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(54) Title: WELLBORE SHUT OFF VALVE WITH HYDRAULIC ACTUATOR SYSTEM

(57) Abstract: A wellbore shut-off valve is operably associated with a valve actuator so that the shut-off valve can be selectively moved between open and closed conditions when desired rather than opening and closing occurring automatically as portions of the production assembly are removed or replaced in the wellbore.



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WELLBORE SHUT OFF VALVE WITH HYDRAULIC ACTUATOR SYSTEM

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BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention generally relates to systems and methods for isolating or closing off a wellbore or a portion of a wellbore.

Description of the Related Art

[0002] During operation of a hydrocarbon production well, it is sometimes necessary to shut off the well or a portion of the wellbore below a particular point. If the well remains live while, for example, a pump is being removed from the production tubing assembly, pressurized fluid can be forced to the surface very quickly, resulting in a dangerous situation at the wellhead and possibly reducing the ability of the well to produce further. Another example of equal importance would involve controlling fluid losses to the formation which could permanently damage the formation. To shut-off the wellbore, a shut-off valve, or barrier valve, can be included in the production tubing assembly.

SUMMARY OF THE INVENTION

[0003] The present invention provides a wellbore shut-off valve that is incorporated within a wellbore production string in conjunction with an associated valve actuator device. In a preferred embodiment, the shut-off valve comprises a ball valve which can be moved between open and closed conditions. A currently preferred embodiment for the valve actuator is a stroker tool having a shifting sleeve that can be positively moved between first position, wherein the shut-off valve is moved to the open condition and a second position, wherein the shut-off valve is moved to the closed condition. In a further preferred embodiment, the valve actuator is hydraulically-actuated.

[0004] The shut-off valve and actuator may be made up into a production tubing assembly that is then disposed into a wellbore. Preferably, the shut-off valve is landed in a packer. The shut-off valve can be placed above or below a lower completion packer. When it is necessary to remove a portion of the production tubing string above the shut-off valve, the valve actuator is operated to cause the shut-off valve to close. The upper portions of the production tubing string can be removed by detaching the valve actuator from the shut-off valve and then withdrawing the detached upper portions from the wellbore.

[0005] Thereafter, the production tubing string can be reinserted into the wellbore and reattaching the valve actuator to the shut-off valve. When reattachment occurs, the shut-off valve is not automatically reopened. Because the valve remains closed, wellbore operators are able to make up the tubing hanger arrangement at the surface before opening the shut-off valve. When it is desired to reopen the flowbore of the production string, the valve actuator is actuated to move the shut-off valve back to the open position.

[0006] In another aspect of the invention, operation of the valve actuator may be controlled by a programmable controller that is programmed to coordinate operation of the shut-off valve with another device associated with the well production system. In a preferred embodiment, the controller controls the valve actuator in response to a condition of operation for a fluid pump within the production assembly. When the pump is turned off, the controller detects this condition and commands the valve actuator to close the shut-off valve. The controller can also command the valve actuator to open the shut off valve in connection with the operation of starting or restarting the fluid pump.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The advantages and other aspects of the invention will be readily appreciated by those of skill in the art and better understood with further reference to the accompanying drawings in which like reference characters designate like or similar elements throughout the several figures of the drawings and wherein:

[0008] Figure 1 is a side, partial cross-sectional view of a wellbore having an upper production string assembly being disposed therein.

[0009] Figure 2 is a side, partial cross-sectional view of the wellbore shown in Figure 1, now with the upper production string assembly having been landed and secured to a lower production string assembly in the wellbore.

[0010] Figure 3 is a side, partial cross-sectional view of the wellbore shown in Figures 1 and 2, now with a portion of the upper completion assembly being removed from the wellbore.

[0011] Figure 4 is a side, one-quarter cross-sectional view of a portion of an exemplary valve actuator in accordance with the present invention, in a first position,

[0012] Figure 5 is a side, one-quarter cross-sectional view of the exemplary valve actuator portion of Figure 4, now in a second position.

[0013] Figure 6 is a cross-sectional view taken along lines 6-6 in Figure 4.

[0014] Figure 7 is a side, cross-sectional view of portions of an exemplary shut-off valve in accordance with the present invention, with the valve in a closed condition.

[0015] Figure 8 is a side, cross-sectional view of the portions of the exemplary shut-off valve shown in Figure 7, now with the valve in an open condition.

