United States Patent

[11] 3,625,281

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[73] Assignee **Rockwell Manufacturing Company Houston, Tex.**

[54] **WELL COMPLETION METHOD AND APPARATUS**
36 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **166/0.6,** 166/212
[51] **Int. Cl.** **E21b 43/01**
[50] **Field of Search** 166/5.6, 120, 123, 125, 212

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ABSTRACT: A method and apparatus for completing an underwater well comprising the steps of: lowering hanger means and at least one tubing string on a handling string into the well casing to a position where said hanger means will be supported substantially below the mudline; cementing the tubing string within the well casing by passing cement through the handling string and the tubing string; disconnecting and removing the handling string; lowering connector means, a tubing riser and valve in the casing; and remotely connecting the connector means to the hanger means, placing the tubing string and tubing riser in fluidtight flow communication, the valve being installed in the tubing riser at a point substantially below the mudline, the tubing riser extending to the well platform.

One hanger embodiment comprises remotely operable hydraulic slip suspension means which may be activated by a remote pressure source in communication with the suspension means through a handling string and setting tool. The setting tool is provided with latches disengageable from the hanger on rotation of the handling string.

One connector means embodiment comprises remotely operable hydraulic latch means which may be activated through a tubing riser to engage the hanger means. An orientation sleeve may be provided on the connector means for aligning the tubing riser and tubing string before engagement. A conduit arrangement is shown which may be used to subsequently disconnect the connector means and riser from the hanger means for removal.

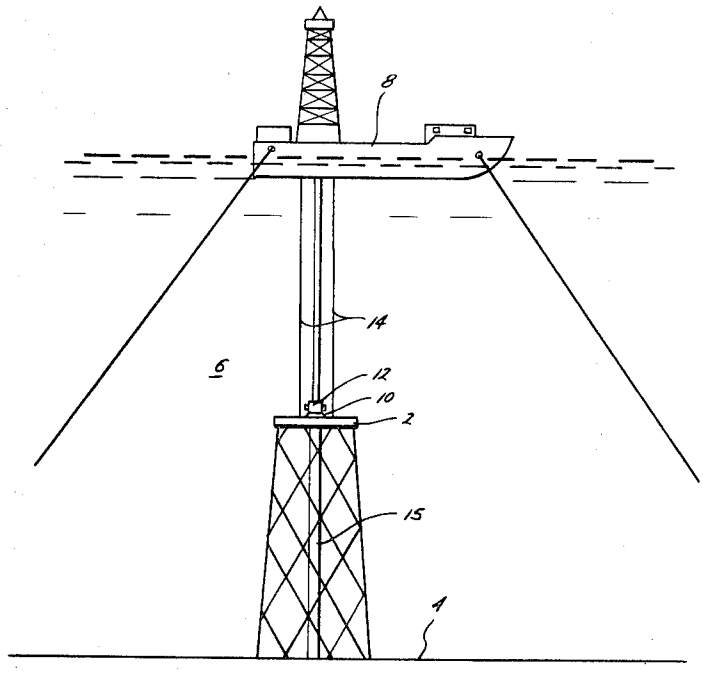
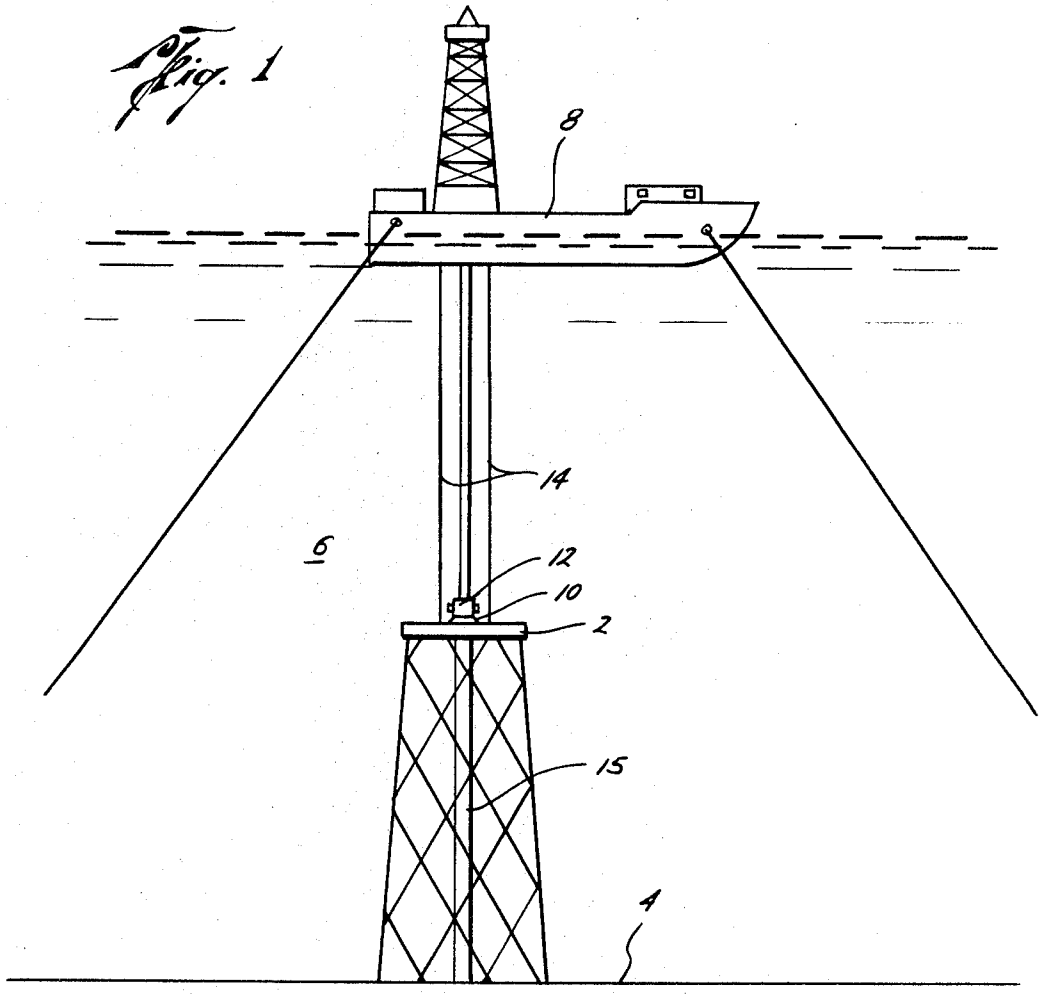


