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(54) Title: LINER HANGER

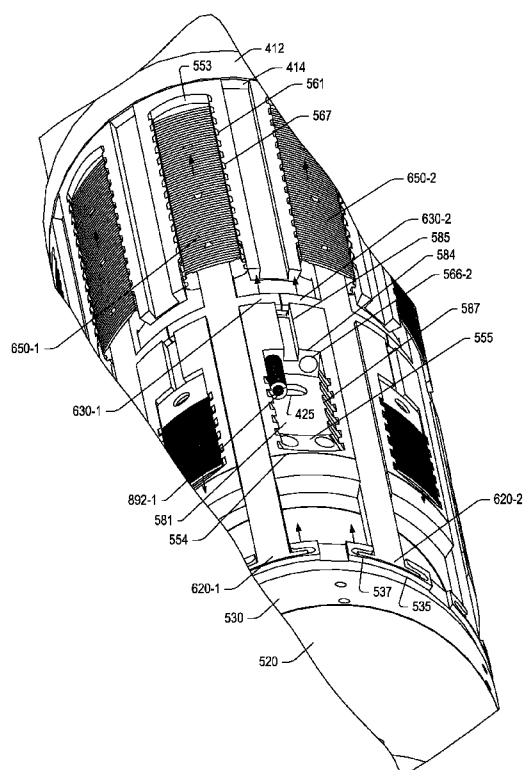


Fig. 7

(57) Abstract: A liner hanger can include a first set of slips; a second set of slips; a first actuation mechanism for actuation of the first set of slips; and a second actuation mechanism for actuation of the second set of slips where the first set of slips, in an unactuated state, prevent actuation of the second set of slips via the second actuation mechanism.



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LINER HANGER

RELATED APPLICATION

[0001] This application claims the benefit of and priority to a US Provisional Patent Application having Serial No. 62/247,888, filed 29 October 2015, which is incorporated by reference herein.

BACKGROUND

[0002] A liner hanger can be utilized to attach or hang one or more liners from an internal wall of a casing.

SUMMARY

[0003] A liner hanger can include a first set of slips; a second set of slips; a first actuation mechanism for actuation of the first set of slips; and a second actuation mechanism for actuation of the second set of slips where the first set of slips, in an unactuated state, prevent actuation of the second set of slips via the second actuation mechanism. A method can include axially translating a first set of slips of a liner hanger to transition a second set of slips of the liner hanger to an actuatable state; and actuating the second set of slips. Various other apparatuses, systems, methods, etc., are also disclosed.

[0004] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Features and advantages of the described implementations can be more readily understood by reference to the following description taken in conjunction with the accompanying drawings.

[0006] Fig. 1 illustrates examples of an environment, equipment and an assembly;

[0007] Fig. 2 illustrates an example of an assembly;

[0008] Fig. 3 illustrates an example a liner hanger;

[0009] Fig. 4 illustrates cross-sectional views of the liner hanger of Fig. 3;

- [0010]** Fig. 5 illustrates an example of a slip of a liner hanger;
- [0011]** Fig. 6 illustrates an example of a slip of a liner hanger;
- [0012]** Fig. 7 illustrates an example of the liner hanger of Fig. 3;
- [0013]** Fig. 8 illustrates cross-sectional views of the liner hanger of Fig. 3 in an unactuated state as to two sets of slips and in an actuated state as to the two sets of slips;
- [0014]** Fig. 9 illustrates enlarged cross-sectional views of portions of the liner hanger of Fig. 3 in the unactuated state and actuated state as to the two sets of slips; and
- [0015]** Fig. 10 illustrates enlarged cross-sectional views of portions of the liner hanger of Fig. 3 in the unactuated state and actuated state as to the two sets of slips.

DETAILED DESCRIPTION

[0016] The following description includes the best mode presently contemplated for practicing the described implementations. This description is not to be taken in a limiting sense, but rather is made merely for the purpose of describing the general principles of the implementations. The scope of the described implementations should be ascertained with reference to the issued claims.

[0017] A liner may be a string of casing in which the top does not extend to the surface but instead is suspended from inside another casing string. As an example, a liner hanger may be used to attach or hang one or more liners from an internal wall of another casing string.

[0018] As an example, a method may include operating one or more components of a liner hanger system. As an example, a lower completion may be a portion of a well that is at least in part in a production zone or an injection zone. As an example, a liner hanger system may be implemented to perform one or more operations associated with a lower completion, for example, including setting one or more components of a lower completion, etc. As an example, a liner hanger system may anchor one or more components of a lower completion to a production casing string.

[0019] Figs. 1 and 2 show an example of an environment 100, an example of a portion of a completion 101, an example of equipment 120 and examples of assemblies 150 and 250, which may be part of a liner hanger system. As an

example, the equipment 120 may include a rig, a turntable, a pump, drilling equipment, pumping equipment, equipment for deploying an assembly, a part of an assembly, etc. As an example, the equipment 120 may include one or more controllers 122. As an example, a controller may include one or more processors, memory and instructions stored in memory that are executable by a processor, for example, to control one or more pieces of equipment (e.g., motors, pumps, sensors, etc.). As an example, the equipment 120 may be deployed at least in part at a well site and, optionally, in part at a remote site.

[0020] Fig. 1 shows an environment 100 that includes a subterranean formation into which a bore 102 extends where a tool 112 such as, for example, a drill string is disposed in the bore 102. As an example, the bore 102 may be defined in part by an angle (Θ); noting that while the bore 102 is shown as being deviated, it may be vertical (e.g., or include one or more vertical sections along with one or more deviated sections). As shown in an enlarged view with respect to an r, z coordinate system (e.g., a cylindrical coordinate system), a portion of the bore 102 includes casings 104-1 and 104-2 having casing shoes 106-1 and 106-2. As shown, cement annuli 103-1 and 103-2 are disposed between the bore 102 and the casings 104-1 and 104-2. Cement such as the cement annuli 103-1 and 103-2 can support and protect casings such as the casings 104-1 and 104-2 and when cement is disposed throughout various portions of a wellbore such as the wellbore 102, cement may help achieve zonal isolation.

[0021] In the example of Fig. 1, the bore 102 has been drilled in sections or segments beginning with a large diameter section (see, e.g., r_1) followed by an intermediate diameter section (see, e.g., r_2) and a smaller diameter section (see, e.g., r_3). As an example, a large diameter section may be a surface casing section, which may be three or more feet in diameter and extend down several hundred feet to several thousand feet. A surface casing section may aim to prevent washout of loose unconsolidated formations. As to an intermediate casing section, it may aim to isolate and protect high pressure zones, guard against lost circulation zones, etc. As an example, intermediate casing may be set at about 6000 feet (e.g., about 2000 m) and extend lower with one or more intermediate casing portions of decreasing diameter (e.g., in a range from about thirteen to about five inches in diameter). A so-called production casing section may extend below an intermediate casing section

and, upon completion, be the longest running section within a wellbore (e.g., a production casing section may be thousands of feet in length). As an example, production casing may be located in a target zone where the casing is perforated for flow of fluid into a bore of the casing.

[0022] As mentioned, a liner may be a casing (e.g., a completion component). As mentioned, a liner may be installed via a liner hanger system. As an example, a liner hanger system may include various features such as, for example, one or more of the features of the assembly 150 and/or the assembly 250 of Figs. 1 and 2.

[0023] As shown in Fig. 1, the assembly 150 can include a pump down plug 160, a setting ball 162, a handling sub with a junk bonnet and setting tool extension 164, a rotating dog assembly (RDA) 166, an extension(s) 168, a mechanical running tool 172, a hydraulic running tool 174, a hydromechanical running tool 176, a retrievable cementing bushing 180, a slick joint assembly 182 and/or a liner wiper plug 184.

[0024] As shown in Fig. 2, the assembly 250 can include a liner top packer with a polished bore receptacle (PBR) 252, a coupling(s) 254, a mechanical liner hanger 262, a hydraulic liner hanger 264, a hydraulic liner hanger 266, a liner(s) 270, a landing collar with a ball seat 272, a landing collar without a ball seat 274, a float collar 276, a liner joint or joints 278 and/or 280, a float shoe 282 and/or a reamer float shoe 284.

[0025] As an example, a method can include setting a liner hanger, releasing a running tool, cementing a liner and setting a liner top packer. As an example, a method can include pumping heavy fluid (e.g., cement) down an annulus from a point above a liner hanger and a liner top packer. In such an example, stress on a formation may be reduced when compared to a method that pumps heavy fluid (e.g., cement) up such an annulus. For example, stress may be reduced as back pressure developed during pumping may be contained in between a casing and a landing string.

[0026] As an example, a liner hanger can include a hold down slip that aims to prevent a liner from moving up during a cementing operation or, for example, when loading exists due to fluid pressure (e.g., well kicking) of a formation. For deep offshore wells, loading due to well kicking can be substantial.

[0027] As an example, a liner hanger can include multiple sets of hold down components. For example, a liner hanger can include two hold down assemblies

with separate sets of slips and with a corresponding cone where use of the two hold down assemblies can help to handle loading due to fluid pressure.

[0028] As an example, a liner hanger can nest the functionality of liner hanging and hold down with a common cone. In operation, a sequential process can include actuating a first set of hold down slips followed by actuating a second set of hold down slips. In such an example, a liner hanger may be set by actuation of the first set of hold down slips and then further secured by actuating of the second hold down slips. A mechanism or mechanisms of a liner hanger can provide for adherence to such a sequence, for example, one or more mechanisms can provide for actuation of the second set of hold down slips once a first set of hold down slips sets the liner hanger, which may reduce risk of sticking (e.g., getting stuck) while running in a hole.

[0029] Fig. 3 shows an example of a liner hanger 300 that includes a pipe 400, actuation components 500, a first set of slips 600 and a second set of slips 800. As shown, the pipe 400 includes opposing axial ends 402 and 404 where the axial end 402 may be an uphole end and where the axial end 404 may be a downhole end. The pipe 400 also includes a first annular portion 410 and a second annular portion 412 where the second annular portion 412 has an outer diameter that exceeds an outer diameter of the first annular portion 410. The second annular portion 412 has an axial length that, at one end, forms a shoulder that has an axial face 414. Various components of the liner hanger 300 are braced by the axial face 414 of the second annular portion 412 of the pipe 400, which, as mentioned, extends from axial end 402 to axial end 404. As an example, the liner hanger 300 may be oriented substantially aligned with gravity (e.g., in a vertical portion of a borehole) or at an angle with respect to gravity (e.g., in a deviated or horizontal portion of a borehole).

