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ROTATING GAS LIFT MANDREL FOR WELL PIPE STRINGS

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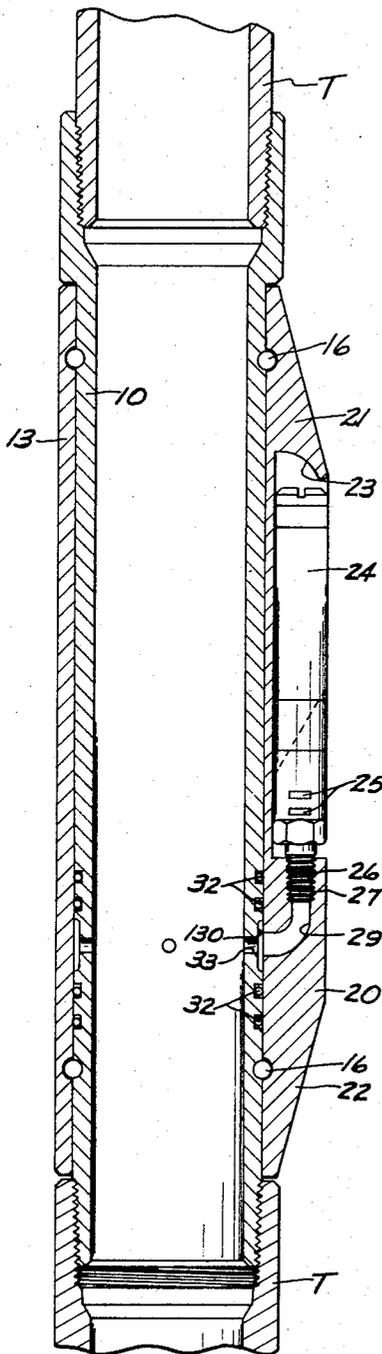


Fig. 4

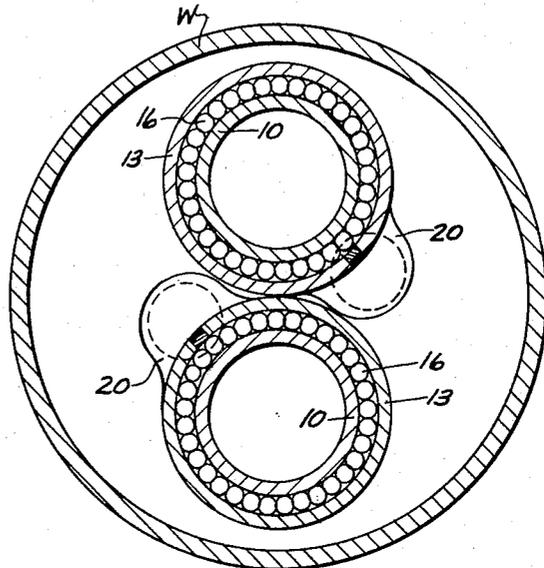


Fig. 5

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ROTATING GAS LIFT MANDREL FOR WELL PIPE STRINGS

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ABSTRACT OF THE DISCLOSURE

A gas lift mandrel including a gas lift valve support member mounted for rotation about a portion of a well pipe string and means for providing continuous fluid flow communication between a valve mounted on the support and the interior of the pipe string at any angular position of the support about the pipe string.

In drilling oil wells, the well bore will frequently intersect a plurality of oil-containing formations and present practices frequently employ procedures for completing and equipping the single well bore for production from a plurality of such oil-containing formations. Usually this involves setting a casing in the well and by the use of packers and separate tubing strings the formations may be isolated from one another and separately produced through individual tubing strings, which are, of course, enclosed within the casing.

Often such wells may require artificial lift means either initially or at some subsequent stage during the life of the particular producing formation, and it is a practice to equip the tubing strings with gas lift valves to provide such artificial lift arrangements. In some cases, the valves will be pre-installed on the tubing strings when the wells are originally equipped; and in others, the tubing strings are removed and gas lift valves installed when the necessity for artificial lift becomes evident.

