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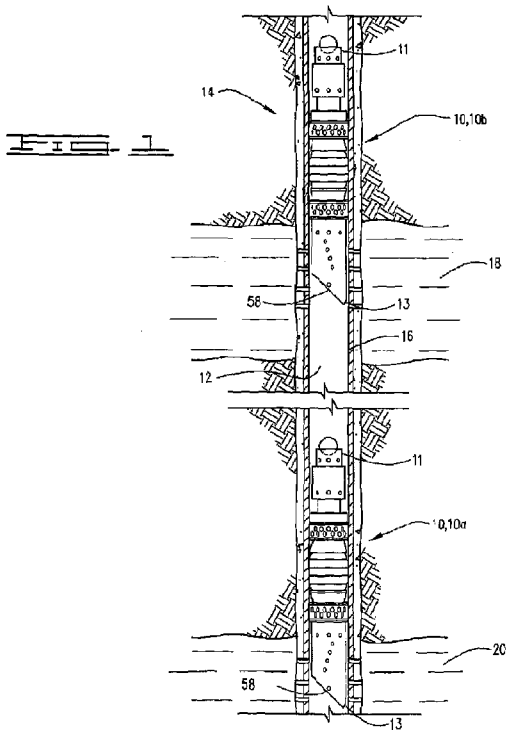
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(54) Title: CONVERTIBLE DOWNHOLE ISOLATION PLUG



(57) Abstract: A downhole tool that is capable of isolating communication pressure from below the set downhole tool, and is capable of being converted to a frac plug is provided. The downhole tool includes a packer with a ball seat defined therein. A plug is disposed at a lower end of the downhole tool to isolate the upper well from the lower well. A sealing ball is carried with the packer into the well by a setting tool. The movement of the sealing ball away from the ball seat is limited by isolation of the sealing ball from the lower well. A rod is disposed through the downhole tool contacting the plug. The rod is partially disposed in the ball seat, preventing the sealing ball from sealing. When the packer is set, flow within the well is isolated, thereby allowing treatment of the well above the packer. With the application of sufficient pressure, the sealing ball applies force to the rod which shears the plug from within the tool. The tool is converted to a standard frac plug.

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CONVERTIBLE DOWNHOLE ISOLATION PLUG

[0001] This disclosure relates to downhole tools for use in oil and gas wellbores and to methods for treating wellbores. This disclosure particularly relates to downhole packers that are convertible from a bridge plug to a frac plug without removing the packer from the wellbore.

[0002] In the drilling or reworking of oil wells, numerous varieties of downhole tools are used. For example, but not by way of limitation, it is often desirable to seal tubing or other pipe in a well casing when it is desired to pump cement or other slurry down the tubing and force the slurry out into a formation. Thus, it becomes necessary to seal the tubing with respect to the well casing, and to prevent the fluid pressure of the slurry from lifting the tubing out of the well. Downhole tools, referred to as packers and bridge plugs, are designed to provide for the ability to seal tubing or other pipe in the well casing, and are well known in the art of producing oil and gas.

[0003] Packers and bridge plugs typically make use of metallic or non-metallic slip elements, or slips. The slips are initially retained in close proximity to the mandrel, but are subsequently forced outwardly away from the mandrel to engage a casing that was previously installed within the wellbore. Thus, when the tool is positioned at the desired depth, the slips are forced outward against the wellbore to secure the packer, or bridge plug, so the tool will not move relative to the casing during operations. Some non-limiting example operations include testing, stimulating production of the well, or plugging all or a portion of the well.

[0004] One problem encountered by well operators using packers and bridge plugs is that the packer and/or plug must be removed prior to the installation of other types of plugs. A frac plug is a good example. A frac plug is essentially a downhole packer with a ball seat for receiving a sealing ball. When the packer is set and the sealing ball engages the ball seat, the casing, or other pipe in which the frac plug is set, is sealed. Once the sealing ball is set, the operator is able to pump fluid into the well, and pumped fluid may be forced into a formation above the frac plug. Often, it is necessary to completely block flow from a lower zone to facilitate treatment of an upper zone, or conduct some other process in the upper zone. After the initial treatment or other process is complete, it may be desirable to allow flow from the

lower zone, and to be able to restrict that flow. There is a need for tools that can be set in the well to act as a bridge plug, and can be converted to a frac plug while in the well.

