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PATENT SPECIFICATION

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(54) WELL COMPLETION EQUIPMENT

(71) We, McEVOY OILFIELD EQUIPMENT COMPANY, a Pennsylvania Partnership of 400, North Lexington Avenue, Pittsburgh, Pennsylvania, 15208, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to well completion equipment and more particularly to means for connecting a hydraulic line to a tubing valve for operating the valve.

In well completion equipment it is often found necessary to actuate a mechanism, such as a valve or the like, disposed within the well. The actuating means is generally powered by a hydraulic fluid in a pipe line or conduit extending down to the mechanism from the top of the well, e.g. from a source of pressurized hydraulic fluid on or above water platform in the case of a subsea well.

It is known to provide a valve in a well tubing string to close the flow passage through the tubing, e.g. in case of accident necessitating shutting off the flow from the well through the tubing. Such a valve may be spring biased or pressure differential biased toward the closed position. The valve may be moved to open position by actuating means powered by the hydraulic fluid. If the hydraulic fluid pressure fails for any reason, e.g. if the platform is blown away in a hurricane, the tubing valve moves to closed position, shutting in the well.

The hydraulic fluid conduit that extends from the tubing valve to the top of the well is usually a small diameter pipe, e.g. 1/2" to 1" in outer diameter, disposed outside of the tubing and parallel thereto. Heretofore, such hydraulic conduit or pipe has been screwed into a socket in the lower end of a longitudinal passage extending up through the body of the tubing hanger. By suitable means such passage is continued upwardly to a level above the tubing head top flange into the master valve or valve adapter spool. At that level the hydraulic fluid passage has been connected to a port extending transversely, e.g. radially, out through the lower flange of the tree element (valve or spool). A hydraulic fluid line coming from a source of fluid under pressure is screwed into a threaded socket at the outer end of such transverse port.

In the case of a multiple parallel tubing string completion the aforementioned means for making connection between the hydraulic fluid passage extending up through the tubing hanger and the transverse port in the tree element flange includes for each tubing string a short pipe nipple integral with or screwed into the tubing hanger at the upper end of the hydraulic fluid passage through the tubing hanger. This hydraulic fluid nipple extends up through the sandwich seal that packs off, between the flow nipple and tubing hanger. The hydraulic fluid nipple extends upwardly into and seals with a vertical socket in the lower face of the tree element, which socket connects with the transverse port in the valve element flange. Alignment means is provided between the tubing head and hanger such that when the tree element is positioned on the tubing head with the bolt holes of the respective tree and head flanges in register, the hydraulic fluid nipple can be in alignment with the vertical socket in the tree element that is to telescope thereover.

The above described connection between the hydraulic fluid transverse passage in the tree element flange and the hydraulic fluid passage extending longitudinally up through the tubing hanger has been modified to omit the need for alignment means in the case of a single tubing well completion. The wall of the flow nipple in a single tubing completion is made thick enough so that the hydraulic fluid passage in the tubing hanger body can be continued up into the flow nipple to the level of the tree element. At that level, the hydraulic fluid passage in the flow nipple is

extended transversely, e.g. radially, horizontally, outwardly to an annular groove around the flow nipple. Such groove is located so as to be at the level of the transverse passage in the tree element flange. Annular seal rings around the tubing nipple above and below the annular groove provide means to seal the connection between the radial passage and the annular groove.

In all of the above described constructions there exists the objection that if the tree is not in position, there is no way to connect the hydraulic fluid conduit in the well with the source of pressurized hydraulic fluid whereby the tubing valve can be opened. Thus, when tubing is run in through blowout preventers mounted on top of the tubing head, it is necessary to omit the tubing valve if any operations are to be conducted through the tubing requiring an open passage through the tubing. The tubing valve must be installed later, e.g. run in on a wire line, and can be opened only when the blowout preventers have been removed and the tree has been installed.

According to the present invention there is provided a well completion apparatus comprising a tubing head, a tubing hanger supported within the tubing head, connection means on an underside of the tubing hanger for making connection to a pressure fluid control line, passage means in said tubing hanger extending upwardly from said connection means and thence outwardly to the side of the tubing hanger adjacent the inner periphery of the tubing head, and passage means extending through the side of the tubing head in fluid flow communication with said passage means in the tubing hanger and adapted for connection with a pressure fluid line outside the tubing head.

