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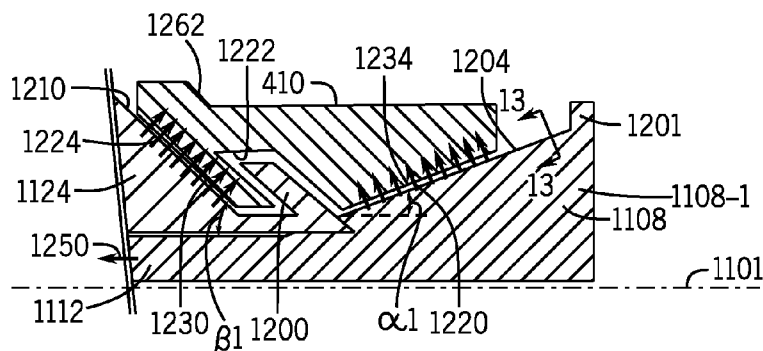


FIG. 12A

(57) Abstract: An apparatus that is usable with a well includes a segmented ring to be run downhole as a unit with the tool. The segmented ring includes a plurality of segmented member. The tool is adapted to radially expand the segmented ring downhole in the well to form a ring and radially contract the segmented ring downhole in the well.

DOWNHOLE EXPANDABLE AND CONTRACTABLE RING ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION

[001] This application claims priority to and the benefit of a US provisional application having Serial No. 62/091,989, filed 15 December 2014, which is incorporated by reference herein.

BACKGROUND

[002] For purposes of preparing a well for the production of oil or gas, at least one perforating gun may be deployed into the well via a conveyance mechanism, such as a wireline, slickline or a coiled tubing string. The shaped charges of the perforating gun(s) are fired when the gun(s) are appropriately positioned to perforate a casing of the well and form perforating tunnels into the surrounding formation. Additional operations may be performed in the well to increase the well's permeability, such as well stimulation operations and operations that involve hydraulic fracturing. The above-described perforating and stimulation operations may be performed in multiple stages of the well.

[003] The above-described operations may be performed by actuating one or more downhole tools (perforating guns, sleeve valves, and so forth) and by forming one or more fluid-diverting fluid barriers downhole in the well.

SUMMARY

[004] The 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.

[005] In accordance with an example implementation, a technique that is usable with a well includes running a ring assembly into a previously installed tubing string on a conveyance line; radially expanding a segmented ring of the ring assembly at a first downhole location inside the tubing string so that the segmented ring transitions from a radially contracted state to a radially expanded state; and performing a first downhole operation using the ring assembly with the segmented ring in the radially expanded state. Subsequent to performing the first downhole operation, the segmented ring assembly is radially contracted to transition the segmented ring from the radially expanded state to the radially contracted state, and the ring assembly is moved from the first downhole location.

[006] In accordance with another example implementation, an apparatus that is usable with a well includes a segmented ring to be run downhole as a unit with the tool. The segmented ring includes a plurality of segmented member. The tool is adapted to radially expand the segmented ring downhole in the well to form a ring and radially contract the segmented ring downhole in the well.

[007] In accordance with yet another example implementation, a system includes a tubing string, a conveyance line and an assembly. The assembly includes a tool and a segmented ring to be run downhole in a single trip on the conveyance line; and the segmented ring includes a plurality of segments. The tool is adapted to radially expand the segments and longitudinally compress a number of layers of the segments to form a continuous ring downhole in the tubing string; and the tool is further adapted to subsequently, radially contract the segments and longitudinally expand the number of layers of the segments to remove the continuous ring.

[008] Advantages and other features will become apparent from the following drawings, description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[009] Fig. 1 is schematic diagrams of a well according to an example implementation.

[0010] Fig. 2 is schematic diagram of the well of Fig. 1 illustrating use of an expandable and contractable ring assembly to form a fluid barrier according to an example implementation.

[0011] Figs. 3A and 3B are schematic diagrams of a well illustrating use of an expandable and contractable ring assembly to operate a sleeve valve assembly according to an example implementation.

[0012] Fig. 4 is a schematic view illustrating a segmented ring of the ring assembly inside a tubing string in a radially contracted state according to an example implementation.

[0013] Fig. 5 is a cross-sectional view taken along line 5-5 of Fig. 4 according to an example implementation.

[0014] Fig. 6 is a cross-sectional view taken along line 6-6 of Fig. 4 according to an example implementation.

[0015] Fig. 7 is a perspective view of the segmented ring in a radially expanded state according to an example implementation.

[0016] Fig. 8 is a top view of the segmented ring of Fig. 7 according to an example implementation.

[0017] Fig. 9 is a flow diagram depicting a technique to deploy and use an expandable and contractable ring assembly in a downhole operation that uses a fluid barrier according to an example implementation.

[0018] Fig. 10 is a flow diagram depicting a technique to deploy and use an expandable and contractable ring assembly to actuate a downhole tool according to an example implementation.

[0019] Fig. 11 is a perspective view of an expandable and contractable ring

assembly according to an example implementation.

[0020] Figs. 12A, 12B and 12C are cross-sectional views of the ring assembly illustrating interaction between a setting/unsetting tool and an upper segment of the segmented ring of the ring assembly to radially expand the segmented ring according to an example implementation.