[0030] As shown in the example of Fig. 3, the actuation components 500 includes a first annular ring 510, an annular component 520, a second annular ring 530, a third annular ring 540 and a slip seating sleeve 550. As shown, the slip seating sleeve 550 is axially fixed between the third annular ring 540 and the axial face 414 of the pipe 400. The slip seating sleeve 550 includes various features that seat the first set of slips 600 and various features that seat the second set of slips 800. As shown, the second annular ring 530 is actuatable to cause the first set of slips 600 to translate axially toward the axial face 414 of the pipe 400 for deployment

of the first set of slips 600, which also move radially outwardly to effectively increase the outer diameter of the liner hanger 300 to secure the liner hanger 300 against an inner surface of a conduit (e.g., casing, etc.). As shown in the example of Fig. 3, an annular component 535 is operatively coupled to the second annular ring 530 to contact the first set of slips 600 and force them axially toward the axial face 414 as well as radially outwardly from the pipe 400 (e.g., via bevel-to-bevel contact). Such a coupling may be radially between an outer surface of the pipe 400 and an inner surface of the second annular ring 530. As an example, the second annular ring 530 may move axially such that it engages a surface of the annular component 535 where further axially movement of the second annular ring 530 causes axial movement of the annular component 535.

[0031] As to the second set of slips 800, axial translation of the first set of slips 600 allows the second set of slips 800 to be in an actuatable state. Actuation of the second set of slips 800 can occur via rotation of the pipe 400 with respect to an inner surface of a conduit (e.g., casing, etc.) where such rotation can shear one or more shear components. For example, each slip of the second set of slips 800 can be axially fixed via a shear screw (e.g., or shear bolt) where, after shearing, a biasing mechanism can apply a biasing force to each slip of the second set of slips 800 to cause translation thereof in a direction toward the third annular ring 540 where movement is also radially outwardly to effectively increase the outer diameter of the liner hanger 300 to further secure the liner hanger 300 against an inner surface of a conduit (e.g., casing, etc.).

[0032] Fig. 4 shows a cross-sectional view of the liner hanger 300 and a cross-sectional view of the liner hanger 300 without the first set of slips 600 and without the second set of slips 800 present. As shown, the slip seating sleeve 550 includes various features 560 that seat the first set of slips 600 and various features 580 that seat the second set of slips 800. As shown, the features 560 include a slip recess 561 (e.g., a pocket) and the features 580 include a slip recess 581 (e.g., a pocket) and an extension recess 583.

[0033] As shown in Fig. 4, the pipe 400 can include at least one opening 409 (e.g., a fluid opening) and can include an aperture 425 that can receive a portion of a shear screw 426, which can axially position a slip of the second set of slips 800. The opening 409 (e.g., or openings) can be in fluid communication with fluid in the interior space of the pipe 400 where an increase in fluid pressure in the interior space (e.g.,

lumen) may be part of a fluid pressure driven actuation mechanism (e.g., a hydraulic mechanism, etc.).

[0034] Fig. 4 shows various features of the actuation components 500, includes the annular rings 510, 530 and 540, as well as, the annular component. As shown in Fig. 4, the annular ring 540 is axially fixed to the pipe 400 and the annular ring 540 includes an axial face 542 that seats an axial end 554 of the slip seating sleeve 550. Thus, the slip seating sleeve 550 is axially fixed at one axial end 552 by the axial face 414 of the pipe 400 and is axially fixed at its opposing axial end 554 by the axial face 542 of the annular ring 540. In such an arrangement, the axial face 542 of the annular ring 540 can be an axial face of a “false shoulder” of the pipe 400; whereas, the axial face 414 can be an axial face of a shoulder that is integral to the pipe 400 per the second annular portion 412 of the pipe 400.

[0035] As to actuation of the first set of slips 600, the first annular ring 510 can be axially fixed to the pipe 400 and the annular component 520 can be releasable from the first annular ring 510 such that the annular component 520 can translate in a direction toward the axial face 414 of the pipe 400. In such an example, the second annular ring 530 and the annular component 535 as operatively coupled to the annular component 520 can translate axially and apply force to the first set of slips 600. In particular, the annular component 535 moves toward the annular ring 540, which is axially fixed to the pipe 400, to cause the first set of slips 600 to translate axially toward the axial face 414 of the pipe 400 while the slip seating sleeve 550 remains axially fixed between the axial face 414 and the axial face 542.

[0036] As an example, the first annular ring 510 may be a latching ring that provides an axial stop for positioning of the annular component 520, which is an axially translatable annular component. As an example, the first annular ring 510 and the annular component 520 may be latched with a particular force that is to be overcome via an actuation mechanism (e.g., hydraulic pressure). As an example, the first annular ring 510 can include a lip that is received by a recess of the annular component 520 where a force may be applied to move the annular component 520 to unlatch the lip from the recess.

[0037] Fig. 4 shows various features of the slip seating sleeve 550 as part of the actuation components 500. At the axial end 552, the slip seating sleeve 550 includes a sloped face 553 and, at the axial end 554, the slip seating sleeve 550 includes a slope face 555. The sloped face 553 is an axially fixed feature that directs

a slip of the first set of slips 600 radially outwardly as the slip is forcibly translated axially via movement of the annular component 535. The sloped face 555 is an axially fixed feature that directs a slip of the second set of slips 800 radially outwardly as the slip is forcibly translated axially via a biasing mechanism (e.g., one or more springs). As shown, the sloped face 553 is sloped to have a larger radial dimension proximate to the axial face 414 while the sloped face 555 is sloped to have a larger radial dimension proximate to the axial face 542 of the annular ring 540. In such an example, the first set of slips 600 and the second set of slips 800 both move radially outwardly away from a longitudinal axis of the pipe 400 and move in opposing axial directions.

[0038] Fig. 4 also shows various axial dimensions z_1 , z_2 and z_3 , which correspond to an axial length of the slip seating sleeve 550, an axial distance between the axial end 554 of the slip seating sleeve 550 and the annular component 520 and an axial length of the annular component 520. As to actuation, as the annular component 520 moves axially toward the axial face 414, the axial distance z_2 decreases. Thus, the axial distance z_2 may be a variable distance that depends on the state of the liner hanger 300 where the axial distance z_2 is shorter (smaller) in an actuated state of the liner hanger 300 when compared to an unactuated state of the liner hanger 300.

[0039] Fig. 5 shows a perspective view of a slip 601 of the first set of slips 600. As shown, the slip 601 includes opposing ends 602 and 604 along with a stem portion 610, a cross-member portion 630 and a slip portion 650. Various dimensions are shown, including z_4 , z_5 and z_6 , which correspond to a slip portion length, a stem portion length and a cross-member portion length.

[0040] As shown in Fig. 5, the stem portion 610 includes an extension 620 at the end 604. The extension 620 can be seated with respect to the annular component 535 (see Fig. 4) such that the annular component 535 can apply an axial force to the extension 620. As shown, the extension 620 can include a sloped surface (e.g., beveled surface) and the annular component 535 can include a sloped surface (e.g., beveled surface) such that application of force results in a force vector that has an axial component and a radial component.

[0041] As shown in Fig. 5, the cross-member portion 630 includes an axial face 632 and an axial face 634 and includes recesses 635-1 and 635-2 as well as end faces 636-1 and 636-2. Various dimensions z_7 , r_1 , r_2 , a_1 and a_2 are shown,

which correspond to a recess axial length, a radial thickness, a radial recess depth, an arc length and a recess arc length. As shown, each of the recesses 635-1 and 635-2 includes dimensions that provide for securing a slip of the second set of slips 800. As an example, a slip of the second set of slips 800 may be secured via two of the slips 601 of the first set of slips 600 where, for example, end faces abut or have a small clearance therebetween.

[0042] As shown in Fig. 5, the slip portion 650 includes a series of ridges 655 that are disposed substantially orthogonally to a longitudinal axis of the slip 601 and includes guide channels 657 that are disposed at an angle where the guide channels 657 mate with corresponding guide channels of the slip seating sleeve 550. As shown, a number of ridges 655 exist between a first ridge 652 and a last ridge 654.

[0043] Fig. 6 shows a perspective view of a slip 801 of the second set of slips 800 as seated with respect to a portion of the slip seating sleeve 550 and a side view of the slip 801. As shown, the slip 801 includes opposing ends 802 and 804 along with a stem portion 810 and a slip portion 850. Various dimensions are shown, including z_8 and z_9 , which correspond to a slip portion length and a stem portion length. Also shown are dimensions a_3 and a_4 that correspond to an arc length of the slip portion 850 and an arc length of the stem portion 810.

[0044] As shown, the slip seating sleeve 550 includes the recess 581 that seats the slip portion 810 of the slip 801, a channel 585 that extends from the recess 581 and that seats the stem portion 810 of the slip 801, a sloped surface 555 proximate to the axial end 554 of the slip seating sleeve 550, a recess end surface 584, biasing element seats 586-1 and 586-2 that seat biasing elements 892-1 and 892-2 (e.g., springs) at the recessed end surface 584 and guide channels 587.

[0045] The slip 801 includes an extension 812 with a radial dimension r_3 , a stem junction 814, an opening 851, an axial face 852, a tip 854, a series of ridges 855 and guide channels 857. As shown, the guide channels 857 can mate with the guide channels 587 such that upon release of the stem portion 810 and upon searing of the shear screw 426 as set in the opening 851, the slip 801 can translate axially and move radially outwardly due to applied force by the biasing elements 892-1 and 892-2 against the axial face 852. As an example, the extension 812 can include a sloped surface (e.g., beveled surface).

[0046] Fig. 7 shows a portion of the liner hanger 300 that shows various arrows that indicate directions of axial movement of various components that occur

during actuation of the slips 600 and the slips 800. In the example of Fig. 7, the slip seating sleeve 550 includes a plurality of the recesses 561 where each of the recesses 561 includes guide channels 567 that mate with the guide channels 657 to guide respective slips of the set of slips 600 during actuation (see, e.g., directions of arrows).

[0047] As shown in Fig. 7, at the bottom of the recess 581, the aperture 425 of the pipe 400 can receive a portion of the shear screw 426 as set in the opening 851 of the slip 801. Where the slips 600 are engaged with respect to a conduit (e.g., casing), the pipe 400 can be moved (e.g., rotated) such that shearing occurs of the shear screw 426 such that force applied by the biasing element(s) 892-1 and 892-2 causes the slip 801 to actuate and engage the conduit (e.g., casing).

