Oct. 17, 1967 W. W. WORD, JR 3,347,311

UNDERWATER WELL COMPLETION

Filed Aug. 19, 1963 8 Sheets-Sheet 1

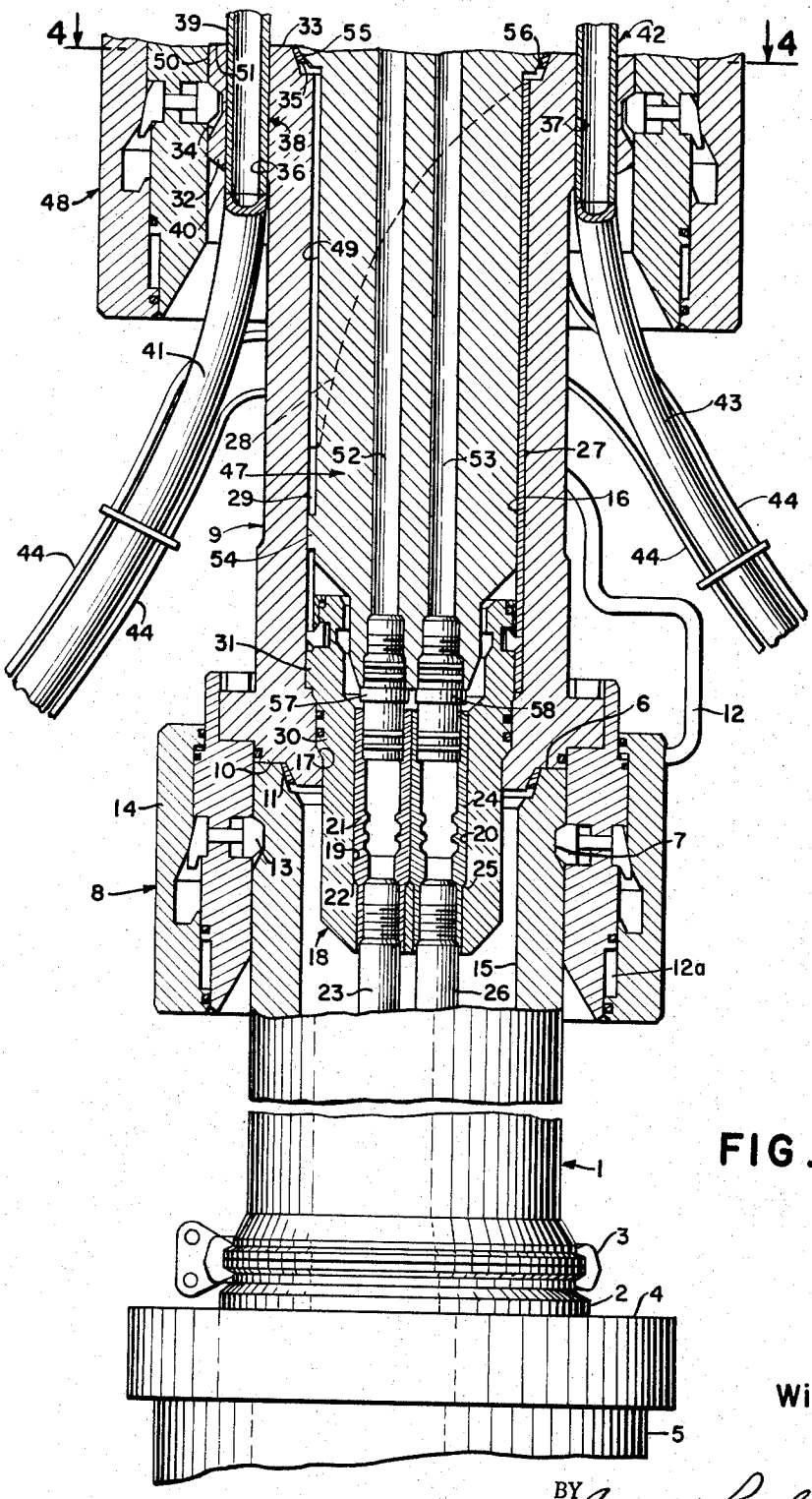


FIG. 1.

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UNDERWATER WELL COMPLETION

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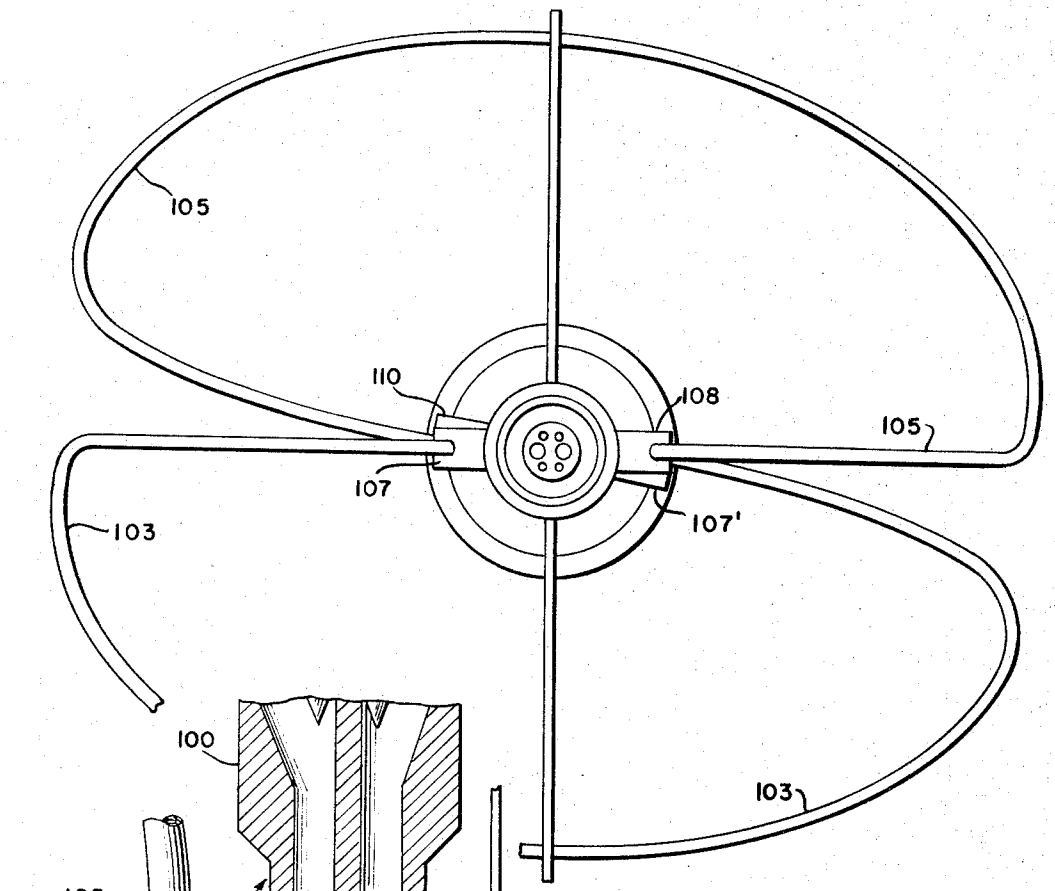


FIG. 6.

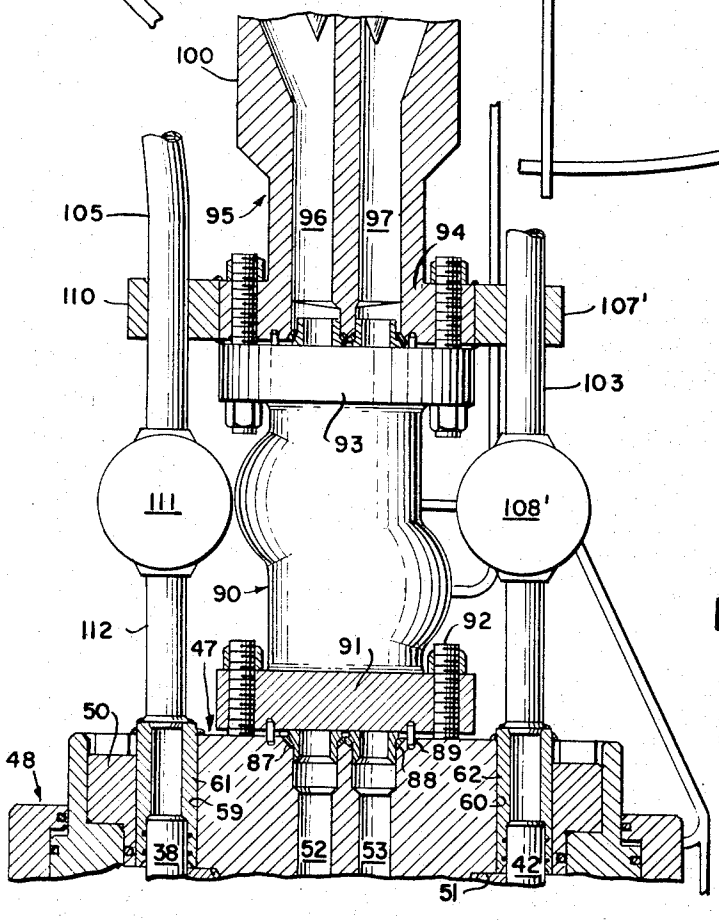


FIG. 2.

