May 9, 1967 L. G. OTTEMAN 3,318,377

PRODUCTION WELLHEAD ASSEMBLY

Filed April 30, 1964 2 Sheets-Sheet 1

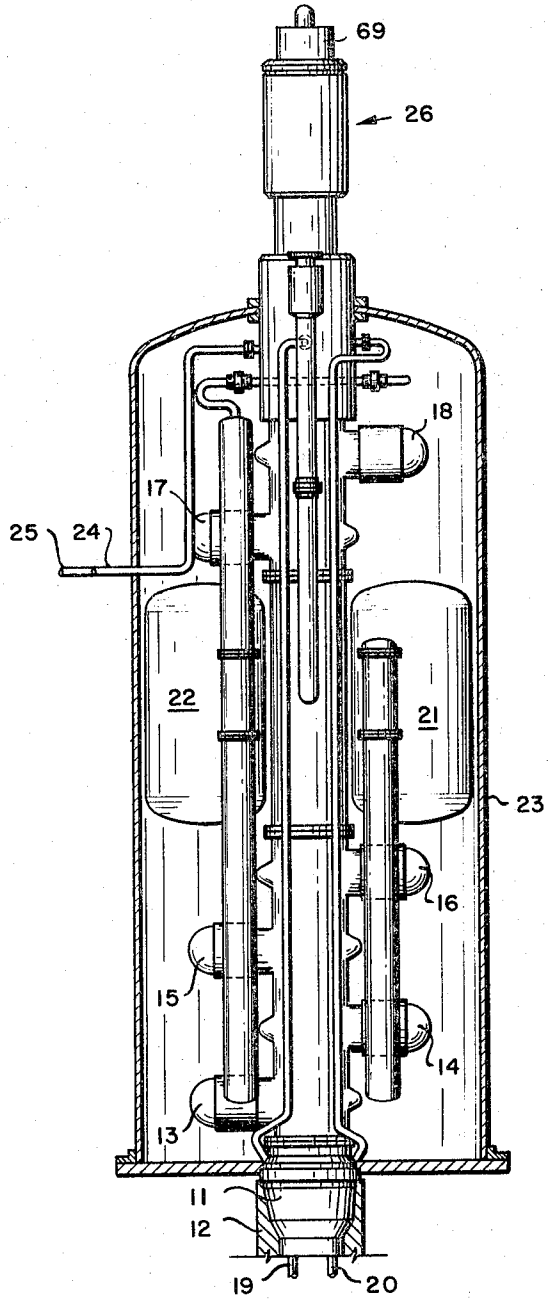

FIG. 1

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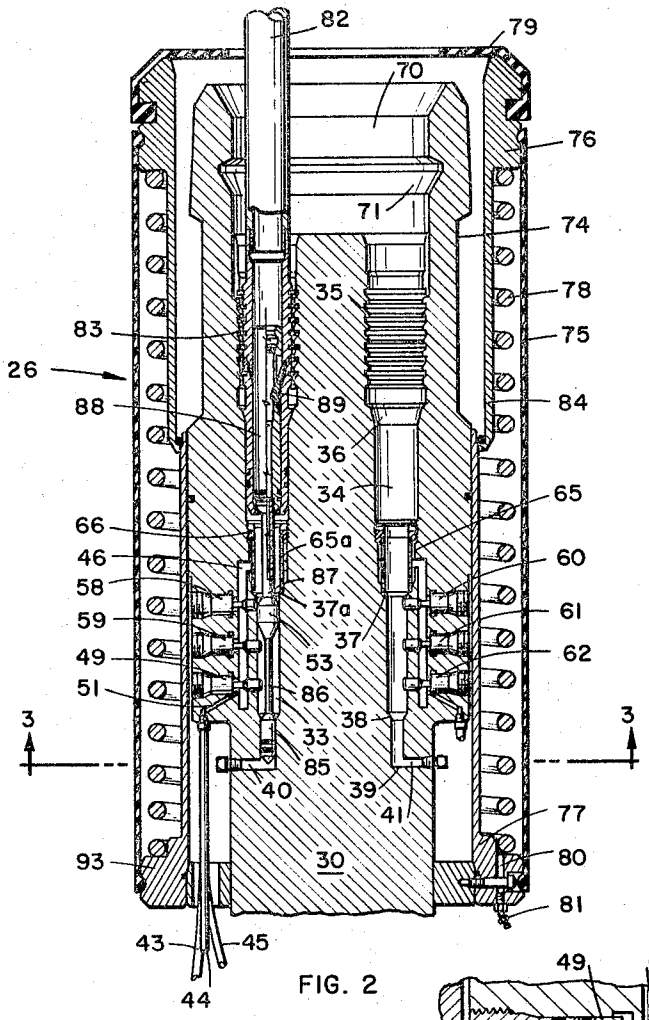