[0016] Figure 9 is a schematic representation of an arrangement wherein a controller controls operation of the valve actuator based upon the operating condition of an electrical submersible pump within the production assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Referring first to Figures 1 and 2, there is depicted an exemplary wellbore 10 which has been drilled into the earth 12 and is lined with casing 14 which will extend upwardly toward the surface of the wellbore 10. The casing 14 defines a central flowbore 16. The wellbore 10 contains an exemplary production string assembly which will be used to illustrate the invention. It is noted that, in this example, the section of the wellbore 10 which is depicted is representative of an

upper pump-assisted completion within the wellbore 10 and that one or more additional completions may be located below the wellbore portion that is shown. As a result, a lower portion of production tubing string 18 is shown extending downwardly within the flowbore 16 from lower packer 20. A landing anchor 22 extends axially upwardly from the packer 20. Collectively, the lower production tubing string portion 18 and elements suspended below it, as well as the packer 20 and anchor 22 may be thought of as a lower completion, generally designated as 24.

[0018] Figure 1 illustrates an upper completion, generally designated as 26, being disposed into the flowbore 16 in the direction of arrow 28. In Figure 2, the upper completion 26 has been landed within the anchor 22 of the lower completion 24. The upper completion 26 is run in on an upper string of production tubing 30 (see Figure 2) and defines an axial flowbore 32 along its length so that hydrocarbon production fluids may be transmitted to the surface of the wellbore 10.

[0019] Beginning at its lower end and moving upwardly, the exemplary upper completion 26 includes a wellbore shut-off valve 34 with a downwardly extending latching portion 36. The latching portion 36 may take the form of collets or other devices which permit it to be locked together with the anchor 22. The shut-off valve 34 preferably takes the form of a ball valve in which a ball having a flowbore is rotated within a flowbore to selectively block and unblock the flowbore 32. The ball is rotated by a shifting member that is biased toward a fail safe position by a fluid spring or mechanical spring. A suitable ball-type shut-off valve for use as the shut-off valve 34 is the Halo Barrier Valve, which is available commercially from Baker Oil Tools of Houston, Texas. In Figure 1, the shut-off valve 34 is shown in a closed position since the ball member 38 is shown to be rotated so that the flow path 40 formed within is oriented at approximately 90 degrees from the axis of the flowbore 32 so that fluid cannot pass through the shut-off valve 34. In Figure 2, the valve 34 is shown in an open condition such that the flowbore 40 of the ball member 38 is aligned with the flowbore 32 such that fluid may pass through the valve 34.

[0020] The shut-off valve 34 is operably associated with a valve actuator 42. The valve actuator 42 is preferably operated from the surface of the wellbore 10 by hydraulic close and open lines 44, 46, respectively, which are fluid conduits. When interconnected with the shut-off valve 34, operation of the actuator 42 will cause the valve 34 to be moved between its open and closed conditions. A suitable actuator for use as the valve actuator 42 is the hydraulic Stroker tool available commercially from Baker Oil Tools of Houston, Texas. Portions of the actuator 42 are depicted in greater detail in Figures 4-6 and will be described in greater detail shortly.

[0021] Also included in the upper completion 26 is a shear out safety joint 48 through which the close and open lines 44, 46 are passed. The shear out safety joint 48 consists of two joint halves 50, 52, which can be readily disconnected, such as by shearing a set of shear screws, to release the two halves 50, 52 from one another. This permits a quick release of components within the upper completion 26. A perforated pup joint 54 is incorporated into the upper completion 26 above the safety joint 48 and immediately below an electrical submersible pump (ESP) 56. An ESP packer 58 is located above the ESP 56 and, in Figure 2, is shown set against the flowbore 16 to secure the ESP 56 in place within the flowbore 16. An electrical power cable 60 extends from the surface of the wellbore 10 downwardly to the ESP 56. A seating nipple 62 is used to affix the ESP packer 58 to the ESP 56. An additional safety valve 64 may be incorporated into the upper completion 26.

[0022] Figures 4-6 illustrate portions of an exemplary valve actuator 42. The valve actuator 42 basically includes an outer, generally cylindrical housing, generally indicated at 66. An interior sleeve 68 is located radially within the housing 66 and is axially moveable with respect to the housing 66. A radial space 70 is defined between the housing 66 and the sleeve 68. A central annular fluid seal 72 resides within the space 70 and divides the space 70 into upper and lower fluid chambers 74, 76 respectively. The upper chamber 74 is defined axially by the central seal 72 at its lower end and by an upper fluid seal 78 at

its upper end. The lower fluid chamber 76 is defined axially by the central seal 72 at its upper end and by a lower fluid seal 80 at its lower end. A first fluid port 82 is disposed through the housing 66 and is interconnected with the close line 44. The first fluid port 82 permits fluid communication between the close line 44 and the lower fluid chamber 76. As hydraulic fluid is flowed into the lower fluid chamber 76 from the close line 44, fluid pressure is exerted upon the lower fluid seal 80 and urges the interior sleeve 68 downwardly to the position illustrated in Figure 5, expanding the lower fluid chamber 76. A second fluid port 84 is also disposed through the housing 66 and is interconnected with the open line 46. The second fluid port 84 provides fluid communication between the open line 46 and the upper fluid chamber 74. As hydraulic fluid is flowed into the upper fluid chamber 74, fluid pressure is exerted upon the upper fluid seal 78 and urges the interior sleeve 68 upwardly to the position depicted in Figure 4, expanding the upper fluid chamber 74.

