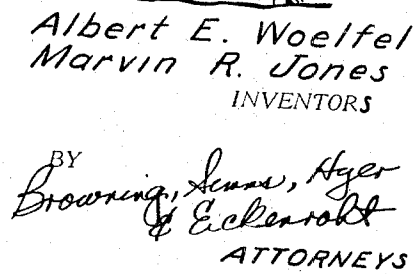


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OFFSHORE WELL APPARATUS

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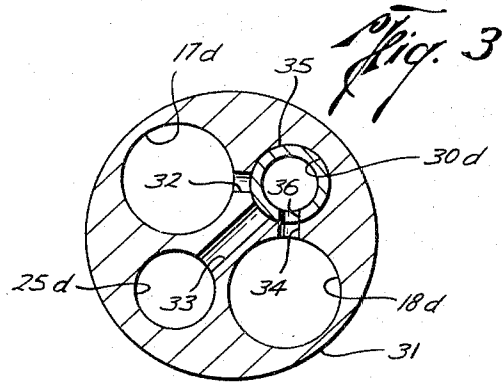
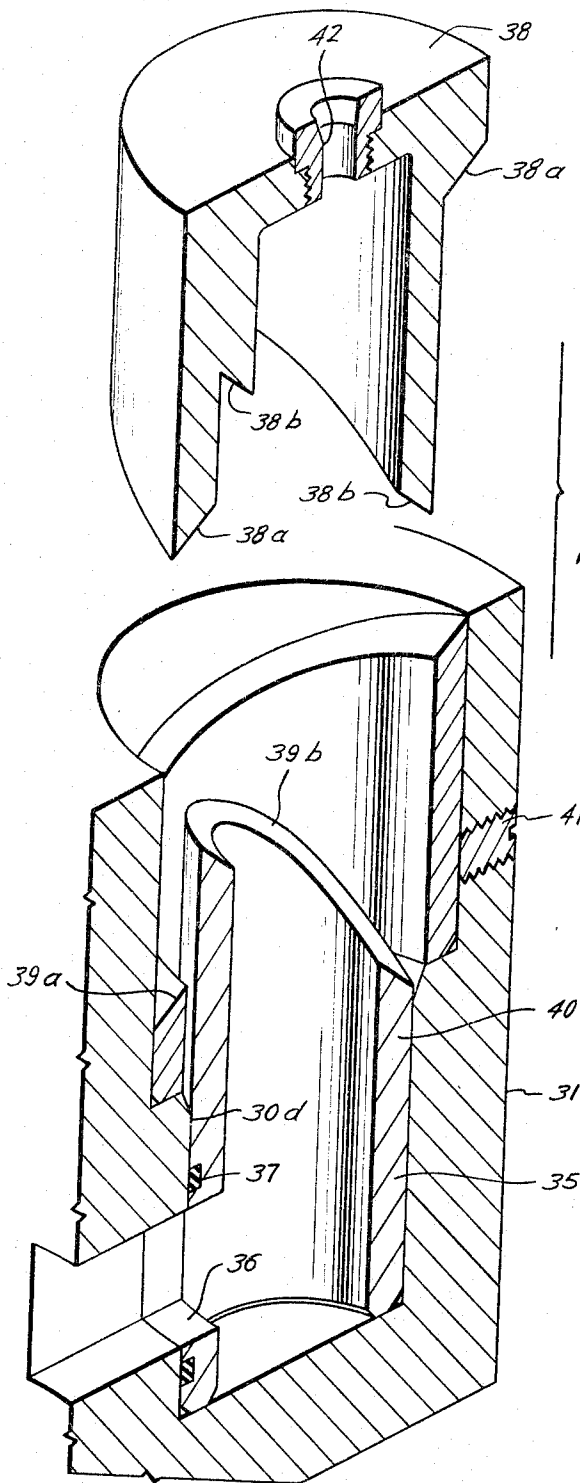
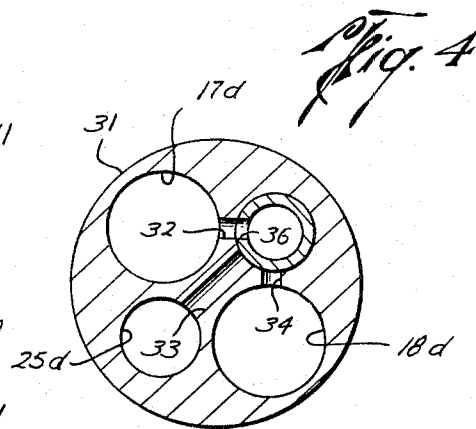


Fig. 5



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OFFSHORE WELL APPARATUS

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10 Claims. (Cl. 166—5)

This invention relates generally to apparatus for use in completing and maintaining offshore wells; and more particularly, to improvements in apparatus for completing and maintaining offshore wells of the type in which the wellhead is located beneath the water level.