FIG. 2

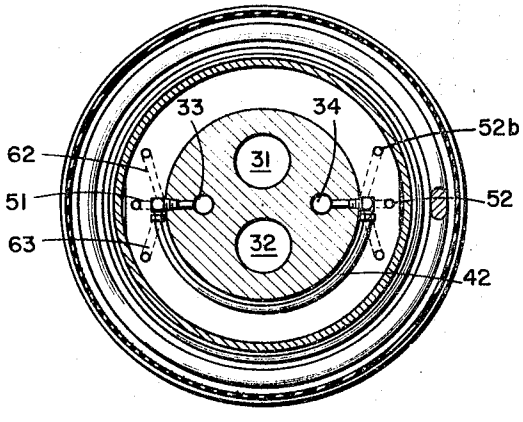

FIG. 3

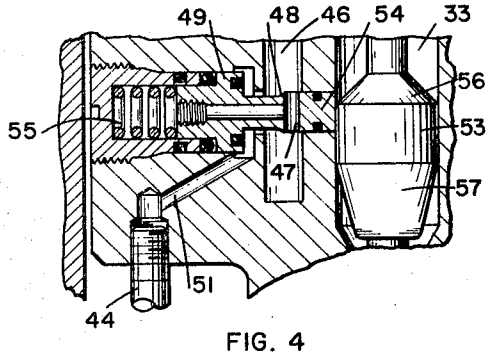

FIG. 4

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3,318,377

PRODUCTION WELLHEAD ASSEMBLY

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11 Claims. (Cl. 166—.6)

The present apparatus relates to oil well equipment for use at underwater locations and pertains more particularly to a wellhead closure apparatus for closing the top of a production wellhead assembly in a fluid-tight manner while providing means for re-establishing hydraulic control of components of underwater wellhead assemblies at offshore locations.

The wellhead apparatus of the present invention is related to and adapted to be used on wellhead assemblies of the type found in copending application, Ser. No. 218,482, filed Aug. 16, 1962, which is a continuation application of Ser. No. 830,587, filed July 30, 1959, and now abandoned. A recent development in the field of oil well drilling is the completion of wells at offshore locations with the wellhead assembly positioned on or close to the ocean floor out of the way of ships which may damage it in the event of a collision. Equipment on the ocean floor, however, faces problems such as the corrosive nature of the sea water and the presence of marine life which tends to grow and become encrusted on metallic structures below the surface of the water.

Since it is necessary from time to time to go back into a well wherever it has been completed, it is desirable to have an underwater wellhead structure in suitable condition so that pieces of equipment can readily be lowered from the surface of the water and attached to the wellhead structure. It is therefore a primary object of the present invention to provide a wellhead closure apparatus by which an underwater wellhead assembly may be entered for the purpose of carrying out workover operations in the well.

A further object of the present invention is to provide suitable connecting means by which equipment can be lowered from the surface of the water into engagement with an underwater wellhead assembly, which surfaces have been protected against exposure to the sea water and to marine life.

Another object of the present invention is to provide an apparatus for normally closing the top of a wellhead assembly while providing means for direct vertical access into the well to carry on workover operations therein.

