SURFACE TO SUBSEA GUIDANCE SYSTEM

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Application Ser. No. 671,365, Sept. 28, 1967; this application over No. 775,590

Int. Cl. B63b 35/04; E21b 33/025, 43/01

U.S. Cl. 61—46.5

8 Claims

ABSTRACT OF THE DISCLOSURE

A cable is attached to a float and pulley system at a subsea location for extension to the surface to act as a guide for structures passed between the surface and the subsea location.

This application is a continuation of Ser. No. 671,365 filed Sept. 28, 1967 and now abandoned.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to structural guidance of structures between the surface and subsea locations. More particularly, the invention relates to landing oil well production equipment on a subsea base structure and guiding it to the surface for adjustment, repair, replacement, etc.

Description of the prior art

Drilling subsea locations is a dynamically developing art. Completing these oil wells drilled is feasible at increasingly deeper subsea locations. However, the basic processing of produced fluids at the wellhead is only now being contemplated. At present, the produced fluids are conducted to the surface where the processing equipment, normally located at the wellhead on shore installations, is mounted on surface platforms. Equipment is being developed for basic wellhead processing at subsea locations. This structure is made up in packages adapted to be mounted on base structures at the subsea location of wellheads. Positive guidance of these packages is demanded in order to land and orient them on their base structures as well as remove them to the surface for workover.

At present the art literally offers the oil industry only a team of divers whose members can but grope through the darkness of the ocean depths, manually guiding crane-lowered equipment to its subsea location. Temporary anchors and cables attached to the subsea location at the time of transfer offer a clumsy, indefinite guide for the equipment.

Summary of the invention

It is a principal object of this invention to positively guide structures in their transfer between the surface and a subsea location.

Another object is to provide a cable system for guidance which is permanently mounted at the subsea location and which can be retracted to a location below navigation and wave action.

Another object is to provide a retracting mechanism which is automatic and which can be readily repaired.

The invention contemplates a float retained within a housing structure at a subsea location. A cable is attached to the float and passes over a system of pulleys and up to a buoyant structure. The float, at the upper limit of its travel within the housing, tethers the buoyant structure to a subsea location.

When the buoyant structure is pulled to the surface, the float is pulled toward its lower limit of travel. The cable then becomes operative as a guide for structures transferred between the surface and the subsea location. Any number of these cables and float-pulley combinations required for precise orientation and guidance of the transferred structure may be employed under the basic concept.

Other objects, advantages and features of this invention will become apparent to one skilled in the art upon consideration of the written specification, appended claims, and attached drawings, wherein:

FIG. 1 is a sectional elevation of a subsea oil wellhead with a guidance system embodying the present invention being engaged for extension to the surface;

FIG. 2 is the structure of FIG. 1 showing the guidance system extended and the guided structure transferred to the surface;

FIG. 3 is the structure of FIG. 2 with the transferred structure buoyed higher than in FIG. 2;

FIG. 4 is the structure of FIG. 3 with the transferred structure removed from the guidance system and the system buoyed at the surface;

FIGS. 5 and 6 are sectional elevations of one float and pulley arrangement of the guidance system illustrating the float in the two extreme positions at each end of its range of travel;

FIGS. 7–9 show, in elevation, the sequence of operations to replace a broken cable of the guidance system;

FIGS. 10 and 11 show, in elevation, a communication cable utilizing the float and pulley system of FIGS. 1–9.

REDUCTION TO PRACTICE

FIGS. 1–4 are to be considered together in their depiction of the complete cycle of operation of the structure in which the invention is embodied. Understanding begins with the fact that a body of water 1 is over a bottom 2 and has a surface 3. The location of petroleum products dictated the drilling and completion of a well, evidenced by a conductor, or connector, pipe 4.

Pipe 4 is the external evidence of the completed well at this subsea location. It is a presently accepted technique to mount a support framework 5 to this pipe, below the wellhead structure not shown here. It is specifically planned to have landing sockets on the framework 5 in which the lower ends of the legs of a base for module 6 of production equipment will be mounted. None of this connecting equipment need be illustrated here. For the present purpose, it is only necessary to regard the upper surface of support framework 5 as a base for module 6. This module 6 is a removable structure to be transferred between base 5 and surface 3 by use of the guidance system in which the present invention is embodied.

The present invention is embodied in the guide system for module 6 as the module is transferred from the location illustrated in FIG. 1 to the location illustrated in FIGS. 2, 3 and 4. Basically, a cable 10 is extended from base 5 to surface 3 and has a sliding connection with the module 6 to guide it during transfer.

Of course, more than one cable 10 may be very desirable. Probably four such cables would be desired, one for each corner of a square module. However, the operation of one cable and its relation to the guide will give a full teaching of the invention.