The passage in the tubing head preferably takes the form of a transverse, e.g. radial, bore for hydraulic fluid in the side of the tubing head at the level of the tubing hanger body below flow nipples and a sandwich pack off that surmount the hanger body. Means may also be provided to connect such transverse bore in the tubing head with the longitudinal, e.g. vertical hydraulic fluid passage in the tubing hanger body.

This latter means preferably is in the form of flexible conduit which is passed through the tubing head bore and is engaged in fluid tight relationship with a transverse, e.g. radial, passage in the side of the tubing hanger body. The transverse passage converts with the longitudinal vertical passage extending downwardly to the lower face of the hanger body. A sufficient distance is provided between the threaded engagement of the tubing hanger and the conduit and the sealing engagement of the tubing head and the conduit that the conduit is permitted to bend so as to thread into the hanger and also to be centered for sealing engagement with the tubing head.

Further, the conduit is sealingly secured to the tubing head bore by means of a compressible seal. The use of the compressible seal permits the conduit to be off-center within the tubing head bore and still provide a sealing connection.

Another advantage of the present coupling is the use of metal-to-metal seal between the coupling and the tubing hanger.

A further advantage is a collar around the conduit to prevent the conduit from blowing out of the tubing head bore.

Another connection means may be in the form of a retractable stinger in the transverse bore and engageable in fluid tight relationship with the transverse passage. As in the prior art constructions, the lower end of the vertical passage in the tubing hanger terminates in a socket to receive the hydraulic fluid conduit that extends down to the safety ball valve in the tubing.

The just described form of connection means requires that the tubing hanger be aligned with the tubing head so as to place the transverse bore in the tubing head in register with the transverse passage in tubing hanger. However, in the case of multiple parallel string completions such alignment means is required in any event in order to place the registry the bolt holes on the tubing head flange and the tree (e.g. multiple valve) flange when the sockets in the latter are placed over the tubing flow nipples. Also, such alignment means is present even in the case of single completion hangers if the latter are of the currently popular type employing retractable lock screws to support all or part of the load on the tubing hanger.

In the case of parallel string multiple completion hangers, wherein the hanger is split, each of the transverse passages in the tubing hanger is located at a part of the hanger body where there is adequate material to provide for a sealing connection with the stinger, in other words, in the part of the body of the hanger to one side of the main flow passages therethrough.

In a further embodiment of the invention, an annular groove is provided around the body of the tubing hanger, and the groove connected by a transverse port with a longitudinal hydraulic fluid passage in the tubing hanger extending down to a threaded socket in the lower face of the hanger body. The socket connects to the hydraulic fluid conduit that extends down alongside of and parallel to the tubing valve. The annular groove in the tubing hanger is at the same

level as a transverse bore in the tubing head and communicates therewith regardless of the azimuthal position of the hanger relative to the head. Annular seals are provided extending around the hanger above and below the annular groove that carries the hydraulic fluid. The annular seals isolate the annular groove and prevent the hydraulic fluid from leaking out between the head and hanger. This construction is especially suited for single completions where no alignment means is provided. It can also be adapted to multiple completions by providing a plurality of annular grooves and annular isolation seals. This can be done easily in the case of multiple completion tubing hangers having integral bodies if there is enough wall thickness to accommodate the grooves and seals, but is more difficult in the case of split hangers, e.g. if the isolation seals extend between the hanger body sectors.

Other objects and advantages of the invention will appear from the following description of preferred embodiments thereof, reference being made for illustration to the accompanying drawings.

Figure 1 is a vertical section through a tubing head and tubing hanger embodying the invention, adjacent parts also being shown;

Figure 2 is a horizontal section taken at plane 2—2 of Figure 1;

Figure 3 is a vertical section to a larger scale, taken at plane 3—3 of Figure 2;

Figure 4 is a vertical section, partly in elevation, similar to Figure 3 showing a modification; and

Figure 5 is a vertical section, partly in elevation, similar to Figure 3 showing a further modification.

Referring now to Figure 1 there is shown a well-head structure including a tubing head 11 surmounting a casing head 13 (shown only fragmentarily). A lower flange 15 of the tubing head is secured to an upper flange 17 of the casing head by bolts 19 and sealed thereto by ring gasket 23. The casing head 13 may surmount further casing heads (not shown), the stack of casing heads being flanged or in other manner connected together in any known manner as desired.

Surmounting the wellhead structure is a tree including, for example, as a lower element thereof, a plural (e.g. dual) bore valve 25. A lower flange 27 of the valve 25 is secured to an upper flange 29 of the tubing head by bolts 31 and nuts 33.