[0021] Fig. 12D is a cross-sectional view of the ring assembly illustrating interaction between the tool and an upper segment of the segmented ring of the ring assembly to transmit force to an outer tubing string according to an example implementation.

[0022] Figs. 12E is a cross-sectional view of the ring assembly illustrating interaction between the tool and an upper segment of the segmented ring of the ring assembly to separate the segmented ring from the tubing string according to an example implementation.

[0023] Figs. 12F and 12G are cross-sectional views illustrating interaction between the tool and an upper segment of the segmented ring of the ring assembly to radially contract the segmented ring according to an example implementation.

[0024] Fig. 13 is a cross-sectional view taken along line 13-13 of Fig. 11 illustrating a tongue-and-groove connection between the tool and an upper segment of the segmented ring of the ring assembly according to an example implementation.

[0025] Fig. 14 is a cross-sectional view of a tongue-and-groove connection between the tool and an upper segment of the segmented ring of the ring assembly according to a further example implementation.

[0026] Fig. 15A and 15B are cross-sectional views of the ring assembly illustrating interaction between the setting/unsetting tool and a lower segment of the segmented ring of the ring assembly to radially expand segmented ring according to an example implementation.

DETAILED DESCRIPTION

[0027] In the following description, numerous specific details are set forth but implementations may be practiced without these specific details. Well-known circuits, structures and techniques have not been shown in detail to avoid obscuring an understanding of this description. "An implementation," "example implementation," "various implementations" and the like indicate implementation(s) so described may include particular features, structures, or characteristics, but not every implementation necessarily includes the particular features, structures, or characteristics. Some implementations may have some, all, or none of the features described for other implementations. "First", "second", "third" and the like describe a common object and indicate different instances of like objects are being referred to. Such adjectives do not imply objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner. "Coupled" and "connected" and their derivatives are not synonyms. "Connected" may indicate elements are in direct physical or electrical contact with each other and "coupled" may indicate elements co-operate or interact with each other, but they may or may not be in direct physical or electrical contact. Also, while similar or same numbers may be used to designate same or similar parts in different figures, doing so does not mean all figures including similar or same numbers constitute a single or same implementation. Although terms of directional or orientation, such as "up," "down," "upper," "lower," "uphole," "downhole," and the like, may be used herein for purposes of simplifying the discussion of certain implementations, it is understood that these orientations and directions may not be used in accordance with further example implementations.

[0028] In accordance with example implementations, a downhole expandable and contractable ring assembly (herein called a "ring assembly") may be used to conduct various downhole operations. For example, the ring assembly may be run downhole in a tubing string and radially expanded downhole to form a removable fluid barrier in the tubing string, and the fluid barrier may be used to divert fluid in connection with a well stimulation operation. As another example, the ring assembly may be run downhole in a

tubing string, radially expanded downhole, and then be used to actuate a downhole tool (shift a sleeve valve, for example).

[0029] In accordance with example implementations described herein, the ring assembly may be run downhole in a radially contracted state on a conveyance mechanism (a coiled tubing string, jointed tubing string, wireline, slickline and so forth) inside a previously installed tubing string (a casing string, for example) to a target location of interest. The ring assembly includes a segmented ring and a setting/unsetting tool that is run downhole as a unit with the ring for purposes of potentially radially expanding and contracting the segmented ring multiple times during the same, single trip into the well.

[0030] More specifically, after being positioned at the target location of interest, the setting/unsetting tool of the ring assembly may be controlled, as described herein, to radially expand the segmented ring. For example implementations that are described herein, in this radially expanded state, the segmented ring may be used as either a shifting ring or a sealing ring. After the segmented ring has been used in this fashion, the setting/unsetting tool may be controlled to radially contract the segmented ring, so that the ring assembly may be repositioned and subsequently radially expanded to perform one or multiple additional downhole sealing or shifting functions before the ring assembly is retrieved from the well.

[0031] In accordance with example implementations, the segmented ring contains multiple curved sections that are constructed to radially contract and axially expand into multiple layers to form the contracted state of the ring; and the sections are constructed to radially expand and axially contract into a single layer to form the ring's radially expanded state. Moreover, as described herein, in accordance with example implementations, a setting/unsetting tool of the ring assembly may be used to physically interact with the segments of the segmented ring for purposes of transitioning the ring between its radially contracted and expanded states.

[0032] Referring to Fig. 1, as a more specific example, in accordance with some implementations, a well 10 includes a wellbore 15, which traverses one or more hydrocarbon-bearing formations. As an example, the wellbore 15 may be lined, or

supported, by a tubing string 20, as depicted in Fig. 1. The tubing string 20 may be cemented to the wellbore 15 (such wellbores are typically referred to as "cased hole" wellbores); or the tubing string 20 may be secured to the surrounding formation(s) by packers (such wellbores typically are referred to as "open hole" wellbores). In general, the wellbore 15 may extend through multiple zones, or stages 30 (four example stages 30-1, 30-2, 30-3 and 30-4, being depicted in Fig. 1, as examples).

[0033] It is noted that although Fig. 1 and other figures disclosed herein depict a lateral wellbore, the techniques and systems that are disclosed herein may likewise be applied to vertical wellbores. Moreover, in accordance with some implementations, the well 10 may contain multiple wellbores, which contain tubing strings that are similar to the illustrated tubing string 20 of Fig. 1. The well 10 may be a subsea well or may be a terrestrial well, depending on the particular implementations. Additionally, the well 10 may be an injection well or may be a production well. Thus, many implementations are contemplated, which are within the scope of the appended claims.