In FIG. 1, cable 10 connects float 11 with buoyant frame 12. Between these two connections, cable 10 passes over a pulley block on float 11 and a pulley block on base 5. Frame 12 is pulled to the surface 3 and float 11 travels downward to the position shown in FIGS. 2, 3 and 4. Module 6 can then be released from its connec-
tions to base 5 and transferred to surface 3, guided by sliding engagement with cable 10. The transferable module 6 is mounted on base 5 and is operating, the guide system is positioned as illustrated in FIG. 1. Buoyant frame 12 is urged downward to a position safely below significant wave action and navigation. A float 13 is shown to demonstrate how frame 12 may be maintained buoyant while tethered by cable 10. A diver 14 is shown, descending to attach hoisting tackle 15 to frame 12 so it may be lifted to the surface as shown in FIG. 2. Obviously, a trailing arrangement to snare frame 12 can be used as an alternate means to move the float between tackle 15 and frame 12.

FIG. 2 discloses the frame 12 hoisted above the surface and the module 6 guided by cable 10. Ballast tanks 20 are filled with gas to float module 6 to the surface. For certain service operations, it may not be desirable to float module 6 higher than this position.

FIG. 3 discloses how lower tanks 21 may be filled with gas to float the module higher on the surface. This position may be desirable for particular service demands.

FIG. 4 discloses how the module may be disconnected from the guide cables and towed to another location for extensive service. While awaiting a module to guide back to base 5, frame 12 may be retained near the surface 3 by a float 22 large enough to support frame 12.

FLOAT-PULLEY SYSTEM

FIGS. 5 and 6 disclose in great detail how the cable 10 is controlled. As pointed out, float 11 is attached to one end and frame 12 is attached to the other. The float 11 has a predetermined range of vertical travel and frame 12 also has a range of travel.

The range of travel for float 11 is fixed by the dimensions of housing 30 which can be given the form of the vertical tube disclosed in FIGS. 5 and 6. Housing 30 is mounted in its vertical position near the base 5. Actually, in FIGS. 5 and 6, the housing is connected to the base 5 although the concept of the invention is not so limited.

Float 11 raises and lowers in tubular housing 30, limited by the closure 31 as the top and the closure 32 as the bottom. Pulley block 33 is mounted on the lower end of float 11 and a similar block 34 is mounted on the bottom closure 32. These blocks are formed of a series of pulleys, arranged side-by-side. Cable 10 is passed over them in sequence to form multiple passes 35 between the two sets of pulleys.

The end of cable 10 attached to the float 11 is held on a bracket 36 by any conventional arrangement. The cable then extends over the pulleys and out aperture 37 near the bottom of the housing. A pulley 38 then leads the cable up a guide tube 39.

Guide tube 39 is generally cylindrical in form and mounted parallel housing 11. This is the structure which is the destination of the transferred module. Cable 10 extends the length of this tube 39 as disclosed in FIGS. 5 and 6 and a protruberance from module 6 slides on cable 10 to be guided down into the tube.

A funnel formation 40 is mounted on the upper end of tube 39 to "catch" the guided pin 41 of module 6. A vertical slit is formed through the funnel 40 and down a length of tube 39 to accommodate the connection 42 which attaches pin 41 to module 6. With pin 41 and the bore of tube 39 having a fairly close fit, the module 6 is oriented with a fair degree of precision with respect to base 5. When the module 6 is thus landed on base 5 the connections not shown here lock the two together for subsequent functioning of the module at the wellhead.

Of course, module 6 may have more than one pin 41 with a bore, each of which can 10 passes. All such pins may land in tube 39 to positively orient module 6 guided to its place on base 5. FIG. 5 shows the float 11 in its upper position. As can be observed in FIG. 1, frame 12 is then urged to its lowermost position. FIG. 6 shows float 11 in its lowermost position. Frame 12 is in its uppermost position. In FIG. 5, module 6 is locked to base 5. In FIG. 6 module 6 is disengaged from tube 39 and base 5 and on its guided way to the surface.

CABLE REPLACEMENT

The depth of these structures beneath the surface will give a measure of protection against marine growth on the moving parts. However, cable 10 may break and its replacement is readily made in this embodiment of the invention.

In FIGS. 5 and 6 the attachment of float 11 to cable 10 is disclosed at bracket 36. In the uppermost position of float 11, access to this bracket is made available through aperture 50 in housing 30. FIGS. 7-9 then disclose how this arrangement facilitates replacement of cable 10.

FIG. 7 discloses cable 10, broken and needing replacement. Diver 14 has taken a reel 51 of replacement cable to the subsurface location and connected one end to the broken end of cable 10.

FIG. 8 discloses that diver 14 has gained access to the bracket 36 and disconnected cable 10 from the float. The broken cable is then pulled through aperture 50 trailing replacement cable 10' through tube 39 and over the pulleys until it can be connected to bracket 36.

FIG. 9 discloses the reel 51 removed to the top of the frame 12. The end of cable 10' is connected to frame 12, replacing cable 10 completely. The broken pieces of cable 10 have been discarded.

SUBSEA TO SURFACE COMMUNICATION

FIGS. 10 and 11 disclose an arrangement employing a float and pulley system similar to that of FIGS. 1-9 to establish communication at the surface with module 6. When module 6 is in position on its base 5 it is desirable to service it periodically in some way.

A battery may be used in the module for power. It is desirable to ascertain the level of power available from the battery and recharge it. When it is desirable to unlock the module from its base and inject gas into its tanks, it is desirable to cause these actions to take place from the surface. A communication link between the module and the surface is very desirable.