SUMMARY

[0005] One disclosed embodiment is a downhole tool for use in a well. The downhole tool comprises a mandrel defining a central flow passage therethrough and a ball seat thereon. A sealing element is disposed about the mandrel. The downhole tool is movable from an unset to a set position in the well in which the sealing element engages the well. A solid plug for blocking flow through the downhole tool is removably connected in the mandrel. A sealing ball is positioned in the well and is longitudinally spaced from the ball seat. The application of a predetermined pressure in the well will simultaneously remove the solid plug and move the sealing ball into engagement with the ball seat.

[0006] Another embodiment provides a downhole tool for use in a well. The downhole tool comprises a mandrel having an upper and a lower end. The mandrel defines a longitudinal central flow passage therethrough. The mandrel also defines a ball seat on the upper end thereof. A sealing element is disposed about the mandrel for sealingly engaging the well. A plug is detachably retained within the mandrel and a rod is disposed within the longitudinal central flow passage. The rod has a first end contacting the plug, and a second end contacting a sealing ball to space the sealing ball from the ball seat.

[0007] Another embodiment provides a method for converting a downhole tool positioned in a well from a bridge plug to a frac plug. The method comprises lowering the downhole tool into the well. The downhole tool defines a longitudinal central flow passage therethrough. The method further includes the step of setting the downhole tool in the well, where the downhole tool engages the well. Flow through the tool is blocked in both an upward and a downward direction through the longitudinal central flow passage with a solid plug detachably connected to the tool. A sealing ball is positioned in the well above the longitudinal central flow passage. Pressure is increased in the well, thereby causing the solid plug to detach from the downhole tool and move the sealing ball into engagement with a ball seat that is positioned on the downhole tool. When the sealing ball is in engagement with the ball seat, downward flow through the downhole tool is prevented but upward flow therethrough is permitted.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 schematically shows two downhole tools positioned in a well.

[0009] FIG. 2 is a cross-sectional view of the downhole tool in an unset position.

[00010] FIG. 3 is a cross-sectional view of the downhole tool in a set position.

[00011] FIG. 4 is a cross-sectional view of the downhole tool with the plug detached.

DETAILED DESCRIPTION

[00012] In the description that follows, similar parts are marked throughout the specification and drawings with the same reference numerals, respectively. The drawings are not necessarily to scale, and the proportions of certain parts have been exaggerated to better illustrate details and features of the invention. In the following description, the terms "upper," "upward," "lower," "below," "downhole" and the like as used herein shall mean in relation to the bottom or furthest extent of the surrounding wellbore. This applies even though the well or portions of it may be deviated or horizontal. The terms "inwardly" and "outwardly" are directions toward and away from, respectively, the geometric center of a referenced object. Where components of relatively well-known designs are employed, their structure and operation will not be described in detail.

[00013] Referring to the drawings, and in particular FIG. 1, the downhole tool of the present invention is shown and designated by the numeral 10. Downhole tool 10 has an upper end 11 and a lower end 13. In FIG. 1, two downhole tools 10 are shown, and may be referred to herein as lower downhole tool 10a and second or upper downhole tool 10b. Downhole tools 10a and 10b may be identical, and the subscripts a and b are used to designate simply that the tools are at different positions in the well.

[00014] FIG. 1 schematically depicts downhole tools 10 in set positions in well 14, which is comprised of wellbore 12 with a casing 16 cemented therein. Well 14 may intersect one or more formations or zones, such as first zone 18 and second zone 20. Downhole tools 10 are shown after being lowered into well 14 with a setting tool 22. Setting tool 22 may be any type known in the art. One example of setting tool 22 is depicted in FIG. 2.

[00015] Referring to FIG. 2, a cross-section of downhole tool 10 is shown with setting tool 22 attached thereto for running downhole tool 10 into well 14. Downhole tool 10 is in an unset position in FIG. 2. Downhole tool 10 is commonly referred to as a packer, and herein is referred to as packer 24. Packer 24 comprises mandrel 26 with first, or upper end 28, and second, or lower end 30. Mandrel 26 defines longitudinal central flow passage 32 to allow fluid communication therethrough. Mandrel 26 defines ball seat 34 on the upper end 28 thereof. Ball seat 34 has a lower end 33 positioned where ball seat 34 flows into longitudinal central flow passage 32. Sealing ball 35 is positioned between setting tool 22 and ball seat 34 and is spaced from ball seat 34. Sealing ball 35 may be referred to as frac ball 35.