A still further object of this invention is to provide a well closure apparatus including valves and fluid manifold means whereby tubing strings may be connected to the wellhead assembly to actuate any of the various components of the wellhead assembly.

These and other objects of the present invention will be understood from the following description taken with regard to the drawing, wherein:

FIGURE 1 is a schematic view illustrating several of the components which may be arranged as an underwater wellhead assembly;

FIGURE 2 is a longitudinal view taken partially in cross-section of the top of the wellhead assembly of the present invention;

FIGURE 3 is a cross-sectional view taken along the line 3—3 of FIGURE 2; and

FIGURE 4 is a fragmental longitudinal view taken in cross-section of the wellhead assembly of FIGURE 2 illustrating one form of a valve structure.

Referring to FIGURE 1 of the drawing a wellhead assembly or production control unit for an offshore well completed underwater is shown as comprising a casing-head closure apparatus **11** for closing the top of a well casing **12** and securing the wellhead assembly thereto, the

wellhead assembly comprising a group of power-actuated components including flow line control valves **13**, **14**, **15** and **16**, and swabbing valves **17** and **18** in the flow lines extending through the assembly, an electro-hydraulic package unit **21** containing a motor, reservoir and pump, and a second package unit **22** containing the various controlling pilot valves which are preferably solenoid-actuated. The entire wellhead assembly may be encased in a container **23**. The wellhead assembly may be provided with a pair of hydraulic pressure lines **24** and **25** which extend through the wall of the container **23** to operate a well component such, for example, as a flow line connector shown and described in U.S. Patent No. 3,090,437. The casing closure unit **11** and the wellhead assembly hold-down unit are provided with one or more tubing strings **19** and **20** as described in greater detail in U.S. Patent No. 3,064,735. The present invention is concerned with a closure and re-entry apparatus **26** for closing the top of an underwater wellhead assembly and permitting re-entry thereto in order to service or perform other operations on the well.

A wellhead closure and re-entry appparatus **26**, in accordance with the present invention, is shown in FIGURE 2 as comprising an elongated cylindrical housing or body member **30** forming the top of the wellhead assembly.

One or more vertical conduits, such, for example, as conduits **31** and **32** of FIGURE 3, extend through the entire length of the closure means and re-entry body member **30** and are in fluid communication with the tubing strings **19** and **20** (FIGURE 1) which depend within the well casing **12**. A second pair of vertical conduits **33** and **34** extended downwardly into or through the body member **30** to provide fluid communication with various hydraulic components of the wellhead assembly. These conduits **33** and **34** are each preferably provided with one or more seating shoulders or annular recesses such as those illustrated at **35–39** whereby various tools, valves and/or other devices may be definitely positioned at various points therein.

Extending through the side wall of the body member **30** near the bottom of conduits **33** and **34** are side conduits **40** and **41** arranged in fluid communication with each other, as by a flushing fluid by-pass line **42** which may bend around the outside of the body member **30** as illustrated in FIGURE 3 or may form an integral part of said body member.

Each of the vertical conduits **33** and **34** and the body member **30** are also in communication through the wall thereof with one or more conduits **43**, **44** and **45** (FIGURE 2) which lead to and are in communication with various hydraulically-operated components of the wellhead assembly. Thus, for example, the vertical bore **33** is in communication through conduit **46** and thence through a fluid port **47** in the stem **48** of valve **49**, and into conduit **51** to which conduit **44** is connected. As shown in FIGURE 4, the actuator head **53** of an actuator tool positioned in bore **33** engages the end **54** of the valve stem **48** which normally protrudes into the vertical conduit **33** and forces the stem **48** back against the compression spring **55** so as to open the valve **49** and bring the fluid conduit **51** into communication with the conduit **46**. The actuator head **53** is provided with upper and lower tapered surfaces **56** and **57**, respectively, so that the actuator head **53** can open or pass a valve without hanging up on it.