Between the flanges 15 and 29 of the tubing head its generally tubular body is provided with ports 34, 35 through which fluids can be introduced into and withdrawn from the tubing head. Around the ports 34, 35, there are bosses 36, 32 to receive cap screws by which connections can be made to the ports 34, 35, or by which cover plates can be secured thereover.

In the upper part of the tubing head there is an annular shoulder 37 on which are supported the sectors 39, 41 of the split body of multiple (e.g. dual) bore tubing hanger 43. Integral with the sectors 39, 41, respectively and extending downwardly therefrom are tubular couplings 45, 47. Tubing strings 49, 51 are supported from the hanger 43 by virtue of the upper ends of the strings being screwed into the couplings 45, 47.

In the tubing strings are connected ball valves 53, 55 biased to closed positions by springs or pressure differential and moved to open position by hydraulic pressure. Such valves are well known, being shown for example, at page 3883 of the Composite Catalogue of Oil Field Equipment and services, 1970—71 Edition, Extending upwardly from the valves 53, 55, are pipes 57, 59 for hydraulic fluid under pressure, the pipes constituting hydraulic control lines for the valves 53, 55. These lines extend upwardly alongside the tubing strings 49, 51 and are screwed into the sockets in the lower ends of the sectors 39, 41 of the tubing hanger body. The sockets are at the lower ends of vertical fluid passages 56, 58 (described in more detail hereinafter) which extend upwardly in the hanger sectors and connect to transverse fluid passages 61, 63 extending out to the sides of the hanger sectors.

Referring now to Figure 2, the passages 61, 63, receive therein retractable tubular stingers 65, 67, (described in more detail hereinafter), which connect to hydraulic fluid lines 69, 71. The lines 69, 71 lead to a suitable source of pressurized hydraulic fluid (not shown) and to valve means for admitting such fluid to the lines and exhausting it therefrom as is required to open and close tubing valves 53, 55.

The sectors 39, 41 are held in predetermined azimuthal position in the tubing head 11 by alignment means comprising retractable lock screws 73, 75. These lock screws also retain the hanger sectors on the seats provided by annular shoulder 37 and may support some of the weight and pressure on the hanger body. The sectors 39, 41 respectively have flow passages 77, 79 therethrough which connect with the couplings 45, 47 at the lower ends of the sectors.

As best shown in Figure 2, the hanger sectors 39, 41 are provided with wings 39A, 39B, 41A, 41B at the sides of the flow passages 77, 79. The control fluid passages 56, 58, 61, 63 are located in the wings 39B, 41B.

Referring once again to Figure 1, there are tubular seal couplings 81, 83 integral

with and extending upwardly from the hanger sectors 39, 41 in fluid flow relationship with the flow passages 77, 79 through the hanger sectors. Flow nipples 85, 87 are screwed into the couplings 81, 83 in fluid tight relationship and extend upwardly into sockets 89, 91 in the bottom of the dual bore valve 25 to which they are sealed, e.g. by O rings or by a suitable dual bore packing gland.

When the well is flowing, oil or gas flows upwardly through tubing strings 49 and 51 and the valves 53, 55 into hanger couplings 45, 47, and thence through flow passages 77, 79 in the hanger sectors 39, 41 and seal couplings 81, 83 into flow nipples 85, 87 and into the dual bore valve, the fluid flow being sealed off from the annulus 101.

Fluid flow in the annulus past the tubing hanger is blocked off by hanger seal 103 comprising metal base plate 105, rubber seal disc 107, and compression plate 109, all of which have two holes therein through which extend seal couplings 81, 83. Retractable lock screws 111, 113, (and others not appearing in the drawing) extend radially through flange 29 and engage the bevel 115 at the outer upper edge of compression plate 109 to wedge it down and compress seal disc 107 into sealing engagement with the seal couplings 81, 83 and the inner periphery of the tubing head 11.

The hanger couplings 45, 47 are adapted to receive retrievable back pressure valves (check valves closing to prevent upward flow) not shown.

Except for the hydraulic control fluid passage means the tubing head and hanger just described are the same as the type R equipment described on page 4196 of the 1971 edition of the Composite Catalogue of Oilfield Equipment and Service and more fully on page 20 of the Rockwell Manufacturing Company catalogue V-404.