[0034] Downhole operations may be performed in the stages 30 in a particular directional order, in accordance with example implementations. For example, in accordance with some implementations, downhole operations may be conducted in a direction from a toe end of the wellbore 15 to a heel end of the wellbore 15. In further implementations, these downhole operations may be connected from the heel end to the toe end of the wellbore 15. In accordance with further example implementations, the operations may be performed in no particular order, or sequence.

[0035] Fig. 1 depicts that fluid communication with the surrounding hydrocarbon formation(s) has been enhanced through sets 40 of perforation tunnels that, for this example, are formed in each stage 30 and extend through the tubing string 20. It is noted that each stage 30 may have multiple sets of such perforation tunnels 40. Although perforation tunnels 40 are depicted in Fig. 1, it is understood that other techniques may be used to establish/enhance fluid communication with the surrounding formation (s), as the fluid communication may be alternatively established using, for example, a jetting tool that communicates an abrasive slurry to perforate the tubing string wall; opening sleeve

valves of the tubing string 20; and so forth.

[0036] Referring to Fig. 2 in conjunction with Fig. 1, as an example, a stimulation operation may be performed in the stage 30-1 by running an expandable and contractable ring assembly 50 into the tubing string 20 on a conveyance line, such as a coiled tubing string 42. It is noted that although Fig. 2 depicts a coiled tubing string 42 as a convenience mechanism 40 for the ring assembly 50, other conveyance mechanisms may be used, in accordance with further example implementations. The ring assembly 50 is run downhole in its radially contracted state, a state in which an outer segmented ring 52 of the assembly 50 is radially contracted, thereby allowing the ring assembly 50 to pass relatively freely through the central passageway of the tubing string 30.

[0037] When positioned by the coiled tubing string 42 at the downhole location of interest (as depicted in Fig. 2), a setting/unsetting tool 51 of the ring assembly 50 is remotely operated from the Earth surface of the well 100 to radially expand the segmented ring 52. The segmented ring 52, in its radially expanded state, engages the inner wall of the outer tubing string 20 to secure, or anchor, the ring assembly 50 to the tubing string 20, close off the annulus that existed about the ring assembly 50, and form a corresponding downhole fluid barrier inside the tubing string 20. For the example implementation that is depicted in Fig. 2, the ring assembly 50 is shown as forming a fluid barrier in the tubing string 20 near the bottom, or downhole end, of the stage 30-1.

[0038] The fluid barrier may be used to divert fluid, such as diverting fluid in a region 170 of the formation in a well stimulation operation (a hydraulic fracturing operation, for example). Once installed inside the tubing string 20, the fluid barrier that is formed from the assembly 50 may be used to divert fluid in the tubing string 20 uphole of the fluid barrier. Therefore, in accordance with an example implementation, the fluid barrier may be used to divert fracturing fluid that is pumped downhole. As examples, the fracturing fluid may be pumped downhole, for example, through the central passageway of the coiled tubing string 42 and exit the string 42 through cross-over ports (not shown) near the ring assembly 50.

[0039] After the well stimulation operation for the stage 30-1 is complete, the tool

51 of the ring assembly 50 may be operated in a manner to radially contract the segmented ring 52. The coiled tubing string 42 may then be used to reposition the ring assembly 50 to another stage 30 so that the above-described operations may be repeated for one or multiple other stages 30. Moreover, after being contracted, the ring assembly 50 may be withdrawn from the wellbore 15 (i.e., pulled out of hole) using the coiled tubing string 42.

[0040] Figs. 3A and 3B depict another use of the expandable and contractable ring assembly 50, in accordance with further example implementations. In particular, Figs. 3A and 3B depict the use of the ring assembly 50 for purposes of actuating a downhole tool, such as a sleeve valve assembly (as an example). In this manner, Fig. 3A depicts a well 300 in which a casing string 312 has been installed in wellbore 15. For this example, the casing string 312 contains sleeve valve assemblies, which may be selectively opened to access the surrounding formation.

[0041] More specifically, referring to Fig. 3A, the casing string 312 has a central passageway 314 and extends through associated stages 30 (stages 30-1, 30-2, 30-3 and 30-4 being depicted as examples in Fig. 3A). For this example, each stage 30 has an associated sleeve valve assembly, which includes a sleeve 240 that resides in a corresponding recessed region 231 of the casing string 312. For the state of the well 300 depicted in Fig. 3A, the sleeve 240 is installed in the well in a closed state, or an uphill position, and therefore, the sleeve 240 covers radial ports 230 in the casing string wall. As an example, each sleeve valve assembly (and stage 30) may be associated with a given set of radial ports 230.

[0042] The ring assembly 50 may be run downhole on a conveyance line, such as the coiled tubing string 42, for purposes of closing and/or opening one or more of the sleeve valve assemblies in the same trip downhole. As depicted in Fig. 3A, the segmented ring 52 of the ring assembly 50 is retraced for purposes of allowing the ring assembly 50 to pass freely through the casing string 312, until the ring assembly 50 is in the appropriate downhole location.