[0023] The lower end of the interior sleeve 68 presents a shifting member 86 (see Figures 2, 7 and 8). The shifting member 86 is shaped and sized to engage operating portions of the shut-off valve 34, as will be described shortly.

[0024] Figure 4 depicts the valve actuator 42 in a first position wherein the sleeve 68 and shifting member 86 are axially raised with respect to the surrounding housing 66 of the valve actuator 42. Figure 5 illustrates the valve actuator 42 in a second position wherein the sleeve 68 and shifting member 86 are axially lowered with respect to the housing 66. Figures 7 and 8 show the shifting member 86 reversibly connected with the shut-off valve 34. As can be seen there, the shut-off valve 34 includes an outer housing, indicated at 88 which retains the ball member 38. A sleeve assembly 90 is axially moveable within the housing 88 and, when moved axially, shifts the ball member 38 between the closed condition shown in Figure 7 and the open condition shown in Figure 8. The upper end of the sleeve assembly 90 presents a number of inwardly directed collet fingers 92. The collet

fingers 92 are shaped and sized to snap into engagement with engagement portions 94 of the shifting member 86.

[0025] In operation, the upper completion 26 is run into the wellbore 10, as depicted in Figure 1, and then landed in the anchor 22 so that the upper completion 26 is secured to the lower completion 24. During run-in, the shut-off valve 34 is in the closed position. Upon being landed in the anchor 22, the valve actuator 42 is actuated to move the shut-off valve 34 to the open condition, as depicted in Figure 2. In the open condition, production fluid may be flowed upwardly from the lower completion 24 through the flowbore 32 of the upper completion 26.

[0026] During production, it may be desirable to shut-off the wellbore 10 and remove the upper completion assembly 26. One reason for doing this might be to service the ESP pump 56. To remove the upper completion assembly 26, the valve actuator 42 is operated to cause the shut-off valve 34 to move to its closed condition, thereby blocking fluid flow upwardly through the flowbore 32. Fluid flow is also prevented going down the wellbore 10, preventing fluid losses to the surrounding formation. Hydraulic fluid is flowed through the close line 44 and into the upper fluid chamber 74 to move the shifting member 86 upwardly, thereby closing the valve 34. Then the valve actuator 42 is detached from the shut-off valve 34 by detaching the engagement portions 94 of the shifting member 86 from the collet fingers 92 of the sleeve assembly 90. The upper completion assembly 26 may be withdrawn from the wellbore 10. At this point, the ESP 56 may be serviced or replaced and other maintenance or repairs may be made to the upper completion 26.

[0027] In order to reestablish production from the wellbore 10, the upper completion 26 is run into the wellbore 10 and the valve actuator 42 is then reattached to the shut-off valve 34 by reattaching the engagement portions 94 of the shifting member 86 with the collet fingers 92 of the sleeve assembly. When this occurs, the shut-off valve 34 will remain in the closed condition. Well operators will be able to make up the tubing hanger arrangement at the surface before opening the shut-off valve 34. When it is desired to reestablish production,

hydraulic fluid is flowed through the open line 46 to the valve actuator 42 to cause the shut-off valve 34 to be moved to its open condition (Figure 8). The ESP 56 may be restarted to cause production to occur once more.

[0028] In a further preferred aspect of the invention, operation of the valve actuator 42 is responsive to the condition of another device within the upper completion assembly 26. In one exemplary embodiment, the valve actuator 42 is operated based upon the operating condition of the ESP pump 56. Figure 9 is a schematic representation of such a control scheme wherein a controller 94 is interconnected with the ESP 56 and a fluid pump 96. The fluid pump 96 is typically surface-based and provides hydraulic fluid through the close and open lines 44, 46 to the valve actuator 42. The controller 94 may be a programmable processor or general purpose digital processing system, such as a personal computer of a type known in the art with suitable software or code for conducting the operations described herein. The controller 94 is equipped with one or more sensors, indicated schematically at 98, which are capable of detecting whether the ESP 56 is on or off. Control line 100 extends from the controller 94 to the pump 96. According to an exemplary control scheme using the controller 94, the controller 94 detects whether the ESP 56 is operating to pump fluid through the upper completion 26 or, alternatively, if the ESP 56 is not operating. If the controller 94 detects that the ESP 56 is not operating, it commands the pump 96 to flow fluid through the close line 44 in order to move the shut-off valve 34 to its closed condition. Therefore, the upper completion 26 may be removed after the operation of turning the ESP 56 off. Also according to the exemplary control scheme, the controller 94 will command the pump 96 to flow fluid through the open line 46 when it detects that the ESP 56 is operating or is being started up. This mode of operation will help prevent fluid from being lost to the surrounding subterranean formation, thus helping to prevent formation damage. By reopening the shut-off valve 34 prior to or in conjunction with starting of the ESP 56, one can ensure that there will be a column of fluid within the flowbore 32 of the upper completion 26 when the