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UNDERWATER WELL COMPLETION

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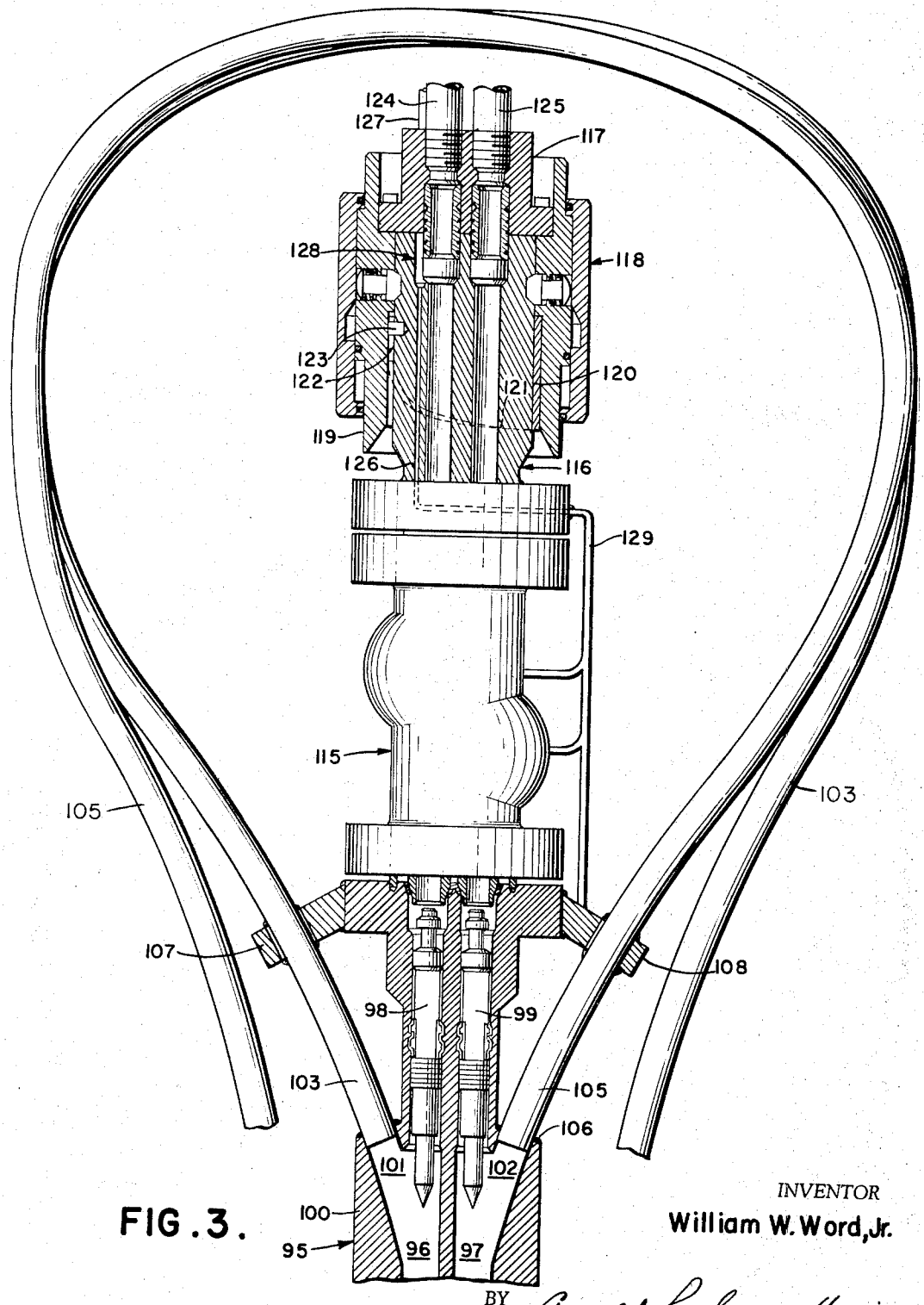


FIG. 3.

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UNDERWATER WELL COMPLETION

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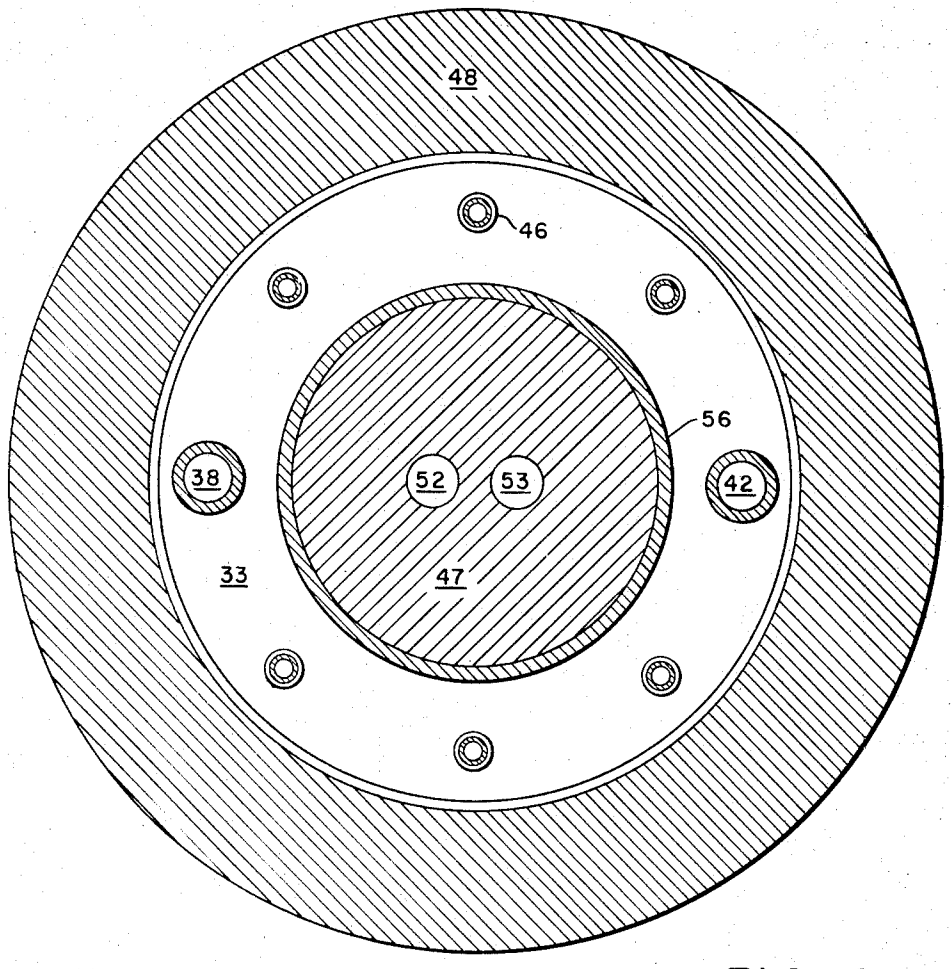


FIG. 4.