As shown in FIGURE 2, the re-entry body member **30** is also provided with any number of other valves **58** through **62** which are similar to valve **49**. Since the flow conduits **62** and **63** come away from the valves **58** and **59**, respectively, at an angle to the flow conduit **51**, as

shown in FIGURE 3; for ease of illustration they are not included in FIGURE 2. However, the conduits **51**, **62**, and **63** are in communication at one end with the flow conduits **44**, **45** and **43**, respectively, and on the other end with the conduit **46** which is in communication with the vertical conduit **33**. Preferably, the inlet end of the conduit **46** may be provided with any suitable type of a screen, such for example, as a cylindrical screen **65***a* which is seated on a shoulder **37***a* formed on the wall of the vertical conduit **33**, while the upper end of the screen **65** may be locked in place, as by screw threads **66**. In a like manner vertical conduit **34** is provided with a cylindrical screen **65**. However, in some instances, when vertical conduit **34** is being used as a return line for fluids passing upwardly through conduit **34**, it may be preferable to omit the screen **65** from the conduit **34** thereby preventing any particles in the system from clogging the outside of the screen and preventing the return of fluid through the screen. Normally, however, two screens **65** and **65***a* are employed especially during the flushing period when fluid is flushed down conduit **33** around the flushing fluid bypass line **42** and up the vertical conduit **34**.

The top of the body member **30** may be recessed, as at **70**. The recess **70** is provided to receive a suitable plug (not shown) having at least a portion of the outer surface made of rubber whereby a fluidtight seal is formed between the plug and the inner wall of the body member **30** within the recess **70** so that the top of one or more vertical conduits, for example, **33** and **34**, passing down through the body member, are closed in a fluidtight manner. Preferably, the wall of the recess **70** is provided with an annular groove **71** for receiving spring-loaded latching dogs or fingers adapted to seat within the recess. The construction of a preferred plug **69** for sealing the upper end of a body member of the present invention is described in detail in U.S. Patent 3,050,127. It is to be understood that rather than forming the recess **70** in the top of the body member **32** to receive a plug, a cap-type plug may be employed instead which fits down over the outside of the top of the body member **30** to seal the top of the body in a fluidtight manner. The lower edge of the cap-type closure member may seat in an annular recess **74** which is normally provided to receive the locking dogs of a device for lowering the present wellhead assembly down into place in the top of a well casing on the ocean floor.

In the event that the outer surface of the body member is provided with an annular recess **74** cut in the outer surface thereof, or any other suitable anchoring device formed on the outer surface thereof, at least the upper portion of the body member **30** is preferably encased in a temporarily removable or retractable sleeve which may act as an outer casing to minimize corrosion and the growth of marine organisms on the outer surface of the body member **30** which might prevent the orientation of the running tool head or other equipment. Such a protective outer casing on the body member **30** may take the form, as illustrated in FIGURE 2, of a spring-loaded bellows sleeve in the form of a thin flexible wall **75** which may be fixedly secured at the top and bottom to ring members **76** and **77**, respectively, the upper ring member **76** being slidably mounted in a low-pressure fluidtight engagement with the outer surface of the body member **30**. A compression spring arranged within the flexible sleeve **75** and between ring members **76** and **77** maintains the sleeve **75** in its normally extended position, as illustrated. The ring members **76** and **77** may be covered with rubber or any other suitable sealing means to form a substantially low-pressure fluidtight seal around the body member and against a plug **69** (FIGURE 1) when it is positioned in recess **70**. A seal of this type is illustrated in FIGURE 2 as element **79**. The spring-loaded protective bellows or sleeve **75** extends from the top of the body member **30** downwardly a distance sufficient so that in its operative position the sleeve covers at least all of the outer surface of the body member from the top thereof to a point below the annular groove **74** to be engaged by a running tool, and also extends a sufficient distance below this point so that the spring-loaded sleeve may be compressed without being injured. A spring-loaded chemically inert bellows is preferred. The wall **75** of the sleeve can be made of flexible metal or any flexible rubber-like or plastic material. A port **80** in the ring member **77** is provided with a grease fitting **81** by which a grease may be injected into the annular space between the outer surface of the body member **30** and the inner surface of the sleeve **75**. This displaces any sea water which has entered.