[0043] For example, to shift the sleeve valve assembly in the stage 30-1 open, the

ring assembly 50 may be run inside (or slightly uphole from, for example) the sleeve 240 of the sleeve valve assembly, and then the tool 51 may be used to radially expand the segmented ring 52, as depicted in Fig. 3B. The connection between the segmented ring 52 and the sleeve 240 may be facilitated using a shoulder 238 on the sleeve 240, which engages a corresponding shoulder of the ring 52. However, in accordance with further implementations, other connection methods may be used, such as recess on the sleeve 240, a direct anchoring with the ring 52, and so forth.

[0044] The coiled tubing string 42 may then be move downhole to shift the sleeve 240 open. In accordance with example implementations, the ring assembly 50 may be subsequently actuated to radially contract the ring 52, thereby allowing the ring assembly 50 to be moved uphole and radially expanded to repeat the above-described process for another sleeve 240. Thus, the ring assembly 50 may be radially expanded and radially contracted multiple times for purposes of actuating multiple downhole tools. Moreover, the ring assembly 50 may be radially contracted for purposes of removing the assembly 50 from the well 300.

[0045] Fig. 4 is a perspective of the segmented ring 52 inside a tubing string 20; and Figs. 5 and 6 illustrate cross-sectional views of the ring 52 of Fig. 4, in accordance with an example implementation. Referring to Fig. 4, this figure depicts the segmented ring 52 in a contracted state, i.e., in a radially collapsed state, which facilitates travel of the ring 52 downhole to its final position. The segmented ring 52, for this example implementation, has two sets of curved segments: three upper segments 410; and three lower segments 420. In the contracted state, the segments 410 and 420 are radially contracted and are longitudinally, or axially, expanded into two layers 412 and 430 of segments.

[0046] In accordance with example implementations, the upper segment 410 is, in general, a curved wedge that has a radius of curvature about the longitudinal axis of the segmented ring 52 and is larger at its top end than at its bottom end; and the lower segment 420 is, in general, an curved wedge that has the same radius of curvature about the longitudinal axis (as the upper segment) and is larger at its bottom end than at its top

end. Due to the relative complementary profiles of the segments 410 and 420, when the segmented ring 52 expands (i.e., when the segments 410 and 420 radially expand and the segments 410 and 420 axially contract), the two layers 412 and 430 longitudinally, or axially, compress into a single layer of segments, such that each upper segment 410 is complementarily received between two lower segments 420, and vice versa, as depicted in Figs. 7 and 8. Referring to Fig. 8, in its expanded state, the segmented ring 52 forms a continuous ring, which circumscribes an interior region 710 occupied by the tool 51 (not shown in Fig. 8).

[0047] When used as a seal, the seal assembly 50 may include a sealing element (not shown) that is pulled into the region 710 by the tool 51 to form a fluid seal inside the segmented ring 52. Moreover, the surfaces of the segments 410 and 420, which contact each other, may contain sealing elements (not shown), such as elastomer or Teflon coatings, to form seal seals between adjacent segment, in accordance with example implementations; and in accordance with some implementations, the segments 410 and 420 may contain sealing elements (elastomer elements, for example) to form fluid seals between the exterior of the radially expanded segmented ring 52 and the surrounding tubing string wall. In accordance with further example implementations, metal-to-metal seals may be formed between ring segments and metal-to-metal seals may be formed between the segmented ring 52 and the surrounding tubing string wall. Thus, many implementations are contemplated, which are within the scope of the appended claims.

[0048] Thus, in accordance with example implementations, a technique 900 that is depicted in Fig. 9 includes deploying (block 902) a ring assembly on a conveyance line into a tubing string that has previously been installed in well and positioning the ring assembly at a targeted downhole location. The technique 900 includes radially expanding a segmented ring of the ring assembly at a downhole location to form a fluid barrier inside the tubing string, pursuant to block 904. A downhole operation (e.g., a well stimulation operation) may then be performed using the fluid barrier, pursuant to block 906. Pursuant to block 908, the segmented ring of the ring assembly may be subsequently radially contracted to remove the fluid barrier, and the conveyance line may be used to move the ring assembly away from the downhole location. In this manner, the

ring assembly may be moved to another downhole location for purposes of repeating the technique 900 one or multiple times; the ring assembly may be withdrawn from the well; and so forth.

[0049] Moreover, in accordance with example implementations, a ring assembly may be used for purposes of actuating a downhole tool. More specifically, referring to Fig. 10, in accordance with example implementations, a technique 1000 includes deploying (block 1002) a ring assembly on a conveyance line into a tubing string that has previously been installed in well and positioning the segmented ring assembly at a downhole location to actuate a downhole tool. The technique 1000 includes radially expanding a segmented ring of the ring assembly at a downhole location, pursuant to block 10004, and using the radially expanded ring assembly to actuate the downhole tool, pursuant to block 1006. Pursuant to the technique 1008, the segmented ring of the ring assembly may subsequently be radially contracted, and the conveyance line may be used to move the ring assembly away from the downhole tool. In this manner, the ring assembly may be moved to another downhole location for purposes of repeating the technique 1000 one or multiple times; the ring assembly may be withdrawn from the well; and so forth.