ESP 56 starts operating, thereby reducing operating stress on the ESP 56.

[0029] It can be seen that the shut-off valve 34 and the valve actuator 42 collectively provide a controllable shut-off valve assembly which can be used to selectively open and close off the wellbore 10 in accordance with a user's desire or a predetermined programmed scheme via controller 94. Optionally, a shut-off valve assembly constructed in accordance with the present invention may also include a fluid pump 96 and a controller 94 for operation of the fluid pump 96 in response to the condition of another component with the upper completion 26.

[0030] Those of skill in the art will recognize that numerous modifications and changes may be made to the exemplary designs and embodiments described herein and that the invention is limited only by the claims that follow and any equivalents thereof.

CLAIMS

What is claimed is:

1. A shut-off valve assembly for use in selectively closing off a section of wellbore to fluid flow, the assembly comprising:

a shut-off valve incorporated within a completion string within the wellbore, the shut-off valve being moveable between an open condition wherein fluid may flow through the completion string, and a closed condition, wherein fluid flow through the completion string is blocked; and

a valve actuator incorporated within the completion string and associated with the shut-off valve, the valve actuator operating the shut-off valve between its open and closed conditions.

2. The shut-off valve assembly of claim 1 wherein the shut-off valve comprises a ball valve.

3. The shut-off valve assembly of claim 1 wherein the valve actuator is hydraulically actuated.

4. The shut-off valve assembly of claim 1 wherein the valve actuator further comprises:

a housing;

a sleeve moveably disposed within the housing; and

a shifting portion affixed to the sleeve, the shifting portion being operable to move the shut-off valve between open and closed conditions upon movement of the sleeve with respect to the housing.

5. The shut-off valve assembly of claim 1 further comprising a programmable controller operably associated with the valve actuator to cause the valve actuator to operate the shut-off valve between open and closed conditions in accordance with a predetermined scheme.

6. The shut-off valve assembly of claim 5 wherein the controller is operably associated with the valve actuator by control of a fluid pump supplying hydraulic control fluid to the valve actuator.

7. A shut-off valve assembly for use in selectively closing off a section of wellbore to fluid flow, the assembly comprising:

a shut-off ball valve incorporated within a completion string within the wellbore, the shut-off ball valve being moveable between an

open condition wherein fluid may flow through the completion string, and a closed condition, wherein fluid flow through the completion string is blocked; and

a valve actuator incorporated within the completion string and associated with the shut-off valve, the valve actuator operating the shut-off valve between its open and closed conditions.

8. The shut-off valve assembly of claim 7 wherein the valve actuator further comprises:

a housing;

a sleeve moveably disposed within the housing; and

a shifting portion affixed to the sleeve, the shifting portion being operable to move the shut-off valve between open and closed conditions upon movement of the sleeve with respect to the housing.

9. The shut-off valve assembly of claim 7 wherein the valve actuator is hydraulically actuated.

10. The shut-off valve assembly of claim 7 further comprising a programmable controller operably associated with the valve actuator to cause the valve actuator to operate the shut-off valve between open and closed conditions in accordance with a predetermined scheme.

11. The shut-off valve assembly of claim 10 wherein the controller is operably associated with the valve actuator by control of a fluid pump supplying hydraulic control fluid to the valve actuator.

12. A method of selectively shutting off a wellbore so that an upper portion of a completion assembly within the wellbore may be removed, the method comprising the steps of:

operably associating a wellbore shut-off valve which is operable between open and closed conditions with a valve actuator that controls movement of the valve between open and closed conditions;

operating the valve actuator to move the shut-off valve to the closed condition; and

detaching and removing the upper completion assembly portion from a lower completion portion within the wellbore after the shut-off valve has been closed.