Referring now to Figure 3 there is shown in more detail the hydraulic control fluid passage means of the present invention. In the tubing head 11 is suspended sector 39 of the tubing hanger, same being hung on support shoulder 37. Tubing 49 is connected to hanger coupling 45. Control line 57 is screwed into threaded socket 125 in the lower face of the hanger sector, whereby it is placed in communication with vertical passage 56 extending upwardly therefrom. Vertical passage 56 connects to radial passage 61 near the upper part of the hanger sector, within the wing 39B below seal coupling 81.

The radial passage 61 is enlarged by counterbores 126, 127. A shoulder 128 is formed between the counterbores. Counterbore 126 received the reduced diameter end 129 of stinger 65. Counterbore 127 receives packing material rings 131, 133, junk ring 135 and compression ring 136 which provide means to seal between the stinger and hanger sector wing. Junk ring 135 bears against shoulder 128. Compression ring 136 receives thrust from shoulder 137 at the juncture of the reduced diameter end 129 of the stinger and the main body 139 of the stinger. Prior to assembly with the tubing hanger the rings 131—136 are held on the end of the stinger between shoulder 137 and split ring 140 snapped into a groove in the end of the stinger.

The main body of the stinger is provided with an enlargement 141 which is exteriorly threaded. The threaded portion 141 is screwed into threaded passage 143 in the tubing head 11. Passage 143 is formed in boss 145 on the side of the tubing head.

From the foregoing it is apparent that stinger 65 is a tubular screw, threaded through the tubing head into the tubing hanger and compressing the packing 131, 133 to seal between the end of the stinger and the tubing hanger passage 61. The flow passage 150 through the stinger is thus sealed in fluid flow relationship with passage 61 in the tubing hanger.

Instead of compressible packing material rings the seal could be effected by means of O rings, in which case the junk and compression rings could be omitted.

The stinger is held in place in the tubing head by means of the threads on portion 141 and passage 143. The outer end of the stinger is interiorly threaded at 148 for connection to a hydraulic line 69.

To seal between the stinger and the tubing head, passage 143 is provided with counterbore 151, 153. Counterbore 153 is threaded and receives a gland nut 155 which is screwed therein. Between the inner end 157 of the gland nut and shoulder 159 at the inner end of counterbore 151 is received packing means including compression ring 161, packing material rings 163, 165, 167 and junk ring 169. By screwing in the gland nut the packing material rings are compressed to seal between the stinger and tubing head.

In the use of the above described apparatus, the stingers will be retracted until the tubing sectors have been landed in the tubing head. The tubing hanger will be azimuthally aligned by lock screws 73, 75 serving as alignment means cooperating with bevel groove 170 formed in the hanger sectors. With the hanger sectors in place and held down by lock screws 111, 113 etc. acting through sandwich seals 105, 107, 109, the stingers are extended into the tubing hanger sectors in fluid flow relationship with the hydraulic control fluid passages 61, 63. The valves 53, 55 can then be opened hydraulically so that whatever operations desired can be performed therethrough. At this time the blowout preventer may be

removed prior to attachment of the master valve 25, the tubing hanger having been lowered through the preventer. With the master valve and tree in place, the well may be produced. Should the above described completion apparatus be broken off of the tubing strings, the hydraulic control lines 57, 59 will be broken off too and valves 53, 55 will automatically shut in the well.

Referring now to Figure 4 there is shown another embodiment of the invention which eliminates the need for azimuthal alignment of the tubing hanger with the tubing head and especially useful for single completions. The Figure 4 construction is the same as that of Figure 3 except that a single bore tubing hanger is used, alignment groove and lock screws are omitted, and the hydraulic control fluid passage means is modified. The single bore tubing hanger 175 is provided with an integral hanger coupling 177 into which tubing 176 is screwed. The hanger is supported on shoulder 179 of the tubing head 181 and is held down by lock screws 183 through sandwich packoff 185.

Around the body of the hanger there are upper and lower isolation seal annular grooves 187, 189 in which are received O rings 191, 193. The latter seal between the body of hanger 175 and the interior of tubing head 181.

Between isolation seal grooves 187, 189 the tubing hanger is provided with annular flow passage groove 195. Groove 195 communicates through radial passage 197 and vertical passage 199 with socket 201 in the lower face of the body of hanger 175. Hydraulic control line 203 screwed into socket 201.

Regardless of the azimuthal position of hanger 175, annular passage 195 will be in communication with port 205 in the tubing head. Port 205 extends through boss 200 at the side of the tubing head. The outer end of port 205 is interiorly threaded at 207 for connection to a hydraulic control fluid line 209.