While the upper ends of the vertical conduits **33** and **34** are illustrated as being of the same diameter, it is to be understood that they may be of different diameters to facilitate the running of tubing string into the various conduits **33** and **34** and maintain identity as to which one is connected to which tubing, to be inserted later. Thus, if vertical conduit **33** had a diameter an eighth of an inch larger than conduit **34**, the larger of two tubing strings would be run into the wellhead assembly first to make sure that it was seated in conduit **33**. Only a single tubing string **82** is illustrated as having its lower end positioned within the upper end of conduit **33**, it being understood that a second tubing string could be similarly inserted in the upper end of conduit **34**.

Any suitable type of latching means may be employed to secure the lower end of a tubing string **82** in the upper end of its mating conduit **33**. For example, simple screw threads may be employed or a combination of a pin and J-slot mechanism, both being well known to the art. Alternatively, the recessed upper end of the vertical conduits **33** and **34** may be provided with a series of screw-thread shoulders in which the lower end of a tubing string may be stabbed. In this case, the lower end of the tubing string **82** is provided with a helically-wound spring **83** which is adapted to stab into seating position by vertical movement of the tubing string and may be later disconnected therefrom by rotation of the tubing string to the right. Connections of this type are common to the art and are manufactured by Baker Oil Tool Company.

In order to enter a wellhead assembly closed by the apparatus in accordance with the present invention, a string of pipe known as a marine conductor pipe (not shown) and having a running head secured to the lower end thereof would be lowered from a drilling barge down through the water to the ocean floor in a manner described in copending application Ser. No. 218,482 filed Aug. 16, 1962. As the running and latching head of the marine conductor pipe is lowered down on the top of the body member **30**, which at this time would still be closed at the top by means of a plug **69** (FIGURE 1), the lower end of the running head or pipe string would come in contact with the upper ring **76** of the protective sleeve unit **75–78**, forcing it downwardly along the side of the body member **30**. By providing a skirt **84** extending downwardly from the slidable ring **76**, damage to the sleeve unit by extreme compression is prevented. A fishing tool would then be run down to remove the plug from the recess **70** and, after running tubular strings (not shown) into conduits **31** and **32**, separate tubing strings, as **82**, would be run into the vertical conduits **33** and **34** and locked therein. Fluid would then be pumped down tubing string **82** from the vessel at the surface, and forced through vertical conduit **33**, around flushing by-pass line **42**, up through the vertical conduit **34** and thence upwardly through a mating tubing string (not shown), if desired, to the surface.

With vertical conduits **33** and **34** having been thoroughly flushed out, which action also cleans the inner surfaces of the cylindrical screens **65** and **65***a*, a plug **85** is dropped or run down one of the conduits, say conduit **33** so as to close the flushing fluid bypass line **42**. The plug **85** is preferably run at the lower end of a valve-actu-

ating tool which may comprise a valve actuator head 53 with a shaft 86 connecting it to the plug 85 at its lower end and with a hollow perforate stem 87 connecting it to a suitable hollow or tubular latching body 88 adapted to seat in the lower end of the tubing string 82 and being secured therein, if desired, against upper movement by suitable latches 89. The latches 89 are only necessary in the event that fluid is to be circulated upwardly through one of the valves 49, 58, or 59 and thence up through the tubular latching body of the valve actuator mechanism. The combination valve actuator mechanism together with the plug 85 may be lowered and retrieved by wire line in a manner well known to the art. Preferably, it would be run in on a wire line and pulled back until the latches 89 latched in their mating grooves so that the operator would be certain that the valve actuator head 53 was positioned opposite the valve to be opened. Alternatively, other spacing arrangements may be made to assure the operator that the proper valve is open. Thus, the stem 87 may be selected of a length such that when the valve actuating mechanism is seated in the lower end of the tubing string 82, the proper valve would be open. Alternatively, the position of the valve actuator head could be adjusted by changing the length of the shaft 86 between the plug 85 and the valve actuator head 53.