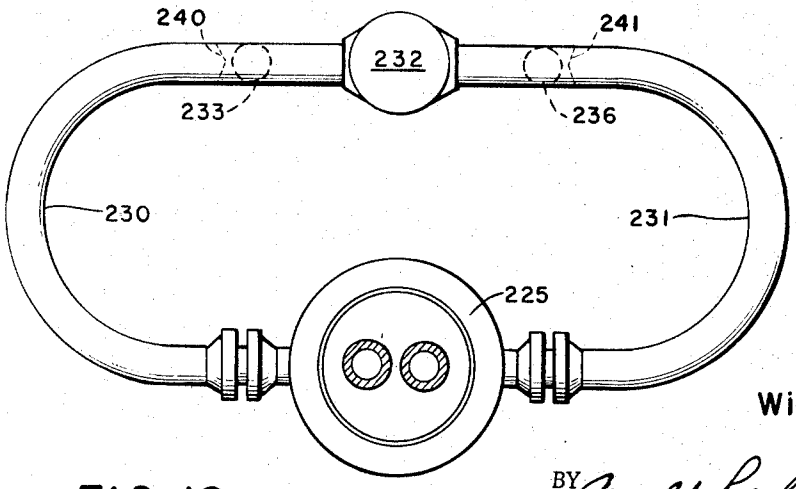


FIG. 10.

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UNDERWATER WELL COMPLETION

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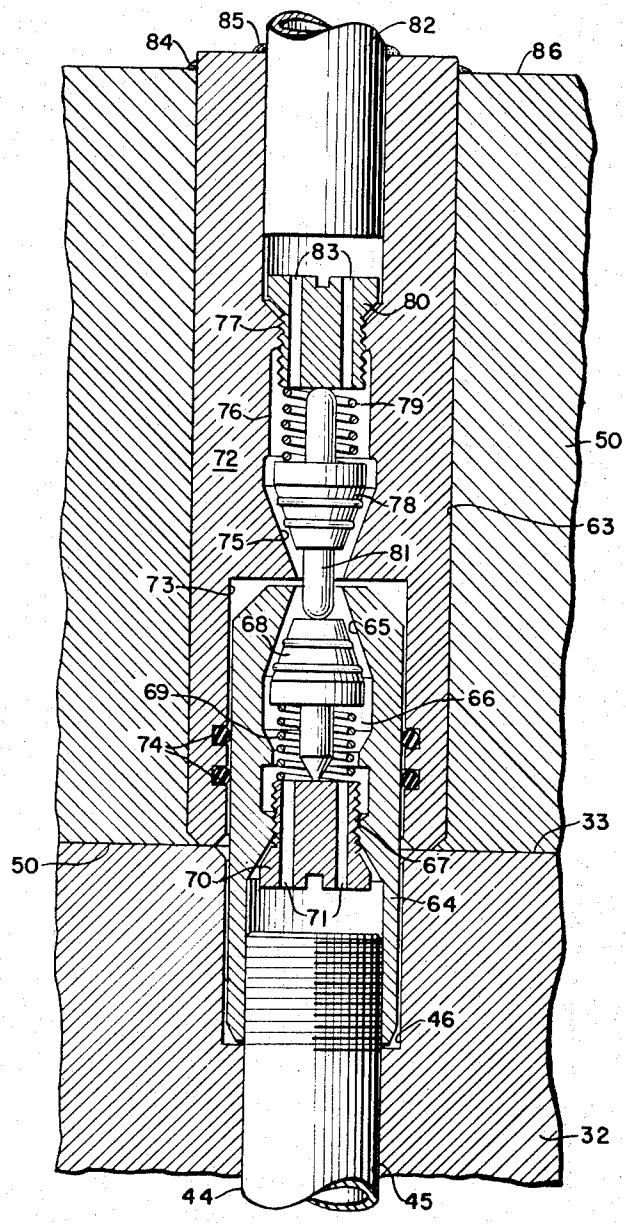


FIG. 5.

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UNDERWATER WELL COMPLETION

Filed Aug. 19, 1963 8 Sheets-Sheet 6

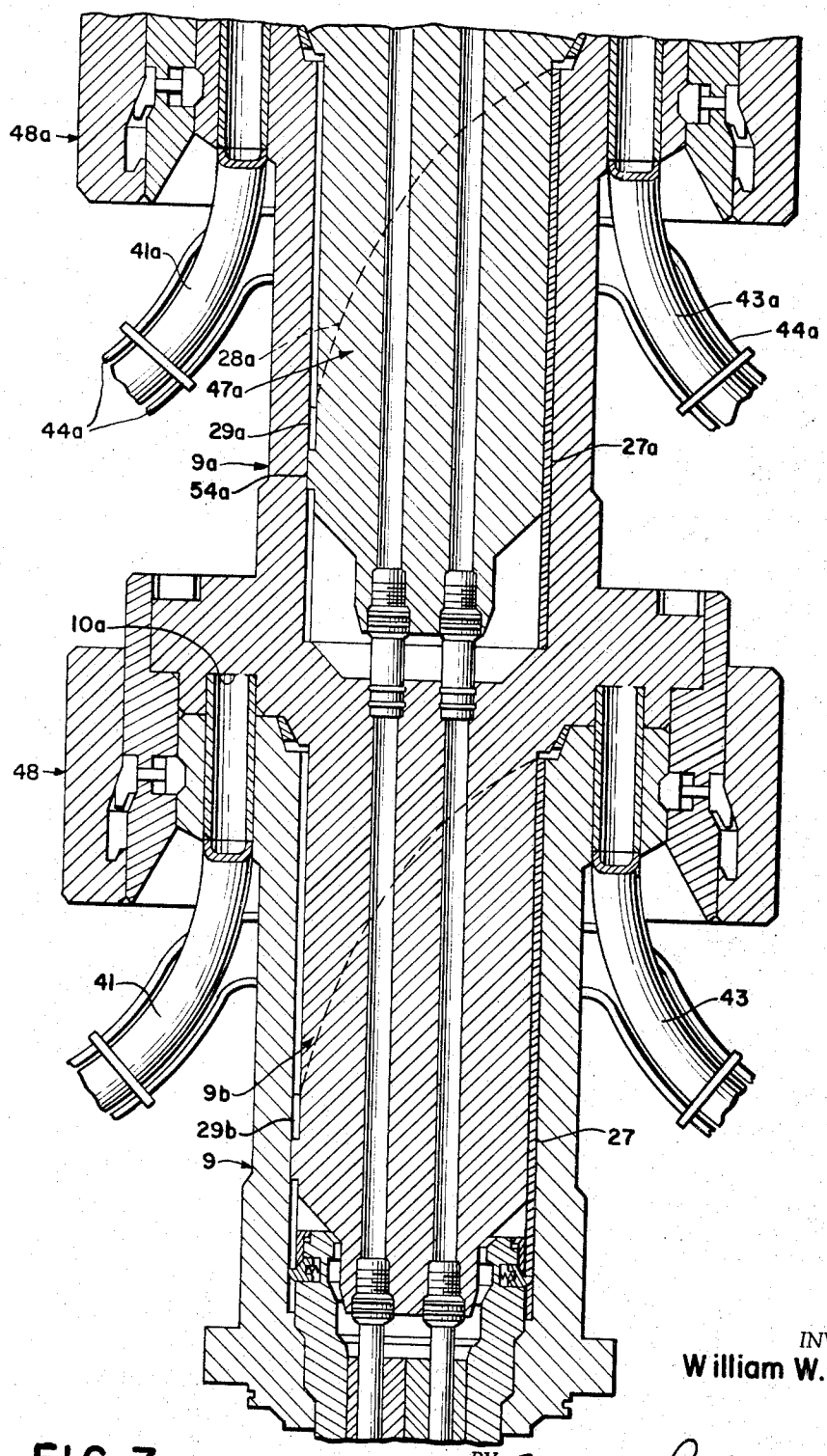


FIG. 7.