Fig. 1



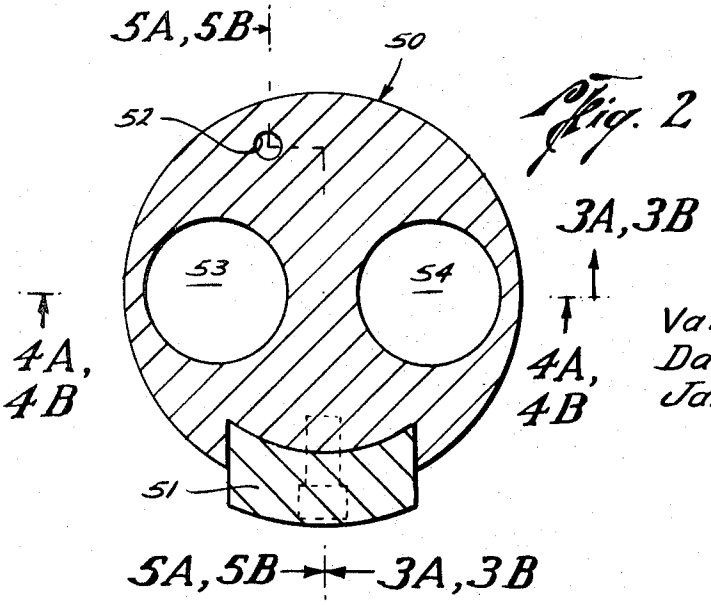


Fig. 2

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Fig. 3A

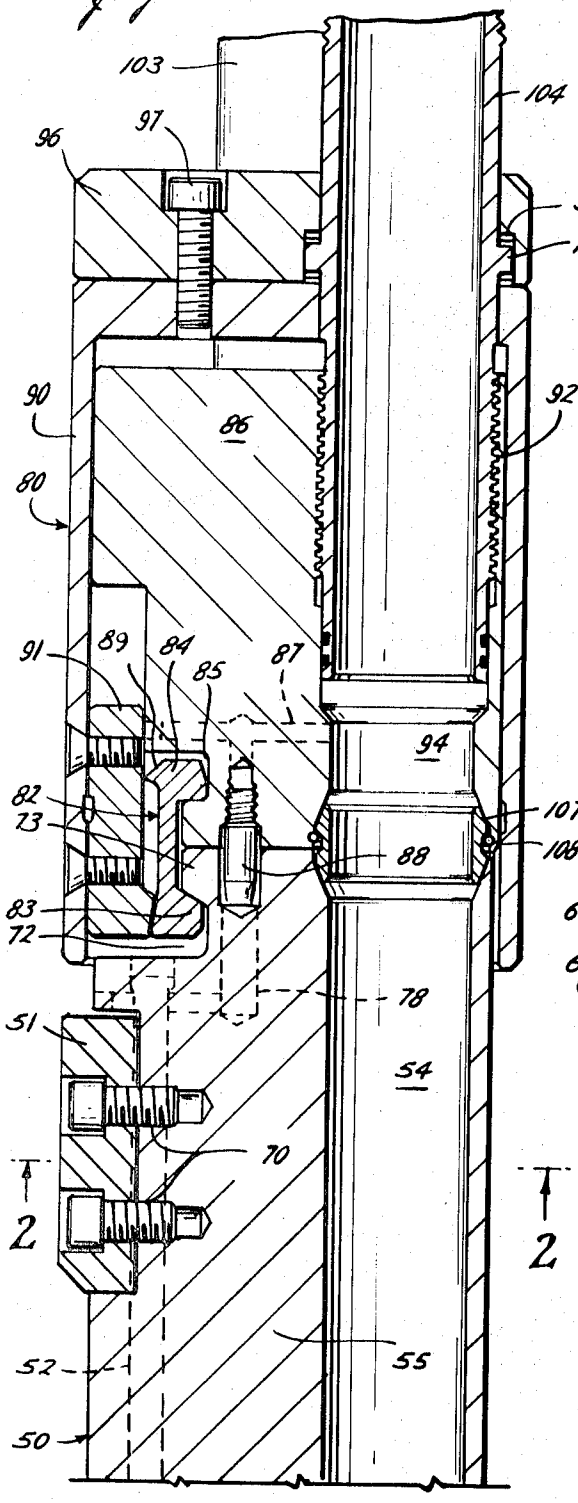

Fig. 3B

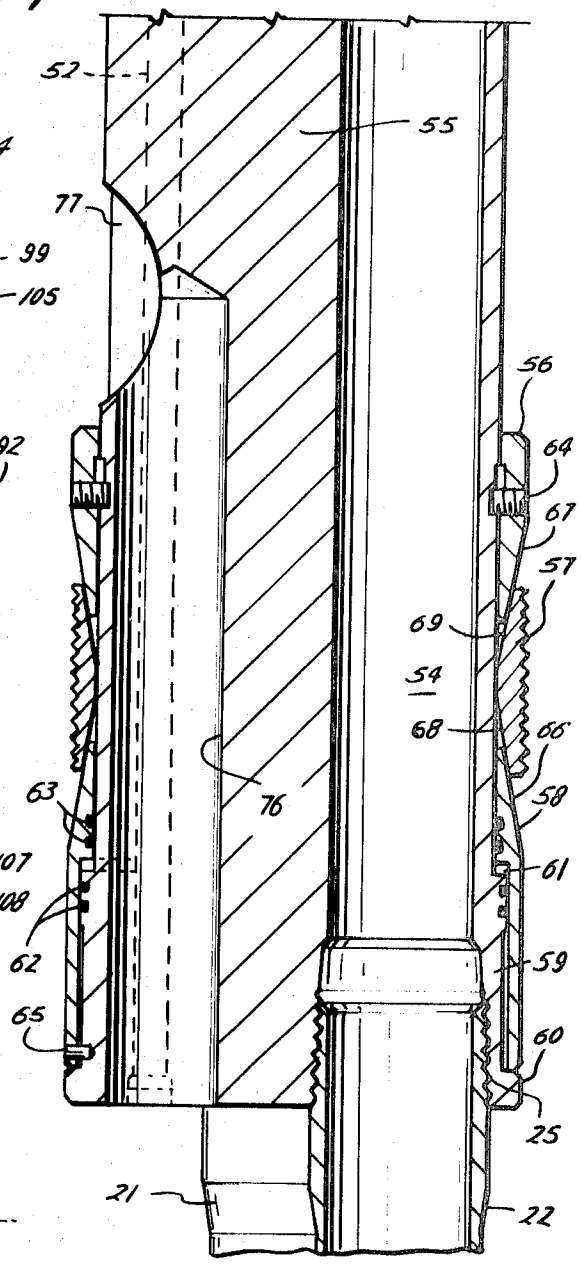

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Fig. 4A

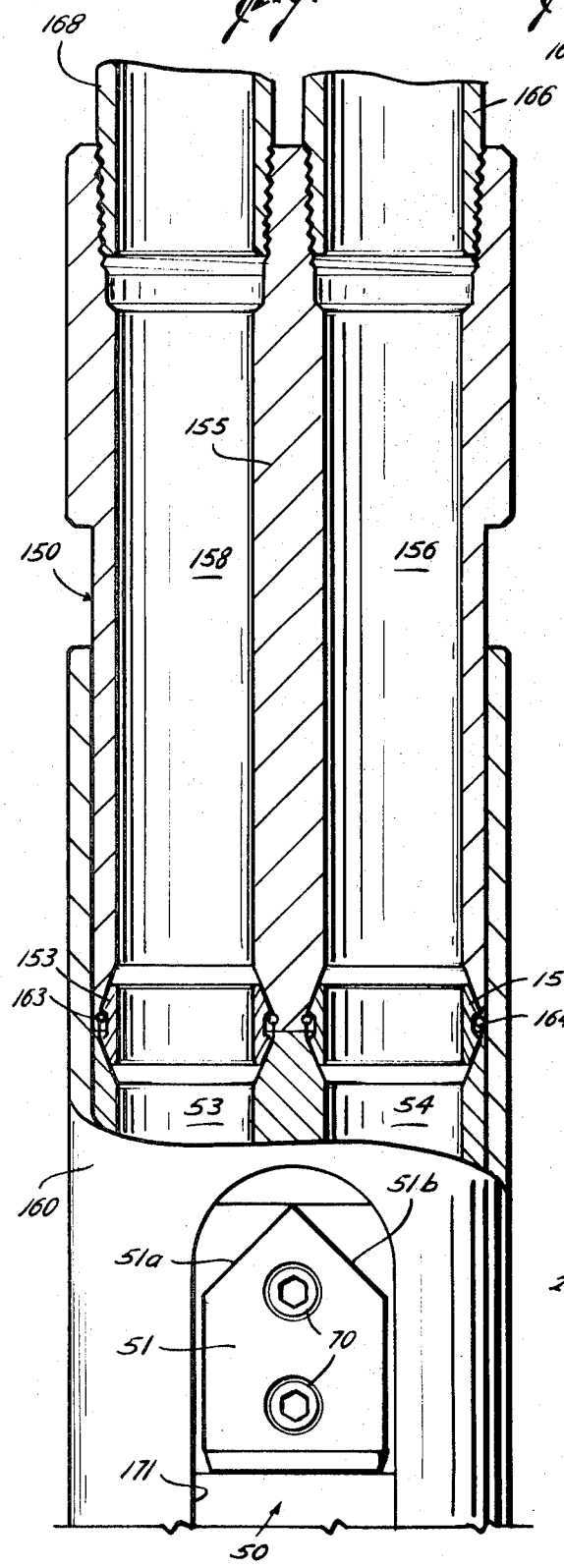

Fig. 4B

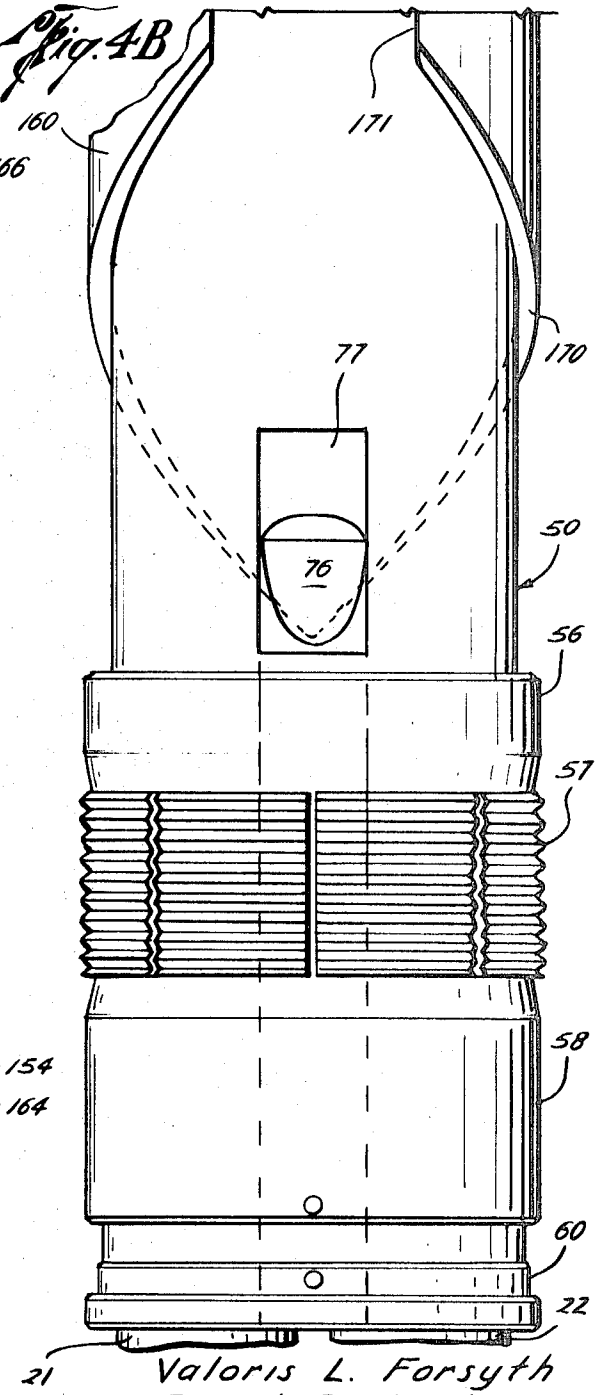

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Fig. 5A

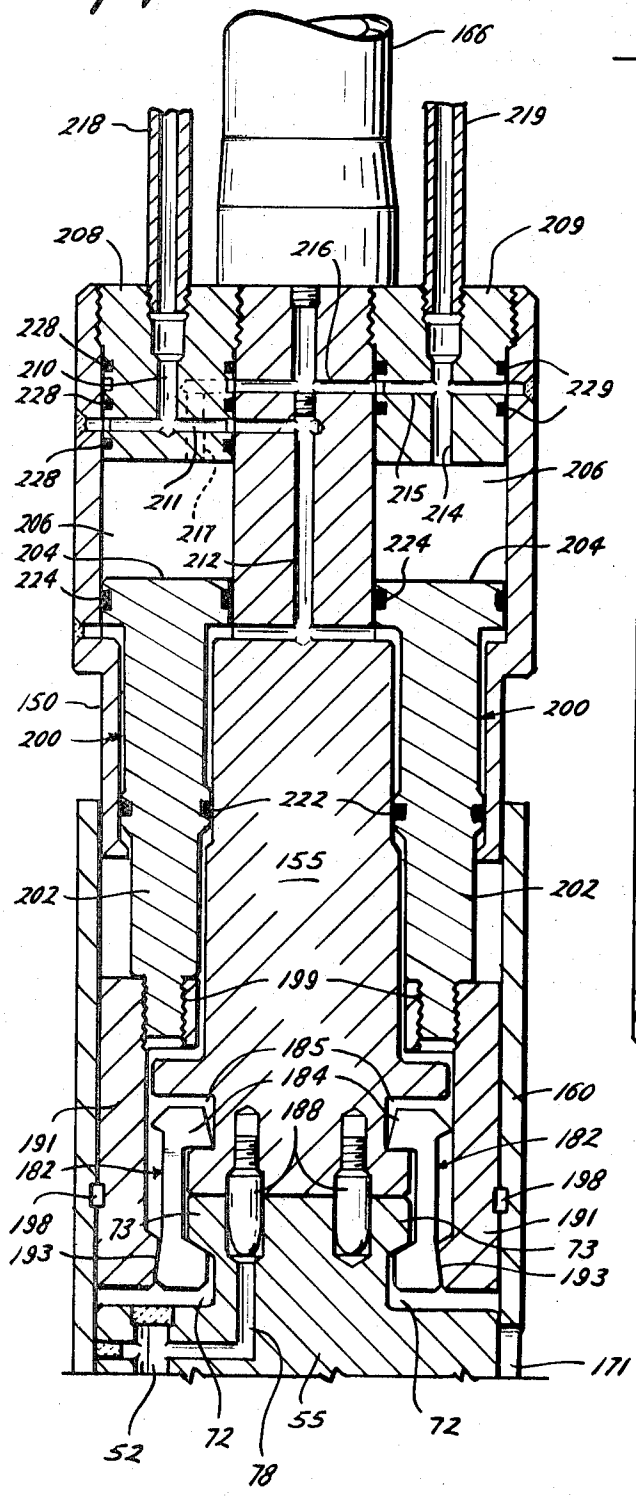

Fig. 5B

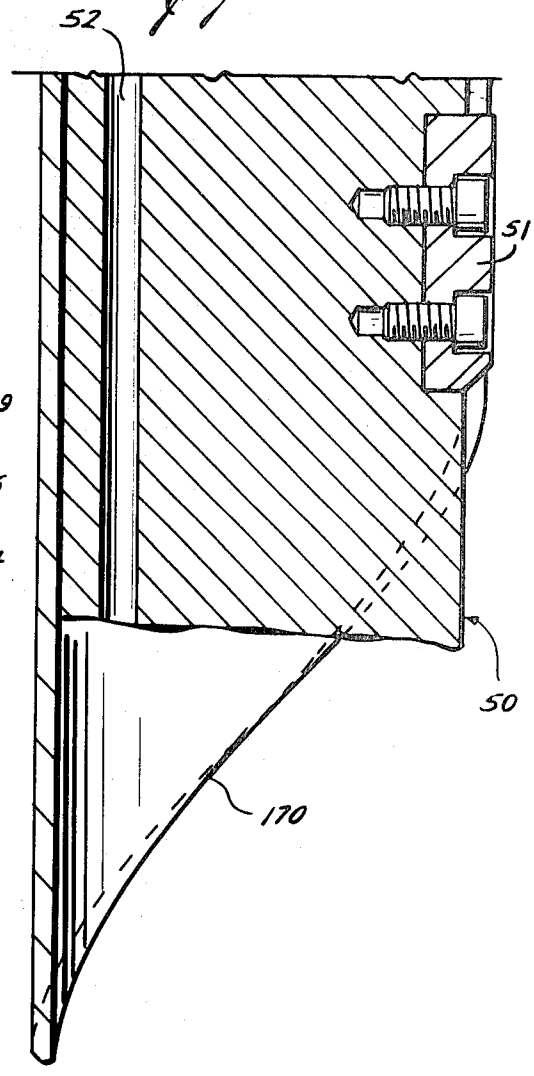

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Fig. 6

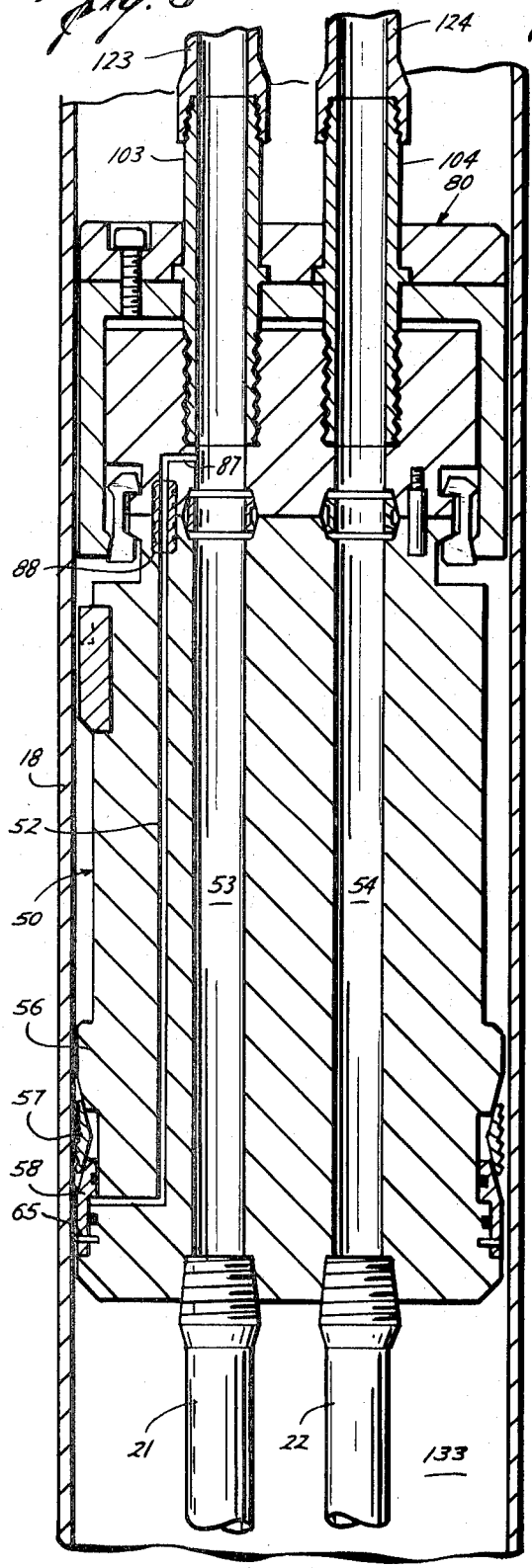

Fig. 7

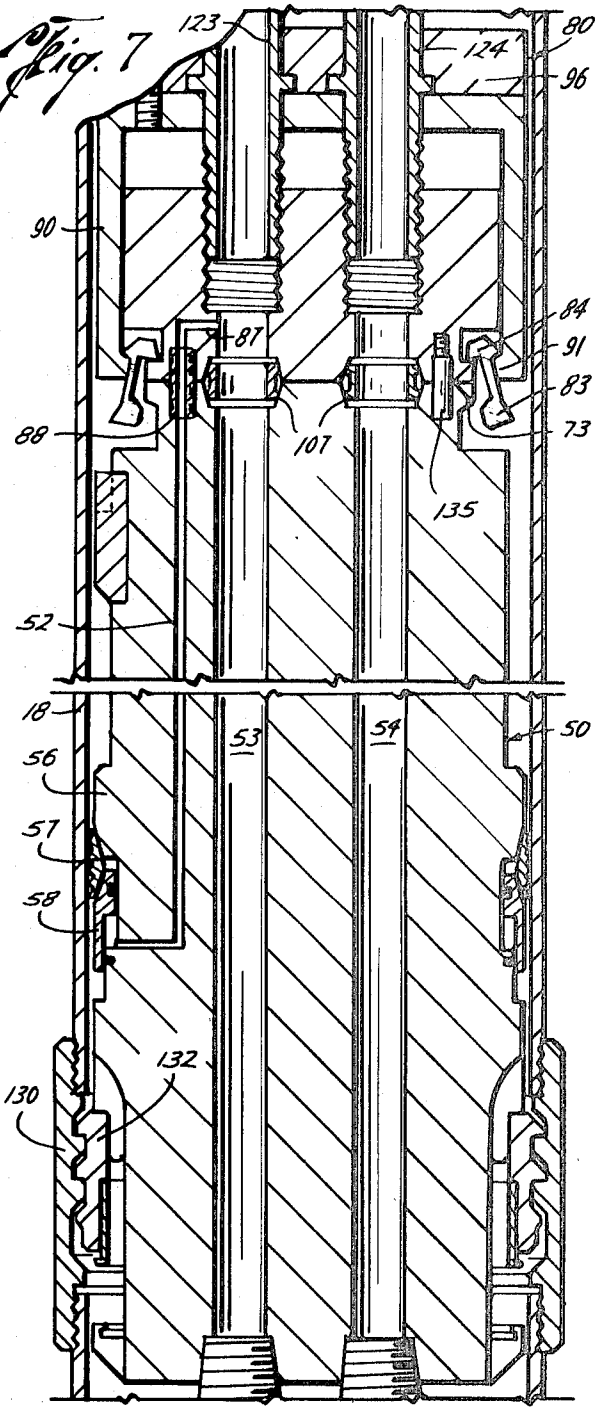

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Fig. 8

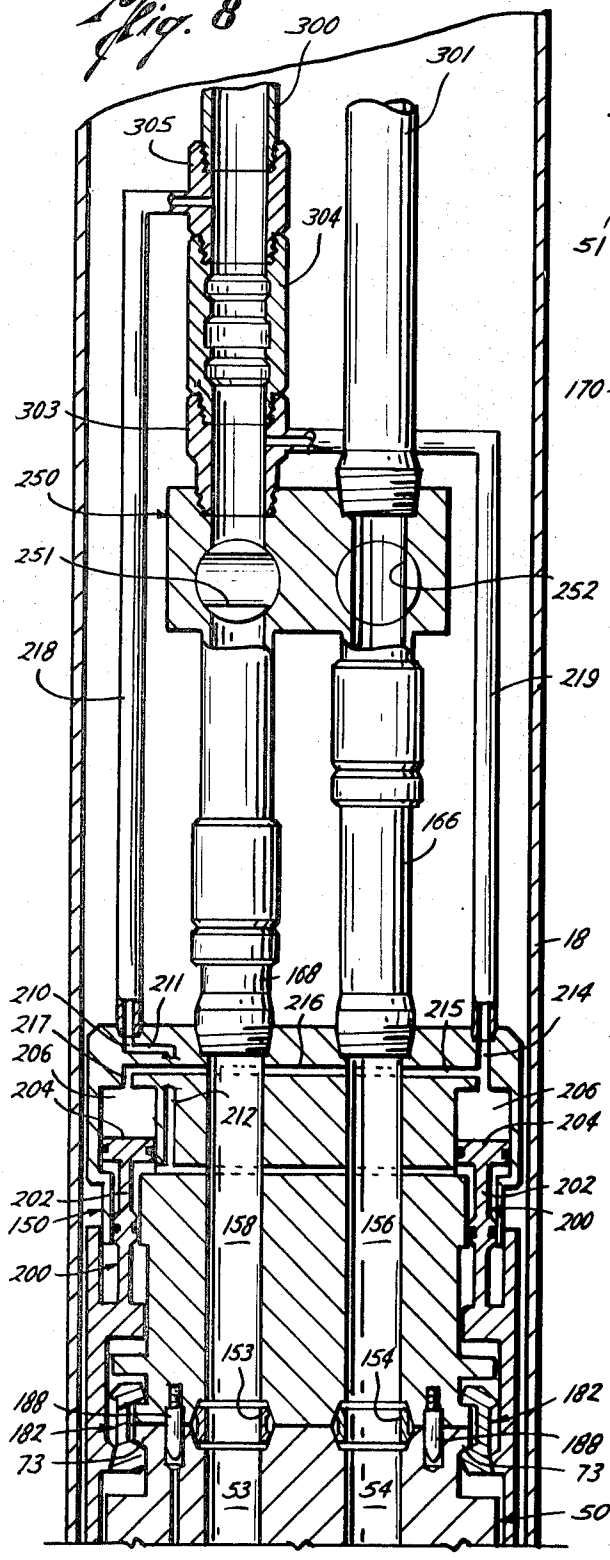

Fig. 9

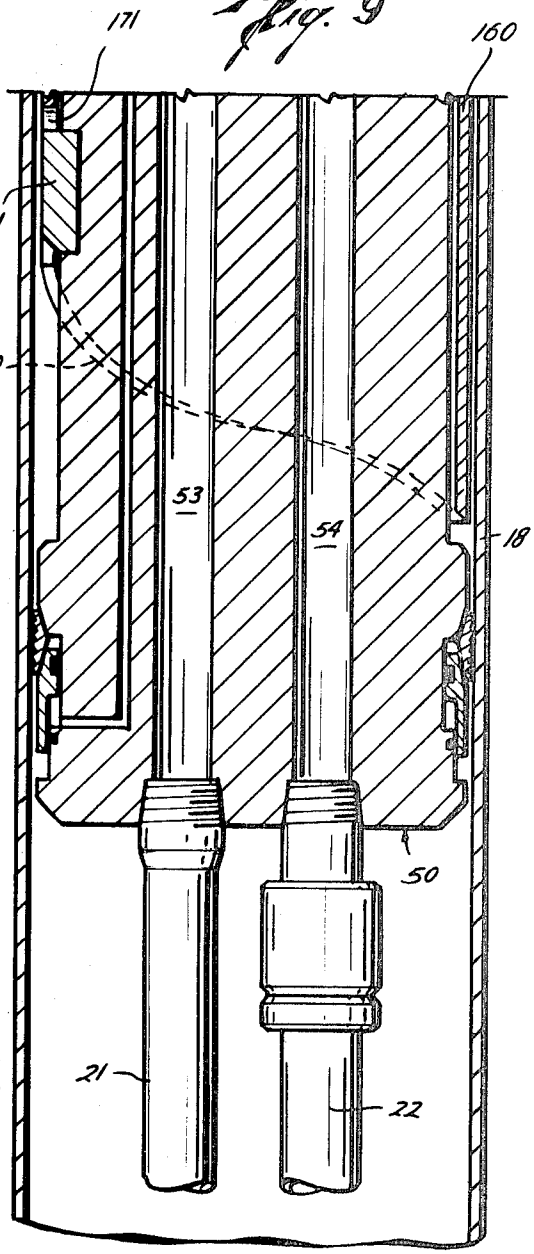

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Fig. 10

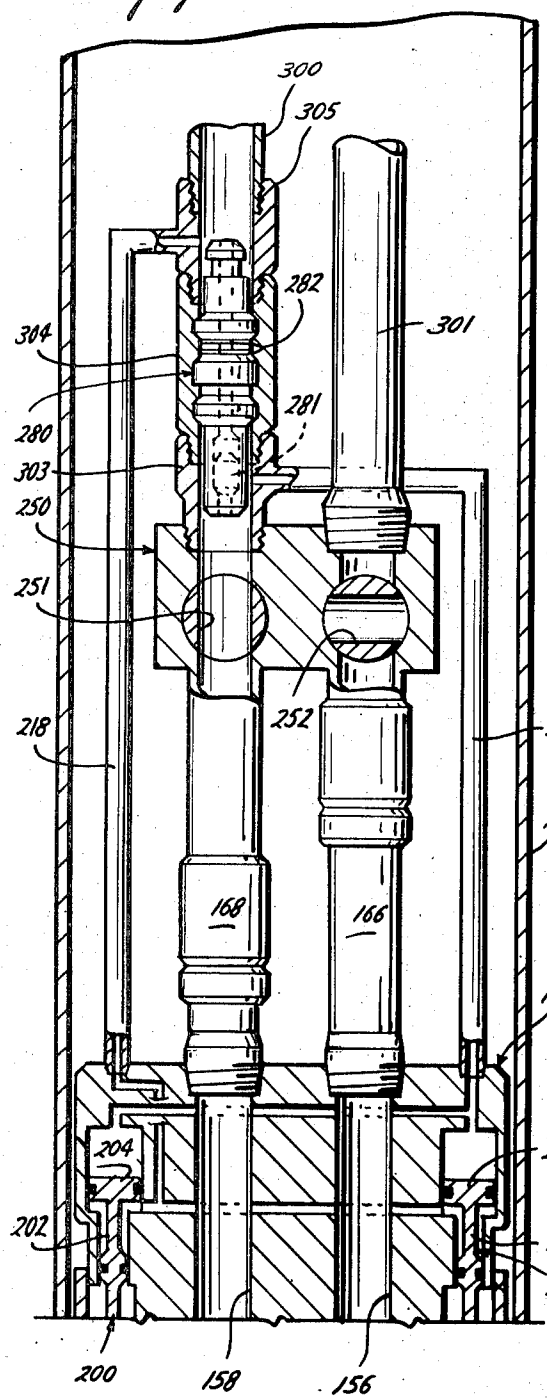
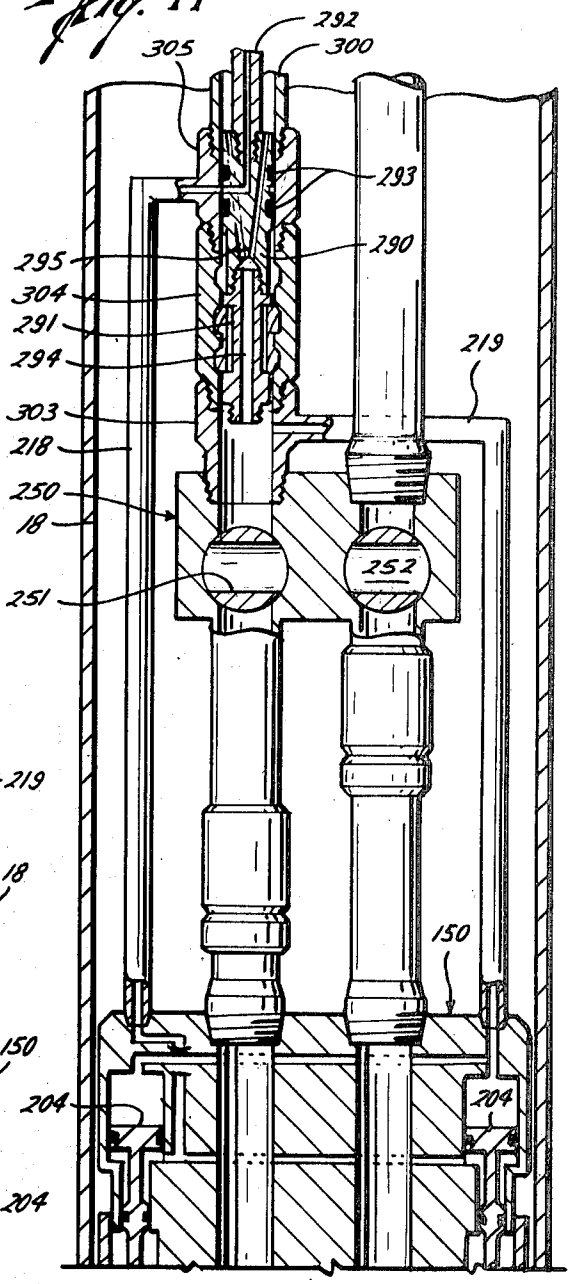


Fig. 11



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WELL COMPLETION METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to drilling and completion of oil and gas wells. In particular it concerns methods and apparatus for completing a well in relatively deep water.

2. Description of the Prior Art

As more and more offshore drilling occurs, oil companies are investigating methods of producing at ever increasing water depths. At the present, a great deal of interest is directed toward depths of 1,200 feet. This exceeds present bottom supported above the water platform technology. Divers are also limited with present day equipment to around 600 feet. Therefore, an ocean floor wellhead and Christmas tree at a depth of 1,200 feet could not be reached for repairs or preventative maintenance.

It has been suggested that a bottom supported subsea platform be installed with its platform submerged at a depth of around 600 feet. The platform would be equipped to receive a multiple number of remote wellheads and Christmas trees and the necessary manifolds, controls etc. for producing the wells. Drilling operations would be conducted from a floating drilling vessel. Such a platform would not be subject to the wind and wave stress of an above the water platform. Present technology, would allow such an installation.