In the event that wellhead assembly employed hydraulically-operated components such as valves, lock down devices, etc., which were actuated in both directions hydraulically, that is, to an open or closed position or to a locked or unlocked position by applying hydraulic pressure in one direction or the other, it may be seen that the apparatus of the present invention could be employed to operate three hydraulically-operated wellhead components since the body member is provided with six valves 49, 58, 59, 60, 61, and 62 in the control conduits. Thus, in order to pump hydraulic pressure fluid through valve 58 to operate a wellhead component, the corresponding valve 60 on the other side of the body member must be opened to allow hydraulic fluid from in back of the piston of the hydraulically-operated component to move up conduit 34. In this case, therefore, it would be necessary to insert a valve-actuating mechanism as described with regard to the one in conduit 33, to be placed or dropped in the lower end of a second tubing string (not shown) which would be latched in the upper end of vertical conduit 34. The actuated tool in conduit 34 would not need to have a plug 85 attached to the lower end thereof as a single plug is all that is necessary to plug the flushing fluid by-pass line 42.

If on the other hand the hydraulically-operated components of the wellhead assembly are spring-loaded in one direction, it is quite apparent that only the single tubing 82 would be needed in order to operate a single valve, say valve 58, in order to provide hydraulic pressure fluid to the wellhead conduit to actuate it. Thus, in the arrangement illustrated in FIGURE 2, the six valves could be employed to control auxilliary hydraulic pressure fluid lines to six components.

I claim as my invention:

1. In a well installation having pressure-fluid actuated components located underwater at an offshore location, a re-entry head on said well installation comprising:

a body member having a pair of longitudinally fluid passageway bores closed at their lower ends and extending downwardly from the upper end of said body member,

flushing conduit means interconnecting the lower end of said pair of longitudinal bores whereby fluid may be flushed down one bore and up the other bore,

side conduit means through the wall of said body member in communication between at least one of said longitudinal bores and at least one of said pressure-actuated components of said well installation,

said body member having means above said side conduit means for receiving and sealing a removable flow conductor, and

valve means in said side conduit means for controlling fluid flow therethrough,

said bore having said side conduit means being provided below said side conduit means with an internal annular seal surface engageable by sealing means of a well tool.

2. The apparatus of claim 1 including filter means carried in said bore across the opening of said side conduit means.

3. The apparatus of claim 1 wherein each of said longitudinal bores is provided with side conduit means and including valve means in all of said side conduit means.

4. The apparatus of claim 1 wherein said valve means of said side conduit means include valve stem means normally extending into the bore of said body member and engageable by a valve operating well tool when said well tool is positioned in said bore.

5. The apparatus of claim 4 well tool means positioned in the bore of said body member at a point opposite to and engagement with said valve stem means of said valve means.

6. The apparatus of claim 5 wherein said well tool means is provided with seal means at the lower end thereof for engaging said seal surface of said bore to close said flushing conduit means.

7. The apparatus of claim 1 wherein both of said bores are provided with side conduit means and valve means for closing said side conduit means.

8. The apparatus of claim 7 wherein both of said longitudinal bores are provided with means for receiving and sealing flow conductors.

9. The apparatus of claim 8 including flow conductors having their lower ends sealed in the bores of said body member and being of a length to extend to a point above the surface of a body of water in which the well installation is positioned.

10. The apparatus of claim 9 including sealing means carried on the outer surfaces of said flow conductors near the lower ends thereof for engaging the inner surfaces of said bores of said body members above the side conduit means thereof, and internal groove latch means on the inner wall of said flow conductors near the lower ends thereof, said groove latch means being engageable by locking means of well devices for releasably securing well devices in said conductors.

11. The apparatus of claim 10 including valve actuating well devices having latching means for engaging said internal groove latch means and having valve stem actuating means carried at a predetermined distance below said latching means to engage said valve stem means of said valve means.

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