13. The method of claim 12 further comprising the steps of:
reattaching the upper completion portion to the lower completion portion; and
after reattaching the upper completion portion to the lower completion portion, operating the valve actuator to move the shut-off valve to the open condition.
14. The method of claim 12 wherein the step of operating the valve actuator to move the shut-off valve to the closed condition is conducted by a programmable controller.
15. The method of claim 13 wherein the step of operating the valve actuator to move the shut-off valve to the open condition is conducted by a programmable controller.

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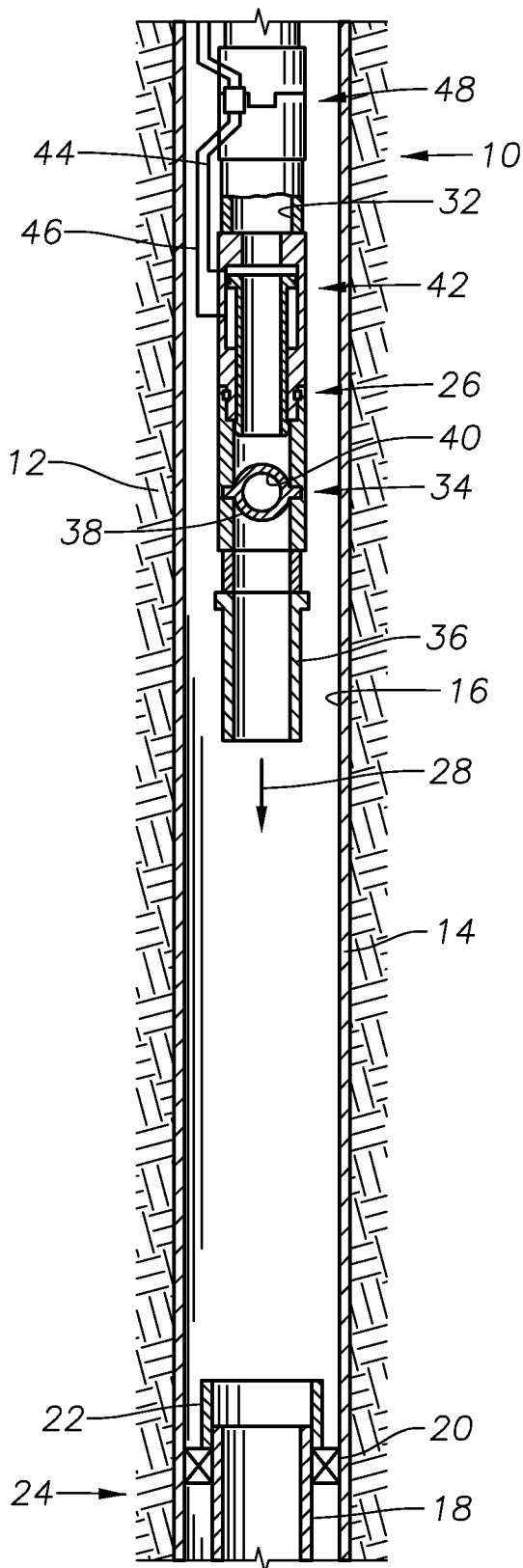