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Oct. 17, 1967 W. W. WORD, JR 3,347,311

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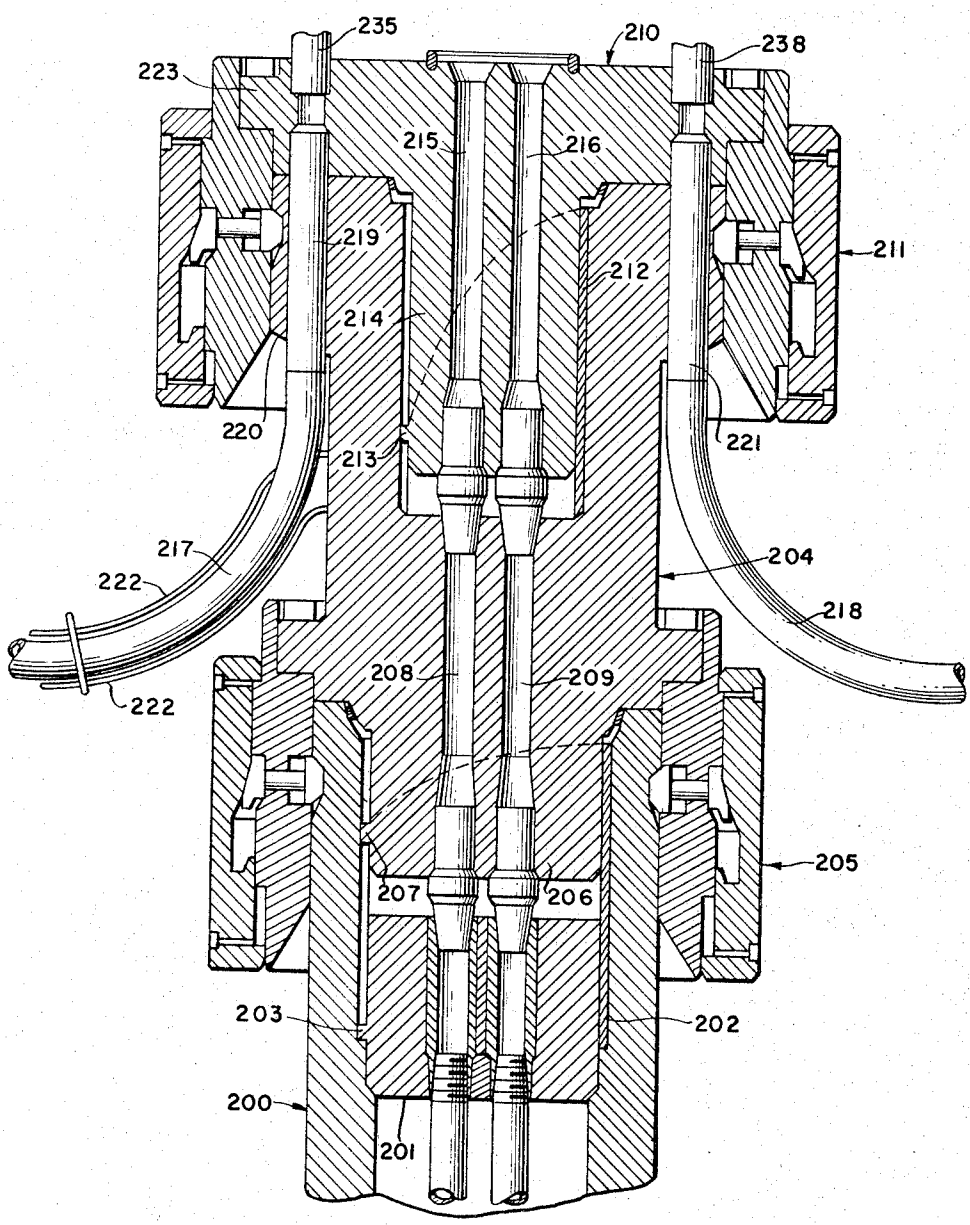


FIG. 8.

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3,347,311

UNDERWATER WELL COMPLETION

Filed Aug. 19, 1963

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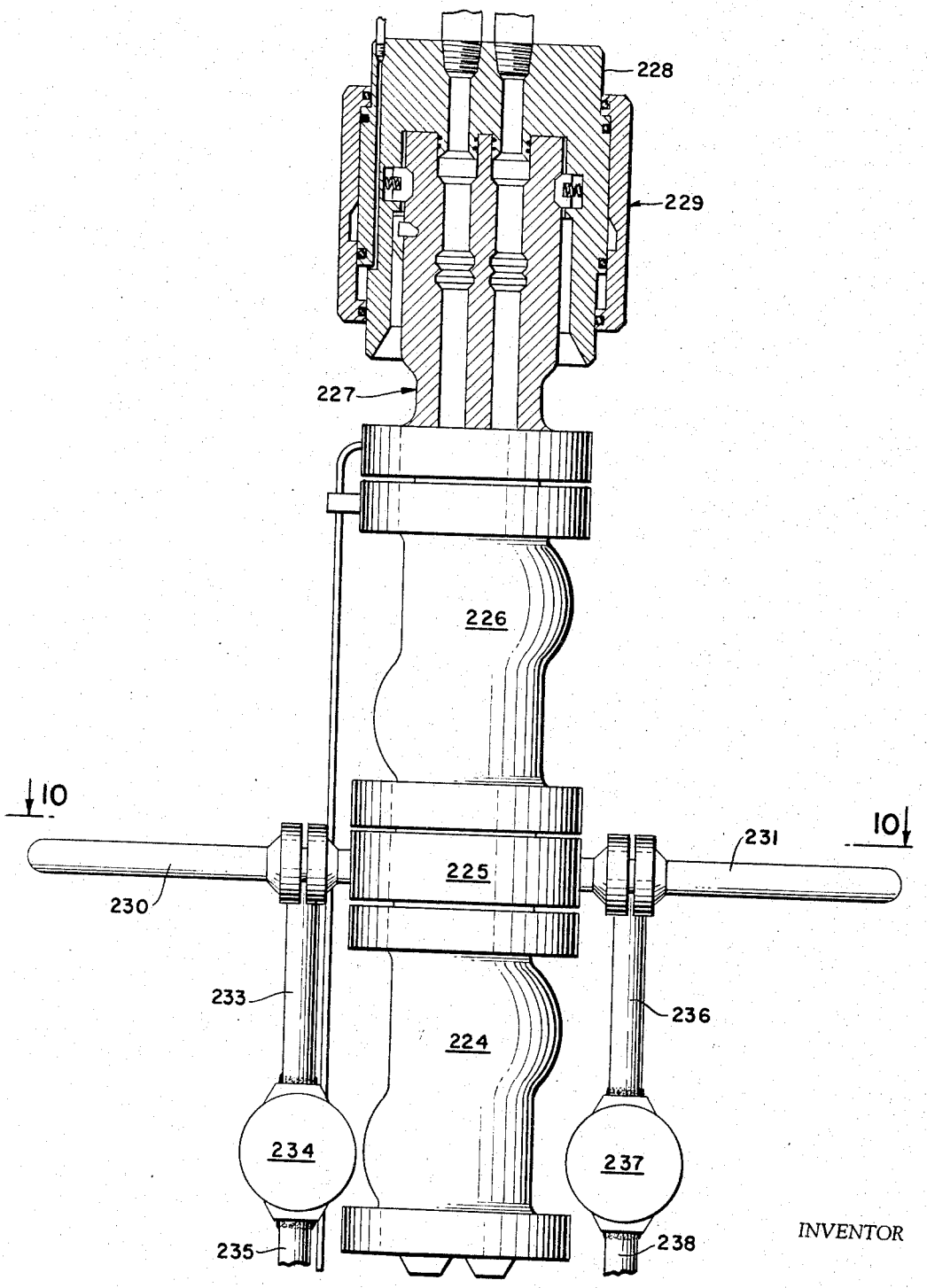


FIG. 9.

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United States Patent Office 3,347,311
Patented Oct. 17, 1967

3,347,311

UNDERWATER WELL COMPLETION

William W. Word, Jr., Houston, Tex., assignor to Armco Steel Corporation, Middletown, Ohio, a corporation of Ohio

Filed Aug. 19, 1963, Ser. No. 302,993
7 Claims. (Cl. 166—.6)

This invention relates to underwater well completion and more particularly to underwater wellhead constructions embodying an improved production unit assembly.

Wellhead installations require, for completion of the well, means for attaching the Christmas tree to the subadjacent wellhead body and completing the production flow lines, usually with provision for reentry into the well. In dry land installations, many such arrangements have been developed and found satisfactory in use. In wellhead constructions assembled under water, at points remote from the drilling vessel or platform, problems are encountered which make the usual dry land apparatus impractical. Thus, for example, a completed underwater well normally involves a flow line or lines connected at one end to the production unit of the wellhead, the lines running under water for considerable distances and frequently being buried in silt, etc. Because of this condition, the flow lines cannot necessarily be recovered in the event of failure of the flow lines or a failure in the production unit of the wellhead.