[00016] Packer 24 is designed to be set in well 14. Thus, mandrel 26 has sealing element 36 disposed thereabout. A spacer ring 38 is secured to mandrel 26 with pins 40. Spacer ring 38 provides an abutment which serves to axially retain slip segments 42, which are positioned circumferentially about mandrel 26. Slip segments 42 may utilize ceramic buttons 44 as described in detail in U.S. Pat. No. 5,984,007, which is incorporated by reference herein. Slip retaining bands 46 serve to radially retain slip segments 42 in an initial circumferential position about mandrel 26. Slip retaining bands 46 may be made of a steel wire, a plastic material, or a composite material having the requisite characteristics of sufficient strength to hold the slip segments 42 in place prior to setting downhole tool 10, and are drillable. Preferably, slip retaining bands 46 are inexpensive and easily installed about slip segments 42. Slip wedge 48 is initially positioned in a slidable relationship to, and partially underneath, slip segment 42. Slip wedge 48 is shown pinned into place by pins 50. Located below the upper slip wedge 48 is at least one sealing element 36. The embodiment of FIG. 2 has a packer element assembly 52 consisting of three expandable sealing, or packer elements 36 disposed about mandrel 26. Packer shoes 56 are disposed at the upper and lower ends of packer element assembly 52 and provide axial support thereto. The particular packer seal or element arrangement shown in FIG. 2 is merely representative, as there are several packer element arrangements known and used within the art.

[00017] Located below a lower slip wedge 48 are a plurality of slip segments 42. A mule shoe 58 is secured to mandrel 26 by radially oriented pins and/or epoxy glue 60. Mule shoe 58 extends below the lower end 30 of mandrel 26 and has a lower end 62, which comprises lower end 13 of downhole tool 10. The lowermost portion of downhole tool 10 need not be a

mule shoe 58, but could be any type of section, which serves to terminate the structure of downhole tool 10, or serves as a connector for connecting downhole tool 10 with other tools, a valve, tubing or other downhole equipment.

[00018] Referring back to FIG. 2, mandrel 26 has a recess 66 positioned at or near lower end 30 thereof. Longitudinal central flow passage 32 has first inner diameter 68 and second inner diameter 70 which defines recess 66. Second inner diameter 70 is thus greater than first inner diameter 68. Recess 66 also defines a shoulder 72. A solid plug 74 is removably disposed in mandrel 26, preferably in recess 66. Plug 74 is detachably connected to mandrel 26 with a shear pin 76 or other retention method. Plug 74 has a receptacle 78 in an upper end 80 thereof. Plug 74 has O-ring 82 to sealingly engage recess 66.

[00019] A rod 84 having upper end 86 and lower end 88 is disposed in longitudinal central flow passage 32. Lower end 88 engages solid plug 74, and is received in receptacle 78, making contact therewith. Upper end 86 extends beyond lower end 33 of ball seat 34 to space ball seat 34 from sealing ball 35 and to prevent sealing ball 35 from prematurely seating in ball seat 34. In an alternative embodiment, receptacle 78 is not utilized, and rod 84 simply contacts upper end 80 of plug 74.

[00020] The operation of downhole tool 10 is as follows. Downhole tool 10 is lowered into wellbore 12 with setting tool 22, which is a setting tool of a type known in the art. As downhole tool 10 is lowered into wellbore 12, flow through longitudinal central flow passageway 32 will be prevented due to solid plug 74. Sealing ball 35 is positioned and spaced from ball seat 34 by rod 84. Once downhole tool 10 has been lowered to a desired position in well 14, setting tool 22 is utilized to move downhole tool 10 from its unset position to the set position, as depicted in FIGS. 2 and 3, respectively. A setting sleeve (not shown) will engage spacer ring 38, so that as setting tool 22 moves upwardly, spacer ring 38 is held in place. Once set, all upward and downward fluid communication from above and below plug 74 is prevented. Tool 10 thus acts as a bridge plug to prevent flow in the well. Tool 10 may be set in the well above a previously perforated and fractured zone, for example, second zone 20 in FIG. 1. A zone thereabove, for example, first zone 18, may be fractured, and tool 10a, acting as a bridge plug, prevents fluid from zone 20 from passing upwardly, and likewise prevents fluid pressure from above tool 10a from acting on zone 20.

[00021] To convert downhole tool 10, plug 74 is removed from mandrel 26. Removing plug 74 requires the exertion of a predetermined pressure to create a sufficient force upon plug 74 to detach or remove plug 74. In one embodiment, plug 74 is retained with shear pin 76 and the predetermined pressure force will shear pin 76. The fluid pressure required to remove plug 74 will be less than the pressure used to fracture a zone thereabove, so that tool 10 automatically converts to a frac plug upon the fracturing of a zone thereabove. The shearing of shear pin 76 allows plug 74 and rod 84 to fall through well 14. Upon the detaching of plug 74, tool 10 performs as a standard frac plug where sealing ball 35 seats and unseats from ball seat 34 according to the pressure of communicated fluid from above. Removing solid plug 74 and contacting sealing ball 35 with ball seat 34 is simultaneous in the described embodiment.