[0048] As shown in Fig. 7, each of the slips of the set of slips 800 can include a respective shear screw as disposed at least in part in a respective aperture of the pipe 400. In such an example, movement of the pipe 400 with respect to the slip seating sleeve 550, as fixed due at least in part to holding force applied by the first set of slips 600, causes shearing of the shear screws as set in the slips of the second set of slips 800 to release the slips of the second set of slips 800.

[0049] As shown in Fig. 7, the annular component 535 can include a recessed surface 537 (e.g., a beveled surface) that can apply force to the extension 620 of a slip of the first set of slips 600 such that the slip moves axially and radially. Where the annular component 535 moves the first set of slips 600, the cross-member portions 630 also move as shown by cross-member portions 630-1 and 630-2 which then uncover and release respective stem portions of the second set of slips 800. In such an example, the second set of slips 800 are secured by the first set of slips 600 and actuation of the second set of slips 800 cannot occur until the first set of slips 600 have been actuated. Such a mechanism can be a safety mechanism.

[0050] Fig. 8 shows the liner hanger 300 in an unactuated state 1002 and in an actuated state 1004. Various dimensions are shown, including z_{10} , z_{11} and z_{12} , which correspond to an axial distance of movement of the annular component 520 away from the annular ring 510, an axial distance of movement of the first set of slips 600 and an axial distance of movement of the second set of slips 800. As shown, the axial distance of movement of the second set of slips 800 can be independently determined from the axial distance of movement of the first set of slips 600 because the actuation mechanisms are in part decoupled. As mentioned, while the actuation

mechanism of the first set of slips 600 places the second set of slips 800 in an actuatable state, a separate actuation mechanism causes actuation of the second set of slips 800 (e.g., rotation of the pipe 400 with the slip seating sleeve 550 being fixed due to engagement of the first set of slips 600 with an inner surface of a conduit (e.g., casing)).

[0051] In the example of Fig. 8, the annular component 520 can be in contact with the annular ring 530 where the annular ring 530 can be translated axially by the annular component 520 to contact the annular component 535. Once in contact, further axial movement of the annular component 520 can move the annular component 535 to thereby apply force to the first set of slips 600.

[0052] In the example of Fig. 8, after the first set of slips 600 are actuated and moved axially upwardly in the illustration, an actuation mechanism can cause shearing of the shear screw 426 as set in the aperture 425 of the pipe 400 to allow the spring 892 to release at least a portion of its potential energy as kinetic energy to move the second set of slips 800 axially downward in the illustration. As shown, shearing of the shear screw 426 can result in a small amount of debris 427 being retained in the aperture 425, which may be a recess in the outer surface of the pipe 400 that may be of a radial depth that is less than a wall thickness of the pipe 400 at the axial location of the aperture 425.

[0053] Fig. 9 shows enlarged views of portions of the liner hanger 300 in the states 1002 and 1004. As shown, the annular component 520 can translate axially to contact the annular ring 530, which can then translate axially as a first group to contact the annular component 535, which can then translate axially as a second group to cause the extension 620 of the slip 601 of the first set of slips 600 to move axially and radially (see, e.g., the recessed surface 537 in contact with a beveled surface of the extension 620).

[0054] Fig. 10 shows enlarged views of portions of the liner hanger 300 in the states 1002 and 1004. As shown, the cross-member portion 630, as may be attached or integral to the slip 601 of the first set of slips 600, is moved axially upwardly in the illustration upon transition from the state 1002 to the state 1004, which uncovers the end 802 of the slip 801 of the second set of slips 800, which includes a stem portion 810 and a slip portion 850; noting that, as shown in Fig. 7, two cross-member portions 630-1 and 630-2 may cover a portion of a single slip of the second set of slips 800. The cross-member portion 630 may be free to move

radially inwardly or outwardly to some extent (see, e.g., the state 1004 of Fig. 9 where the extension 620 may be supported by the recessed surface 537 yet where some resiliency may exist along the stem portion 610 of the slip 601).

[0055] Upon shearing of the shear screw 426, the slip 801 can move axially downwardly in the illustration as the spring 426 releases a portion of its potential energy as kinetic energy, increasing in its axial length to an extent to force the slip 801 against an inner surface of the 1010 casing. As mentioned, shearing of the shear screw 426 may occur via movement of the pipe 400 where the slip seating sleeve 550 is secured via deployment of the first set of slips 600 against the inner surface of the casing 1010.

[0056] As shown, the extension 812 at or proximate to the end 802 of the slip 801 can move via force applied by the spring 426 from being seated at least in part in the extension recess 583 of the slip seating sleeve 550 to being out of the extension recess 583 (e.g., unseated from the extension recess of the slip seating sleeve 550).

[0057] As an example, various components of a liner hanger can be made of metal or metal alloy, which may be referred to as metallic materials. As an example, one or more components may be made of hardened steel. As an example, biasing elements may be made of metallic materials. As an example, slips may be of a hard material that has a hardness that is greater than a hardness of casing (e.g., for the slips to grip into the casing). As an example, a casing can be made of plain carbon steel that is heat-treated or may be a specially fabricated stainless steel, aluminum, titanium, fiberglass and other material.

[0058] As an example, a liner hanger can include one or more components made of a metallic material such as a carbon steel material. As an example, a material utilized for a liner hanger component may be a chrome alloy (e.g., 9 Cr:1 Mo). As an example, a material utilized for a liner hanger component may be a nickel alloy. As an example, a material utilized for a liner hanger component may be MONEL™ alloy, an INCONEL™ alloy, (e.g., INCONEL™ 718, etc.), etc. For example, consider an age hardenable nickel-iron-chromium alloy.

[0059] As an example, an amount of axial movement of the first set of slips 600 may differ from an amount of axial movement of the second set of slips 800. As an example, a liner hanger can include two actuation mechanisms, one for a first set of slips and one for a second set of slips. In such an example, actuation of the

mechanisms may be serially where the first actuation mechanism after actuation places the second actuation mechanism in an actuatable state.

[0060] As an example, the slip seating sleeve 500 may be referred to as a cone. As an example, a liner hanger can include a single cone which houses both the liner hanger slips as a first set of slips and hold down slips as a second set of slips.

[0061] As an example, an actuation mechanism may be hydraulic and/or mechanical. As an example, a liner hanger can include multiple actuation mechanisms where such mechanisms may be of a common principle or of differing principles (e.g., one hydraulic and one mechanical). As an example, one or more actuation mechanisms may be setting mechanisms that act to set a liner hanger.

[0062] As an example, as to a hydraulic actuation mechanism, pressure can be increased to the pipe 400 (e.g., a liner hanger body), thereby increasing the pressure in the annular component 520 that can act as a hydraulic cylinder, causing shear screws that constrain the annular component 520 to the first annular ring 510 (e.g., a gage ring) to shear, resulting in movement of the annular component 520 relative to the pipe 400. The relative movement causes the second annular ring 530 (e.g., a push ring) and the recessed surface 537 (e.g., a beveled surface) to apply force to the set of slips 600 (e.g., via each extension 620) such that the set of slips 600 move to bite the inner surface of the casing 1010.

[0063] As to a mechanical example of setting a liner hanger, such an approach may be implemented optionally without pressure build-up. For example, a liner hanger can be set using mechanical manipulation of a string.

[0064] As shown in Fig. 5, the slip 601 can include a feature that projects outwardly circumferentially to form a cross shape (see the cross-member portion 630). As shown in Fig. 6, the slip 801 can be designed like a cantilever with a lock in one end (see the extension 812) which may include an approximately 45 degree bevel on it. As an example, a hold down when assembled, can have the lock end sitting in a pocket (e.g., an extension recess) milled in a cone (e.g., a slip seating sleeve). As an example, a cross portion of a hanger slip can be sitting right on top of the hold down lock arm region to thereby prevent movement of the hold down slip before the hanger slips have set.

[0065] As an example, a cone can include two holes on a hold down side to seat two springs per hold down slip. Such holes may be spade drilled holes that can

seat springs that store potential energy to set the hold down slips and keep the hold down slips engaged with an inner surface of conduit (e.g., casing). The hold down slips can be selectably fixed to the slip seating sleeve via shear screws which retain those slips in the run position until they are sheared in rotation, which is prevented without the hanger slips first being engaged with an inner surface of conduit (e.g., casing). As an example, a shear rating may be selected to be less than about 50 percent of a specified connection torque.

[0066] As an example, as to deployment, after a desired depth has been reached and the liner hanger setting process has been initiated, relative movement of an annular component with respect to a pipe causes a first set of slips to move axially with respect to a slip seating sleeve. The axial movement of the slips, along with their cross portions, exposes hold down locks of a second set of slips. Due to this movement, the first set of slips (liner hanger slips) are no longer constraining movement of the second set of slips (hold down slips).

[0067] After the first set of slips (liner hanger slips) are set and the weight has been slacked off, the pipe can be rotated with respect to the slip seating sleeve (e.g., cone). The applied torque may be gradually increased until shearing of screws occurs. This shearing event causes the stored spring energy to release, which causes the second set of slips (hold down slips) to move and engage (e.g., to bite) an inner surface of a conduit (e.g., casing). The slip seating sleeve can be constrained at an end via a "false" shoulder" (e.g., of a liner hanger body) as formed by the third annular ring 540. In such an example, the second set of slips (hold down slips) are set mechanically, which removes the possibility of using a hydraulic cylinder for the hold down slips and a set of elastomeric seals to prevent a leak path which could possibly induce a failure mode.

[0068] As an example, a slip may be a single piece or a multi-piece slip. For example, a liner hanger slip and a cross-member can be manufactured as a single part or can be made as at least two parts and be welded or fastened together. As an example, die springs may be utilized for hold down slip deployment, for example, to store potential energy with a relatively small size factor and relatively high loading capability.

[0069] As an example, a liner hanger can include a hold down setting mechanism that is mechanical and features that are nested in a way that hold down slips cannot prematurely set before the hanger slips have been set. In such an

example, rotation shear features can help in setting the hold down slips, as may be desired depending on one or more factors. As an example, after setting a liner hanger via a first set of slips, if an operator senses some problem with a string, the operator may pull the string out of the hole because a second set of slips (hold down slips) do not set simultaneously with the first set of slips (hanger slips). If a hanger liner is set prematurely by a first set of slips (hanger slips), for example, due to pressure spikes, an operator can reverse pressure in an annulus and send the slips of the first set of slips back in to their pockets (e.g., recesses) and continue progressing in a downhole direction.