Further, while wellhead connections in a dry land installation are relatively simple, since most parts of the wellhead can be observed and handled directly by the operators, underwater wellheads are vastly more complicated, particularly because various devices in the wellhead must be of the remotely actuated type, involving hydraulic pressure fluid lines, for example, which must extend from the wellhead to a control point. Thus, in underwater installations, it is necessary to provide not only for remotely making and breaking the flow line or lines but also for remotely making and breaking the hydraulic pressure fluid lines.

A general object of this invention is to provide an underwater wellhead construction having a production unit assembly which provides for simpler and more dependable underwater operation.

Another object is to devise, in such a wellhead construction, improved means for accommodating and orienting the flow line or lines and the hydraulic control lines.

A further object is to provide such a wellhead construction which allows the Christmas tree to be recovered in one operation without disturbing the flow line or lines, save for disconnection thereof from the Christmas tree.

Yet another object is to provide such a wellhead construction which allows installation of a new flow line or flow lines, in event of failure of the line or lines already installed, without requiring handling of the original flow line or lines.

A still further object is to provide, in a wellhead construction of the type described, means whereby one or more reserve fluid pressure control lines, present at the time of original installation of the wellhead, can be employed in event of failure of the fluid pressure control line or lines first employed.

Stated generally, the objects of the invention are achieved by incorporating in the wellhead assembly an additional body member, termed a production body, which is locked to the upper end of the subadjacent body member, such as that from which the casing strings are suspended, and on which the lowermost Christmas tree member is seated and locked, the production body having an internal passage through which the flow lines or ducts extend to the Christmas tree, the external flow line or

lines and the fluid pressure control lines extending upwardly through the production body in locations outside of the internal passage and being connected to the Christmas tree via connector means carried by the lowermost Christmas tree member. The arrangement is such that all of the flow line and control line connections are made and broken automatically simply by attachment of the lowermost Christmas tree member to the top of the production body, an operation which is accomplished simply by landing the lowermost Christmas tree body and operating a hydraulic control drive.

Since all lines leading from the wellhead, including the flow line or lines and the control lines, but excluding reentry lines, terminate at the production body, the entire Christmas tree can be recovered simply by breaking the joint at the top of the production body and raising the Christmas tree. In event of flow line failure, the Christmas tree can be recovered, a second production body with new flow and control lines installed on top of the original production body, and the Christmas tree reinstalled on top of the second production body.

In order that the manner in which the aforementioned objects are achieved in accordance with the invention can be understood in detail, reference is had to the accompanying drawings, which form a part of this specification, and wherein:

FIGS. 1–3 combine to provide a view, partly in vertical section and partly in elevation, of a wellhead construction in accordance with one embodiment of the invention;

FIG. 4 is a transverse sectional view taken on line 4—4, FIG. 1;

FIG. 5 is a fragmentary, enlarged vertical sectional view taken on line 5—5, FIG. 4;

FIG. 6 is a top plan view of the wellhead construction shown in FIGS. 1–3;

FIG. 7 is a vertical sectional view of a portion of the wellhead construction of FIGS. 1–3, modified for installation of a second set of flow lines;

FIGS. 8 and 9 combine to provide a view, partly in vertical section and partly in elevation, of a wellhead construction in accordance with another embodiment of the invention; and

FIG. 10 is a transverse sectional view taken on line 10—10, FIG. 9, FIG. 6 being on smaller scale than FIGS. 1–3 and the conduits **103** and **105** being distorted in elevation in FIGS. 2 and 3 for simplicity of illustration.

Referring now to the drawings in detail and first to FIGS. 1–3 thereof, the wellhead installation here illustrated includes a lower, unitary body member **1** seated on a stub body **2** and clamped thereto, as by a conventional ring clamp **3**. Body **2** is supported by a landing plate **4** which in turn is supported by the upper end of the outer casing **5**. Body member **1** can take any suitable form and, for example, may be constructed in accordance with copending application Serial No. 302,974, filed concurrently herewith by William W. Word, Jr., and now U.S. Patent 3,268,243. Body member **1** is a unitary tubular structure having at its upper end a flat transverse face **6** and an outwardly opening transverse annular locking groove **7**. It will be understood that the body member **1** encloses and supports the various casing hangers (not shown) in usual fashion.

Seated directly on body member **1**, and clamped thereto by a connector indicated generally at **8**, is a production body **9**. Body **9** has a transverse annular lower end face **10** engaged directly with upper end face **6** of body **1**. Inwardly of faces **6** and **10**, body members **1** and **9** have cooperating downwardly and inwardly slanting frustoconical surfaces between which is wedged, under axial pressure, a conventional metal sealing ring **11**. Hydraulically actuated by pressure fluid supplied via control line **12**, coupling **8** includes lock elements **13** adapted for en-

gagement in groove 7 when the actuator ring 14 is forced downwardly by pressure fluid supplied to annular space 12*a*. Though the coupling 8 can take various forms, it is advantageously of the type fully described and claimed in copending application Serial No. 264,195, filed March 11, 1963, by Claude R. Neilon, Michael A. Walker and William W. Word, Jr., now Patent 3,228,715, issued January 11, 1966. It will be understood that the effect of coupling 8 is to apply axial clamping pressure to body members 1 and 9 so that the lower end of body member 9 is rigidly connected to the upper end of body member 1 and a good fluid-tight seal is established at 11.

Body member 1 has a vertical through passage 15. Body member 9 has a vertical through passage 16 aligned coaxially with passage 15. At the lower end of body member 9, an upwardly directed downwardly and inwardly slanting frusto-conical shoulder 17 is provided to support the dual string tubing hanger 18. Hanger 18 is provided with a pair of vertical through bores 19 and 20. Bore 19 accommodates mandrel 21 which is rigidly supported by a transverse annular shoulder 22 in bore 19, the lower end of mandrel 21 being internally threaded for attachment to tubing string 23. Bore 20 accommodates a mandrel 24 seated on shoulder 25 and internally threaded at its lower end for attachment to tubing string 26.

Commencing a short distance above shoulder 17, passage 16 includes a portion of slightly enlarged diameter accommodating a guide sleeve 27 which is rigidly affixed, as by welding, to body member 9. Constructed and employed generally in accordance with Patent 3,097,695, issued July 16, 1963, to Robert K. LeRouax et al., guide sleeve 27 has a downwardly slanting guide surface 28 leading to a vertical locator notch or slot 29 which extends to the bottom of the sleeve. The upper portion 30 of hanger 18 is of such outer diameter as to fill the surrounding passage 16 and is provided with a rigidly fixed locator lug 31 which is dimensioned to be received in slot 29 and projects radially outwardly from portion 30 so that, as the hanger descends into passage 16, lug 31 first engages guide surface 28 and travels therealong until it comes to rest within notch 29. Accordingly, lug 31 and sleeve 27 coact to locate hanger 18 in a predetermined rotational position within body member 9 as the hanger is landed, and this position determines the rotational positions of mandrels 21 and 24.

At its upper end, body member 9 has an outwardly projecting transverse annular flange 32 which, though of substantial axial dimension, occupies only a small portion of the total length of body member 9. Flange 32 presents a flat transverse annular upwardly directed end face 33 and is formed with an outwardly opening transverse annular locking groove 34. Commencing at the inner edge of end face 33 is a downwardly and inwardly slanting frusto-conical surface 35 adapted to support a sealing ring as later described.

As will be clear from a comparison of FIGS. 1 and 4, the flange 32 is provided with two larger vertical bores 36 and 37. Bore 36 accommodates a rigid cylindrical conduit member 38 having an upper end portion 39 projecting upwardly above end face 33. Conduit member 38 also includes a lower end portion 40 which projects below flange 32 and is welded to flow line 41. Member 38 is rigidly secured to flange 32, as by welding, at the bottom of the flange. Bore 37 accommodates a rigid conduit member 42 identical with conduit member 38, the lower end portion of member 42 being welded to the second flow line 43.