It will be apparent that in the Figure 4 embodiment of the invention, the same as in the Figure 1—3 embodiment, the hydraulic fluid passage means is connected without reference to the presence or absence of the blowout preventer or the master valve of the tree. It is therefore possible, as with the Figure 1—3 embodiment, to install the tubing shut off valve when the tubing is run in through the preventer and to move the shut off valve to open position as may be required for other operations prior to removing the preventer and installing the valve and tree.

The construction of Figure 4 could be adapted to split hangers for multiple completions by carrying the isolation seals completely around each hanger sector and joining the upper and lower seals on each sector over the area where the sectors abut. Compare the pack-off seals shown in United States patent number 2,794,505 to H. Allen.

Instead of joining the upper and lower seals, additional sets of upper and lower seals could be provided at different levels, each, each set with a tubing hanger control fluid passage arcuate groove therebetween, for connection to tubing head passages at different levels.

Tubing hanger constructions employing integral bowls receiving a plurality of hanger nipples could conceivably be adapted to the present invention, e.g. by employing Figure 3 type stingers in the tubing head entering radial passages in the bowl, the bowl passages being connected to the hanger nipples by isolation seals similar to the Figure 4 construction, but the construction must be adapted to pass the shut off valves and control tubing, e.g. as in United States patent number 2,830,665, with appropriate modification and relocation of the isolation seals.

Referring now to Figure 5 there is shown a third and preferred embodiment of the apparatus in accordance with the invention. Transverse fluid passage 61 is aligned or registered with horizontal bore 310 passing from the internal periphery of tubing head 11 to the external periphery of head 11. Bore 310 is formed in boss 145 on the side of tubing head 11. Bore 310 further includes a counterbore 312 (to be discussed later) adjacent the external periphery of head 11 creating annular shoulder 344. Internal threads 314 are provided on a portion of counterbore 312.

A hydraulic control fluid passage means or control line exiting coupling 300 is mounted within bore 310 of head 11 to link transverse fluid passage 61 with hydraulic fluid line 69. Line 69 leads to a suitable source of pressurized hydraulic fluid (not shown) and to valve means for actuating the mechanism disposed within the well.

The coupling 300 includes flow means as for example conduit 302 for providing fluid tight communication between fluid passage 61 and hydraulic fluid line 69. Conduit 302 passes through bore 310 for sealing connection to fluid passage 61 at its mouth or outlet 308. The sealing connection between conduit 302 and hanger 43 provides a metal-to-metal seal. One such connection means includes externally tapered pipe threads 304 on the interior end 316 of conduit 302 threadingly and sealingly engaging internally tapered pipe threads 306 in outlet 308 of passage 61.

Bore 310 has a diameter sufficiently large to permit the alignment and registry of outlet 308. The diameter of bore 310 may be dictated by the general margin of error

generally encountered in such an operation. It is, of course, the purpose of the present invention to avoid the requirement that bore 310 and passage 61 have coincident londitudinal axes before passage 61 and line 69 can be properly linked in fluid tight relationship and before coupling 300 can be sealingly secured within tubing head bore 310.

Conduit 302 provides one means of avoiding the alignment problem. Conduit 302 is made of a ductile material such as steel. This ductile material is as flexible as possible and yet still has the strength and corrosive resistance to handle the internal pressures and corrosion caused by the hydraulic fluid. The greater the flexibility, the easier the linkage between passage 61 and line 69 through the bending of conduit 302 between outlet 318 and shoulder 344 to permit conduit 302 to have one portion coaxial with passage 61 and another portion coaxial with counterbore 312.

In the prior art couplings no clearance is provided between the interior of bore 310 and the periphery of conduit 302 to permit any bending of conduit 302 within bore 310. Further even if such a clearance existed, there was insufficient distance between the connection of the conduit 302 to tubing hanger 43 and the connection of the conduit 302 to tubing head 11. The apparatus provides such clearances and distances to permit conduit 302 to flex between those connections. The clearance between bore 310 and conduit 302 and the distance between the hanger connection and the head connection are only limited by the size of boss 145.