With such a submerged platform it would be desirable to place a hydraulically controlled safety valve in the tubing strings below the mudline. The valve would shut-in and control the well in the event of damage to the platform or casing and tubing strings above the mudline. If conventional equipment and techniques were used, the tubing strings with the safety valves and control lines would be run in the well and suspended in place. This method has at least three disadvantages:

a. the safety valves might be made inoperative by cement pumped through the tubing string;
b. the tubing string might become stuck before reaching total depth, causing the safety valve to be located above the mudline and preventing the hanger mechanism from reaching the remote wellhead; and
c. should the safety valve malfunction it could not be removed during the producing life of the well.

SUMMARY OF THE PRESENT INVENTION

The present invention eliminates these and other problems by providing a method of completion comprising the steps of: lowering hanger means and at least one-tubing string on a handling string into the well casing to a position where said hanger means will be supported substantially below the mudline; cementing the tubing string within the well casing by passing cement through the handling string and the tubing string; disconnecting and removing the handling string; lowering connector means, a tubing riser and valve in the casing; and remotely connecting the connector means to the hanger means, placing the tubing string and tubing riser in fluidtight flow communication, the valve being installed in the tubing riser at a point substantially below the mudline, the tubing riser extending upwardly to the well platform. Apparatus for performing this method is also disclosed herein including a unique tubing hanger, handling tool and riser connector.