Extending beside each of flow lines 41 and 43 are primary hydraulic control lines 44 which are connected to operate the master valves and wing valves of the Christmas tree assembly later described. Advantageously, the control lines 44 include at least one reserve control line, that is, a control line in excess of the number actually required for operation of the wellhead devices. Advantageously, a complete duplicate set of the control lines 44 is included. Flange 32 is provided with a plurality of vertical bores 45 adequate in number to accommodate all of the hydraulic control lines which must be passed through the flange. Each bore 45 has an enlarged upper cylindrical portion 46 which opens through the upper end face 33.

The upper end of body member 9 is closed by a closure body indicated generally at 47 which is locked to body member 9 by hydraulically actuated coupling 48, coupling 48 again being constructed as disclosed and claimed in copending application Serial No. 264,195, filed March 11, 1963, by Claude R. Neilon, Michael A. Walker and William W. Word, Jr. Closure body 47 includes a dependent cylindrical portion 49 and a transverse annular outwardly projecting upper flange 50. Flange 50 has a downwardly directed transverse annular flat face 51 adapted to seat directly on the upwardly directed end face 33 of flange 32. Portion 49 has a diameter adequate to substantially fill the space defined in passage 16 by sleeve 27 and is provided with a pair of vertical parallel bores 52 and 53 which extend entirely through the closure body and are disposed for coaxial alignment with tubing hangers 21 and 24, respectively. Dependent portion 49 has an outwardly projecting rigidly fixed lug 54 dimensioned to be received in locator slot 29. Hence, as the closure body is landed, lug 54 rides down guide surface 28 and enters slot 29, orienting the closure body in a predetermined rotational position, relative to production body member 9, such that bores 52 and 53 are aligned coaxially with mandrels 21 and 24, respectively. At the inner edge of surface 51, body 47 has a downwardly and inwardly slanting frusto-conical surface 55, and a metal sealing ring 56 is wedged between surfaces 35 and 55, with axial sealing pressure being maintained by the coupling 48.

The lower end of bore 52 is interiorly threaded to receive a connector 57, the lower end portion of connector 57 engaging within the upper end of mandrel 21 as the closure body is landed. Similarly, the lower end of bore 53, interiorly threaded for attachment of connector 58, engages in the upper end portion of mandrel 24. Hence, though the tubing strings 23 and 26 are suspended from the production body 9 via hanger 18 and mandrels 21 and 24, respectively, bores 52 and 53 communicate with the respective tubing strings once the closure body has been installed.

Flange 50 is provided with two vertical bores 59 and 60 which accommodate rigid cylindrical connector tubes 61 and 62, respectively, the connector tubes being rigidly affixed to flange 50 by welding, as shown. At its lower end, connector tube 61 has an enlarged internal diameter and is provided with sealing rings to receive in sealed relation the projecting upper end portion 39 of member 38. Connector tube 62 is similarly constructed to receive the projecting upper end portion of member 42. In this regard, it will be understood that the cooperation between lug 54 and the guide surface 28 and slot 29 serves to assure that tubes 61 and 62 will be properly positioned rotationally to receive members 38 and 42, respectively, as flange 50 comes into engagement with flange 32.

Flange 50 is also provided with a plurality of vertical bores 63 equal in number to the bores 45 in flange 32. Bores 63 are so located that, when body 47 has been fully landed, with lug 54 engaged in slot 29, each bore 63 will be coaxially aligned with a different one of the bores 45.

The enlarged upper portion 46 of each bore 45 accommodates the lower end of an upright check valve body 64. The lower end of body 64 is tubular and interiorly threaded, being engaged with the exteriorly threaded upper end of the corresponding conduit 44. Body 64 projects upwardly above surface 33 and is generally tubular, defining an upwardly and inwardly tapering valve seat 65, an intermediate chamber 66, and a threaded bore 67. A movable valve member 68, with an outer frusto-conical surface matching surface 65, is urged upwardly toward surface 65 by a spring 69 engaged between the movable valve element and an exteriorly threaded stop member 70

provided with a plurality of axially extending bores **71**. It will be apparent that spring **69** normally urges valve element **68** into its closed position, engaging surface **65**. When valve element **68** is in its lower, open position, however, pressure fluid supplied via conduit **44** can pass through bores **71** and around valve element **68**, discharging upwardly from member **64**.

Each bore **63** accommodates a tubular body **72** having at its lower end a cylindrical downwardly opening recess **73** dimensioned to receive and snugly embrace the projecting upper end portion of the corresponding body **64**. The side wall of recess **73** is grooved to accommodate sealing rings **74** to provide a fluid-tight seal between members **63** and **64**. Immediately above recess **73**, body **72** defines a downwardly and inwardly slanting frusto-conical valve seat **75**, an intermediate chamber **76** and a threaded bore **77** being located thereabove. A movable valve element **78**, having a downwardly and inwardly slanting frusto-conical surface matching seat **75**, is disposed above the valve seat, being urged downwardly by a spring **79** engaged between the movable valve element and a stop member **80** secured in bore **77**. Movable valve element **78** includes a dependent pin portion **81** adapted to engage the upper end of movable valve element **68**. The length of pin **81** is so chosen that, when faces **50** and **33** are engaged, upon landing of the closure body **47**, engagement of pin **81** with valve element **68** will cause both valve elements **68** and **78** to be moved away from their corresponding valve seats, so that hydraulic pressure fluid supplied from conduit **44** may pass upwardly through body **72**.

One end of a conduit **82** is disposed within the upper end of body **72**, and stop member **80** is provided with a plurality of axially extending bores **83** to pass fluid to or from the conduit **82**.

It will be understood that body **72** is rigidly secured to flange **50**, as by welding at **84**, and that the conduit **82** is similarly secured to body **72**, as by welding at **85**.

Whenever flange **50** is separated from flange **32**, so that pin **81** no longer engages valve element **68**, valve elements **68** and **78** are forced into engagement with seats **65** and **75**, respectively, sealing off both conduits **44** and **82**.

Flange **50** presents a flat transverse upper face **86** through which bores **59**, **60** and **63** open. At the upper ends of each bore **52** and **53**, the closure member is recessed to receive sealed connector devices **87** and **88**, respectively, devices **87** and **88** being constructed in accordance with U.S. Patent 3,062,565, issued Nov. 6, 1962, to William W. Word, Jr. Surrounding the location of devices **87** and **88** is an upwardly opening groove which accommodates a conventional sealing ring **89**.

Closure member **47** supports a multiple port hydraulically operated fail-safe closed master valve of conventional type, indicated generally at **90**. The bottom flange **91** of the master valve is recessed to seat on sealing ring **89** and is clamped in place by bolts **92**, in the usual fashion. Bolted to the upper flange **93** of master valve **90** is the base flange **94** of a multiple port flow line fitting **95**.

The lower portion of fitting **95** is provided with two parallel bores **96** and **97** which extend coaxially with bores **52** and **53**, respectively, and communicate respectively with the outlet of the master valve **90**. Bores **96** and **97** open through the upper end of fitting **95** and, in the upper portion of the fitting, accommodate combination plug and flow line diverter devices **98** and **99**, respectively. Fitting **95** has a laterally enlarged intermediate body portion **100** in which are formed upwardly and outwardly slanting side ports **101** and **102**. The lower end of port **101** opens into bore **96** below the plug and diverter **98**, and the upper end of port **101** receives one end of a conduit **103** which is fixed to portion **100** of the fitting, as by welding at **104**. The lower end of port **102** opens into bore **97** below device **99**, the upper end of port **102** receiving one end of a conduit **105** which is rigidly secured to body portion **100**, as by welding, at **106**. The portion of conduit **103** adjacent fitting **95** is supported and stabilized by a brace **107** secured to the upper flange of the fitting. In identical but complementary fashion, the corresponding portion of conduit **105** is supported by brace **108**.

The other end portion of conduit **103** passes downwardly through the vertical bore of a bracket **107'** which is secured to and projects laterally from the bottom flange **94** of fitting **95**, the bore of bracket **107** being aligned vertically above connector element **62**. Disposed between bracket **107'** and connector element **62** is a hydraulically operated fail-safe wing valve **108'** having one of its ports connected to the end of conduit **103** and the other of its ports connected to element **62** by a short conduit **109**. The remaining end portion of conduit **105** extends downwardly through the vertical bore of a bracket **110** which is fixed rigidly to flange **94** at a point diametrically opposite bracket **107'**. Bracket **110** is disposed with its vertical bore in alignment with connector element **61**. A hydraulically operated fail-safe wing valve **111** is connected between conduit **105** and a short length of pipe **112**, the latter being received in and rigidly attached to the upper end of element **61**. Accordingly, with the wellhead assembled as shown, flow line **41** is connected, via wing valve **111**, conduit **105**, side port **102**, bore **97** of fitting **95**, the corresponding portion of master valve **90**, bore **53** and mandrel **24**, to tubing string **26**. Similarly, flow line **43** is connected via wing valve **108**, conduit **103**, side port **101**, bore **96**, the corresponding portion of master valve **90**, bore **52**, and mandrel **21**, to tubing string **23**.