In most instances, the gas lift valves will be mounted on the exteriors of the tubing strings or inside enlargements, commonly referred to as "side pocket mandrels," which necessarily form lateral projections at various points along the tubing strings. Where two or more strings of tubing are run inside a casing, it is obvious that the space available is necessarily very restricted and since the several tubing strings are generally run successively into the casing for connection to or through the packers in order to communicate with the several producing formations a great deal of difficulty will be encountered in orienting the valve-equipped tubing strings, so that the valves or the enlarged mandrels on one string in place will not obstruct the longitudinal movement of a subsequent string into or out of the surrounding casing. Also, it is very often necessary, in order to connect the tubing strings to their respective packers or to run one string through a packer carried by the other string, or to set the packers, to require rotational movements of the tubing strings; and here again, because of the restricted space available, the enlargements on one tubing string will be engaged by the enlargements on the second string during rotation, and, therefore, prevent the rotation necessary to complete the installation of the tubing strings or other operations requiring such rotation.

The present invention has for its primary object the provision of a gas lift mandrel which is adapted particularly for use in multiple pipe string wells and which will obviate difficulties such as those enumerated above in the installation and manipulating of a plurality of tubing strings inside a single casing.

In accordance with the present invention, there is provided a gas lift mandrel including a tubular body adapted

to be installed in a tubing string to form a part thereof and a valve support member which is rotatably mounted about the exterior of the mandrel body and adapted to support a gas lift valve. Passage means are provided between the support member and the mandrel body or tubing section, which will provide continuous communication between a gas lift valve mounted on the support member and the interior of the tubing string throughout rotation of the support member and valve about the tubing, so as to provide continuous communication at any angular position of the gas lift valve about the tubing string.

By means of the described arrangement the support member may have radially extending enlargements defining receptacles for the gas lift valves which, while they may come into contact with similar enlargements on an adjacent pipe string, will, nevertheless, by the rotational mounting of the valve support members, permit free rotation of the tubing strings for any operations requiring such rotation during the equipping of the well. Also, with one string in place in the well, a second string may be run into the casing and if the valve supports on the second string should contact the valve supports on the first string, the enlargements on the second string will easily be caused to pass those on the first string, either by the provision of tapered or bevelled surfaces on the respective enlargements which would tend to rotate one with respect to the other, or by a slight angular rotation of the second string with respect to the first as the string is lowered or raised in the well.

As noted previously, a well may be initially equipped with gas lift valves for immediate use or for subsequent activation when artificial lift becomes desirable or necessary, or the mandrels may be subsequently installed on the strings. Here also, the valves may be installed in inactive form for later activation or may be activated immediately after installation. The present invention contemplates mandrel embodiments adapted to meet any of these several conditions.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates two useful embodiments in accordance with this invention.

In the drawing:

FIG. 1 is a longitudinal, partly sectional view of a portion of a well pipe string equipped with a gas lift mandrel in accordance with one embodiment of this invention wherein fluid communication between a gas lift valve supported on the exterior of the mandrel and the interior of the pipe string is initially closed off and showing a means disposed in the mandrel for opening such communication;

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view through a well casing enclosing two parallel tubing strings each equipped with a mandrel in accordance with this invention;

FIG. 4 is a longitudinal sectional view of a portion of a pipe string equipped with a gas lift mandrel in accordance with another embodiment of this invention; and

FIG. 5 is a view similar to FIG. 3 illustrating a modified orientation of the mandrels on the tubing strings.

Referring first to FIGS. 1, 2 and 3 which illustrate what may be termed the "initially closed" embodiment of the invention, the mandrel comprises a tubular body 10 having an axial bore 11 and provided at its opposite ends with connection means, such as the externally threaded pins 12—12, receivable in the internally threaded sockets S—S carried by the related ends of adjacent sections of a tubing string T. Body 10 thus is adapted to form a

portion of the tubing string with bore 11 having substantially the same diameter as that of the tubing string.

A tubular sleeve 13, comprising the valve support member, is mounted for free rotation about body 10 between spaced apart upper and lower shoulders 14 and 15, respectively, upper shoulder 14 being defined by the downwardly facing end of upper socket S and lower shoulder 15 by an enlargement of body 10.