A second means of resolving the alignment problem is the new securement means provided to sealingly secure conduit 302 within bore 310 even though conduit 302 is off-center and is not coaxial with counterbore 312. The securement means includes a packoff assembly 320 which has a common bore 328 of a diameter slightly larger than the outside diameter of conduit 302. Packoff 320 includes packing 326, such as a rubber ring, sandwiched between float rings 322, 324. Packoff 320 is inserted into counterbore 312 to circumscribe conduit 302. Rings 322, 324 have an outside diameter substantially less than the inside diameter of counterbore 312. This permits rings 322, 324 to fit snugly around conduit 302 and yet allow conduit 302 to be secured off-center within bore 310 since rings 322, 324 will not prevent a misalignment of conduit 302 within bore 310 due to a premature engagement of the periphery of rings 322, 324 and the interior of counterbore 312. The securement means does not fix conduit 302 within counterbore 312 but permits conduit 302 to float or slip within the securement means upon the application of sufficient force. However, the securement means does provide a frictional engagement between conduit 302 and packing 326.

A compression means, as for example a gland nut 330 having external threads 332 for threaded engagement with threads 314 of counterbore 312, is provided to compress packoff 320 to sealingly secure conduit 302 within bore 310. Nut 330 has a central core 336 for passage of nut 330 around conduit 302. Nut 330 further includes a plurality of wrench surfaces 338 on the end opposite threads 332 for the rotation of nut 330.

Since rings 322, 324 have an outer diameter substantially less than the inner diameter of counterbore 312 permitting the misalignment of conduit 302 within bore 310, upon compression of packing 326 between rings 322, 324, packing 326 is extruded over the top of rings 322, 324. Means for containing packing 326, as it extrudes over rings 322, 324, is required to maintain a sealing force normal to the inner surface of counterbore 312. As packing 326 is compressed it will extrude in every unbounded direction, and if it is permitted to extrude horizontally without containment, there will be no radial sealing force to achieve a satisfactory sealing engagement with the inner surface of counterbore 312. Therefore the annular spaces 323 and 325 are necessarily made small so that packing 326 can extrude into those annular spaces and yet have sufficient compression remaining to further compress packing 326 radially to provide an adequate sealing engagement with the inner surface of counterbore 312. Since rings 322, 324 have an outer diameter substantially less than the inner diameter of counterbore 312, rings 322, 324 have a small thickness as compared to the thickness of packing 326 to reduce the volume of annular spaces at 323 and 325 and to achieve the desired objective. Shoulder 344 contains the extrusion of packing 326 over ring 324. However, to contain packing 326 over ring 322, it is necessary to plug the annular space around the periphery of ring 322. This may be done by projecting the inner end of gland nut 330 beyond the terminus of threads 314 or by providing a special plug such as bearing ring 334. In either case the outer periphery of the projection or ring slidingly engages the inner surface of counterbore 312.

On the preferred embodiment bearing ring 334 is inserted over conduit 302 and into counterbore 312 prior to the engagement of gland nut 330 primarily as a means to contain packing 326 but also as a means to reduce the friction between nut 330 and ring 322. As nut 330 is rotated to

threadingly engage tubing head threads 314, bearing ring 334 bears against float ring 322 and shoulder 344 receives the thrust from float ring 324. Packoff 320 therefore contracts causing packing 326 to expand into sealing engagement between the interior of counterbore 312 and the external surface of conduit 302 thereby sealingly securing conduit 302 to tubing head 11. The distance between shoulder 344 and inlet 318 in bore 310 and the clearance between the interior of bore 310 and the periphery of conduit 302 provide space for conduit 302 to bend and flex within bore 310.

It is preferred that flexible conduit 302 and the securement means be used together rather than independently of each other, but it should be understood that the use of one does not require the use of the other. If they are used together, a successful connection will be obtained under a maximum of adverse conditions than if used separately. Together the securement means will provide a means for centering flexible conduit 302 within counterbore 312. Also using them together will not require conduit 302 to be coaxial with counterbore 312 thereby requiring an excessive bending of conduit 302 at shoulder 344 to obtain a good seal.

A collar 342 may be disposed on the external periphery of conduit 302 between shoulder 344 and inlet 318. Collar 342 has an outer diameter slightly larger than the inner diameter of float ring 324. A shoulder 343 is created between collar 342 and conduit 302 which will engage float ring 324 if conduit 302 slips radially within packoff 320. Collar 342 provides a means for removing packoff 320 upon disassembly of coupling 300. Further collar 342 is a safety feature by providing means for preventing conduit 302 from blowing out of bore 310 under pressure if the connection at outlet 308 breaks or if conduit 302 breaks between the collar 342 and inlet 318. This portion of the conduit is a critical portion since much stress and strain will be placed on it during assembly.

