base at a spaced distance from the axis thereof, a flexible guide line means having the lower end thereof fixedly secured in said auxiliary tubular guide column means, said guide line means extending upwardly through said water to said operational base thereabove, said guide column means having aligning means into which at least a cooperating portion of an equipment carriage means is receivable, and stop means affixed to said support structure and engageable by the carriage means for fixedly positioning said carriage means at a predetermined level above said support base.

5. Apparatus for guiding wellhead equipment from an operational base above the surface of a body of water to a predetermined point below the surface of the water, said apparatus comprising wellhead support structure having a support base positioned below the surface of the water, and having a hole therein for passing a well pipe therethrough, anchoring means attached to said support

base and extending into the earth formations below said body of water to fixedly anchor said support base, a tubular well member extending upwardly from said support base, a plurality of tubular guide columns with the lower ends thereof being fixedly secured to said support base above the hole therein, a flexible guide line fixedly secured in each of said guide columns and coaxial therewith, said guide lines extending upwardly through said water to said operational base thereabove, contact tension means carried on said operational base and operatively connected to said guide lines for maintaining tension thereon, tubular guide elements coaxially slidably mounted on said guide lines for movement therealong, a plurality of support arms, one end of each of said arms rigidly positioning a guide element a fixed radial distance from the vertical axis of said hole in said support base, the other ends of said arms being affixed to a wellhead component to be guided into place on the tubular member of said support base, each of said tubular guide columns having a longitudinal slot through the wall thereof substantially adjacent the well axis, said slots being at least slightly wider than the arms that slide therein, said tubular guide columns being of a height sufficient to receive a plurality of guide elements moving in spaced relationship to each other, said support structure including auxiliary tubular guide column means fixedly secured to said support base at a spaced distance from the axis thereof, flexible guide line means fixedly secured at the lower end thereof in said auxiliary tubular guide column means, said guide line means extending upwardly through said water to said operational base thereabove, said guide column means having aligning means into which at least a cooperating portion of an equipment carriage means is receivable, and stop means affixed to said support structure and engageable by the carriage means for fixedly positioning said carriage means at a predetermined level above said support base.

References Cited by the Examiner

UNITED STATES PATENTS

2,808,230	10/57	McNeill et al.	175—7
2,909,359	10/59	Bauer et al.	175—7
2,981,347	4/61	Bauer et al.	175—7
3,012,610	12/61	Bauer et al.	175—7
3,050,138	8/62	Outwin et al.	175—7
3,052,299	9/62	Geer et al.	166—665

CHARLES E. O'CONNELL, *Primary Examiner.*