Longitudinally spaced anti-friction bearings, such as ball bearings 16, are circumferentially arranged between body 10 and the upper and lower end portions of sleeve 13, the races for the bearings being provided by arcuate registering grooves 17—17 and 18—18 formed in the opposed surfaces, respectively, of body 10 and sleeve 13.

A radial enlargement 20 extends longitudinally along sleeve 13 and is generally cylindrical in cross section but provided with upper and lower end portions 21 and 22, respectively, the outer faces of which slope inwardly toward the exterior of sleeve 13 and are smoothly faired into the surface of the latter. The intermediate portion of enlargement 20 is hollowed out to form a generally cylindrical receptacle or pocket 23 for receiving a gas lift valve 24, which may be of any generally conventional and known construction, having inlet ports 25 and a threaded outlet nozzle 26 by which the valve may be screwed into a threaded socket 27 provided in lower end portion 22. The outer wall of pocket 23 is cut away at an angle to form an opening 28 through which valve 24 may be inserted into the pocket for connection into socket 27. The latter is in communication with a passage 29 formed in the interior of end portion 22 and chamber 29 communicates with a channel 30 cut circumferentially in the inner wall of sleeve 13, the outer wall of the channel being defined by an opposed portion 31 of body 10. Seal elements 32—32 are sealingly arranged between body 10 and sleeve 13 at points above and below channel 30 to prevent fluid leakage from channel 30.

Portion 31 of the body initially closes off channel 30 from communication with bore 11 of body 10, but may be pierced or perforated in a manner to be described, to provide an opening 33 to establish such communication.

From the foregoing it will be seen that socket 27, passage 29, channel 30 and openings 33, when present or subsequently formed, constitute flow passage means providing fluid flow communication between the interior of body 10 and the interior of pocket 23 and that when connected into socket 27, valve 24 will be operable to control fluid communication between this passage means and inlet ports 25 of the valve. By the provision of channel 30 extending entirely around body 10, continuous fluid communication will be maintained between the valve-controlled passage means and the interior of body 10 at all angular positions of valve 24 about body 10.

It will be understood that openings 33 may be provided initially if the valves are to be immediately activated or such openings may be initially provided and blocked off with a conventional sliding sleeve valve or the like, which may be opened by known means when it is desired to activate the valve.

In the present embodiment means is provided to permit perforation of portion 31 to provide the opening 33. The means includes an annular recess 34 in the wall of bore 11 defining upper and lower shoulders 35 and 36, respectively. Recess 34 constitutes a locator seat for a perforating gun G, which may be of any known design, which carries on its lower end a hinge-type latch L, also of known design, which when disposed in recess 34 will position the perforating charge, indicated at C, opposite wall portion 31 and in registration with channel 30.

FIG. 3 is a representation, substantially to scale, of a pair of standard 2-inch tubing strings equipped with mandrels in accordance with this invention, disposed in parallel inside a 5-inch well casing W. It will be evident that despite the restricted space within casing W, either or both strings of tubing may be rotated freely as may

be desired without interference from the valve support members when the enlargements engage each other or the surrounding casing wall and are stopped. In this illustration, it will be seen that the enlargements on both tubing strings are on the same side of a plane intersecting the centers of both tubing strings.

Similarly, when one tubing string is to be run into or out of casing W while the other is in place, the enlargements on the support sleeves on one of the tubing strings need be angularly displaced only a small amount relative to the enlargements on the other string to permit free passage therebetween. The sloping and faired surfaces on the ends of the enlargements will act as thrust surfaces to cause such angular displacement upon endwise contact between the enlargements, so that one string will readily slide by the other when being moved longitudinally relative to one another. Also these sloping end surfaces overhanging the ends of valve 24 and the pocket in which the valve is seated, function to guard and protect the valves from impacts occurring in the running of the tubing strings.

FIG. 4 illustrates another embodiment in which body 10 is initially provided with openings 33 to provide for installations in which the gas lift valves will be activated immediately on installation of the related tubing string in the well.