In the drilling of a well of this latter type, the casing head is anchored to the upper end of a conductor casing located at or near the underwater ground level. The various casings and production tubing are run through the blowout preventer stack above the casing head and suspended from the casing head for extension downwardly into the conductor casing. When the production tubing has been run and suspended, the preventer stack is replaced by the Christmas tree which has flow passages connecting with each of the tubings and valves for controlling flow through them. The production is conveyed from the tree through flow lines connecting with the flow passages and extending laterally from the tree along the underwater ground level to a suitable gathering station, which is usually on land. Of course, there may be two or more production tubings each connecting with a separate production zone, and, as will be apparent from the description to follow, although not limited thereto, this invention has particular utility in such multiple zone wells.

It is often necessary, in the completion and maintenance of a well, to circulate one or more tools into and out of each of the production tubings. Examples of such tools are paraffin scrapers, bottom hole pressure test bombs, temperature recording bombs, and recording tubing calipers. With respect to each zone to be produced, it has been proposed to provide a gently curving flow line which is capable of passing such tools and a parallel service line and tubing opening into the same zone, whereby circulation is provided to pump the tools into and out of the particular production tubing. Insertion and circulation of the tool is controlled by suitable means at the gathering station. Thus, each production zone has required two lines and tubings extending from the production zone to the gathering station.

It is customary to install a production packer above each production zone to seal off the annulus between the casing and the production tubings. Access to the annulus above the upper packer is often desirable as, for example, to replace the residual fluid with a corrosion inhibitor. It has also been proposed that two lines be run from a remote point to the annulus for this purpose.

Obviously, this duplication of lines and tubings to each production zone and to the upper annulus involves considerable expense.

An object of this invention is to provide offshore well apparatus of this type in which such tools may be pumped into and out of selected ones of two or more production tubings without the necessity of providing a separate service string for each such production tubing.

Another object is to provide such apparatus in which access may be had to the annulus above the production packer to replace the fluid therein and in which tools of the type described may be pumped into and out of one or more production tubings without the necessity of providing a separate service string for the annulus and each such tubing.

Another object is to provide for use with such apparatus a subsurface valve operable by means of plugs

pumpable through a single service line and tubing to and from the valve for selectively positioning the valve member thereof to fluidly connect the service tubing with a selected one of a number of other tubings.

These and other objects are accomplished, in accordance with this invention, by offshore well apparatus in which there are at least three passages through the underwater wellhead, one for connection with the production tubing, a second for connection with either another production tubing or the annulus above the upper packer, and third for connection with a single service tubing. More particularly, in the illustrated embodiment of the invention, there are four such passages, two of which are connected with production tubings for communication with separate production zones of the well, a third of which is connected to the annulus, and the fourth of which is connected to the service tubing. The upper end of each such passage in turn connects with a line which extends from the wellhead to the remote station.

The service tubing extends downwardly into the well in side-by-side relation to the production tubing to a depth approximately that to which the aforementioned tools are to be lowered. At this level, which is higher than that of the upper packer, there is a valve body which has separate chambers therein corresponding in number to the flow passages. One such chamber connects with the lower end of the service tubing, another communicates with the annulus, and the others with intermediate portions of the production tubings.

Ports in the valve body connect the service tubing chamber with each of the other chambers, but not with one another, and a valve member is movable within the service tubing chamber for controlling flow through each of these ports. This movement of the valve member is controlled by plugs which are pumpable through the service tubing and line into and out of engagement with the valve member.