[0050] Referring to Fig. 11, in accordance with an example implementation, the segmented ring 52 may be mounted on the setting/unsetting tool 51. More specifically, as further described herein, the tool 51 includes components that move relative to each other to expand or contract the segmented ring 52: a rod 1112 and a mandrel 1124, which generally circumscribes the rod 1102. The relative motion between the rod 1112 and the mandrel 1124 causes surfaces of the mandrel 1124 and the rod 1112 to contact the upper 410 and lower 420 segments of the segmented ring 52 for purposes of radially expanding the segments 410 and 420 and longitudinally contracting the segments 410 and 420 to form a continuous ring.

[0051] For example implementations that are discussed herein, an upper end 1109 of the rod 1112 may be attached to a mechanism to pull the rod 1112 uphole relative to the mandrel 1124 and push the rod 1112 downhole relative to the mandrel 1124 for such

purposes as radially expanding the segmented ring 52, radially contracting the segmented ring 52 and transmitting forces between a radially expanded segmented ring 52 and a surrounding tubing string. For example implementations, in which the conveyance line for the ring assembly 50 is sufficiently rigid (a coiled tubing string, for example) to exert a downward force, the tool 51 may be constructed so that upper and downward movements of the conveyance line causes corresponding upper and downhole movements of the rod 1112 relative to the mandrel 1124. For example implementations in which the conveyance line is insufficiently rigid (a slickline or wireline, for example) to exert a downhole force, the tool 51 may be constructed so that upward movements of the conveyance line causes corresponding upper movements of the rod 1112 relative to the mandrel 1124, whereas downhole movement of the rod 1112 relative to the mandrel may be effected using over force-transmitting mechanisms. For example, in accordance with some implementations, fluid pressure or a tractor may be used to move the rod 1112 downhole relative to the mandrel 1124. In accordance with further example implementations, fluid pressure or a tractor may be used to effect upward motion of the rod 1112 relative to the mandrel 1124. Thus, many variations are contemplated, which are within the scope of the appended claims.

[0052] As depicted in Fig. 11, in accordance with example implementations, the rod 1112 and the mandrel 1124 may generally be concentric with a longitudinal axis 1101 and extend along the longitudinal axis 1101. A bottom end 1110 of the rod 1112 may be free or attached to a downhole tool or string, depending on the particular implementation.

[0053] In accordance with example implementations, in general, the rod 1112 contains radially extending vanes 1108 for purposes of contacting inner surfaces of the ring segments 410 and 420: vanes 1108-1 to contact the upper segments 410; and vanes 1108-2 to contact the lower segments 420. For the specific example implementation that is illustrated in Fig. 11, the tool 51 includes six vanes 1108, i.e., three vanes 1108-1 contacting the upper segments 410 and three vanes 1108-2 contacting the lower segments 420. Moreover, as shown, the vanes 1108 may be equally distributed around the longitudinal axis 1101 of the tool 51, in accordance with example implementations. Although the examples depicted herein show two layers of three segments, it is noted that

an infinite possibility of combinations with additional layers or with a number of segments per layer may be used (combinations of anywhere from two to twenty for the layers and segments, as examples) and contemplated and are within the scope of the appended claims.

[0054] For example implementations in which the ring assembly 50 is used to seal, surfaces of the vanes 1108, which contact the segments 410 and 420 may contain fluid sealing elements (Teflon or elastomer coatings, for example). Moreover, for these example implementations, the tool 51 may contain sealing elements (elastomer elements, for examples) that radially extend between gaps between adjacent vanes 1108.

[0055] Figs. 12A, 12B and 12C illustrate a time sequence of interactions between the tool 51 and upper segment 410 for purposes of radially expanding the segmented ring 52. More specifically, referring to Fig. 12A in conjunction with Fig. 11, in accordance with example implementations, after the ring assembly 50 is in position to be radially expanded, the rod 1112 (see Fig. 11) may be pulled uphole (represented by direction 1250) for purposes of creating contact forces 1220 between an upward and radially outward facing inclined surface 1204 of the vane 1108-1 and the upper segment 410, and contact forces 1224 between a downward and radially outward facing inclined surface 1210 of the mandrel 1124 and the upper segment 410.

[0056] In this manner, as depicted in Fig. 12A, the inclined surface 1204 of the vane 1108-1 may be sloped, or inclined, at an angle α_1 with respect to the longitudinal axis 1101; and the inclined surface 1204 contacts a corresponding downward and radially inward facing inclined surface 1234 of the upper segment 410. Moreover, the inclined surface 1210 of the mandrel 1124 is sloped at an angle β_1 with respect to the longitudinal axis 1101; and the inclined surface 1210 may contact a corresponding upward and radially inward facing inclined surface 1230 of the upper segment 410.

[0057] In accordance with example implementations, a tongue-and-groove connection may be formed between the vane 1108-1 and the upper segment 410 for purposes of constraining the upper segment 410 to move along the longitudinal axis 1101 (not rotate) and prevent the upper segment 410 from being separated from the vane 1108-

1 due to an external force (flow, gravity, friction and so forth).