In FIGS. 10 and 11 a terminal station is indicated at 60. A similar terminal fixture is indicated at 61, mounted on frame 12. Between these terminals, a cable 62 is extended, controlled by a float and pulley system on the module 6.

The foregoing float and pulley system teaches how the cable 62 can be controlled. In FIG. 10 float 63 is at its uppermost position, frame 12 being at its retracted position below the hazards near the surface 3. In FIG. 11, terminal fixture 61 has been brought to the surface 3 after having been disconnected from frame 12. From a boat 64, power is fed down to module 6, or other desired action caused through the communication afforded by cable 62.

It is visualized that if frame 12 is brought to surface 3, terminal 61 would simply be brought with it. Then module 6 could be signaled to unlock from base 5 and the buoyancy could be increased by injecting gas into the tanks of the module as desired. Conceivably these actions could result in a completely automated transfer of the module 6 to the surface.

CONCLUSIONS

The present invention facilitates transfer of equipment between surface and subsea locations. In facilitating transfer, the equipment is given positive guidance through sliding engagement with one or more cables. The cable or cables, passing in or out at the subsea location, combined with a float and pulley system which extends the cable to the surface location and retracts the cable beneath navigation and wave activity.

When the guidance cable is extended to the surface, and while it is retained by tackle 15, the wave action on the boat carrying the tackle is erratic. However, with the
applying a consistent tension on the cable, the cable is not constantly slacking and jerking while acting as a guide. The stability of the guidance system greatly increases the ease and efficiency of the transfer between subsea and surface locations.

The system also makes practical the use of tackle with a relatively low capacity. After all, with only the force of the float system to overcome, tackle 15 can be relatively light. The module 6 is buoyed to the surface with its tanks. The cable system is basically all that is drawn to the surface with the tackle. There is not a great deal of additional strain on the tackle as the module is guided to the surface.

Additionally, the invention provides a positive orientation structure at the subsea location which coacts with the guidance cable. This combination brings the equipment to its working subsea location accurately so it can be readily locked in position on a base.

The transfer system is usually at a depth which mitigates against marine growth which would foul its moving components. Also, the arrangement provides ready access for replacement of broken cables.

Finally, the float and pulley system is adaptable to provide an efficient communication link with the surface. A cable for signals and various power mediums can be arranged on the pulleys and float system to provide complete communication and control from the surface to the module at its subsea location.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus. It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A subsea guide system for structures passed between the surface and a subsea location, including:
   a base structure mounted at a subsea location,
   a float guided between two vertical locations near the base structure,
   a cable and pulley system attached to the float to permit an end of the cable a range of travel from a predetermined vertical distance above the base to the surface, the cable acting as a guide for structures passed between the surface and the base structure,
   and
   a buoyant frame attached to the end of the cable moving over the range of travel, whereby a connection can be made to the frame with which the frame can be pulled to the surface.

2. The system of claim 1, including a guide tube mounted at the subsea location and arranged to direct the cable vertically as the cable travels over the subsea to surface range of travel.

3. The system of claim 1, including a housing for the float with which to establish the two vertical locations between which the float is guided by the housing.

4. The system of claim 1, including a pulley system of multiple pulley groups, one group attached to the float and the other attached near the base with the cable running over the pulleys in series.

5. A landing and retrieval system for subsea structures, including:
   a base structure permanently mounted at a subsea location,
   a guide tube mounted on the base structure,
   a removable structure arranged to be positioned on the base structure and having an orienting member arranged to be inserted into the guide tube to desirably position and orient the removable structure on the base structure,
   a cable extending through the guide tube, a buoyant guide frame attached to one end of the cable, and a system of pulleys and a float attached to the other end of the cable to urge the guide frame to a predetermined distance from the base and maintain the guide frame at that position.

6. The system of claim 5, including a funnel structure mounted on the top of the guide tube to receive a guide protuberance of the removable structure with a vertical slot in the side of the guide tube to receive the guide protuberance support of the removable structure as the structure is landed on the base structure.

7. The system of claim 5, including a communication system including:
   a further float mounted on the removable structure at the subsea location with which communication from the surface is desirable,
   means for guiding the said further float between two vertical locations,
   a communications cable and pulley system attached to said further float to control the travel of one end of the cable over a range from a predetermined vertical distance above the structure to the surface, and terminals at each end of the cable for connection between the structure and sources of communication and utilities at the surface.

8. A subsea guide system for structures passed between the surface and subsea location, including:
   a base structure mounted at a subsea location,
   a cable and pulley system mounted near the base structure and arranged to provide an end of the cable with a range of travel from a predetermined vertical distance above the base to the surface, the cable acting as a guide for structures passed between the surface and the base structure, means connected to the cable and pulley system and arranged to apply a force to the system directed to return the moving end of the cable to the lower end of its range, and
   a buoyant frame attached to the end of the cable moving over the range of travel, whereby a connection can be made to the frame with which the frame can be pulled to the surface.

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U.S. Cl. X.R.

61—69, 72.3; 166—6; 175—7