In the use of the above described apparatus shown in Figure 5, the tubing hanger 43 is landed in the tubing head 11. Hanger 43 is azimuthally aligned within tubing head 11 by lock screws. With hanger 43 in place and held down with lock screws, conduit 302 is inserted into bore 310 and threadingly engaged and sealed to outlet 308 of passage 61. The packoff 320 and bearing ring 334 are inserted into counterbore 312 and nut 330 compresses gland 320 for sealing securement between head 11 and conduit 302. Hydraulic line 69 is attached to conduit 302 such as by threads 346. The mechanism within the well may then be operated hydraulically.

All embodiments of the apparatus are adapted for use not only with single and dual, but triple, quadruple and other higher multiple parallel string completions.

The coupling as hereinbefore described is disclosed and claimed in British Patent Application No. 2589/75 (Serial No. 1419850).

While preferred embodiments of the invention have been shown and described, modifications thereof can be made by one skilled in the art without departing from the scope of the invention.

WHAT WE CLAIM IS:—

1. A well completion apparatus comprising a tubing head, a tubing hanger supported within the tubing head, connection means on an underside of the tubing hanger for making connection to a pressure fluid control line, passage means in said tubing hanger extending upwardly from said connection means and thence outwardly to the side of the tubing hanger adjacent the inner periphery of the tubing head, and passage means extending through the side of the tubing head in fluid flow communication with said passage means in the tubing hanger and adapted for connection with a pressure fluid line outside the tubing head.

2. An apparatus as claimed in claim 1, including seal means at the juncture of said passage means to prevent escape of pressure fluid from said passage means in the tubing hanger into the tubing head.

3. An apparatus as claimed in claims 1 or 2, wherein the passage means in the tubing head is formed by a tubular stinger which is disposed in the side of the tubing head and is movable between an extended position in which the inner end of the stinger is received in the passage means in the tubing hanger, and a retracted position in which said end is withdrawn from the passage means in the tubing hanger.

4. An apparatus as claimed in claim 3, in which the passage means in the tubing head includes means for holding the stinger in the desired one of said positions against forces acting axially thereon.

5. An apparatus as claimed in claims 2 or 4, or claim 3 when dependent on claim 2, wherein said seal means comprises a packing means in the annulus between the end of the stinger and the passage means in the tubing hanger.

6. An apparatus as claimed in claim 5, wherein said means for holding the stinger in the desired position comprises threads on the stinger and tubing head, and said seal means includes means whereby said packing means is compressed when said stinger is moved to said extended position.

7. An apparatus as claimed in any of the preceding claims, wherein said passage

threadingly engage tubing head threads 314, bearing ring 334 bears against float ring 322 and shoulder 344 receives the thrust from float ring 324. Packoff 320 therefore contracts causing packing 326 to expand into sealing engagement between the interior of counterbore 312 and the external surface of conduit 302 thereby sealingly securing conduit 302 to tubing head 11. The distance between shoulder 344 and inlet 318 in bore 310 and the clearance between the interior of bore 310 and the periphery of conduit 302 provide space for conduit 302 to bend and flex within bore 310.

It is preferred that flexible conduit 302 and the securement means be used together rather than independently of each other, but it should be understood that the use of one does not require the use of the other. If they are used together, a successful connection will be obtained under a maximum of adverse conditions than if used separately. Together the securement means will provide a means for centering flexible conduit 302 within counterbore 312. Also using them together will not require conduit 302 to be coaxial with counterbore 312 thereby requiring an excessive bending of conduit 302 at shoulder 344 to obtain a good seal.

A collar 342 may be disposed on the external periphery of conduit 302 between shoulder 344 and inlet 318. Collar 342 has an outer diameter slightly larger than the inner diameter of float ring 324. A shoulder 343 is created between collar 342 and conduit 302 which will engage float ring 324 if conduit 302 slips radially within packoff 320. Collar 342 provides a means for removing packoff 320 upon disassembly of coupling 300. Further collar 342 is a safety feature by providing means for preventing conduit 302 from blowing out of bore 310 under pressure if the connection at outlet 308 breaks or if conduit 302 breaks between the collar 342 and inlet 318. This portion of the conduit is a critical portion since much stress and strain will be placed on it during assembly.

In the use of the above described apparatus shown in Figure 5, the tubing hanger 43 is landed in the tubing head 11. Hanger 43 is azimuthally aligned within tubing head 11 by lock screws. With hanger 43 in place and held down with lock screws, conduit 302 is inserted into bore 310 and threadingly engaged and sealed to outlet 308 of passage 61. The packoff 320 and bearing ring 334 are inserted into counterbore 312 and nut 330 compresses gland 320 for sealing securement between head 11 and conduit 302. Hydraulic line 69 is attached to conduit 302 such as by threads 346. The mechanism within the well may then be operated hydraulically.