[0058] Fig. 13 depicts a tongue-and-groove connection between the vane 1108-1 and the upper segment 410 according to an example implementation, and Fig. 14 depicts a tongue-and-groove connection according to a further example implementation. As depicted in Fig. 13, the tongue-and-groove connection may include a longitudinally extending rail 1320, which is received by a longitudinal groove 1308 that is formed in vane 1108-1. For this example implementation, the groove 1304 may have a dovetail cross-section, and as shown, the vane 1108-1 may have a curved outer surface 1204 that corresponds to the surface 1234 of the upper segment 410, which is also curved. For the tongue-in-groove connection that is depicted in Fig. 14, a rail 1420 of the upper segment 410 may have a round cross-section that resides in a corresponding groove 1402 of the vane 1108-1.

[0059] Other connections may be used to constrain the movement of the upper segment 410. For example, in accordance with further example implementations, tongue-and-groove connections may have other shapes, such as square, trapezoid and ellipsoid shapes, as just a few examples. Moreover, the tongue may be disposed on the vane 1108-1, and the groove may be disposed on the upper segment 410, in accordance with further example implementations.

[0060] Referring to Fig. 12B in conjunction with Fig. 11, the contact forces 1220 and 1220 due to the force along the direction 1250 results in axial and radial movement of the upper segment 410. In this manner, the axial and radial movement means that the upper segment 410 moves in a direction 1261 with respect to the mandrel 1124 and moves in a direction 1252 with respect to the rod 1112. The axial and radial movement of the upper segment 410, in turn, radially expands the upper 410 and lower 420 segments of the segmented ring 52 and at the same time, longitudinally contracts the segmented layers of the segmented ring 52, as discussed above.

[0061] Referring to Fig. 12C in conjunction with Fig. 11, the axial and radial movement of the upper segment 410 due to the movement of the rod 1112 in the direction 1250 reaches an endpoint. In this manner, in accordance with example implementations,

the vane 1108-1 may contain a physical stop 1201 at the downhole end of the sloped surface 1204, which limits travel of the upper segment 410 relative to the vane 1108-1 along the direction 1252 (Fig. 12B). In accordance with some implementations, the axial and radial movement of the upper segment 410 may be limited by a radial stop, such as, for example, a radial stop that is imposed by an outer tubing string 20, as depicted in Fig. 12D.

[0062] Referring to Fig. 12D in conjunction with Fig. 11, in accordance with example implementations, after the upper segment 410 contacts an outer tubing member (such as the tubing string 20 of Fig. 12D) when the segmented ring 52 is radially expanded, and the tool 51 may be used to cause the radially expanded segmented ring 52 to exert a force against the outer tubing member. In this manner, the outer tubing member may be the tubing string 20 (as depicted in Fig. 12D), such as when the ring assembly 50 is being used to form a fluid barrier. The tubing member may be however, other types of tubing members, such as sleeve of a sleeve valve assembly, a shifting element of a tubing string, and so forth. The force that is exerted by the segmented ring 52 against the outer tubing member may therefore be used for a wide variety of purposes, such as anchoring, or securing, the segmented ring 52 to a tubing string; engaging a sleeve to allow subsequent movement of the ring assembly 50 to shift the sleeve; and so forth.

[0063] For the example implementation that is depicted in Fig. 12D, the upper segment 410 contains a shoulder formed from a downwardly and outwardly radially-directed sloped surface 1262 that is configured to mate with a corresponding upset, or inclined annular surface 1260, of the tubing string 20. A force may be applied on the mandrel 1124 in downward direction 1270. The force may be derived from a number of sources. For example, the force may be pressure pumping (force from a pressure differential, for example), by pushing the conveyance downhole or through internal tool force actuation (hydraulic piston, power charge or mechanical actuation). The resulting force may then be transmitted along the surface interfaces to the tubing string 20, such surface 1260.

[0064] After the ring assembly 50 is used to perform its downhole operation or function, the ring assembly 50 may then be radially contracted. More specifically, referring to Fig. 12E in conjunction with Fig. 11, in accordance with some implementations, contraction of the ring assembly 50 includes moving the rod 1112 in an uphole direction 1272 for purposes of disengaging the segmented ring 52 from the tubing member. During this step, the upper segment 410 is separated from the tubing string 20, as depicted in Fig. 12E, as the upper segment 410 ring assembly 50 is pulled uphole. The action moves both the vane 1108-1 and the mandrel 1124, as well as the upper 410 and lower 420 (not shown in Fig. 12B) segments away from contact surface 1260.

[0065] Referring to Fig. 12F in conjunction with Fig. 11, after disengagement of the segmented ring 52 from the tubing member, the rod 1112 may be moved in a downhole direction 1274 by reversing the movement described above for the radial expansion of the segmented ring 52, as depicted in Fig. 12F. The contraction of the segmented ring 52 uses other features of the mandrel 1124 and upper segment 410: an inclined extension 1200 of the mandrel 1124 and a corresponding, inner inclined slot 1222 of the upper segment 410. In this manner, as depicted in Fig. 12F the inclined extension 1200 is directed upwardly and radially outwardly; and the extension 1200 extends inside the slot 1222. During the contraction of the segmented ring, an upper surface 1201 of the extension 1200 contacts an downward facing sidewall 1203 for the slot 1222, and this contact produces contact forces 1277 that allow the upper segment 410 to slide along the sloped face 1204 of the vane 1108-1 (due to contact forces 1269) and contraction. In this manner, Fig. 12G depicts the fully contracted upper segment 410. For this example, a continued exerted force in downhole direction 1279 produces corresponding contact forces 1276 and 1275. However, full engagement of the extension 1200 within the slot 1222 constrains further radial contraction of the upper segment 410.