Using the method and apparatus of the invention, a safety valve may be installed below the mudline and in the event of damage to the well platform, the well may be shut-in below the mudline, preventing costly production losses. The valve is not subject to malfunction from cement since cementing is performed before the valve is installed. Should the tubing string become stuck before reaching total depth the hanger apparatus permits the hanger to be installed at several levels and still assures that the valve is below the mudline. In addition, the connector apparatus allows removal of the riser and valve subsequent to installation permitting a malfunctioning valve to be repaired or replaced.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent from the description which follows taken in conjunction with the attached drawings in which:

FIG. 1 is a schematic representation of a submerged platform installation in which a preferred embodiment of the invention might be used;

FIG. 2 is a horizontal cross section of a tubing hanger assembly according to a preferred embodiment of the invention taken on line 2—2 of FIG. 3A, primarily for showing where other sectional elevation views are taken;

FIGS. 3A and 3B are sectional elevation views of tubing hanger and setting tool apparatus, according to a preferred embodiment of the invention, taken on lines 3A, 3B–3A, 3B of FIG. 2. FIG. 3A being the upper portion, FIG. 3B being the continuing lower portion thereof;

FIGS. 4A and 4B are elevation views partially in section of the tubing hanger assembly of FIGS. 3A and 3B and a tubing riser connector, according to a preferred embodiment of the invention, taken on lines 4A, 4B–4A, 4B of FIG. 2, FIG. 4A being the upper portion, FIG. 4B the continuing lower portion thereof.

FIGS. 5A and 5B are sectional elevation views similar to FIGS. 4A and 4B but taken on lines 5A, 5B–5A, 5B of FIG. 2 with a portion of the hanger assembly broken away; and