Flow lines **41** and **43** are attached to the flange **32** of production body **9** before that body is installed. The Christmas tree, including closure body **47**, master valve **90**, fitting **95**, conduits **103** and **105**, and wing valves **108** and **111**, is, of course, preassembled and installed as a unit. A primary advantage of the invention is the fact that the Christmas tree assembly can be installed and retrieved, with appropriate operation of coupling **48**, without requiring any special manipulation to accomplish connection of the flow lines **41** and **43** to the Christmas tree assembly.

Referring to FIGS. 1–3 and 6, it will be observed that the conduits **103** and **105** are disposed generally in the form of loops which involve only relatively large radii of curvature. Thus, conduit **103** passes first upwardly beside the body of fitting **95**, then gradually outwardly away from the vertical axis of the Christmas tree still in the same general plane of curvature. Conduit **103** then curves toward the viewer, as FIGS. 1–3 are seen, and then passes to the opposite side of the Christmas tree assembly, curving gradually back into the original plane of curvature and downwardly toward side port **101**. Commencing from a point diametrically opposite to that from which conduit **103** started, conduit **105** follows a similar but complementary gradually curving path. Arranged in this fashion, and taking into consideration the normal height of the wellhead assembly, conduits **103** and **105** can be installed without requiring them to have a radius of curvature less than five feet for example. This allows the use of relatively long well service tools which otherwise would tend to jam during their passage through conduits **103** and **105**.

Secured to the upper flange of fitting **95** is a conventional hydraulically operated port fail-safe swab valve **115** which, in turn, supports the Christmas tree top adapter fitting **116**. Fitting **116** is closed by a top closure member **117** locked down to fitting **116** by a hydraulically actuated reentry connector **118** constructed generally in accordance with the aforementioned application Serial No. 264,195. Connector **118** includes an annular dependent skirt **119** which embraces adapter **116** and to the inner surface of which is secured a guiding and locating sleeve **120**. Constructed generally in accordance with the aforementioned Patent 3,097,695 to LeRouax et al., sleeve

120 has a downwardly facing guide surface 121 which slants upwardly to a vertical locator slot 122. The body of adapter 116 is provided with a laterally projecting locator pin 123 dimensioned to be received in slot 122. Upon installation of the reentry connector 118, pin 123 and surface 121 and slot 122 coact to rotationally orient connector 118 and body 117 to assure proper alignment of the tubing risers 124 and 125 with the tubing hanger mandrels. The body of adapter 116 is provided with a plurality of bores, one of which is indicated at 126, which are each connected to a different hydraulic flow riser 127 via a double acting check valve connector indicated diagrammatically at 128 and constructed in the same general fashion illustrated in FIG. 5. The bores 126 communicate with hydraulic control lines, such as line 129, for operation of the coupling 8 and 48, as well as the master valve 90, the wing valves 108 and 109 and the swab valve 115. Bore 126 and communicating hydraulic line 129 also combine with a suitable conventional hydraulic relay device (not shown) to provide a secondary, overriding means for hydraulic operation of the master valve 90, swab valve 115 and wing valves 108 and 111.

Just as the locator means comprising sleeve 120 and pin 123 in the reentry connector assure proper connection for the hydraulic control lines on reentry, the locator means comprising sleeve 27 and lug 54 assures proper connection through coupling 48 of the hydraulic control lines 12 required to operate elements of the wellhead below coupling 48. With the wellhead constructed as illustrated, the minimum requirement for control line connections through flange 32 and flange 50 is one primary control line for each tubing string and two control lines necessary for operating the lower coupling 8. As seen in FIG. 4, however, provision is made for six of the double check valve connector units of FIG. 5, two of the bores 63 being closed by suitable plugs so that only four connections are completed in the fashion seen in FIG. 5 when the closure body 47 is landed, even though a total of four primary control lines 44 are installed with production body 9. Those of the bores 63 in flange 50 of closure member 47 which are not to be used at the time of initial installation of the closure body are closed by suitable plugs. Then, in the event of failure of one or more of the primary hydraulic control lines, and after having suitably plugged the bores of tubings 23 and 26 at some distance below mandrels 21 and 24, coupling 48 is disconnected, the Christmas tree recovered, the plugs removed from appropriate ones of the bores 63 and replaced by upper valve assemblies of the type seen in FIG. 5, the bores 63 corresponding to the faulty hydraulic lines then being closed, and the Christmas tree then reinstalled.

In the event of flow line failure under circumstances where recovery of the flow lines 41 and 43 is impractical, a second production body, comprised of upper body portion 9*a* and lower body portion 9*b*, is installed on top of the body 9, as seen in FIG. 7, this second production body 9*a* and 9*b* being equipped with new flow lines 41*a* and 43*a* as well as new primary hydraulic control lines 44*a*. This second production body 9*a* and 9*b* is, of course, equipped with a hydraulically actuated coupling 48*a*, constructed in the same fashion as coupling 48. Closure member 47, FIG. 1, is removed and the depending portion of body 9*a* and 9*b* is landed in the same fashion as the closure member it replaces by means of the locator sleeve 27 and slot 29*b*. Body 9*a* is positioned so that groove 10*a* in its lower face accommodates the upper portion of flow lines 41 and 43, as well as the upper portions of hydraulic control lines 64, which have failed. A new closure 47*a* is then installed in the Christmas tree assembly, being positioned into place internally to body 9*a* in the same fashion as body portion 9*b*, using slanting guide surface 28*a*, sleeve 27*a*, slot 29*a*, and lug 54*a*, as shown. The Christmas tree is then again lowered into place and coupling 48*a* employed to lock the upper end of production body 9*a* in the same fashion as coupling 48 has been employed to lock body 9.

FIGS. 8–10 illustrate a wellhead assembly in accordance with another embodiment of the invention wherein the tubing hanger is supported in the lower wellhead body member, rather than in the production body, and a simplified flow line arrangement is employed in the Christmas tree assembly.

Here, the lower wellhead body member 200, in addition to supporting the usual casing hangers and like internal wellhead elements, supports the dual string tubing hanger 201 and includes a guide sleeve 202, the hanger 201 having a locator lug 203 cooperating with the sleeve to assure that the hanger will be disposed in a predetermined rotational position with respect to body 200. Production body 204 is supported by the upper end of lower body member 200 and is locked thereto by a hydraulically actuated coupling 205 of the type disclosed in the aforementioned copending application Serial No. 264,195. Production body 204 includes a dependent portion 206 disposed in the upper end of the passage of body member 200 and therefore within the guide sleeve 202. Portion 206 of production body 204 is provided with a radially projecting locator lug 207 which cooperates with the locator slot in guide sleeve 202 to assure that the bores 208 and 209 of the production body are properly oriented rotationally with respect to the tubing hanger mandrels supported by hanger 201.

The upper end of production body 204 is closed by a closure member 210 which is seated on body 204 and locked thereto by a hydraulic actuated coupling 211. The passage of body 204 is provided with a guide sleeve 212 having a locator slot which receives the laterally projecting locator lug 213 carried by the dependent portion 214 of closure body 210. Accordingly, the bores 215 and 216 of closure body 210 are automatically brought into alignment with the bores 208 and 209, respectively, of production body 204.

Flow lines 217 and 218 are attached to the closure body 210 in the same fashion hereinbefore described with reference to FIGS. 1–3. Thus, flow line 217 is connected to an upright tubular connector 219 which extends vertically through and is rigidly attached to the flange 220 of the closure body. Flow line 218 is similarly connected to element 221. The primary hydraulic control lines 222 also terminate in connectors (not shown) carried by flange 220, these connectors being constructed in accordance with FIG. 5. Closure body 210 has an upper flange 223 provided with suitable bores which, because of the coaction between locator lug 213 and guide sleeve 212, register automatically with the respective ones of elements 219 and 221. Flange 223 of course also carries the appropriate number of hydraulic control line connectors (not shown) as will be understood from FIG. 5.