[0070] As an example, a liner hanger can include a single cone that houses liner hanger slips and hold down slips. In such an example, the cone can include features to house biasing elements (e.g., one or more springs per hold down slip) that store potential energy to set the hold down slips and keep them engaged. As an example, a liner hanger slip can include a cross shaped feature that functions as a lock to secure one or more hold down slips from setting before the liner hanger slips are set. As an example, a hold down slip can include a stem portion as a cantilever flexible arm that includes a lock feature (e.g., at an end) that locks the hold down slip to a cone (e.g., slip seating sleeve).

[0071] As an example, liner hanger slips can be arranged about the circumference of a cone (e.g., a slip seating sleeve) in such manner that terminal ends of adjacent cross features (e.g., members) abut one another. As an example, cross features can cover a portion of respective hold down slips.

[0072] As an example, a liner hanger slip can include a head portion, a tail portion, and a member that can cover at least a portion of a hold down slip. In such an example, the member may be a cross feature such as a cross-member.

[0073] A cross feature (e.g., a cross-member) may be disposed at a position along a head portion (e.g., slip portion) or a tail portion (e.g., stem portion) of a slip. A cross feature may be of a desired shape, including, but not limited to, a generally rectangular, ovoid, oval, or triangular shape.

[0074] As an example, a hold down slip can include a body portion, a hind portion, and a lock bevel at a distal end of the hind portion.

[0075] As an example, a unitized cone (e.g., unitized slip seating sleeve) can include channel where a tail portion of a hold down slip extends under cross features of liner hanger slips. As an example, a cone can include pockets and holes. As an

example, a spring, as a biasing element, can be inserted at least in part into one of the holes.

[0076] As an example, cross features of liner hanger slips can be, in an unactuated state, locking features with respect to hold down slips as they can lock the hold down slips in place to prevent premature setting of the hold down slips.

[0077] As an example, a liner hanger can include a first set of slips; a second set of slips; a first actuation mechanism for actuation of the first set of slips; and a second actuation mechanism for actuation of the second set of slips where the first set of slips, in an unactuated state, prevent actuation of the second set of slips via the second actuation mechanism. In such an example, the first set of slips can be liner hanger slips and, for example, the second set of slips can be hold down slips.

[0078] As an example, in a liner hanger, each slip of a first set of slips can include a member and each slip of a second set of slips can include a stem portion where the members cover the stem portions to prevent actuation of the second set of slips. In such an example, the members can translate axially responsive to actuation of a first actuation mechanism.

[0079] As an example, a first actuation mechanism can include an annular component that is axially translatable to move (e.g., directly or indirectly) the first set of slips in an axial direction.

[0080] As an example, a second actuation mechanism can include biasing elements that release stored potential energy to move the second set of slips in an axial direction. In such an example, the biasing elements can be springs.

[0081] As an example, a first actuation mechanism can include an annular component that is axially translatable to move a first set of slips in a first axial direction and a second actuation mechanism can include biasing elements that release stored potential energy to move a second set of slips in a second axial direction. In such an example, the first and second axial directions can be opposite directions. For example, a liner hanger may be secured via a first set of slips that applies a force with a component directed axially in one direction and via a second set of slips that applies a force with a component directed axially in another, opposite direction. In such an example, the liner hanger may be secured from movement in either of the axial directions via such forces.

[0082] As an example, a second actuation mechanism can include shear screws (e.g., shear bolts) where each slip of a second set of slips includes an opening that receives at least a portion of a respective one of the shear screws.

[0083] As an example, a liner hanger can include a first actuation mechanism that is fluid pressure actuatable and/or a second actuation mechanism that is mechanically actuatable.

[0084] As an example, a liner hanger can include a second actuation mechanism that is not actuatable via fluid pressure and can include a first actuation mechanism that is actuatable via fluid pressure.

[0085] As an example, a liner hanger can include a slip seating sleeve where, for example, the slip seating sleeve seats a first set of slips and seats a second set of slips. As an example, a liner hanger can include a pipe where a slip seating sleeve is disposed on the pipe. As an example, such a pipe may be referred to as a liner hanger body. As an example, a pipe of a liner hanger can be rotatable with respect to a slip seating sleeve. In such an example, a second actuation mechanism can include the pipe and the slip seating sleeve where the second actuation mechanism is actuatable for an actuated state of a first set of slips that fixes the azimuthal position and axial position of the slip seating sleeve. In such an example, the second actuation mechanism can include one or more shear elements that shear responsive to rotation of the pipe with respect to the fixed azimuthal position and axial position of the slip seating sleeve. As an example, a first set of slips of a liner hanger may be actuated to engage an inner surface of a casing to secure a slip seating sleeve of the liner hanger. Once engaged, a liner hanger body or pipe of the liner hanger may be rotatable with respect to the slip seating sleeve. In such an example, the liner hanger body or pipe can include one or more shoulders where one or more of the shoulders may be integral shoulder and/or one or more of the shoulders may be false shoulders, for example, formed via an annular ring that is axially fixed to the liner hanger body or pipe. In such an example, the slip seating sleeve may be disposed axially between two shoulders such that when a first set of slips engage an inner surface of a casing, the liner hanger body or pipe is fixed axially, yet rotatable azimuthally, due to the slip seating sleeve being fixed axially and azimuthally by the first set of slips. In such an example, the first set of slips can be liner hanger slips where another set of slips can be hold down slips that can be

actuated after the liner hanger slips to further secure the liner hanger with respect to the inner surface of the casing.

[0086] As an example, a liner hanger can include a cone; a liner hanger slip disposed on an exterior of the cone, the liner hanger slip having a head portion, a tail portion, and a cross feature; and a hold down slip having a body portion, and a hind portion, the hold down slip disposed on the exterior of the cone such that the body portion of the hold down slip is distal to the head portion of the liner hanger slip and such that at least a portion of the hind portion of the hold down slip is restrained under at least a portion of the cross feature of a liner hanger slip when the liner hanger slip is in an un-set position. In such an example, at least a portion of the hind portion of the hold down slip can extend through a channel disposed on an outer surface of the cone. As an example, at least a portion of the body portion of the hold down slip can be disposed within a pocket formed in the exterior of the cone. In such an example, the liner hanger can include at least one spring disposed within the pocket in such manner as to exert a force against the cone and the hold down slip.

[0087] As an example, when a liner hanger slip is in a set position, in an arrangement of components, no portion of a hind portion of a hold down slip is disposed under a cross feature (e.g., restricted by a cross feature or cross features of a liner hanger slip or liner hanger slips).

[0088] As an example, for a liner hanger, when a set of liner hanger slips is in a set position, an actuation mechanism can become actuatable to cause a set of hold down slips to be set. Such an approach can be a safety approach that prohibits pre-mature actuation of the hold down slips.

[0089] As an example, a method can include axially translating a first set of slips of a liner hanger to transition a second set of slips of the liner hanger to an actuatable state; and actuating the second set of slips. In such an example, actuating the second set of slips can include releasing stored potential energy of one or more biasing elements for axially translating the second set of slips. As an example, such actuating can include shearing at least one shear element (e.g., a shear screw, a shear bolt, etc.). As an example, each of the slips of the second set of slips can include an opening that receives at least a portion of a respective one of the at least one shear element.

[0090] As an example, actuating can include mechanically actuating a second set of slips. As an example, actuating of a second set of slips can be via a mechanism that does not include fluid pressure actuating of the second set of slips.

[0091] As an example, axially translating a first set of slips can occur responsive to actuating a fluid pressure actuation mechanism.

[0092] As an example, surface equipment may be utilized to initiate one or more actuation processes that occur via at least two different actuation mechanisms for two different sets of slips of a liner hanger. In such an example, surface equipment may be utilized to increase fluid pressure in a liner hanger and/or may be utilized to move one component of a liner hanger with respect to another component of a liner hanger. For example, surface equipment can include rotating a string to cause rotation of a pipe (e.g., liner hanger body) of a liner hanger.

Conclusion

[0093] Although only a few examples have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the examples. Accordingly, all such modifications are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. § 112, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words “means for” together with an associated function.

CLAIMS

What is claimed is:

1. A liner hanger comprising:
a first set of slips;
a second set of slips;
a first actuation mechanism for actuation of the first set of slips; and
a second actuation mechanism for actuation of the second set of slips
wherein the first set of slips, in an unactuated state, prevent actuation of the second set of slips via the second actuation mechanism.
2. The liner hanger of claim 1 wherein the first set of slips comprises liner hanger slips.
3. The liner hanger of claim 1 wherein the second set of slips comprises hold down slips.
4. The liner hanger of claim 1 wherein each slip of the first set of slips comprises a member and wherein each slip of the second set of slips comprises a stem portion wherein the members cover the stem portions to prevent actuation of the second set of slips.
5. The liner hanger of claim 1 wherein the first actuation mechanism comprises an annular component that is axially translatable to move the first set of slips in an axial direction.
6. The liner hanger of claim 1 wherein the second actuation mechanism comprises biasing elements that release stored potential energy to move the second set of slips in an axial direction.
7. The liner hanger of claim 1 wherein the first actuation mechanism comprises an annular component that is axially translatable to move the first set of slips in a first axial direction and wherein the second actuation mechanism comprises biasing

elements that release stored potential energy to move the second set of slips in a second axial direction.

8. The liner hanger of claim 1 wherein the second actuation mechanism comprises shear screws wherein each slip of the second set of slips comprises an opening that receives at least a portion of a respective one of the shear screws.

9. The liner hanger of claim 1 wherein the first actuation mechanism is fluid pressure actuatable.

10. The liner hanger of claim 1 wherein the second actuation mechanism is mechanically actuatable.

11. The liner hanger of claim 1 wherein the first actuation mechanism is fluid pressure actuatable and wherein the second actuation mechanism is mechanically actuatable.

12. The liner hanger of claim 1 comprising a slip seating sleeve wherein the slip seating sleeve seats the first set of slips and seats the second set of slips.

13. The liner hanger of claim 12 comprising a pipe wherein the slip seating sleeve is disposed on the pipe.

14. The liner hanger of claim 13 wherein the pipe is rotatable with respect to the slip seating sleeve.

15. The liner hanger of claim 14 wherein the second actuation mechanism comprises the pipe and the slip seating sleeve and wherein the second actuation mechanism is actuatable for an actuated state of the first set of slips that fixes the azimuthal position and axial position of the slip seating sleeve.