FIGS. 6 through 11 are schematic drawings showing the step by step installation of the apparatus shown in FIGS. 2 through 5B with the exception of FIG. 7 which shows a slight variation of the tubing hanger assembly of the embodiment shown in FIGS. 2 through 5B.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, a submerged platform 2 is shown supported at the floor 4 of a body of water 6. The floor 4 may be at a depth of 1,200 feet while the platform level is at a depth of 600 feet. A floating drilling vessel 8 is anchored above platform 2 from which drilling and completion operations take place. The platform 2 is equipped to receive a multiple number of wellheads 10, drilling control equipment 12 and eventually Christmas trees, manifolds, controls etc. (not shown). The drilling control equipment 12 could be installed on the drilling vessel. Guidelines 14 may be attached to the platform 2 for guiding equipment into place. A conductor casing 15 connects the wellhead 10 to the subsea floor 4. Drilling, installation and cementing of surface casing and any intermediate casing strings take place through conductor 15 as in other submerged wells.

In the preferred embodiment of the invention the well would be completed by the tubingless method. For example, using a 30 inch × 16 inch × 10—¾ inch casing program and dual-tubing strings, a 16 inch surface casing (not shown) would be installed in 30 inch conductor casing 15. Then the 10—¾ inch innermost casing string (not shown) would be installed within this 16 inch surface casing. Next the dual-tubing strings (not shown) would be run through the control equipment 12 and suspended on a hanger as much as several hundred feet below the level of floor 4 within the 10—¾ inch innermost casing.

Referring now to FIGS. 2 through 5A and 5B, the equipment for installing tubing strings and safety valves will be described. FIG. 2 is a horizontal section of a portion of a tubing hanger assembly 50 taken on line 2—2 of FIG. 3A and is primarily for the purpose of showing where other sectional views are taken. Shown in this view are dual-tubing run bores 53 and 54, internal port 52, and an alignment dog 51, the construction and purposes of which will be better understood subsequently.