Almost all of the parts are substantially identical with the parts of the previously described embodiments, these being designated by the same numerals. As no means for perforating the wall of the body 10 will be required, the present embodiment does not include a locating seat 34, thereby simplifying the structure. A circumferential channel 130, corresponding to channel 30 of the previously described embodiment, is formed in the exterior surface of body 10 rather than in the inner wall of sleeve 13 but functions in exactly the same manner in cooperation with passage 29 and openings 33 to maintain continuous fluid communication between the interior of body 10 and the interior of pocket 23, subject to the control of valve 24.

In the present embodiment multiple seals 32 are provided between body 10 and sleeve 13 above and below channel 30.

FIG. 5 is a view similar to FIG. 3 showing the valve-containing enlargements 20 initially disposed on opposite sides of a plane intersecting the centers of both tubing strings, whereas in the arrangement shown in FIG. 3 the enlargements are on the same plane. In either arrangement the enlargements on each tubing string are free to swing through a substantial arc extending between the other tubing string and the wall of the casing so that one string will readily pass the other when required.

It will be understood that various changes and alterations may be made in the details of the illustrative embodiments within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A gas lift mandrel for well pipe strings, comprising:
(a) a tubular body connectible into a well pipe string to form a part thereof;

(b) an annular support member for a gas lift valve mounted for relative rotation about said body; and

(c) cooperating passage means carried by said body and said support member arranged to maintain fluid flow communication between the interior of the body and gas lift valve mounted on the support member at any angular position of the support member about the body.

2. A gas lift mandrel according to claim 1 including:
(a) a gas lift valve mounted on said support member in flow controlling relation to said passage means.

3. A gas lift mandrel according to claim 1 wherein said support member comprises:

(a) a tubular sleeve, and

(b) longitudinally spaced-apart anti-friction bearing means between the sleeve and the body.

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4. A gas lift mandrel according to claim 1 wherein said passage means includes:

(a) a circumferential channel defined between said body and said support member, and

(b) circumferential seal means sealingly disposed between the body and the support member on opposite sides of said channel.

5. A gas lift mandrel according to claim 4 wherein the wall of the body defining one wall of said channel initially closes off communication between the channel and the interior of the body and is perforatable to establish such communication.

6. A gas lift mandrel according to claim 1 wherein said support member includes:

(a) an external enlargement defining a receptacle for a gas lift valve, and

(b) a passageway communicating with the interior of said receptacle and forming a part of said passage means.

7. A gas lift mandrel according to claim 3 wherein said anti-friction bearing means includes:

(a) ball-shaped bearings, and

(b) races for said bearings comprising registering circumferential grooves in the opposed surface of said body and said sleeve.

8. A gas lift mandrel for well pipe strings, comprising:

(a) a tubular body connectible into a well pipe string to form a part thereof;

(b) a sleeve member mounted for relative rotation about said body;

(c) a radial enlargement on said sleeve member defining a receptacle for a gas lift valve;

(d) a circumferential channel defined between the sleeve member and the opposed wall of the body;

(e) a passage communicating said receptacle with said channel and adapted for connection to a gas lift valve installed in said receptacle; and

(f) means for establishing fluid communication through

said wall between said channel and the interior of said body.

9. A gas lift mandrel according to claim 8 wherein said last-mentioned means comprises one or more radial openings.

10. A gas lift mandrel according to claim 8 wherein said last mentioned means includes:

(a) positioning means in the bore of said body arranged to seat a wall-perforating device inserted through said pipe string and to locate the same in registration with said channel.

11. A gas lift mandrel according to claim 10 wherein said positioning means comprises an annular recess in the bore wall of the body below said channel.

12. A gas lift mandrel according to claim 8 including circumferential seal means between the body and the sleeve at points above and below said channel.

13. A gas lift mandrel according to claim 8 including longitudinally spaced anti-friction bearing means mounted between the body and the sleeve member.

14. A gas lift mandrel according to claim 8 including a gas lift valve installed in said receptacle in flow-controlling relation to said passage.

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