Fig. 1

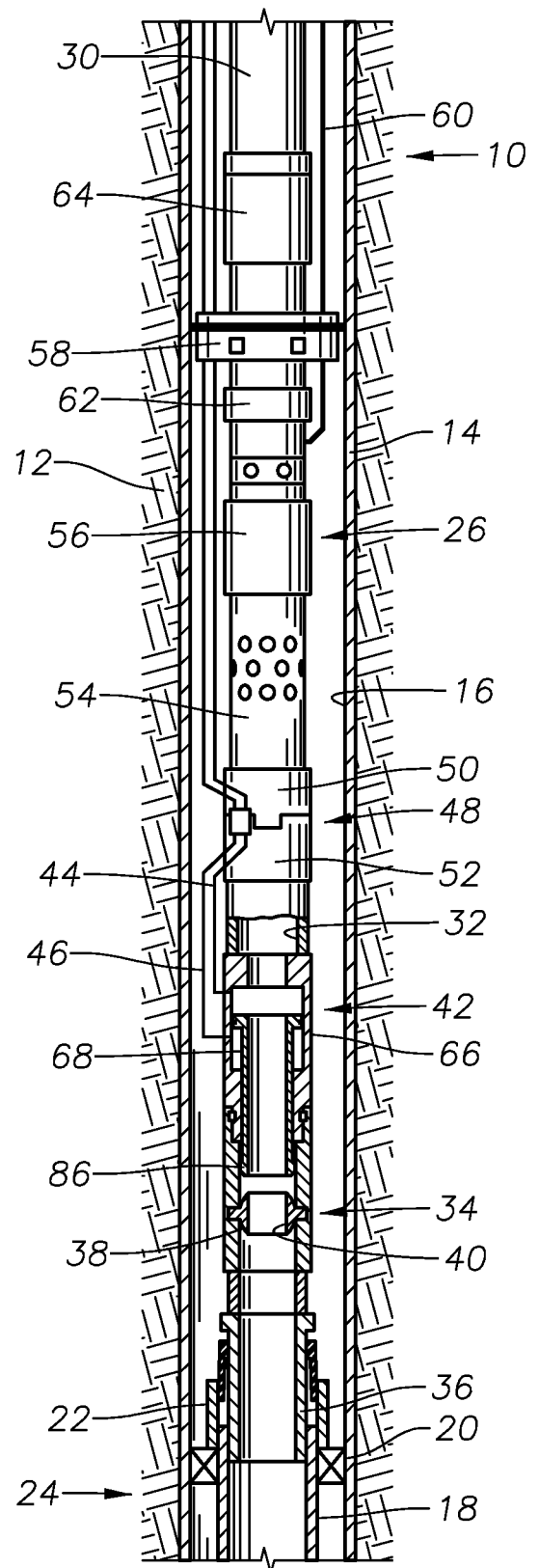


Fig. 2

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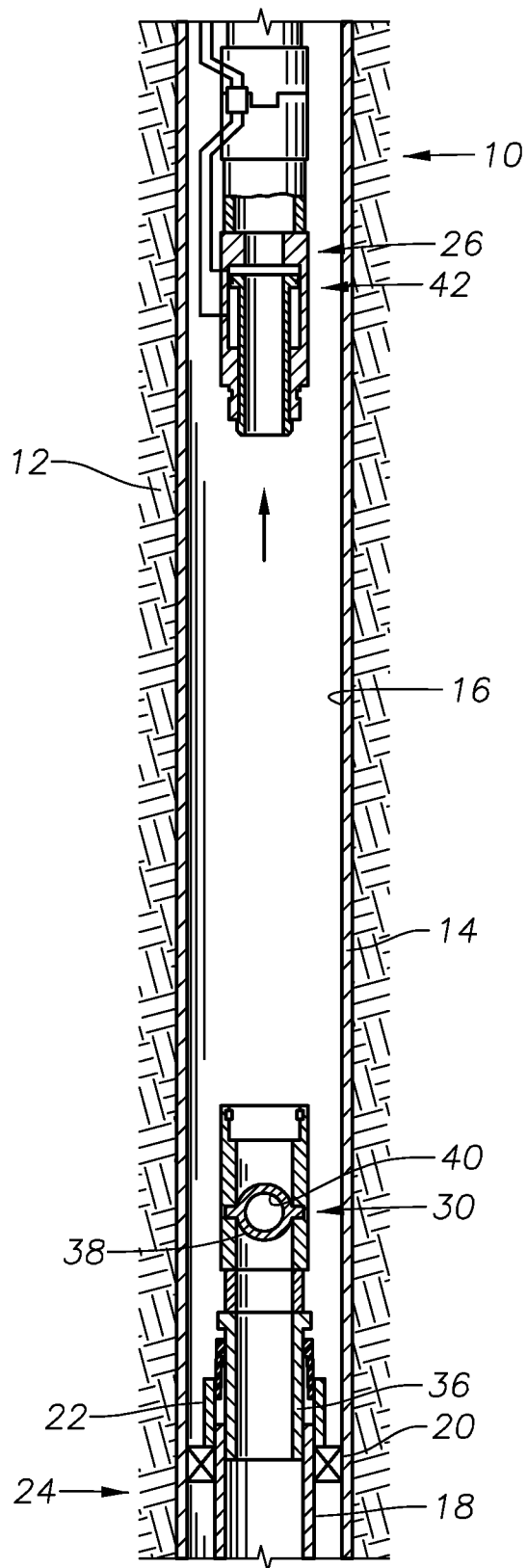