Referring specifically now to FIGS. 3A and 3B, a preferred embodiment of the apparatus for suspending dual-tubing strings 21 and 22 in the innermost casing string of an underwater well at a point below the mudline will be described. The apparatus shown comprises a running tool 80 and tubing hanger 50 the upper portion of which is shown in FIG. 3A, the

lower portion in FIG. 3B. The tubing strings 21 and 22 are attached to the bottom of hanger 50 by threaded connections 25.

Tubing hanger 50 comprises a generally cylindrical body portion 55 through which pass vertical tubing run bores 54, internal port 52, and cement return bore 76. A half-moonlike slot 77 is cut in the side of hanger body 55 into the upper end of cement return bore 76.

Mounted around the lower end of hanger body 55 are slip suspension means comprising mandrel 56, a plurality of slip segments 57, and setting cone 58. The lower end of body 55 has a larger diameter portion 59 and a lower shoulder 60. Shoulder 60 limits the downward movement of setting cone 58 and the larger diameter portion 59 cooperates with a skirt portion of setting cone 58 to provide an annular piston arrangement whereby hydraulic pressure may be applied to the annular space 61 to force setting cone 58 upwardly. Annular cells 62 and 63 on portion 59 and setting cone 58, respectively, seal the annular space 61. Slip segments 57 may be assembled along with setting cone 58 by sliding them down around body 55 before mandrel 56 is installed. Slip segments 57 may be held together by a spring ring (not shown) or the like. After slips 57 are mounted, mandrel 56 may be placed around body 55 and fastened in the mounting position shown by setscrews 64. To prevent premature setting of the slips 57, setting cone 58 may be attached to body 55 by shearpins 65. To set clips 57, a pressure would be introduced into annular space 61 sufficient to shearpin 65 and move setting cone 58 upwardly behind slips 57. The frustoconical surfaces 66 and 67 on setting cone 58 and mandrel 56 respectively, would cooperate with the opposing frustoconical surfaces 68, 69 on the back of slips 57 causing them to be wedged outwardly into engagement with the walls of a surrounding casing (not shown). The weight of the tubing strings 21 and 22 would maintain support engagement even if pressure were relieved from annular space 61. However, with pressure maintained, holddown of the string against down-the-hole pressure would be assured.

A receptacle slot is cut near the upper portion of hanger body 55 for the mounting of alignment dog 51. The dog 51 is fastened to hanger body 55 by capscrews 70. The upper edge of dog 51 is an inverted V-shape and can best be seen in FIG. 4A. The purpose of alignment dog 51 is to orient apparatus which may be subsequently attached to hanger 50. The upper end of hanger body 55 is provided with pockets 72 and hub shoulder 73 for attachment to tool 80 or any other equipment designed for that purpose.

The running tool 80 comprises two latch segments 82 which clamp the running tool 80 to hanger 50. Latch segments 82 comprise a lip portion 83 which engages hub shoulder 73 within pocket 72, a foot portion 84, retained in recess 85 of tool 80 and heel portion 89 for disengagement as will be more fully understood hereafter. Latches 82 are set by sleeve 90 and attached wedge block 91 which are driven down to the position shown by left-hand rotation of couplings 103 and 104 attached to handling strings (not shown). Couplings 103 and 104 are threaded into tool body 86 such as at 92 and communicate with hanger bores 54 through tool body bores 94. A retainer plate 96 is attached to sleeve 90 by capscrews 97, providing annular pockets 99 in which are located bearing shoulders 105 of couplings 103 and 104. One of the bores 94 through tool body 86 is connected to hanger port 52 by internal tool ports 87, nipple 88 and internal hanger port 78. An alignment pin (not shown) projecting out of tool body 86 similar to nipple 88 and a socket (not shown) in hanger body 55 may be provided to aid in alignment of tool 80 with hanger assembly 50. The flow bores 54, 94 are sealed by ring gaskets 107 which are held to tool body 86 by a spring retainer and groove arrangement 108. The complete operation of hanger assembly 50 and tool 80 will be described in detail subsequently hereto. For the present, it is sufficient to say that hanger assembly 50 may be lowered into an underwater well casing, attached to tool 80, then suspended therein by setting the slips 57. Then tool 80 may be removed, withdrawing nipple 88 and seal rings 107, for further operations.

Referring now to FIGS. 4A, 4B, 5A and 5B a tubing riser connector unit 150 for attachment to hanger assembly 50 will be described. FIG. 4A is a vertical section view of the upper portion of connector unit 150 connected to hanger assembly 50. FIG. 4B is a continuation of FIG. 4A showing the lower portion of connector sleeve 160 and hanger assembly 50 from which tubing strings 21 and 22 are suspended. FIGS. 5A and 5B are views similar to FIGS. 4A and 4B, except rotated 90°.

In FIGS. 4A and 4B the hanger assembly 50; including lower shoulder 60, setting cone 58, slips 57, mandrel 56, slot 77, the upper end of cement bores 76, alignment dog 51 and tubing run bores 53, 54; can easily be seen. The tubing riser connector body 155 has dual-tubing run bores 156, 158 communicating with hanger bores 53, 54. This connection is sealed by ring seals 153 and 154 affixed to connector body 155 by spring ring and groove arrangements 163, 164. Threadingly connected at the top of connector bore 156, 158 are nipples 166, 168 which extend upwardly to a safety valve package (not shown) above which tubing risers project upwardly for extension to a submerged platform such as 2 in FIG. 1. Connector sleeve 160 surrounds the lower end of connector body 155 and the upper end of hanger assembly 50. The lower portion of connector sleeve 160 is a double-helix alignment surface 170 which converges in a vertical slot 171. The purpose of the double-helix 170 and slot 171 is to automatically align the connector 150. If connector 150 is lowered toward hanger 50, the double-helix surface 170 will first contact one side of the inverted V-shaped upper edge 51_a, 51_b of alignment dog 51, causing the entire unit to rotate until a slot 171 and alignment dog 51 are fully engaged. Final alignment of bores 54, 156 and 53, 158 are assured by alignment pins and holes (see 188 in FIG. 5A).

Referring now to the 90° rotated views of FIGS. 5A and 5B the details of the latching apparatus of connector 150 will be described. The pockets 72 and hub shoulder 73 of hanger body 55 previously described are used for attaching to connector 150 in a similar manner as to the running tool 80 in FIG. 3A. Oppositely opposed latches 182 are retained in connector body recesses 185 by latch foot portions 184. Wedge pieces 191 hold the lips 183 of latches 182 in engagement with hub shoulder 73. The cooperating surfaces 193 between latches 182 and wedge pieces 191 are self-locking tapers.

Mounted in connector body 155 for longitudinal movement by pressure are two pistons 200 which have rod portions 202 and heads 204. The rods 202 are connected to wedge pieces 191 by threaded connections 199 and move simultaneously with them and sleeve 160 which is tied to wedge pieces 191 by keys 198. The piston heads 204 are mounted in piston cylinders 206 for movement from a disengaged position at the upper end of the cylinders 206 to the engaged position shown. The upper ends of the cylinders 206 are closed by cylinder plugs 208, 209. Connected to the upper end of each cylinder plug 208, 209 are external conduits 218, 219 the purpose of which will be better understood subsequently hereto. Internal ports 210, 211 and 212 connect the rod side of pistons 204 with conduit 218. Internal ports 214, 215, 216 and 217 connect the head side of pistons 204 with conduit 219. Each cylinder plug 208, 209 is provided with annular seals 228, 229 which seal and isolate the various ports and areas of pressure. Piston heads 204 and piston rods 202 are also provided with annular seals 224 and 222, respectively. A full description of the operation of pistons 204 and latches 193 will follow. For the present, it is sufficient to note that the downward movement of pistons 204 causes latches 182 to engage hanger hub shoulders 73 and the upward movement of pistons 204 causes them to be disengaged.

Referring now to the remaining schematic drawings, FIGS. 6–11, a step by step explanation of the operation and procedure for utilizing the previously described apparatus will be given. The same reference numbers used in FIGS. 2–5B will be given to corresponding parts in FIGS. 6–11.

As previously explained with reference to FIG. 1, drilling and setting of casing is performed from a floating drilling vessel and the wellhead equipment is to be located at a sub-

merged platform 2. In the 30 inch × 15 inch × 10–¾ inch representative casing program given, the 16 inch surface casing would be installed inside of the 30 inch conductor casing 15. Then, the 10–¾ inch innermost casing would be installed and suspended in the 16 inch casing.

At this point tubing would be run in the innermost casing represented in FIG. 6 by the reference number 18. The dual-tubing strings 21, 22 are lowered into casing 18 attached to the tubing hanger assembly 50 which is in turn attached to the running tool 80 as previously described with reference to FIG. 3A. The hanger 50 and running tool 80 are lowered on running or handling strings 123 and 124 with slips 57 in the retracted position, until the tubing strings 21, 22 reach their total depth. The strings 21, 22 are of such a length that hanger 50 will then be at a point in casing 18 approximately 100 feet or more below the floor of the body of water in which the well platform is submerged. At this point the slips 57 are set by applying pressure to setting cone 58 through handling string 123, internal port 87, nipple 88 and internal port 52. First, shear-pins 65 are sheared releasing the setting cone for upward movement. Then coaction of stationary mandrel 56 and the moving setting cone 58 causes slips 57 to move outwardly into engagement with the walls of casing 18 as shown in FIG. 7.