[00022] Using FIG. 1 for exemplary purposes, first tool 10a may be lowered into well 14 and set above formation 20, which will have been perforated and fractured prior to setting tool 10a in well 14. Pressure may be increased to fracture zone 18 thereabove. When initially set in well 14 tool 10 will act as a bridge plug to prevent flow upwardly through the tool from formation 20. The fracture pressure will be greater than that required to move or disconnect plug 74 from mandrel 26 in tool 10a so that the application of the fracturing pressure will automatically convert tool 10a into a frac plug. Conversion simply results from the increased pressure which will act upon plug 74 to remove it therefrom and simultaneously move sealing ball 35 into engagement with seat 34. Fracturing thus continues in the normal manner. Once zone 18 has been fractured, pressure may be relieved and fluid from zones 20 and 18 may pass upwardly to the surface. Thus, tool 10a acts simply as a frac plug. If desired, the process may be repeated such that a second tool referred to in FIG. 1 as tool 10b may be set in the well above zone 18 and the process described herein repeated. The process can be repeated as many times as desired in a well. Thus, as described herein, the tool 10 may be converted from a bridge plug to a frac plug while in the well to effectively prevent communication from a lower zone into an upper zone and vice versa until fracturing is complete. The automatic conversion to the frac plug will allow all zones to communicate to the surface once all fracturing has been completed.

[00023] Thus, it is seen that the apparatus and methods of the present invention readily achieve the ends and advantages mentioned as well as those inherent therein. While certain

preferred embodiments of the invention have been illustrated and described for purposes of the present disclosure, numerous changes in the arrangement and construction of parts and steps may be made by those skilled in the art, which changes are encompassed within the scope and spirit of the present invention as defined by the appended claims.

CLAIMS:

1. A downhole tool for use in a well comprising:

a mandrel defining a central flow passage and a ball seat;

a sealing element disposed about the mandrel and movable from an unset to a set position in the well;

a plug detachably disposed in the mandrel for completely preventing flow through the central flow passage; and

a sealing ball longitudinally spaced from the ball seat, wherein application of a predetermined pressure in the well will detach the plug from the mandrel and move the sealing ball into engagement with the ball seat.

2. A downhole tool according to claim 1, further comprising a rod disposed in the mandrel, wherein the rod engages the sealing ball to space the sealing ball from the ball seat until the plug is detached.

3. A downhole tool according to claim 1, the plug having a rod extending therefrom to engage the sealing ball and space the sealing ball from the ball seat.

4. A downhole tool according to claim 1, wherein the tool comprises a bridge plug prior to detachment of the plug from the mandrel, and a frac plug after detachment.

5. A downhole tool for use in a well, the tool comprising:

a mandrel having an upper and a lower end, the mandrel defining a longitudinal central flow passage therethrough, wherein the mandrel defines a ball seat on the upper end thereof;

a sealing element disposed about the mandrel for sealingly engaging the well;

a plug detachably retained in the mandrel; and

a rod disposed in the longitudinal central flow passage, the rod having first and second ends, the first end contacting the plug and extending therefrom in the longitudinal flow passage.

6. A downhole tool according to claim 5, further comprising a sealing ball spaced apart from the ball seat.

7. A downhole tool according to claim 6, wherein a second end of the rod engages the sealing ball to space the sealing ball from the ball seat and to prevent the sealing ball from engaging the ball seat until a pressure of a predetermined amount is applied in the well.

8. A downhole tool according to claim 7, wherein the predetermined pressure is sufficient to detach the plug from the mandrel.

9. A downhole tool according to claim 7, wherein the plug is detached and removed from the mandrel and the ball moved into engagement with the ball seat upon the application of the predetermined pressure in the well.

10. A downhole tool according to claim 7, wherein the tool converts from a bridge plug to a frac plug in the well upon detachment of the plug from the mandrel.

11. A downhole tool according to claim 5, wherein the downhole tool is movable from an unset to a set position in the well.

12. A method for converting a downhole tool from a bridge plug to a frac plug comprising:

lowering the downhole tool into the well, the downhole tool defining a longitudinal central flow passage therethrough;

blocking flow in both an upward and a downward direction through the longitudinal central flow passage with a solid plug disposed therein;

setting the downhole tool in the well so that the downhole tool sealingly engages the well;

positioning a sealing ball in the well above the longitudinal central flow passage;

increasing a pressure in the well to a predetermined pressure to remove the solid plug; and

contacting a ball seat on the downhole tool with the sealing ball, the sealing ball preventing flow in the downward direction through the longitudinal central flow passage.