16. The liner hanger of claim 15 wherein the second actuation mechanism comprises one or more shear elements that shear responsive to rotation of the pipe

with respect to the fixed azimuthal position and axial position of the slip seating sleeve.

17. A method comprising:
 - axially translating a first set of slips of a liner hanger to transition a second set of slips of the liner hanger to an actuatable state; and
 - actuating the second set of slips.
18. The method of claim 17 wherein actuating the second set of slips comprises releasing stored potential energy of one or more biasing elements for axially translating the second set of slips.
19. The method of claim 17 wherein the actuating comprises shearing at least one shear element and wherein each of the slips of the second set of slips comprises an opening that receives at least a portion of a respective one of the at least one shear element.
20. The method of claim 17 wherein the actuating comprises mechanically actuating and wherein the axially translating occurs responsive to actuating a fluid pressure actuation mechanism.

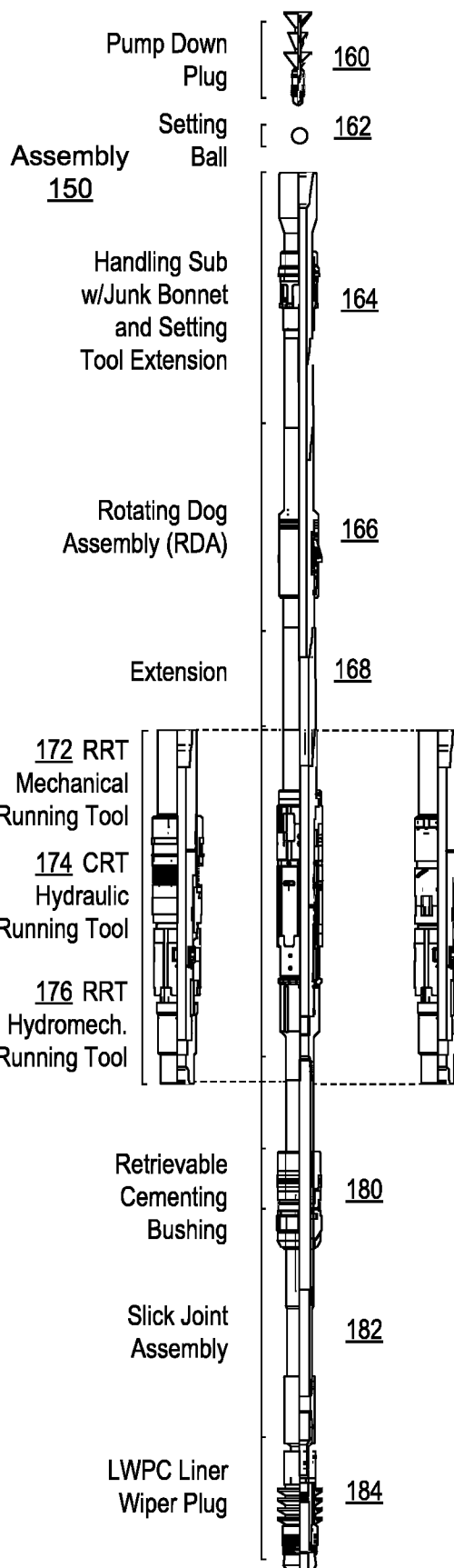
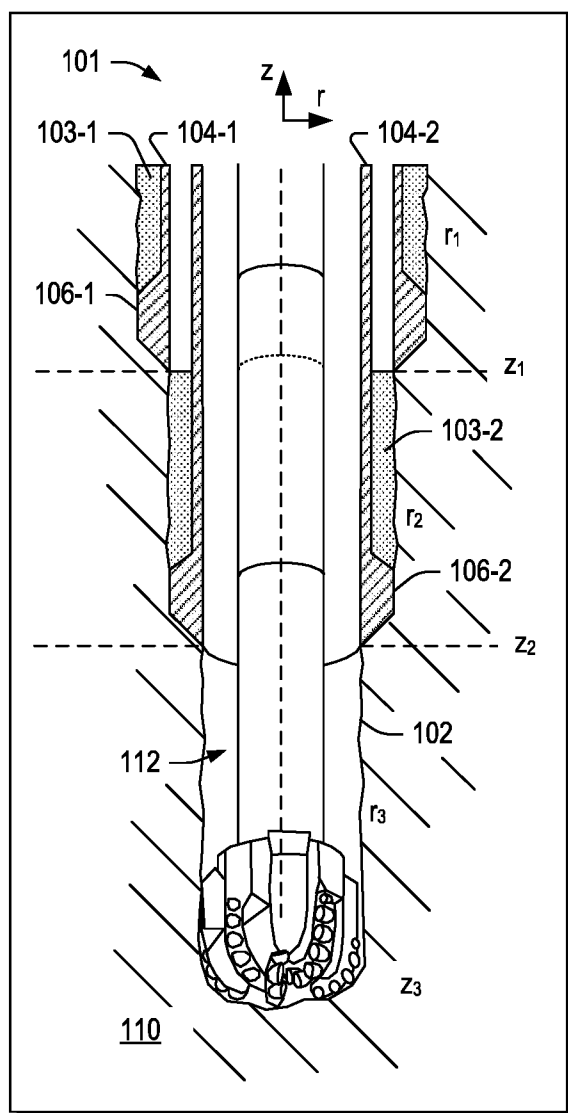
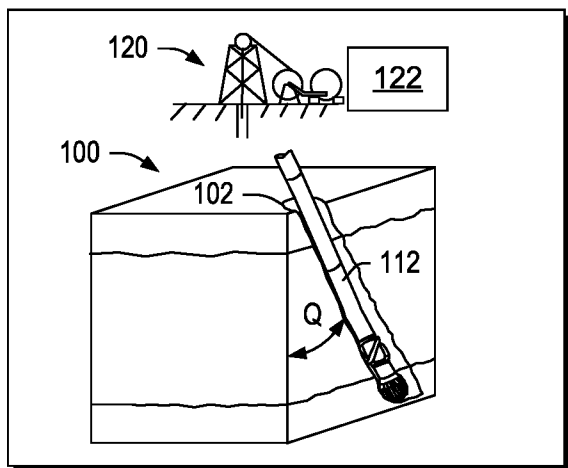