Thus, a selected plug may be pumped through the service line and tubing to position the valve member for fluidly connecting the service string with any one of the production tubings or annulus in order to establish circulation therewith for the operations described above. Obvious modifications of the illustrated embodiment may be made to accommodate other numbers of production tubings or to eliminate the annulus service.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is an elevational view of a wellhead constructed in accordance with the present invention, with a portion thereof broken away to show a hanger from which the service tubing and two production tubings are suspended;

FIG. 2 is an enlarged elevational view of the Christmas tree below section 2—2 of FIG. 1 and the tubing hanger of the wellhead shown in FIG. 1, and further showing the lower ends of the production tubings and service tubing and the circulating valve body within the well bore;

FIG. 3 is an enlarged cross sectional view of the valve body, as seen along broken line 3—3 of FIG. 2, and with the valve member moved to a position connecting the service tubing chamber with one of the production tubing chambers;

FIG. 4 is a cross sectional view similar to FIG. 3, but with the valve member moved to a position in which it connects the service tubing chamber with the other production tubing chamber; and

FIG. 5 is an exploded vertical sectional view of the valve member within the service tubing chamber and the pumpable plug for selectively rotating the valve member into a desired position.

With reference now to the details of FIG. 1, a conductor casing 10 extends downwardly within a well bore

11 drilled at the underwater ground level 12. The upper end of this casing is supported by means of a base structure 13 extending laterally outwardly from the well bore and resting upon the level 12. The casing is anchored within the well bore by means of a column 11a of cement.

A casing head 14 is connected to the upper end of the conductor casing 10 and has a bore 14a extending there-through, as shown in the broken away portion of FIG. 1. The lower end of the casing head is further connected to a string of surface casing (not shown) which extends downwardly within the conductor casing 10. As is well known in the art, an additional casing 15 is suspended within the surface casing by means of casing hanger 15a supported on a seat in the upper portion of the bore of the casing head. As also shown in FIG. 1, a tubing hanger 16 is supported on a shoulder within the casing hanger 15a for suspending a pair of production tubings 17 and 18 within the casing 15. As previously mentioned, and as is also well known in the art, these casings, production tubings and hangers are lowered through a blowout preventer stack (not shown) which is connected above the casing head 14 during the drilling operation.

Upon completion of this operation, the preventer stack is removed upwardly from the casing head 14 and replaced by a Christmas tree 19. As shown in FIG. 1, the Christmas tree is connected to the upper end of the casing head by a remotely actuated connector device 20 bolted or otherwise secured to the lower end of the tree. The tree and connector device are guidably lowered onto the upper end of the casing head 14 by means of tubular followers 21 which extend radially outwardly from the connector device for sliding vertically along guide cables 22, which are anchored as at 23 to the base 13 for extension upwardly toward the water level at circumferentially spaced apart locations about the casing head.

The upper ends of production tubings 17 and 18 are connected to the lower ends of bores through the tubing hanger 16, and tubes 17a and 18a extend downwardly from the lower end of Christmas tree 19 for fitting closely within the upper ends of these bores. The upper ends of these tubes are suspended from the lower ends of bores 17b and 18b through the tree, and gently curving flow lines 17c and 18c are in turn connected to the upper ends of the tree bore for extension from the tree laterally along the underwater ground level to the remote station. Thus, the tubes 17a and 18a together with the bores of the tree and tubing hanger at their opposite ends provide flow passages through the wellhead connecting tubings 17 and 18, respectively, with flow lines 17c and 18c.

As shown in FIG. 2, there is a production packer 23 disposed about the production tubings 17 and 18 so as to isolate the upper production zone 24 therebeneath from the annulus 25 about the production tubings beneath the tubing hanger 16. As also shown in FIG. 2, the production tubing 18 has ports 26 in its lower end beneath the production packer 23 so as to communicate with the upper zone 24. On the other hand, production tubing 17 extends downwardly past the upper zone 24 and through a second production packer 27 which is above the lower production zone 28. This latter zone is produced through the production tubing 17 through ports 29 in the latter beneath the packer 27.

Annulus 25 communicates with the lower end of a bore (not shown) through tubing hanger 16, and a tube 25a extends downwardly from a bore 25b in the lower end of Christmas tree 19 for fitting closely within the upper end of the tubing hanger bore. Still further, there is a line 25c connecting with the upper end of the bore of the tree and extending laterally from the tree to the aforementioned station. Thus, the tube 25a and bores in the tree and hanger provide a passage through the wellhead connecting the annulus 25 with line 25c.