13. A method according to claim 12, further comprising the step of perforating the well above the tool prior to the step of increasing the pressure in the well to the predetermined pressure.

14. A method according to claim 12, further comprising the step of fracturing a zone above the tool after the step of contacting the ball seat with the sealing ball.

15. A method according to claim 12, further comprising spacing the ball from the ball seat with a rod that engages the solid plug.

16. A method of fracturing a plurality of zones in a well comprising:

(a) fracturing a first zone in the well;

(b) lowering a bridge plug into the well, the bridge plug comprising a mandrel with a sealing element disposed thereabout and a solid plug disposed therein, the mandrel defining a longitudinal flow passage therethrough;

(c) placing a sealing ball in the well prior to setting the bridge plug in the well;

(d) spacing the sealing ball from the longitudinal flow passage;

(e) setting the bridge plug in the well above the first fractured zone;

(f) simultaneously detaching the solid plug and moving the sealing ball into engagement with the ball seat to convert the bridge plug to a frac plug; and

(g) fracturing a second zone above the tool.

17. A method according to claim 16, where the simultaneous detaching and moving step comprises increasing pressure in the well above the bridge plug.

18. A method according to claim 16, further comprising decreasing pressure in the well to allow fluid from the first zone to pass upwardly through the longitudinal flow passage.

19. A method according to claim 16, further comprising:

repeating steps (a) - (e) above the second fractured zone with a second bridge plug;

simultaneously detaching the solid plug and moving the sealing ball of the second bridge plug into engagement with the ball seat of the second bridge plug to convert the second bridge plug to a second frac plug; and

fracturing a third zone above the second frac plug.

20. A method according to claim 19, further comprising decreasing pressure in the well after fracturing the third zone so that fluid from the first, second and third fractured zones may pass upwardly in the well.

21. A method of converting a downhole tool from a bridge plug to a frac plug in the well comprising:

lowering a mandrel having an upper and lower end into the well, the mandrel defining a longitudinal central flow passage therethrough and a ball seat on the upper end thereof, the mandrel having a solid plug connected therein for blocking flow therethrough;

positioning a frac ball in the well spaced from the ball seat; and

simultaneously detaching the solid plug from the mandrel and moving the sealing ball into engagement with the seat, so that flow downwardly through the longitudinal central passage is prevented and upward flow therethrough is allowed.

22. A method according to claim 21, further comprising:

positioning a rod in the longitudinal flow passage; and

spacing the sealing ball from the seat with the rod prior to detaching the plug from the mandrel.