Fig. 1

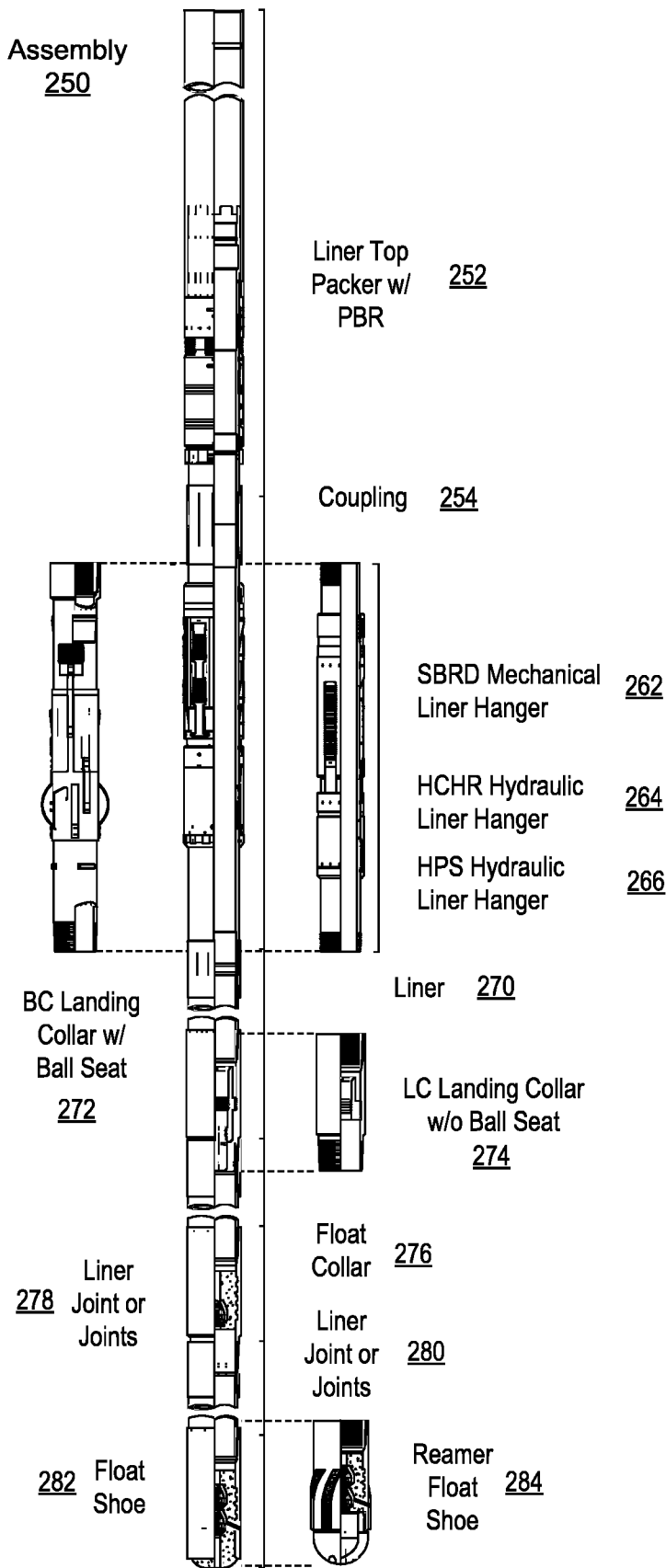


Fig. 2

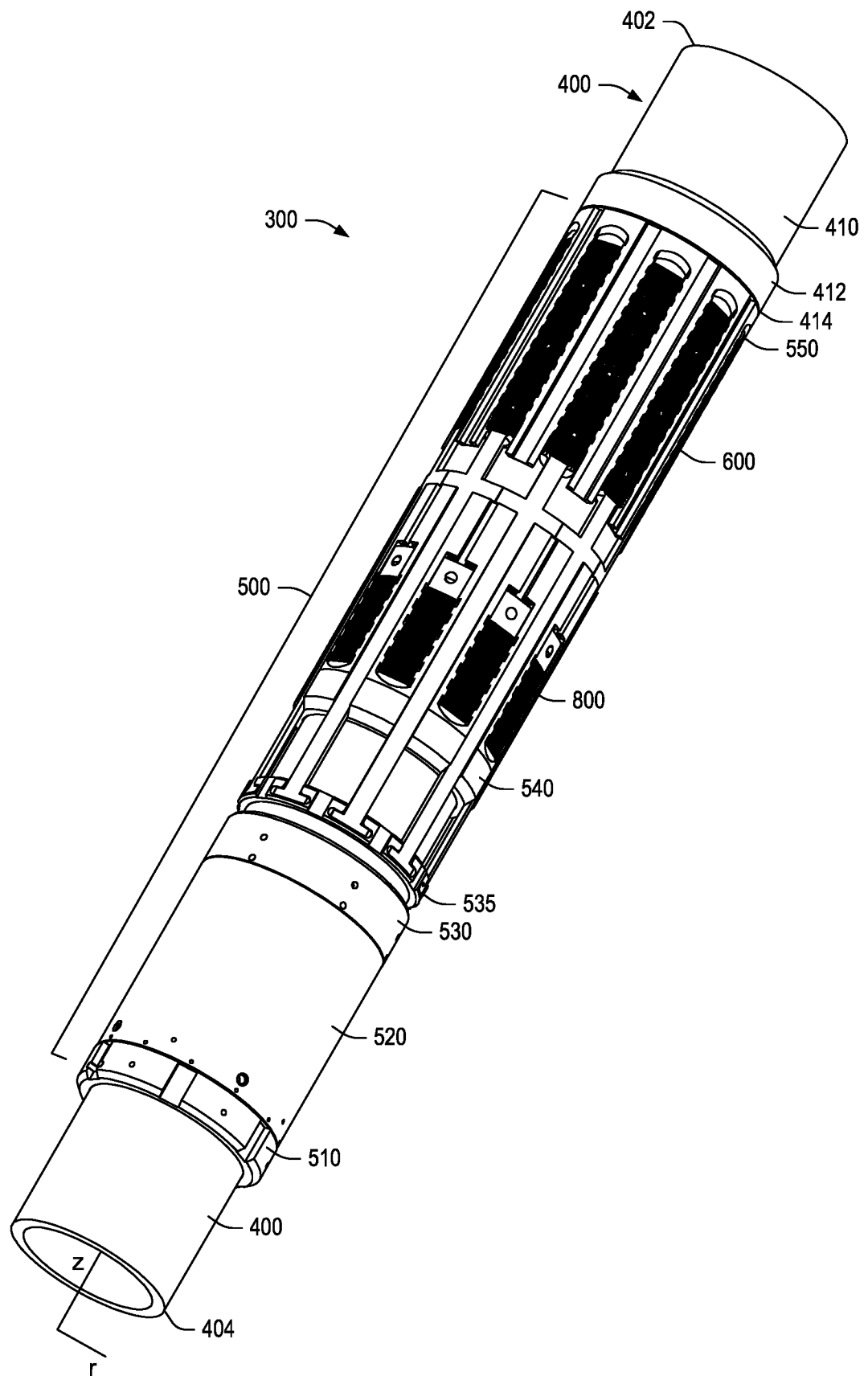


Fig. 3

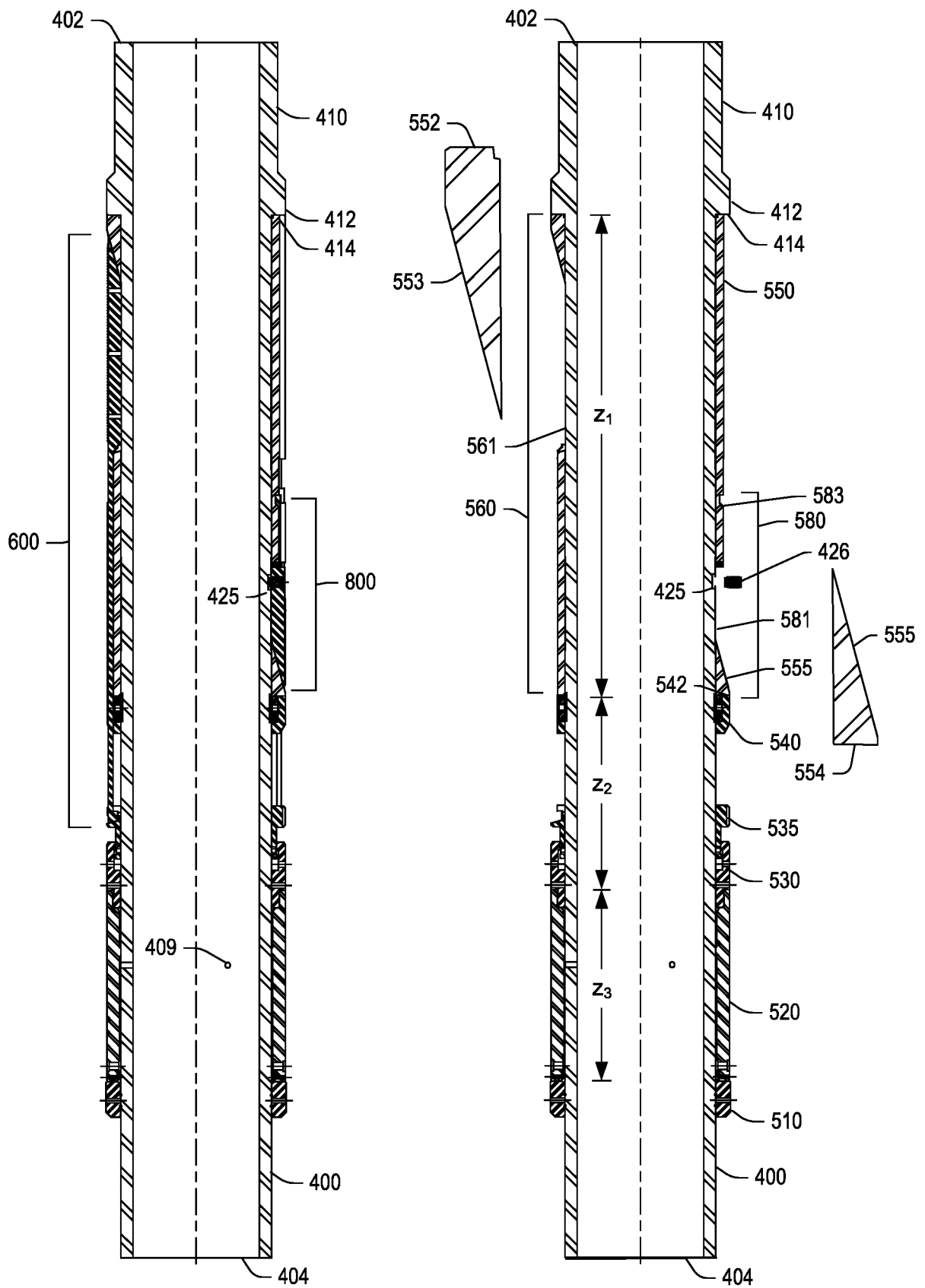