FIG. 7 also shows an alternative suspension arrangement whereby casing 18 is provided with a support head 130 and the lower end of hanger assembly 50 is provided with a spring-loaded latch assembly 132 which automatically engages latch grooves in the head 130 for primary support of hanger 50 and the tubing strings 21, 22. In this case the slip means could be used as secondary suspension in the event the tubing strings 21, 22 become stuck before the latch assembly 132 reaches head 130.

After the hanger assembly 50 is set tubing strings 21, 22 would be cemented in place by pumping cement down through the handling strings 123, 124, tubing strings 21, 22 and back up through the space 133 surrounding tubing strings 21, 22 in casing 18. FIG. 3B shows the cement return bore 76 and slot 77 for allowing cement returns through the hanger assembly 50. At the operator's option the cementing step could be performed before the setting of hanger assembly 50. This would allow reciprocation of the tubing strings during cementing, as some operators prefer.

Next, running tool 80 would be disconnected from hanger assembly 50 and removed from the well. This is accomplished by rotating couplings 123 and 124 to the right causing retainer plate 96 and sleeve 90 to move upwardly. The wedge blocks 91 attached to sleeve 90 catch the heel of latch foot portion 84 causing latch lip 83 to pivot out of engagement with hub shoulder 73. As tool 80 is removed, nipple 88, guide pin 135 and ring seals 107 are withdrawn also.

Referring now to FIGS. 8 and 9, the next step is to install tubing riser connector 150, safety valve package 250 and tubing risers 300, 301. The safety valve package 250 is installed in the riser strings above nipples 166, 168 which are shown in FIG. 4A. Control lines (not shown) would be run in with the risers 300, 301 for remotely operating the valves 251 and 252. Connected in riser string 300 are ported nipples 303, 305 and a landing nipple 304 such as Otis type "S." External conduit 218 is connected to ported nipple 305 and external conduit 219 is connected to ported nipple 303. External conduits 218, 219 communicate with piston cylinders 206 through the internal porting 210, 211, 212, 214, 215, 216 and 217 as more fully described heretofore with reference to FIG. 5A.

As the connector 150 is lowered into place the alignment surface 170 of connector sleeve 160 contacts alignment dog 51 causing the sleeve 160 along with the entire connector assembly 150 to rotate until slot 171 engages the alignment dog 51 preventing further rotation. Final alignment is accomplished by pins 188 engaging corresponding holes in the upper face of hanger assembly 50. Thus, the tubing run bores 53, 158 and 54, 156 are properly aligned and sealed by ring seals 153, 154.

During the lowering operations pistons 200 and sleeve 160 are held in their upper positions so that latches 182 are pivoted away from hanger shoulder 73. After connector 150 and hanger 50 are abutting each other connector 150 is latched to hanger 50 by applying pressure through riser 300 with valve 251 closed. Thus, pressure is applied below pistons heads 204 through conduit 218 and above piston heads 204 through conduit 219. Since the effective pressure area is the area of piston rods 202, pistons 200 and sleeve 160 are forced downward wedging latches 182 into engagement with hanger shoulder 73 as previously described.

The tubing risers 300, 310 pass upwardly through casing 18 to the submerged platform (2 in FIG. 1) where they are connected to a production manifold or "Christmas tree" as it is sometimes called. The control lines (not shown) which run from safety valve package 250 to a remote operating station control the opening and closing of valves 251, 252. If for any reason the submerged platform should become damaged to the extent that there is danger of losing well fluid, valves 251, 252 could be closed, shutting the well in at a point well below the mudline. Then, even if the platform turned completely over, the well would be protected.

Referring also now to FIG. 10 a method for releasing connector 150 from the well hanger 50 will be described. If valve 251 is operative, a locator mandrel with tubing plug 280 is run on a wire line through riser 300 and latched in landing nipple 304. Pressure is applied through riser 300. Check valve 281 and seals 282 connect pressure to external conduit 218 routing the pressure below piston heads 204 causing the pistons 200 to move up, releasing the connector latches (182 in FIG. 8). The area of the piston heads 204 less the area of rods 202 is greater than the area of rods 202. Therefore, using the same pressure as was used in setting the latches a greater upward releasing force is applied. The latches should be easily released. Fluid above the piston heads 204 is displaced through external conduit 219 through open valve 251.

Referring also to FIG. 11, an alternate method for releasing the connector 150, when valve 251 is inoperative and in the closed position, will be described. A releasing adapter or plug 290 is attached to a locating mandrel 291 and run in place on small diameter tubing 292. Pressure is applied through tubing 292. Seals 293 on adapter 290 seal above and below the port in nipple 305, routing the pressure through external conduit 218 below piston heads 204 for releasing the connector 150. Fluid above pistons heads 204 is displaced through external conduit 219, a port 294 in mandrel 291 and adapter internal ports 295 to the annulus between small tubing 292 and riser 300.

The foregoing description has shown how the tubing strings of an underwater well with a submerged platform may be suspended from a hanger set at a point below the mudline and how risers may be attached above the hanger with a safety valve package located also below the mudline to close in the well in the event the platform or risers thereto are damaged. Both the installation and removal of such equipment has been described. Such methods and apparatus for the performance thereof permit safe and easily maintainable underwater well installation at depths previously prohibited. Although the primary intended use for such a method and apparatus is with a submerged platform, it could also be used with an above the water platform as a safety feature in the event the platform were damaged or turned over by hurricanes, sea action or collision with a sea going vessel.

We claim:

1. A method of completing an underwater well having a platform supported from the floor of a body of water and casing means penetrating said floor and projecting upwardly through said body of water to said platform, comprising the steps of: lowering hanger means and at least one-tubing string on a handling string into said casing means to a position where said hanger means will be supported substantially below said floor; cementing said tubing string within said casing means by passing cement through said handling string and said tubing

string; disconnecting and removing said handling string; lowering connector means, at least one-tubing riser and valve means into said casing means; and remotely connecting said connector means to said hanger means, placing said tubing string and said tubing riser in fluidtight flow communication, said valve means being installed in said tubing riser at a point substantially below said floor, said tubing riser extending upwardly to said platform.

2. A method of completing an underwater well as set forth in claim 1, characterized in that said platform is submerged in said body of water substantially below the surface thereof; said method of completion being conducted from a floating vessel.

3. A method of completing an underwater well as set forth in claim 1, characterized in that said hanger means comprises hydraulically operable slip means in fluid communication with said handling string, the supporting of said hanger means within said casing means being accomplished by applying pressure to said slip means through said handling string forcing said slip means into engagement with said casing means.

4. A method of completing an underwater well as set forth in claim 1, characterized in that said hanger means is attached to said handling string by tool means, said tool means having latch means thereon engaging said hanger means, said disconnecting of said handling string being accomplished by rotation of said handling string to release said latch means allowing the removal of said tool means along with said handling string.

5. A method of completing an underwater well as set forth in claim 1, characterized by the further steps of: remotely disconnecting said connector means from said hanger means; and removing said connector means, said tubing riser and said valve means from said casing means.

6. A method of completing an underwater well as set forth in claim 1, characterized in that said connector means is provided with hydraulically operable latch means in fluid communication with said tubing riser, said remotely connecting said connector means to said hanger means being accomplished by applying pressure to said latch means through said tubing riser causing latch means to engage a portion of said hanger means.

7. A method of completing an underwater well as set forth in claim 6, characterized by the further step of: removing said connector means, said tubing riser and said valve means by applying pressure to said latch means through said tubing riser, causing said latch means to disengage said hanger means portion.

8. A method of completing an underwater well as set forth in claim 6, characterized in that said latch means comprises piston means within a cylinder, the rod end of said piston means being connected to wedge means, said pressure being applied to both the head end and rod end of said piston means, resulting in an effective force in the direction of said wedge means forcing latch elements into engagement with said hanger means portion.

9. A method of completing an underwater well as set forth in claim 8, characterized by the further step of: removing said connector means by applying pressure through said tubing riser to the rod end of said piston means while blocking pressure to said head end of said piston means, resulting in an effective force directed away from said wedge means to release said latch elements from said engagement with said hanger means portion.

10. An underwater well comprising:

a fixed platform rigidly supported at the floor of a body of water,

casing means penetrating the floor of said body of water and extending upwardly through said body of water to said platform,

hanger means supported in said casing means at a point substantially below said floor;

at least one-tubing string connected to said hanger means and extending downwardly through said casing means;

at least one-tubing riser and remotely actuatable engageable and disengageable connector means connected to said tubing riser and remotely operable valve means installed in said tubing riser,

said riser and connector means and valve means being lowerable as a unit separate from said tubing string through said casing for remote engagement with said hanger means,

said remotely actuatable engageable and disengageable connector means being disposed at the lower end of said riser in engagement with said hanger means placing said tubing string and said tubing riser in fluidtight flow communication through flow bores in said hanger means and said connector means,

said remotely operable valve being installed in said riser in such position that when said connector means is in said engagement with said hanger means said valve is located at a point substantially below the floor of said body of water.