23. A method according to claim 22, wherein the rod engages the solid plug and the sealing ball.

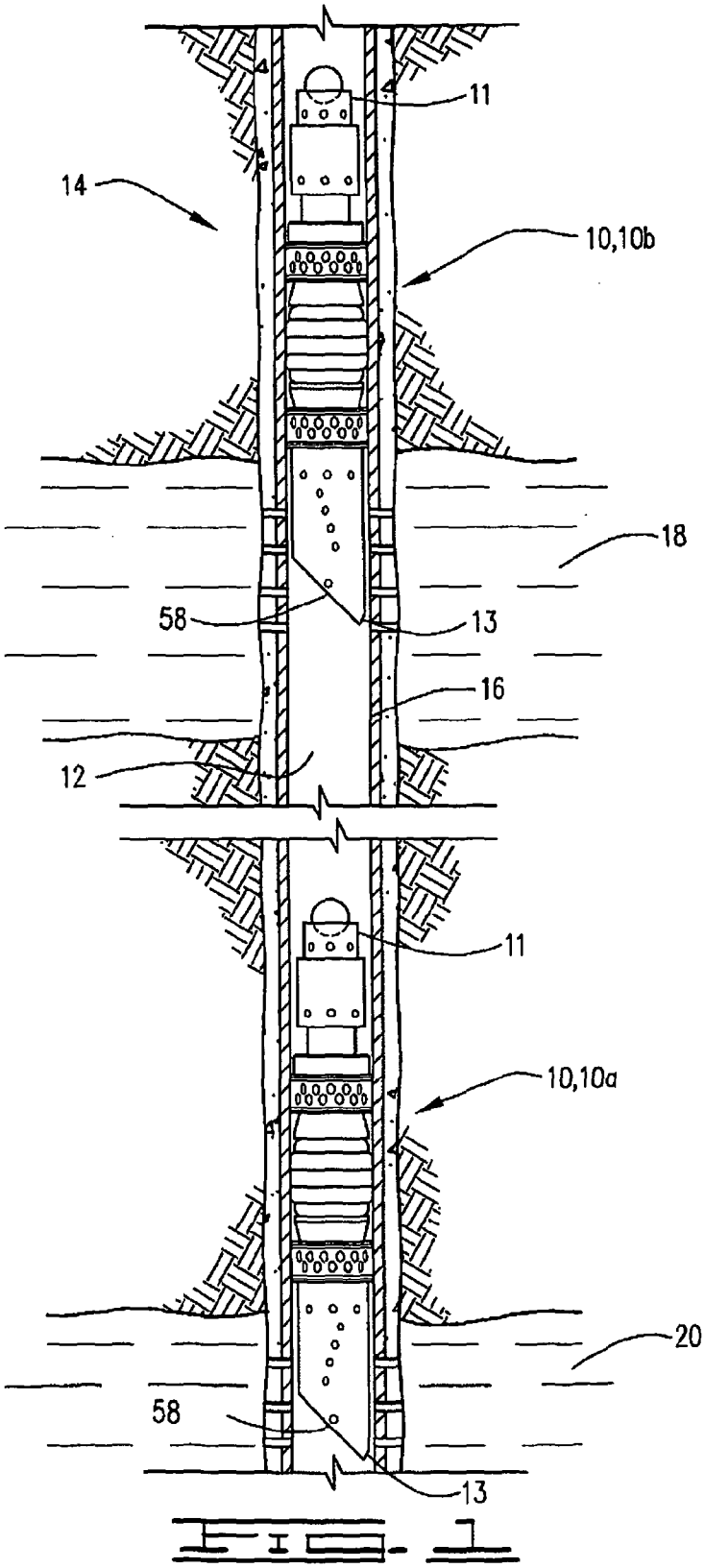


FIG. 1

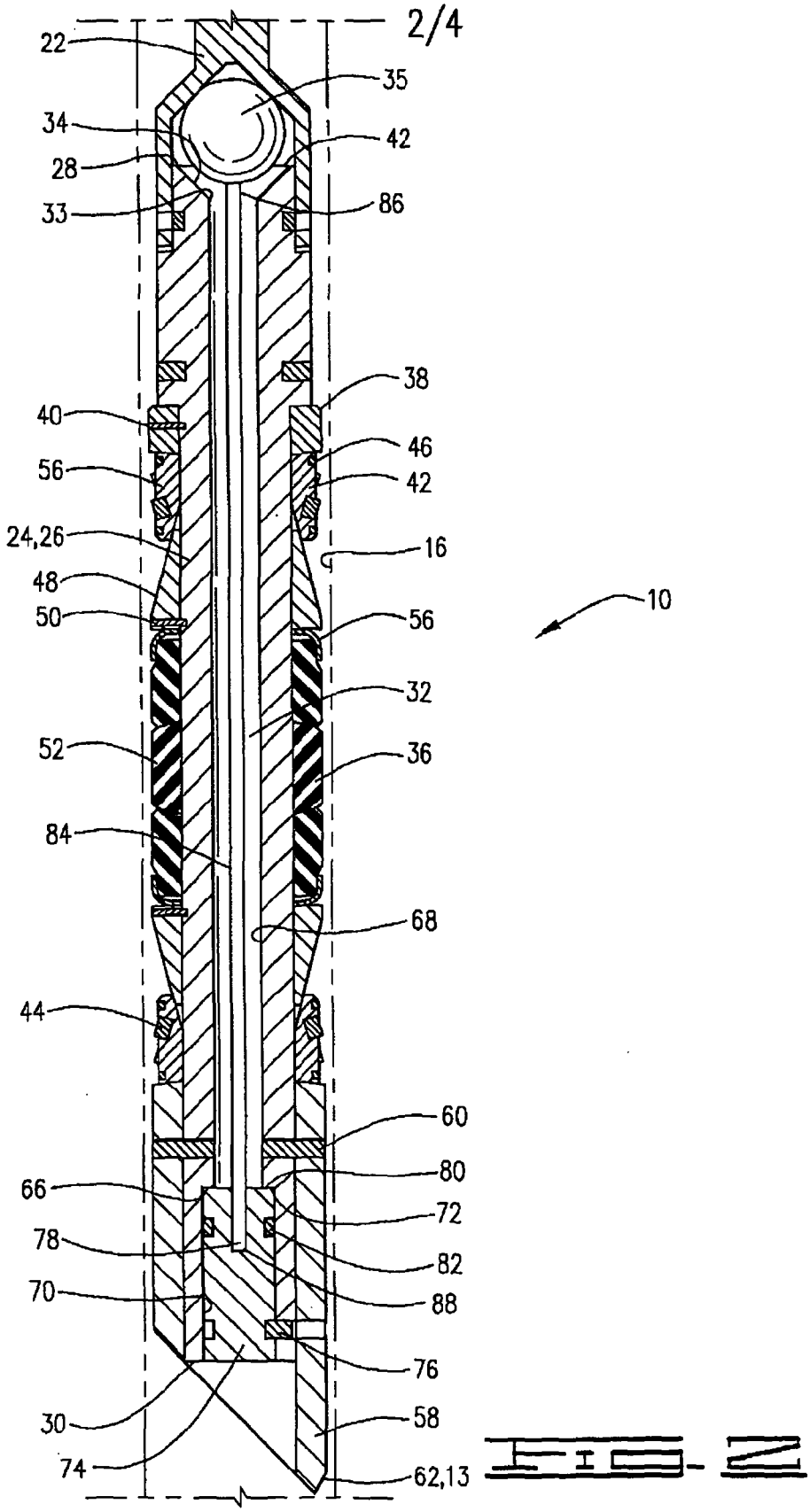
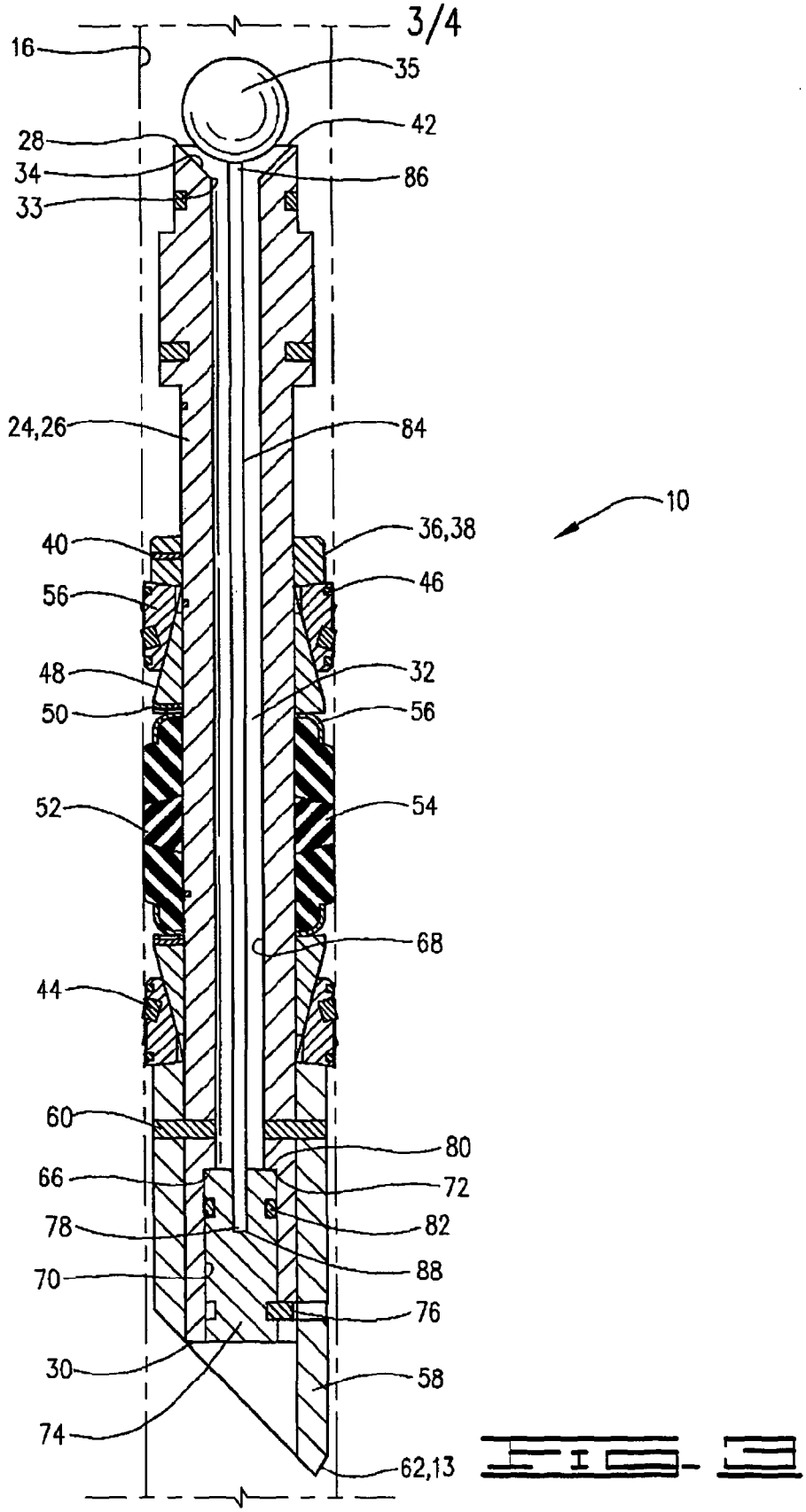