Closure body 210 forms the lower element of a Christmas tree assembly including a hydraulically operated fail-safe master valve 224, a multiport flow line fitting 225, a hydraulically operated fail-safe swab valve 226, a top adapter fitting 227, and a closure body 228 which is locked to fitting 227 by a hydraulically actuated reentry coupling 229.

Fitting 225 is provided not only with through bores but also with two side ports each communicating with a different one of the through bores, it being understood that the through bores of fitting 225 are aligned respectively with the two tubing strings. Connected respectively to the side ports of fitting 225 are conduits 230 and 231 which extend in semicircular fashion and are disposed in a common horizontal line. At their ends opposite fitting 225, conduits 230 and 231 are interconnected via a hydraulically operated fail-safe flow line valve 232. Adjacent valve 232, conduit 230 is provided with a T-connection from which a short length of pipe 233 depends, being connected to a hydraulically oper-

ated fail-safe wing valve **234**. The remaining port of valve **234** is connected to a short length of pipe **235** which is welded to flange **223** of the closure body and is aligned with and in communication with the connector tube **219** of flow line **217**. Conduit **231** is similarly provided with a T-connection adjacent valve **232** from which depends a short length of pipe **236** connected to one port of a hydraulically operated fail-safe wing valve **237**. The remaining port of valve **237** is connected to a short length of pipe **238** welded to flange **223** and in communication with connector tube **221** of flow line **218**. A ball diverter, indicated at **240**, is disposed in conduit **230** adjacent the T-connection for pipe **233** and is oriented to prevent balls or like cleaning devices from entering conduit **230**. Similarly, a ball diverter, indicated at **241**, is disposed in conduit **231** adjacent the T-connection for pipe **236** and is oriented to prevent balls and the like from entering conduit **231**.

If flow line **217** should be plugged, master valve **224** is closed, valve **232** is opened, and a cleaning ball or the like is inserted in flow line **218** and pumped through that line, pipe **238**, valve **237** and pipe **236**, then being deflected by deflector **241** to travel through valve **232**. Deflector **240** then directs the ball down pipe **233**, so that the ball is forced through valve **234** and pipe **235** into flow line **217**. With master valve **224** closed and valve **232** open, a ball or other cleaning device can follow the same course just described, but in the opposite direction, when pumped through flow line **217** toward the wellhead.

While advantageous embodiments of the invention have been chosen to illustrate the same, various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In an underwater wellhead construction, the combination of

upright wellhead body means having a vertical through passage accommodating at least one production string, and

upwardly facing shoulder means disposed at the upper end of said body means;

a Christmas tree assembly comprising a base member seated on said upwardly facing shoulder means and having a vertical through passage,

flow passage means placed in communication with said production string when said base member is seated on said upwardly facing shoulder means,

a plurality of vertical upper flow devices secured to said base member outwardly of said through passage therein, and

production conduit means interconnecting said production string and one of said upper flow devices via said flow passage means;

at least one production flow line for conveying product away from the wellhead,

said production flow line having an end portion secured to said wellhead body means outwardly of said through passage therein and in a location below said upwardly facing shoulder means, said flow line extending downwardly and thence away from said wellhead body means; and

a plurality of vertically disposed lower flow devices secured to said wellhead body means,

one of said lower flow devices communicating with and extending upwardly from said production flow line,

said lower flow devices communicating respectively with said upper flow devices, whereby said production flow line communicates with said production conduit means, and thus with said production string, via said one upper flow device and the corresponding one of said lower flow devices.

2. An underwater wellhead construction according to claim **1**, wherein at least one of said wellhead body means and said base member has an outwardly projecting transverse flange located above said end portion of said production flow line and in the area occupied by like ones of said flow devices, such flow devices extending through said flange.

3. In an underwater wellhead construction, the combination of

an upright wellhead body member having a vertical through passage accommodating at least one production string, and an upper transverse outwardly projecting flange;

at least one production flow line and at least one fluid pressure control line,

each of said lines being attached to said wellhead body member outwardly of said passage,

said wellhead body member having a plurality of vertically disposed lower flow devices each communicating with and extending upwardly from a different one of said lines, said flow devices being spaced in an annular series about said passage and extending through said flange;

a Christmas tree assembly comprising a base member adapted to seat on said wellhead body member and having a vertical through passage,

flow passage means placed in communication with said production string when said base member is seated on said wellhead body member,

a plurality of vertical upper flow devices carried by said base member outwardly of said through passage therein and arranged in a spaced annular series corresponding to said first-mentioned series,

fluid pressure-operated valve means connected to control production flow through said flow passage means,

production conduit means interconnecting said flow passage means and one of said upper flow devices and

valve control conduit means connected to another of said upper flow devices;

cooperating locator means carried by said wellhead body member and said base member and operative to rotationally position said base member with corresponding ones of said upper and lower flow devices vertically aligned; and

remotely actuated connector means operative to lock said base member to said wellhead body member.

4. A wellhead construction in accordance with claim **3** and wherein said base member is a closure body having a transverse outwardly projecting flange, and said upper flow devices extend through said last-mentioned flange.

5. A wellhead construction in accordance with claim **3** and wherein said fluid pressure control lines number at least one more than the total of control lines necessary to control the fluid pressure-operated devices of said Christmas tree assembly.

6. In an underwater wellhead construction, the combination of

an upright wellhead body member having a vertical through passage accommodating at least one production string;

at least one production flow line and at least one fluid pressure control line,

each of said lines being attached to said wellhead body member outwardly of said passage,

said wellhead body member having a plurality of vertically disposed lower flow devices each communicating with and extending upwardly from a different one of said lines, said flow devices being spaced in an annular series about said passage;

a Christmas tree assembly comprising a base member adapted to seat on said wellhead body member and having a vertical through passage,

flow passage means placed in communication with said production string when said base member is seated on said wellhead body member,

a plurality of vertical upper flow devices carried by

said base member outwardly of said through passage therein and arranged in a spaced annular series corresponding to said first-mentioned series,

fluid pressure-operated valve means connected to control production flow through said flow passage means,

production conduit means interconnecting said flow passage means and one of said upper flow devices and

valve control conduit means connected to another of said upper flow devices;

said Christmas tree assembly including a flow line fitting having a side port,

said one of said upper flow devices to which said production conduit means is connected being disposed on the other side of the central axis of the Christmas tree assembly from said side port,

said production conduit means extending upwardly in a loop and terminating at said side port;

cooperating locator means carried by said wellhead body member and said base member and operative to rotationally position said base member with corresponding ones of said upper and lower flow devices vertically aligned; and

remotely actuated connector means operative to lock said base member to said wellhead body member.

7. In an underwater wellhead construction, the combination of an upright wellhead body member having a vertical through passage accommodating two production strings;

two production flow lines and at least one fluid pressure control line,

each of said lines being attached to said wellhead body member outwardly of said passage,

said wellhead body member having a plurality of vertically disposed lower flow devices, two of said flow devices each communicating with and extending upwardly from a different one of said production flow lines, another of said flow devices communicating with and extending upwardly from said control line,

said flow devices being spaced in an annular series about said passage, with said two flow devices spaced diametrically across said through passage;

a Christmas tree assembly comprising a base member adapted to seat on said wellhead body member and

having two through passages each communicating with a different one of said production strings,

fluid pressure-operated valve means connected to control production through said two through passages,

a flow line fitting having two diametrically opposed side ports each communicating with a different one of said two through passages,

a plurality of vertical upper flow devices carried by said base member outwardly of said two through passages and arranged in a spaced annular series corresponding to said first-mentioned series,

production conduit means connecting said two side ports each to a different one of said upper flow devices, the two of said upper flow devices to which said side ports are connected being spaced apart diametrically across the vertical axis of said Christmas tree assembly, each of said two upper flow devices being located on the opposite side of said Christmas tree assembly from the side port to which it is connected, and

valve control conduit means connected to another of said upper flow devices;

cooperating locator means carried by said wellhead body member and said base member and operative to rotationally position said base member with corresponding ones of said upper and lower flow devices vertically aligned; and

remotely actuated connector means operative to lock said base member to said wellhead body member.

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