Fig. 3

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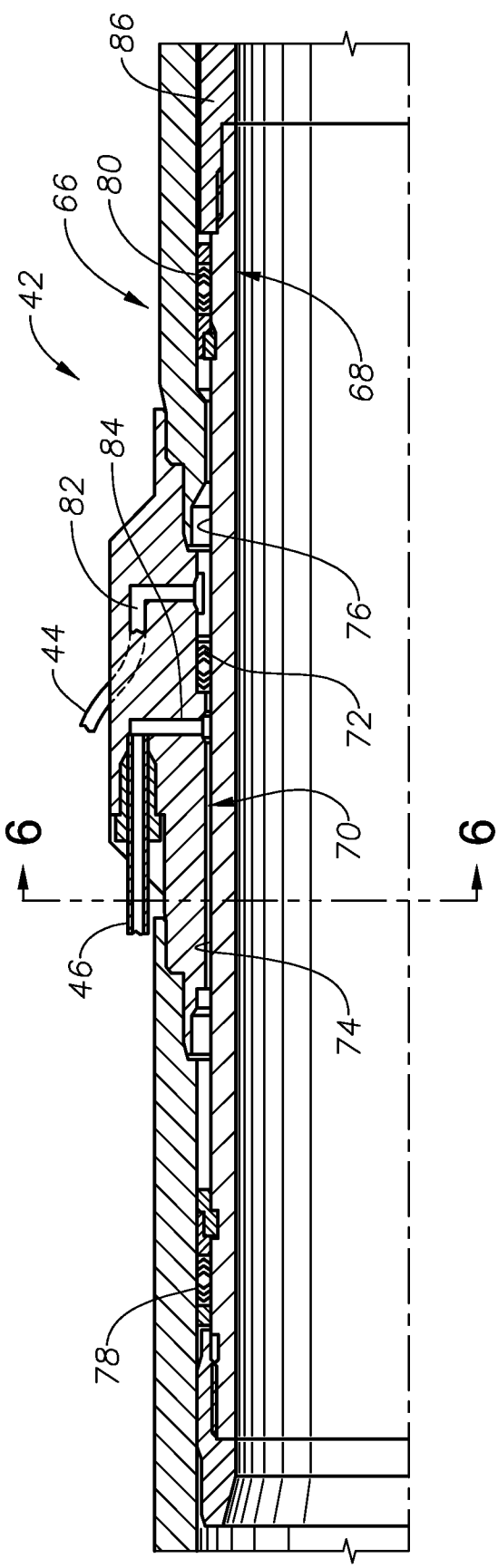


Fig. 4

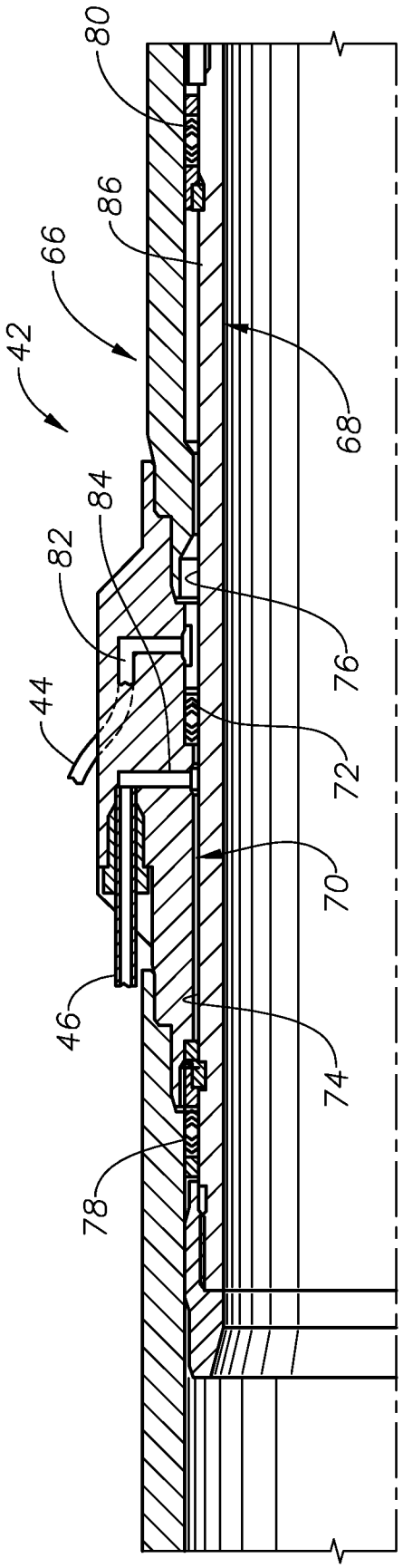


Fig. 5

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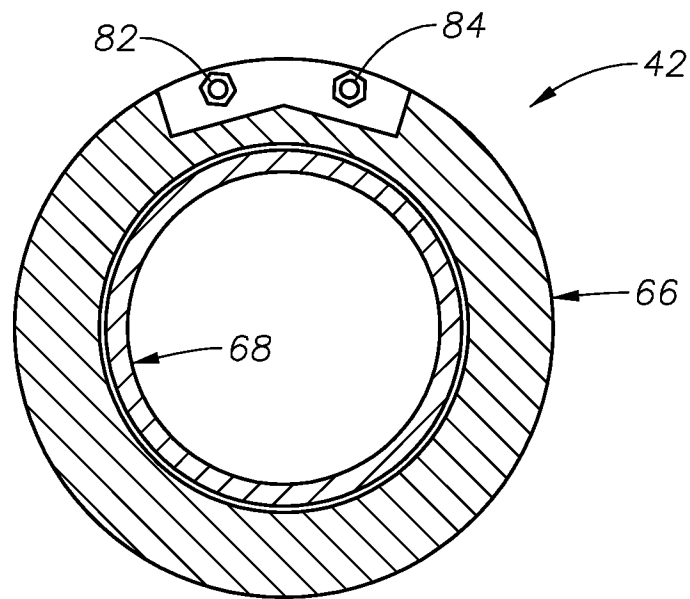