[0066] Referring to Fig. 11, the other upper segments 410 of the segmented ring 52 are similarly mounted to the other vanes 1108-1 and similarly radially expand and contract due to interactions with surfaces of the vanes 1108-1 and surfaces of the mandrel 1124. Moreover, in accordance with example implementations, the lower segments 420 radially expand and contract in a similar manner.

[0067] More specifically, Fig. 15A depicts an upward and radially outward facing inclined surface 1530 of the vane 1108-2. The inclined surface 1530 is sloped at an angle β_2 with respect to the longitudinal axis 1101 and contacts a corresponding downward and radially inward facing inclined surface 1531 of the upper segment 410. Moreover, the mandrel 1124 contains a downward and radially outward facing inclined surface 1540, which is inclined at an angle α_2 with respect to the longitudinal axis 1101 and contacts a corresponding upward and radially inward facing sloped surface 1541 of the lower segment 420. The vane 1108-2 contains a downward and radially outward extending extension 1500 that is associated with a corresponding inclined inner slot 1520 of the lower segment 420. In a similar manner to the radial expansion of the upper segment 410, uphole movement of the rod 1112 causes radial expansion of the lower segment 420, as well as movement of the lower segment 420 uphole toward the upper segment 410, as depicted in Fig. 15B. In a similar manner to the contraction of the upper segment 410, the lower segment 420 may be radially contracted by moving the rod 1112 in the downhole direction. Moreover, the ring assembly 50 may have tongue-and-groove connections between the vanes 1108-2 and lower segments 420, and in accordance with some implementations, sealing elements may be disposed between the vanes 1108-2 and lower segments 420.

[0068] While a limited number of examples have been disclosed herein, those skilled in the art, having the benefit of this disclosure, will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations

WHAT IS CLAIMED IS:

- 1 1. A method usable with a well, comprising:
2 running a ring assembly into a previously installed tubing string on a conveyance line;
3 radially expanding a segmented ring of the ring assembly at a first downhole location
4 inside the tubing string so that the segmented ring transitions from a radially contracted state to a
5 radially expanded state;
6 performing a first downhole operation using the ring assembly with the segmented ring in
7 the radially expanded state; and
8 subsequent to performing the first downhole operation, radially contracting the
9 segmented ring assembly to transition the segmented ring from the radially expanded state to the
10 radially contracted state and moving ring assembly from the first downhole location.
1
1 2. The method of claim 1, wherein moving the ring assembly from the first
2 downhole location comprises moving the ring assembly to a second downhole location, the
3 method further comprising:
4 at the second downhole location, transitioning the segmented ring from the radially
5 contracted state to the radially expanded state and performing a second downhole operation
6 using the segmented ring in the radially expanded state.
1
1 3. The method of claim 1, wherein performing the first downhole operation
2 comprises actuating a downhole tool.
1
1 4. The method of claim 1, wherein the ring assembly in the radially expanded state
2 forms a fluid barrier, and performing the first downhole operation comprises diverting fluid
3 using the fluid barrier.

1 5. The method of claim 1, wherein the ring assembly comprises a tool comprising a
2 rod and a mandrel, and transitioning the segmented ring from the radially contracted state to the
3 radially expanded state comprises:

4 moving a rod relative to a mandrel of the setting tool; and
5 contacting segments of the segmented ring with surfaces of the mandrel and surfaces of
6 the rod to radially expand the segments.

1
1 6. The method of claim 5, wherein the segmented ring contacts a feature of the
2 tubing string in the radially expanded state, the method further comprising:

3 while the segmented ring is in the radially expanded state, exerting a force on the mandrel
4 to transfer a force from segmented ring to the feature of the tubing string.

1
1 7. The method of claim 6, wherein exerting the force comprises exerting a fluid
2 pressure or moving the conveyance line.

1
1 8. The method of claim 6, wherein the feature comprises a sleeve or a tubing string
2 wall.

1 9. The method of claim 1, wherein the ring assembly comprises a tool comprising a
2 rod and a mandrel, and transitioning the segmented ring from the radially expanded state to the
3 radially contracted state comprises:

4 moving a rod relative to a mandrel of the setting tool; and
5 contacting segments of the segmented ring with surfaces of the mandrel and surfaces of
6 the rod to radially contract the segments.

1
1 10. The method of claim 1, wherein performing the first downhole operation
2 comprises shifting a sleeve of the tubing string.

11. An apparatus usable with a well, comprising:
a tool; and
a segmented ring to be run downhole as a unit with the tool, the segmented ring comprising a plurality of segmented members,
wherein the tool is adapted to radially expand the segmented ring downhole in the well to form a ring and radially contract the segmented ring downhole in the well.

12. The apparatus of claim 11, wherein the tool is adapted radially expand the segmented members and axially contract the segmented members to form the ring.

13. The apparatus of claim 11, wherein:
the tool and segmented ring are adapted to be run downhole on a conveyance line inside a tubing string in a contracted state of the segmented ring; and
the tool is adapted to radially expand the segmented ring downhole in the well to engage a feature of the tubing string with the formed ring.

14. The apparatus of claim 13, wherein the tool is adapted to radially expand the segmented ring to form a fluid barrier in the tubing string.