As best shown in FIG. 2, a service tubing 30 extends downwardly from the lower end of a bore (not shown) through tubing hanger 16 for connection at its lower end

with a valve body 31. The upper end of this bore closely receives the lower end of a tube 30a extending downwardly from the lower end of bore 30b in the Christmas tree 19. Also, and as shown in FIG. 1, gently curving service line 30c is connected to the upper end of bore 30b for extension to the aforementioned remote station. Thus, the tube 30a and the bores at its opposite ends provide a passage through the wellhead connecting the service tubing 30 and line 30c.

As shown in FIGS. 3 and 4, there are four chambers in the valve body 31, two of which are continuous with the production tubings. Thus, the upper lengths of the tubings 17 and 18 are connected to the upper ends of chambers 17d and 18d, respectively, and the lower lengths thereof are connected to the lower ends of such chambers. Alternatively, of course, the production tubings may actually extend through the valve body chambers.

Chamber 30d in the valve body has an upper end connecting with the lower end of service tubing 30, and chamber 25d therein communicates through its upper end with the annulus 25. The lower ends of each of chambers 25d and 30d are closed, as shown for chamber 30d in FIG. 5. Thus, in summary, the production tubings 17 and 18 and the annulus 25 constitute conduits which separately communicate one of the wellhead passages with one of the valve body chambers.

Chamber 30d is connected with chamber 17d by a port 32, with chamber 25d by a port 33, and with chamber 18d by a port 34. Thus flow into and out of any one of these latter chambers may be achieved by flow through the single chamber 30d. For this purpose, valve member 35 is rotatably mounted in the lower end of chamber 30d and has a port 36 therethrough for selective communication with one of the ports 32, 33 and 34. More particularly, and as shown in FIG. 5, the hollow cylinder 35 is fitted closely within the lower end of chamber 30d and carries an O-ring 37 for sealing about the port 36 and the selected one of ports 32, 33 and 34.

Thus, assuming that the valve member has been moved to the position of FIG. 3, wherein it connects chamber 30d with chamber 18d, circulation can then be had between the service tubing and the production tubing 18. By means of such circulation, a tool may be pumped downwardly into the production tubing 18 to a desired level above the aligned ports of valve body 30 and located to prevent further lowering through the production tubing by means of a seat or the like therein (not shown). When this tool has performed its intended function, it may be pumped out of the production tubing and returned to the remote station through flow line 18c merely upon a reversal of the circulation. Obviously, a tool may be similarly pumped into and returned from the production tubing 17 upon movement of the valve member to its FIG. 4 position. Also, of course, upon moving of the valve member 35 into a position in which its port connects with the port 33, circulation may be had within the annulus 25 so as to permit the fluid therein to be pumped out and replaced with another.

The valve member 35 is caused to be moved to one of its various flow controlling positions by means of a plug 38 having concentric and oppositely sloping cam surfaces 38a and 28b on its lower end cooperable with respectively parallel cam surface 39a on the bore 30d and cam surface 39b on the upper end of the valve member 35. As shown in FIG. 5, the cam surface 39a is formed upon a cylindrical insert 40 fixedly retained in the chamber 30d by means of a set screw 41 or the like, although it may be formed on a permanent portion of the chamber, if desired. At any rate, cam surface 39a is in fixed relation to the valve body 31 so that it cooperates with the cam surface 38a and the plug 38 as the plug is moved downwardly into engagement with it so as to move the valve member 35 into a predetermined position. Thus, valve member 35 is moved to a selected position by one of three plugs which are similar except

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for having their cam surfaces 38a and 38b in different but appropriate azimuthal relationship. After the plug has been moved into engagement with the valve body and valve member to rotate the latter to a desired position, it may be removed from the chamber 30d through the service tubing and service line, so that, when it is again desired to move the valve member 35, another plug may be lowered through the line and tubing for engaging the valve body and valve member.

After it has performed its function, the valve operating plug 38 may be pumped out of the service string prior to use of the string for its desired service function. Alternatively, and as shown in FIG. 5, plug 38 may be provided with orifice 42 through its upper end to produce a pressure differential across the plug when it is being circulated and still permit flow therethrough when it is positioned in valve body 31.