Fig. 4

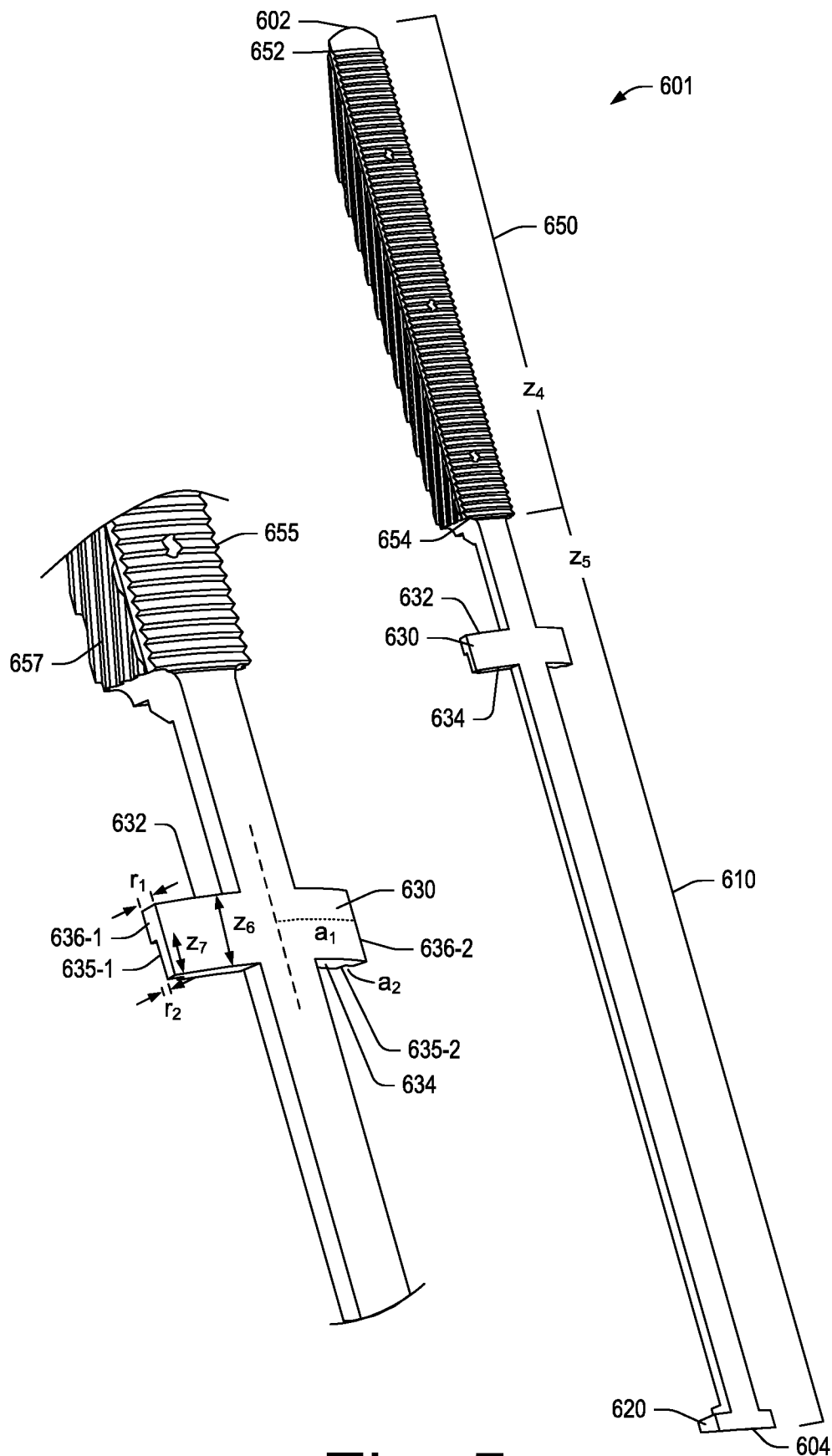


Fig. 5

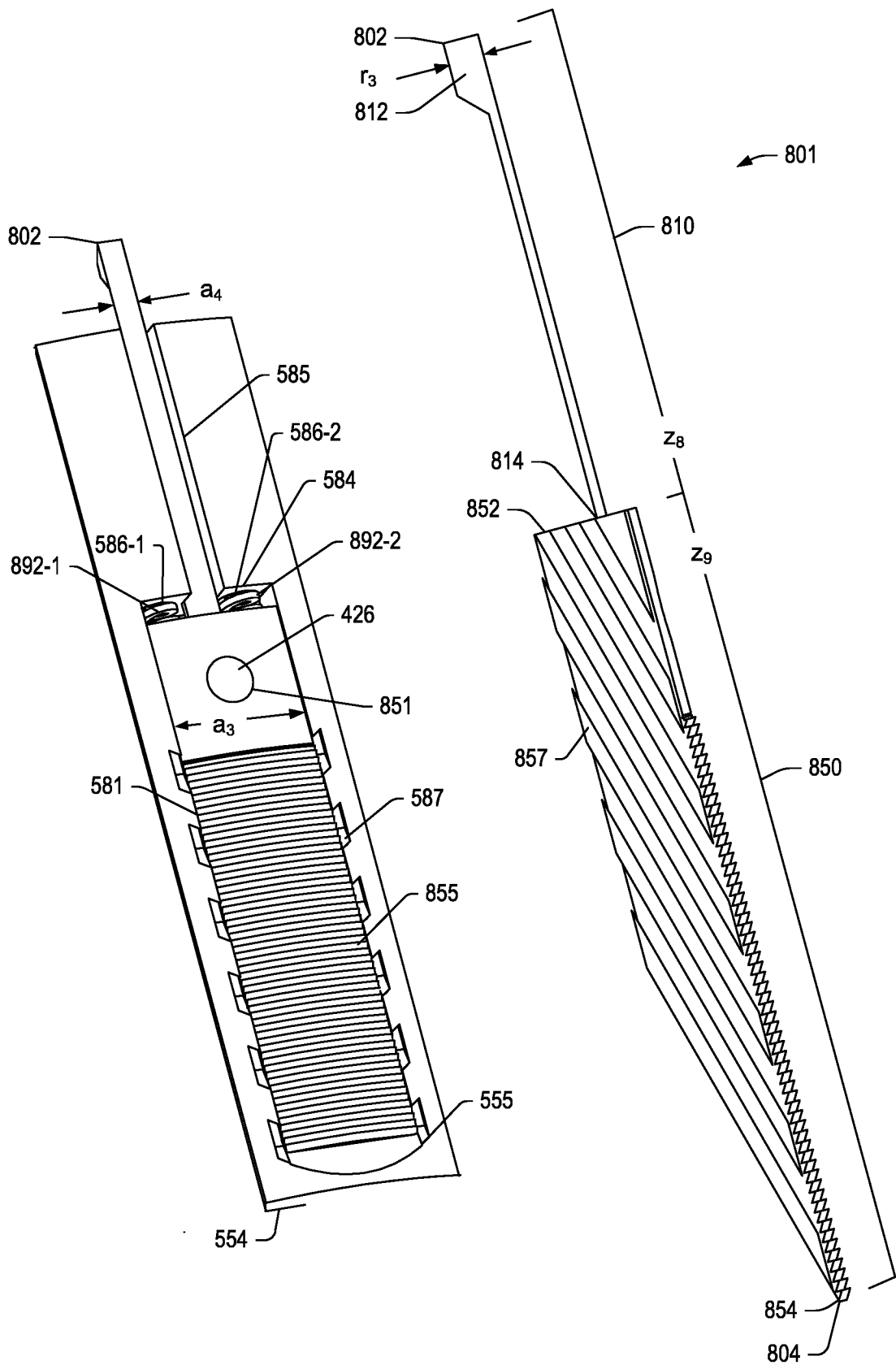
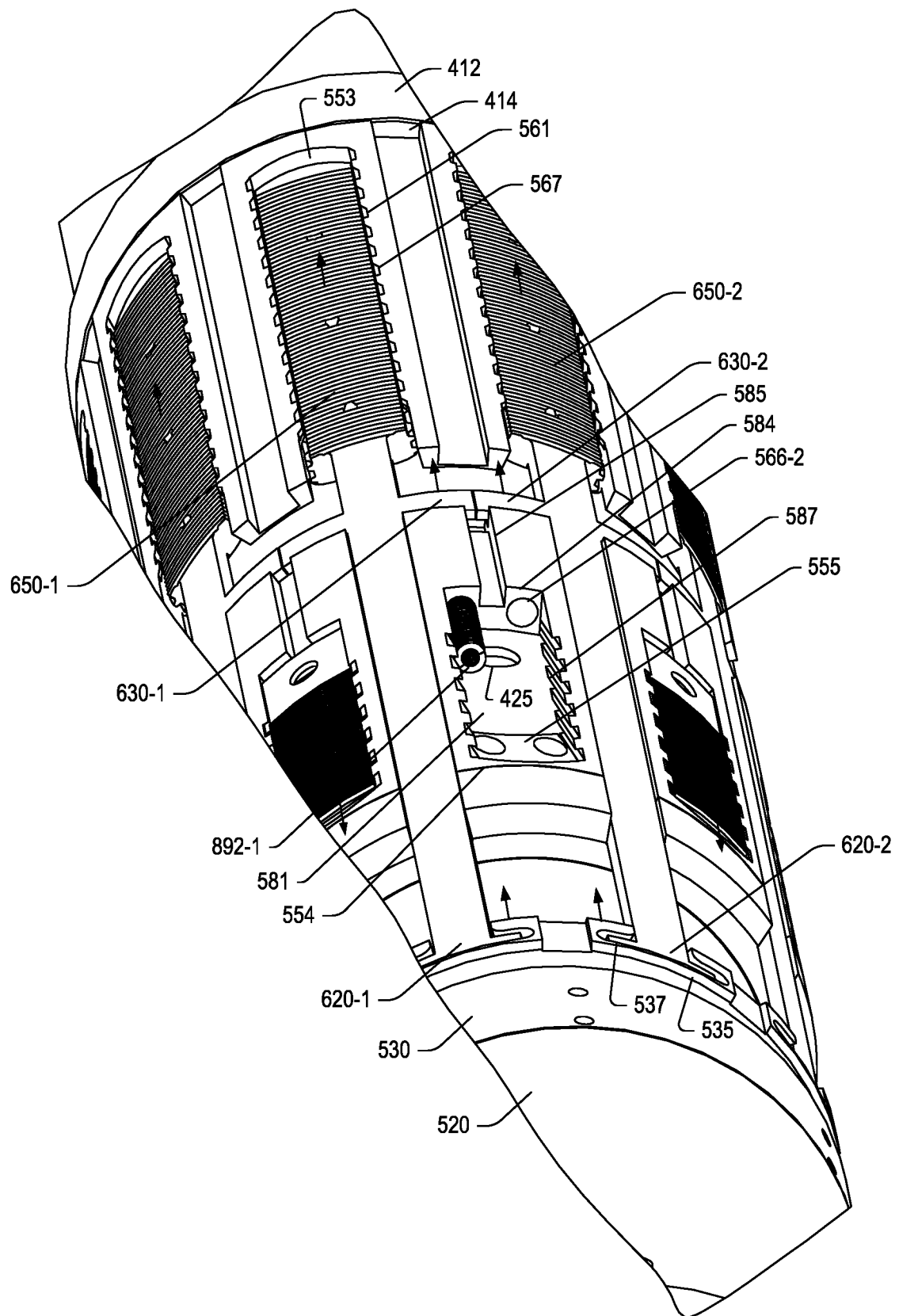