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FIG. 2


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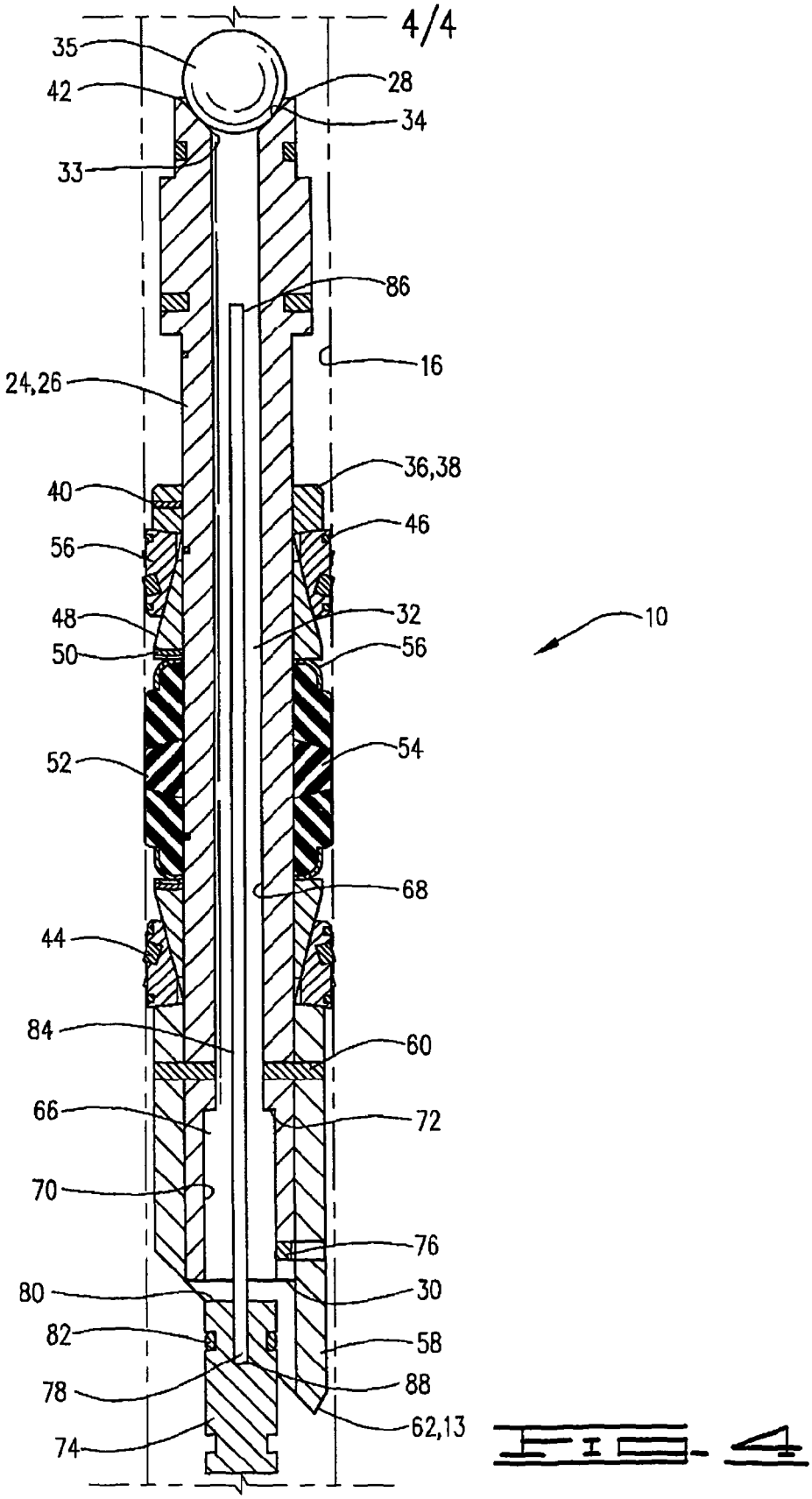

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FIG. 4