As can be seen from FIGS. 3 and 4, the valve member port 36 is of a diameter greater than the separations between adjacent chamber ports 32, 33 and 34. Thus, the chamber 30d with which the service string is connected is at all times in communication with at least one of the chambers 17d, 18d and 25d as the valve member 35 moves between its positions for connecting with selected ones of such chambers. In this manner, circulation is maintained through the service string so that the plug will be moved to the limit of its valve member operating position.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

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

The invention having been described, what is claimed is:

1. Offshore well apparatus, comprising a wellhead at the upper end of a well below the water level and having three passages therethrough, a line providing a continuation of the upper end of each of said passages for extension to a remote location, a service tubing extending downwardly from one of said passages, a valve body in the well beneath the wellhead and having three chambers therein, a first of said chambers connecting with said service tubing and the second and third chambers communicating with conduits within the well which separately communicate with the other two passages through said wellhead, means including a valve member movable between positions within the first chamber for connecting the service tubing selectively with one or the other of said conduits and sealing said conduits from one another, and plug means pumpable through said service tubing and line for moving the valve member between said positions.

2. Offshore well apparatus of the character defined in claim 1, wherein each of said conduits comprises a production tubing extending downwardly from one of said other passages and connecting with one of said second and third chambers.

3. Offshore well apparatus of the character defined in claim 1, wherein one of said conduits comprises a production tubing extending downwardly from a first of said other passages and connecting with one of said second and third chambers, and the other conduit comprises the annulus within the well about the production tubing.

4. Offshore well apparatus, comprising a wellhead at the upper end of a well below the water level and having three passages therethrough, a line providing a continua-

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tion of the upper end of each of said passages for extension to a remote location, a production tubing extending downwardly from a first of the passages, a packer within the well about the production tubing to separate a production zone therebelow from another portion of the well communicating with a second of the passages, a service tubing extending downwardly from the third passage, a valve body in the well above the packer and having one chamber therein connecting with the service tubing, an additional chamber connecting with said production tubing, and a third chamber communicating with said another portion of the well, respectively, ports in the valve body connecting the one chamber with each of the other chambers, a valve member movable within said one chamber for controlling flow through said ports, and plug means pumpable through said service tubing and line providing a continuation of the third passage for selectively moving said valve member between different flow controlling positions.

5. Offshore well apparatus of the character described in claim 4, wherein said another portion of the well comprises another production zone beneath a second packer in the well about another production tubing extending downwardly from the second wellhead passage and connecting with the third chamber.

6. Offshore well apparatus of the character described in claim 4, wherein said another portion of the well comprises an annulus above the packer.

7. Offshore well apparatus, comprising a wellhead at the upper end of the well below the water level and having four passages therethrough, a line providing a continuation of the upper end of each of said passages for extension to a remote location, a production tubing extending downwardly from each of two of said flow passages, upper and lower packers within the well about the production tubings to separate a lower production zone with which one production tubing communicates from an upper production zone with which the other production tubing communicates and to separate the upper production zone from the annulus above the upper packer which communicates with a third of said passages, a service tubing extending downwardly from the lower end of the fourth passage, a valve body in the well beneath the wellhead and above the upper packer and having four chambers therein, one of said chambers connecting with the service tubing, second and third chambers each connecting with one of said production tubings, and the fourth chamber communicating with the annulus, ports in the valve body connecting the one chamber with each of the other chambers, a valve member movable within said one chamber for controlling flow through said ports, and plug means pumpable through said service tubing and line providing a continuation of the fourth passage for selectively moving said valve member between different flow controlling positions.

8. Valve apparatus for controlling flow between a service tubing extending downwardly within a well and at least two conduits within the well, comprising a body having a first chamber therein for connection with the service tubing and second and third chambers each for communication with one of said conduits, respectively, ports in the body connecting the second and third chambers with the one chamber but not with one another, a valve member movable within the first chamber between positions connecting the one chamber with a selected one of said second and third chambers, first plug means pumpable through the service tubing and into engagement with said valve member to move it from one of said positions to the other, and second plug means pumpable through said service tubing and into engagement with said valve member to move it from said other into said one position.

9. Apparatus of the character defined in claim 8, wherein, the first chamber remains connected with at least one of said second and third chambers during movement

of the valve member so as to maintain circulation between said service tubing and at least one of said conduits.

10. Subsurface valve apparatus, comprising a body having first, second and third chambers therein, ports in the body connecting the second and third chambers with the first chamber but not with one another, a hollow valve member having a port therein and rotatable within the first chamber between positions aligned with each of the body ports to connect one end of said first chamber with a selected one of said second and third chambers, and cam surfaces on said valve member and valve body within said first chamber cooperable with cam surfaces on selected plug means pumpable into said first

chamber for rotating said valve member between said positions.

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