Fig. 6

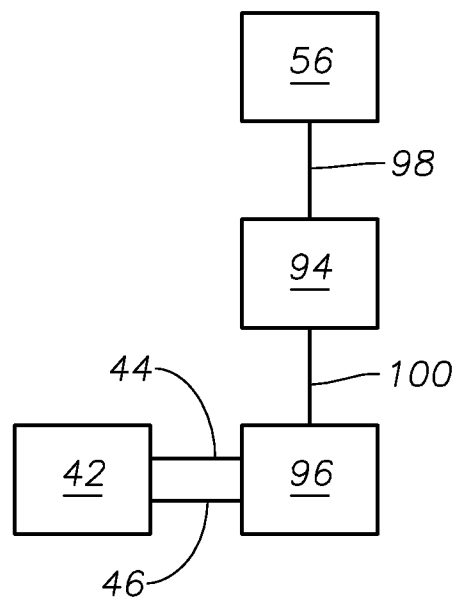
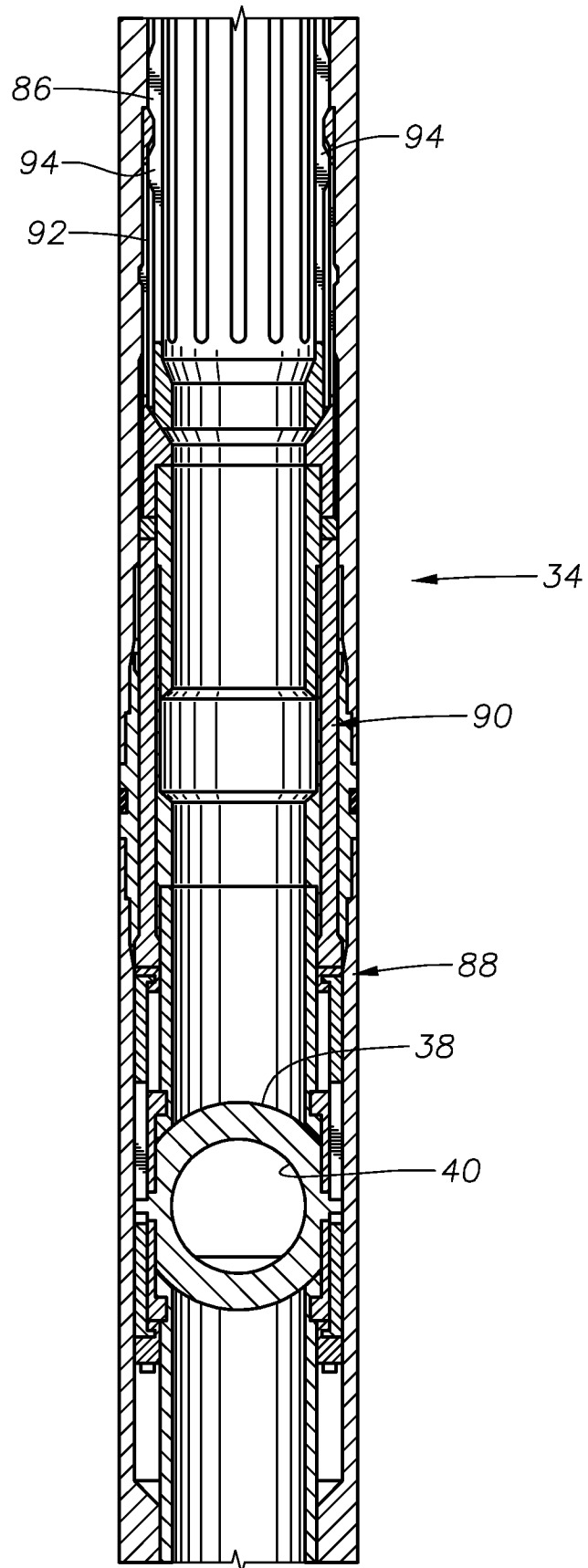


Fig. 9

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Fig. 7



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Fig. 8