Fig. 6

**Fig. 7**

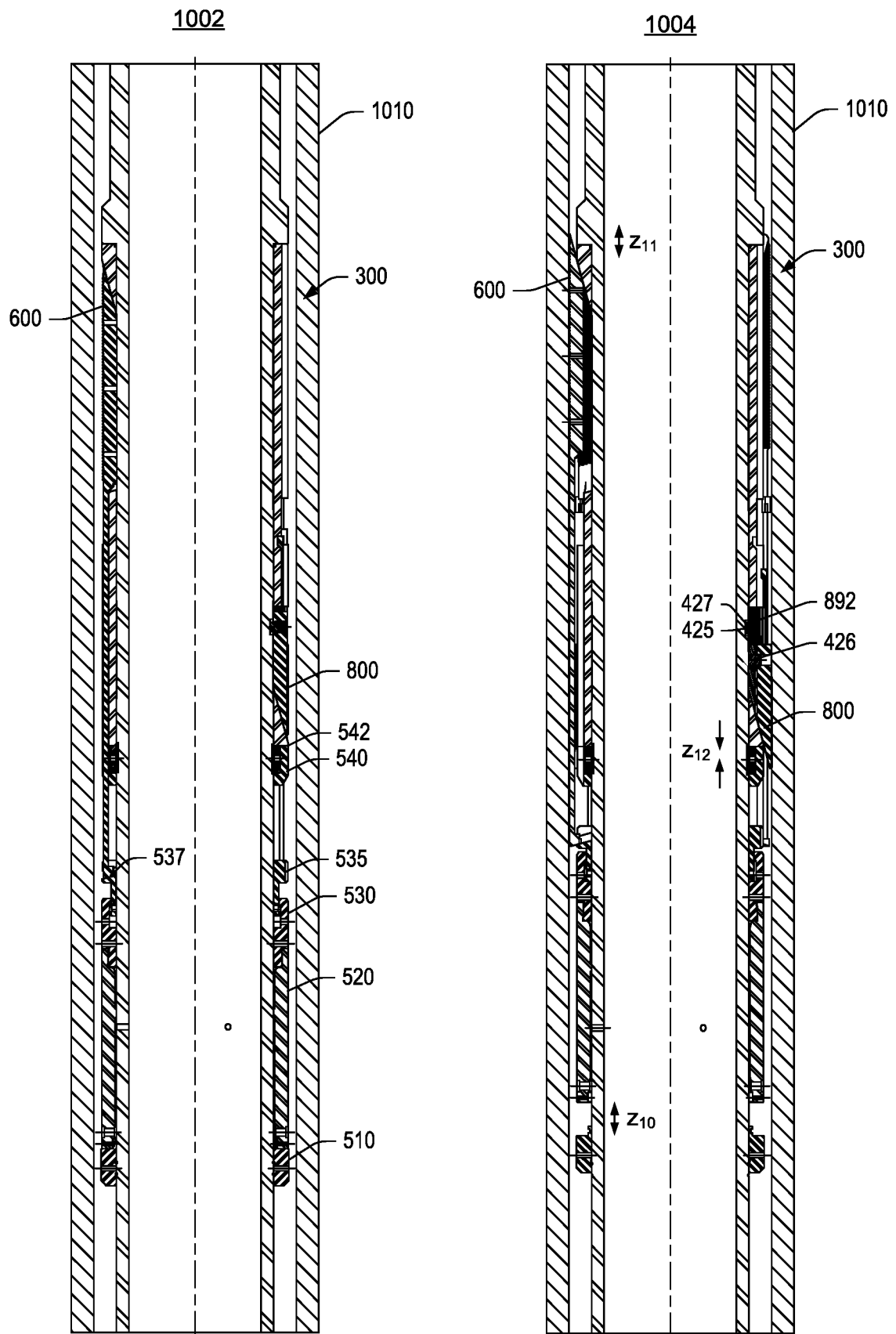


Fig. 8

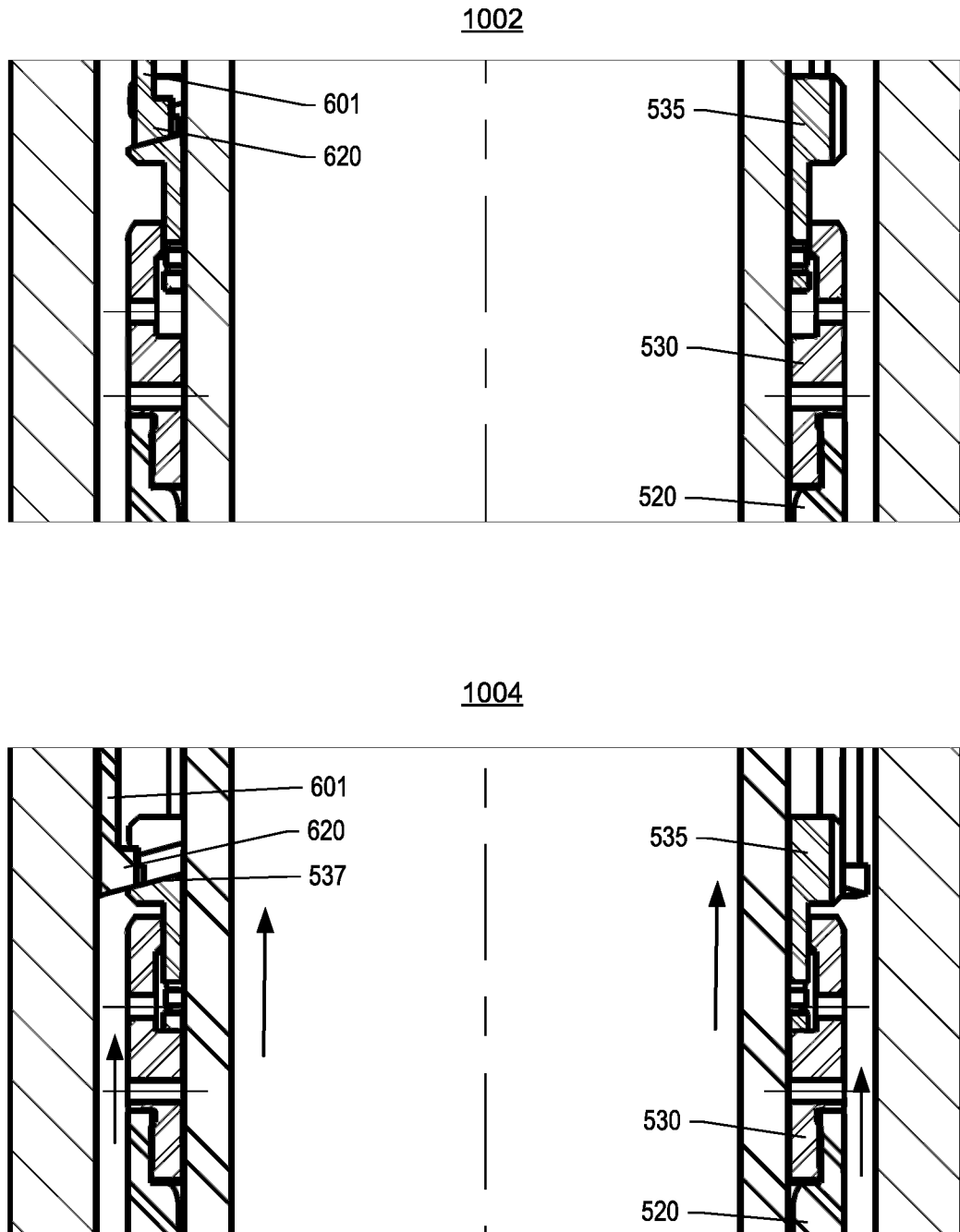


Fig. 9

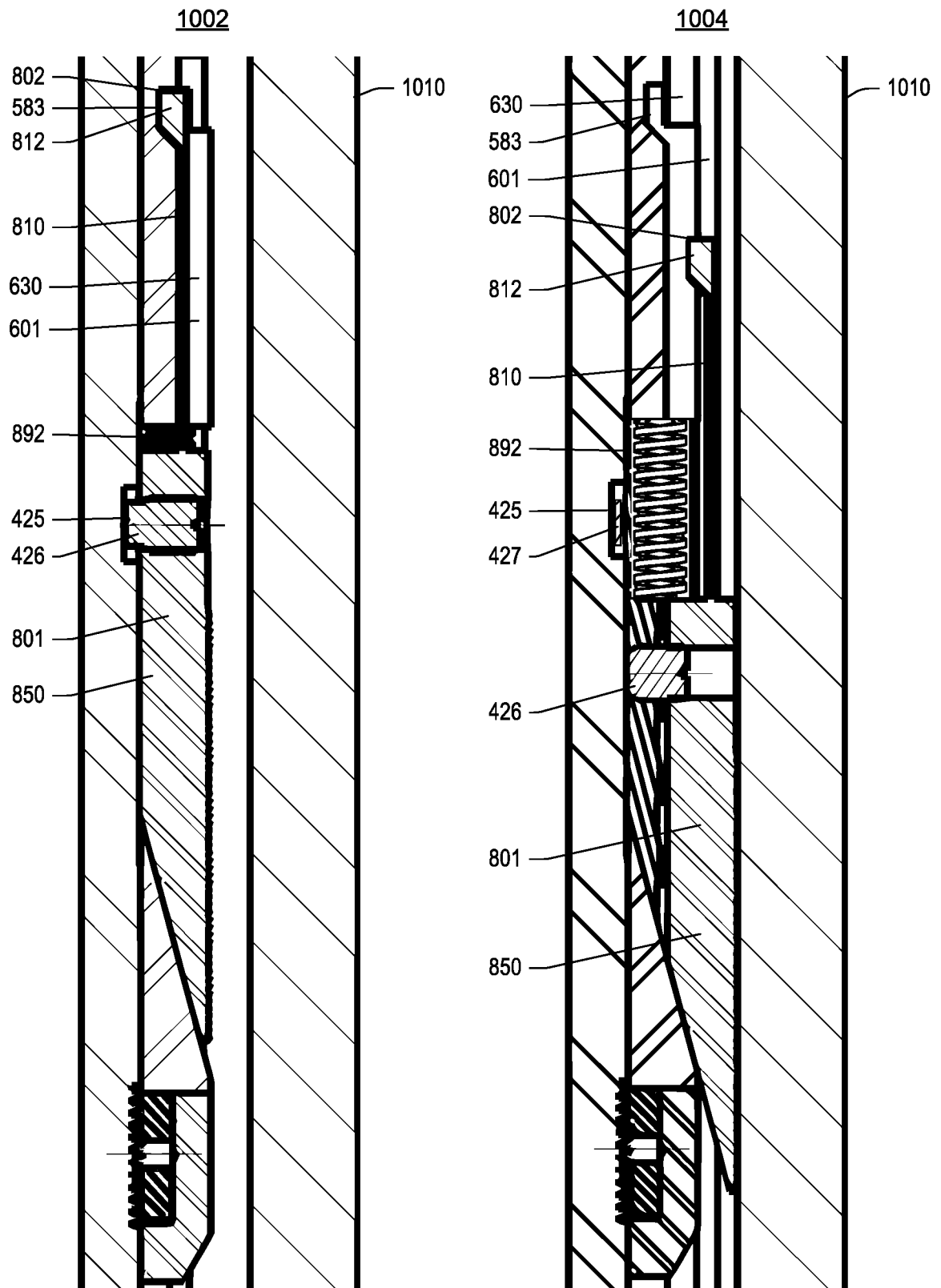


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/056929**A. CLASSIFICATION OF SUBJECT MATTER****E21B 43/10(2006.01)i, E21B 23/01(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 43/10; E21B 33/128; E21B 23/06; E21B 43/116; E21B 19/10; E21B 23/00; E21B 23/01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: anchor, slip, packer, actuator, prevent, seat, sleeve, and ring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2015-0191991 A1 (EZELL, MICHAEL DALE) 09 July 2015	1-3,5-7,9-11,17-18
A	See paragraphs [0030]-[0038] and figures 2A-3D.	,20 4,8,12-16,19
Y	US 7762343 B2 (SONNEVELD et al.) 27 July 2010	1-3,5-7,9-11,17-18
A	See column 11, lines 24 - 65 and figure 9.	,20
A	US 4044826 A (CROWE, TALMADGE L.) 30 August 1977	1-20
A	See column 3, lines 22 - 49 and figure 1g.	
A	US 2013-0220637 A1 (BASTION TECHNOLOGIES, INC.) 29 August 2013	1-20
A	See paragraph [0017] and figure 1.	
A	US 5429192 A (HUBER et al.) 04 July 1995	1-20
A	See column 6, lines 13 - 27 and figure 1.	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

11 January 2017 (11.01.2017)

Date of mailing of the international search report

12 January 2017 (12.01.2017)

Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/056929

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