All embodiments of the apparatus are adapted for use not only with single and dual, but triple, quadruple and other higher multiple parallel string completions.

The coupling as hereinbefore described is disclosed and claimed in British Patent Application No. 2589/75 (Serial No. 1419850).

While preferred embodiments of the invention have been shown and described, modifications thereof can be made by one skilled in the art without departing from the scope of the invention.

WHAT WE CLAIM IS:—

1. A well completion apparatus comprising a tubing head, a tubing hanger supported within the tubing head, connection means on an underside of the tubing hanger for making connection to a pressure fluid control line, passage means in said tubing hanger extending upwardly from said connection means and thence outwardly to the side of the tubing hanger adjacent the inner periphery of the tubing head, and passage means extending through the side of the tubing head in fluid flow communication with said passage means in the tubing hanger and adapted for connection with a pressure fluid line outside the tubing head.

2. An apparatus as claimed in claim 1, including seal means at the juncture of said passage means to prevent escape of pressure fluid from said passage means in the tubing hanger into the tubing head.

3. An apparatus as claimed in claims 1 or 2, wherein the passage means in the tubing head is formed by a tubular stinger which is disposed in the side of the tubing head and is movable between an extended position in which the inner end of the stinger is received in the passage means in the tubing hanger, and a retracted position in which said end is withdrawn from the passage means in the tubing hanger.

4. An apparatus as claimed in claim 3, in which the passage means in the tubing head includes means for holding the stinger in the desired one of said positions against forces acting axially thereon.

5. An apparatus as claimed in claims 2 or 4, or claim 3 when dependent on claim 2, wherein said seal means comprises a packing means in the annulus between the end of the stinger and the passage means in the tubing hanger.

6. An apparatus as claimed in claim 5, wherein said means for holding the stinger in the desired position comprises threads on the stinger and tubing head, and said seal means includes means whereby said packing means is compressed when said stinger is moved to said extended position.

7. An apparatus as claimed in any of the preceding claims, wherein said passage

means in said tubing head includes packing gland means to seal between said stinger and said tubing head, said packing gland means being provided in a boss on the side of said tubing head.

8. An apparatus as claimed in claim 7, in which said tubing head includes an upper flange above said boss and a lower flange below said boss, said flanges providing means for making connection respectively to an upper tree element and a casing head respectively.

9. An apparatus as claimed in any of claims 2, 4 to 8, and claim 3 when dependent on claim 2, wherein said tubing hanger includes sandwiched packoff means for sealing between the tubing hanger and tubing head above the level of said seal means between said passage means.

10. An apparatus as claimed in any one of the preceding claims including tubing suspended from said tubing hanger, valve means in said tubing biased to closed position and adapted to be opened by the pressure of a control fluid, conduit means connecting said valve to said connection means in the tubing hanger for conducting said control fluid to the valve to hold the valve open, and means for supplying said control fluid to said passage means in the tubing head.

11. An apparatus as claimed in any of claims 2, 4 to 10 and claim 3 when dependent on claim 2, wherein said seal means comprises upper and lower annular seals disposed around said tubing hanger between said hanger and head respectively above and below the terminus at the exterior of said hanger of said passage means in said hanger, said seals being respectively above and below the terminus at the interior of said head of said passage means in said head, and said passage means in said hanger including an annular groove around the outside of said hanger at a level between said annular seals which are respectively above and below said annular groove.

12. An apparatus as claimed in any of claims 2, 4 to 11 and 3 when dependent on claim 2, wherein said tubing hanger including a plurality of sectors for suspending a plurality of tubing strings, each sector including a vertical flow passage and wings at each side of said flow passage, said passage means in said tubing hanger being disposed in one of said wings.

13. An apparatus as claimed in claim 12, said passage means in said head and hanger being duplicated in each sector, each passage means in each sector including a vertical portion extending upwardly from a lower face of the hanger and a radial portion extending inwardly from the outer periphery of the hanger to said vertical portion.

14. An apparatus as claimed in any one of the preceding claims, wherein said tubing hanger and tubing head are provided with means for azimuthally aligning said hanger in said head for registry of said passage means in said head and hanger.

15. A well completion apparatus substantially as hereinbefore described with reference to, and as illustrated by, Figures 1, 2 and 3, or Figure 4 of the accompanying drawings.

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