11. Apparatus for completing an underwater well having a platform supported at the floor of a body of water and casing means penetrating the floor of said body of water and extending upwardly through said body of water to said platform, said apparatus comprising: hanger means supported in said casing means at a point substantially below said floor; at least one-tubing string connected to said hanger means and extending downwardly through said casing means; at least one-tubing riser connected above said hanger means by remotely engageable and disengageable connector means, said tubing riser extending upwardly through said casing means to said platform; and valve means installed in said tubing riser at a point substantially below the floor of said body of water,

said hanger means being provided with suspension means around its exterior and connection means whereby a disengageable setting tool may be connected to said hanger and lowered therewith on a handling string to said point of support, said suspension means being in fluid communication with said handling string for hydraulic activation of said suspension means for engaging said casing means to support said hanger means therein.

12. Apparatus as set forth in claim 11, characterized in that said suspension means comprises slip means, mandrel means fixed relative to said hanger means and setting cone means longitudinally movable on said hanger means, said mandrel means having a frustoconical surface, said setting cone means having a frustoconical surface converging in a direction opposite to said mandrel frustoconical surface, said slip means having oppositely converging frustoconical surfaces on its inner faces and tooth engagement means on its outer faces, said slip means frustoconical surfaces being in contact with said mandrel and setting cone frustoconical surfaces and cooperating therewith on longitudinal movement of said setting cone in response to fluid pressure in said handling string, to wedgingly force said tooth engagement means into engagement with said casing means.

13. Apparatus as set forth in claim 11, characterized in that said fluid communication is established through internal ports in said setting tool and said hanger means sealingly connected at the interface of said setting tool and said hanger means.

14. Apparatus as set forth in claim 11, characterized in that said connection means comprises shoulder means, said setting tool being provided with latch means and wedge means, said wedge means being longitudinally movable on said setting tool to force said latch means into engagement with said shoulder means providing fluidtight flow communication between said handling string and said tubing string through flow bores in said setting tool and hanger means.

15. Apparatus as set forth in claim 14, characterized in that said wedge means comprises sleeve means around said setting tool longitudinally fixed to said handling string by retainer means, said handling string being threadingly coupled to said setting tool so that upon make up of said coupling said sleeve is longitudinally displaced to force said latch means into said engagement with said shoulder means.

16. Apparatus for completing an underwater well having a platform supported at the floor of a body of water and casing means penetrating the floor of said body of water and extending upwardly through said body of water to said platform, said

apparatus comprising: hanger means supported in said casing means at a point substantially below said floor; at least one-tubing string connected to said hanger means and extending downwardly through said casing means; at least one-tubing riser connected above said hanger means by remotely engageable and disengageable connector means, said tubing riser extending upwardly through said casing means to said platform; and valve means installed in said tubing riser at a point substantially below the floor of said body of water,

said tubing riser being connected to said hanger means by connector means, said connector means being provided with latch means engageable with shoulder means on said hanger means to provide fluidtight flow communication between said tubing riser and said tubing string through flow bores in said connector means and said hanger means.

17. Apparatus as set forth in claim **16**, characterized in that said connector means, said tubing riser and said valve means are lowerable through said casing means from said platform to said hanger means, said latch means being remotely operable to engage said shoulder means to provide said fluidtight communication.

18. Apparatus as set forth in claim **17**, characterized in that said connector means and said hanger means are provided with orientation means cooperating to automatically align said tubing riser and connector means flow bore with said tubing string and hanger means flow bore as said connector means and said tubing riser are lowered to said hanger means.

19. Apparatus as set forth in claim **18**, characterized in that said orientation means comprises dog means on one of said hanger means and said connector means and sleeve means around the other of said hanger means and said connector means, said sleeve means having a double-helix surface facing toward said dog means as said connector means is lowered to said hanger means, said double-helix surface converging in slot means whereby said double-helix surface first contacts said dog means causing said connector means to rotate until said dog means engages said slot means.

20. Apparatus as set forth in claim **17**, characterized in that said connector means comprises wedge means connected to at least one piston means movable in a cylinder within said connector means, said cylinder being in fluid communication with a remote pressure source whereby fluid pressure may be applied to said piston means causing said wedge means to force said latch means into said engagement with said hanger shoulder means.

21. Apparatus as set forth in claim **20**, characterized in that plug means are installed in said tubing riser above said valve means, said fluid communication between said remote pressure source and said cylinder being established through first conduit means, between said cylinder and first port means in said tubing riser, said first port means being isolated from said valve by said plug means.

22. Apparatus as set forth in claim **21**, characterized by second port means in said tubing riser below said plug means and second conduit means establishing fluid communication between said tubing riser and the rod end of said cylinder means, said first conduit means being connected to the head end of said cylinder means.

23. Apparatus as set forth in claim **22**, characterized in that said remote pressure source is connected to said first port means through tubing means connected to said plug means and concentrically disposed in said tubing riser leaving an annular space therebetween, said second conduit means being in fluid communication with said annular space through third port means in said plug means.

24. Apparatus for completing an underwater well, comprising hanger means for supporting at least one-tubing string in a casing, said hanger means having a generally cylindrical body through which passes a flow bore in fluidtight communication with said tubing string, remotely operable suspension means being mounted around said hanger body comprising mandrel means, setting cone means and slip means mounted therebetween so that movement of one of said mandrel means and said setting cone means toward the other forces said slip means into supporting engagement with said casing,

and a least one-handling string for lowering said hanger means and tubing string into said casing, said suspension means being in fluid communication with a remote pressure source through said handling string and conduit means in said hanger means for remotely operating said suspension means for said supporting engagement with said casing.

25. Apparatus as set forth in claim **24**, characterized in that said setting tool and said hanger mans are connected by disengageable latch means comprising a plurality of laterally movable latches carried by said letting tool in engagement with shoulder means on said hanger means.

26. Apparatus as set forth in claim **25**, characterized in that said latch means comprises wedge means carried by said setting tool operable on the rotation of said handling string to disengage said latches from said hanger shoulder means.

27. Apparatus as set forth in claim **26**, characterized in that said handling string is threadingly connected to the body of said setting tool, said wedge means comprising a sleeve member surrounding said setting tool body and attached to said handling string by retainer means adapted for longitudinal movement relative to said setting tool body on the said rotation of said handling string to disengage said latches.

28. Apparatus for completing an underwater well, comprising hanger means for supporting at least one-tubing string in a casing, said hanger means having a generally cylindrical body through which passes a flow bore in fluidtight communication with said tubing string, remotely operable suspension means being mounted around said hanger body comprising mandrel means, setting cone means and slip means mounted therebetween so that movement of one of said mandrel means and said setting cone means toward the other forces said slip means into supporting engagement with said casing,

in combination with connector means, at least one-tubing riser and valve means lowerable together into said casing for connection to said hanger means, said connector means having remotely operable latch means for engagement with shoulder means on said hanger means to place said tubing riser and said tubing string in fluidtight communication through said hanger flow bore and a flow bore in said connector means.

29. Apparatus as set forth in claim **28**, characterized in that said latch means comprises a hydraulically movable sleeve and a plurality of laterally acting latches activated on the longitudinal movement of said sleeve to engage said hanger shoulder means, said sleeve being provided with first orientation means cooperable with second orientation means on said hanger means to align said tubing riser with said tubing string as said connector means and said tubing riser are lowered toward said hanger means.

30. Apparatus as set forth in claim **29**, characterized by piston means within cylinder means carried by said connector, said piston means being connected to said sleeve and movable therewith on introduction of fluid pressure into said cylinder from said remote pressure source to activate said latches.

31. Apparatus for completing a well drilled in the floor of a body of water, comprising hanger means for supporting at least one-tubing string within a casing at a point substantially below said water body floor and connector means and at least one-tubing riser lowerable as a unit through said casing for remote engagement with said hanger means, placing said tubing string and said tubing riser in fluidtight flow communication through flow bores in said hanger means and said connector means, said riser projecting upwardly from said connector means to a wellhead at the upper end of said casing for connection to a Christmas tree,

said connector means being provided with a plurality of latches remotely and laterally movable into engagement with shoulder means on said hanger means to effect said fluidtight flow communication.

32. Apparatus as set forth in claim 31, characterized in that said connector means is provided with sleeve means in contact with said latches and longitudinally movable by hydraulic means to effect said lateral movement of said latches.

33. Apparatus as set forth in claim 32, characterized in that said hydraulic means comprises piston means connected to said sleeve means, said piston means being movable in a cylinder within said connector means, said cylinder being connected through said riser to a remote pressure source for moving said piston means and said sleeve means.

34. Apparatus as set forth in claim 32, characterized in that said sleeve means and said hanger means are provided with alignment means cooperating as said connector means is lowered into contact with said hanger means to automatically align said tubing string and said riser.

35. Apparatus as set forth in claim 33, characterized by first port means in said riser connected to one end of said cylinder through first conduit means and second port means in said riser connected through second conduit means to the other end of said cylinder and plug means installable in said riser between said first and second port means sealingly isolating one end of said cylinder from the other end.

36. Apparatus as set forth in claim 35, characterized in that a remotely operable valve is installed in said riser below said first and second ports at a point substantially below said water body floor.

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