15. A system comprising:
a tubing string;
a conveyance line; and
an assembly comprising a tool and a segmented ring to be run downhole in a single trip on the conveyance line, the segmented ring comprising a plurality of segments;
wherein the tool is adapted to:
radially expand the segments and longitudinally compress a number of layers of the segments to form a continuous ring downhole in the tubing string; and
subsequently, radially contract the segments and longitudinally expand the number of layers of the segments to remove the continuous ring.

1 16. The system of claim 15, wherein the tool is further adapted to, subsequent to the
2 the radial contraction and longitudinal expansion of the number of layers and in the same trip,
3 radially expand the segments and longitudinally compress the number of layers of the segments
4 to remove the continuous ring.

1
1 17. The system of claim 15, wherein the conveyance line comprises a coiled tubing, a
2 slickline or a wireline.

1
1 18. The system of claim 15, method of claim 1, wherein the tubing string comprises a
2 sleeve, and the tool is adapted to radially expand the segments to cause the continuous ring to
3 engage the sleeve such that movement of the conveyance line shifts a position of the sleeve.

1
1 19. The system of claim 15, wherein the tool is adapted to radially expand the
2 segments to form a fluid barrier in the tubing string.

1
1 20. The system of claim 19, wherein the tubing string comprises a casing string.

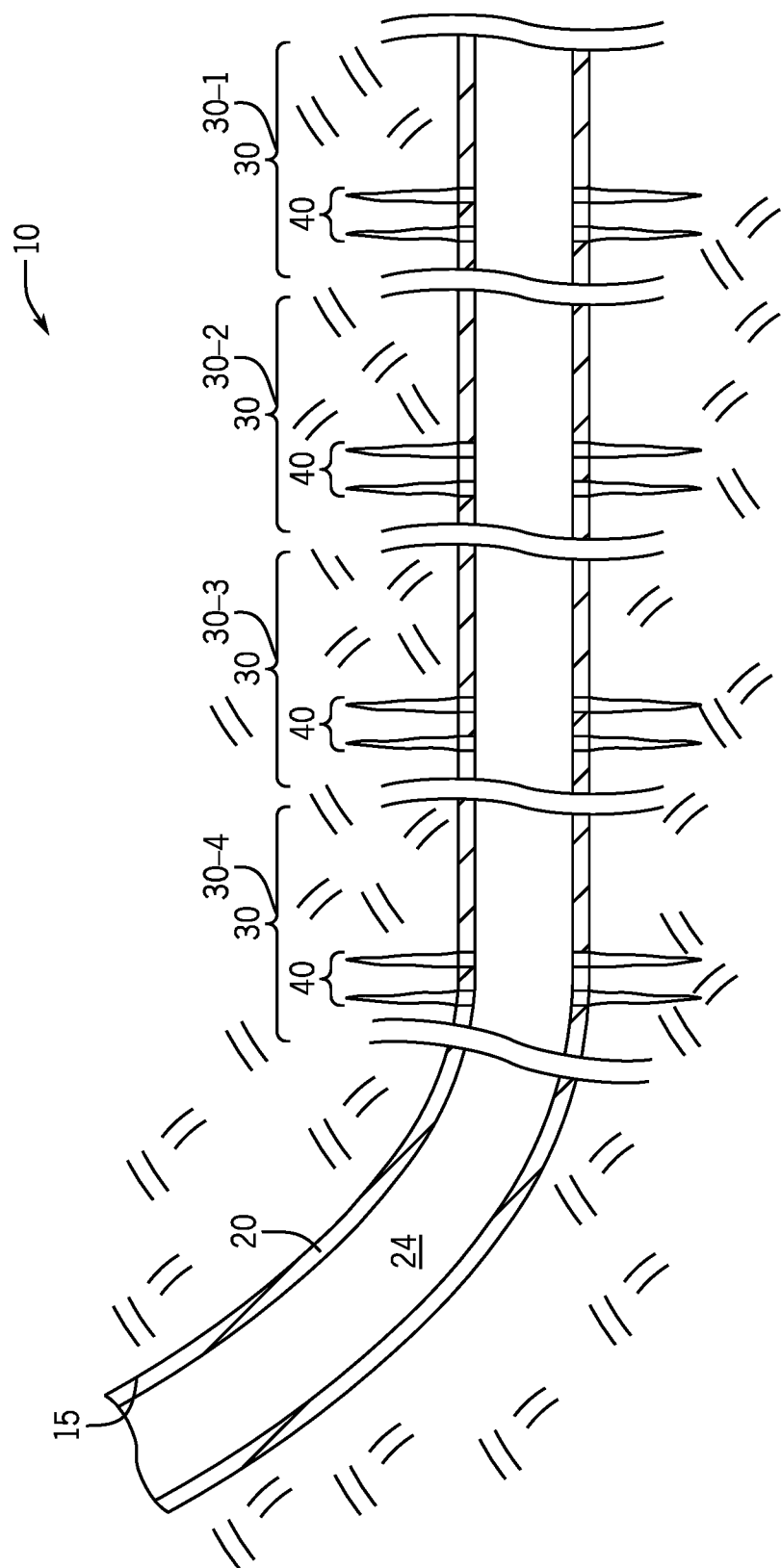


FIG. 1

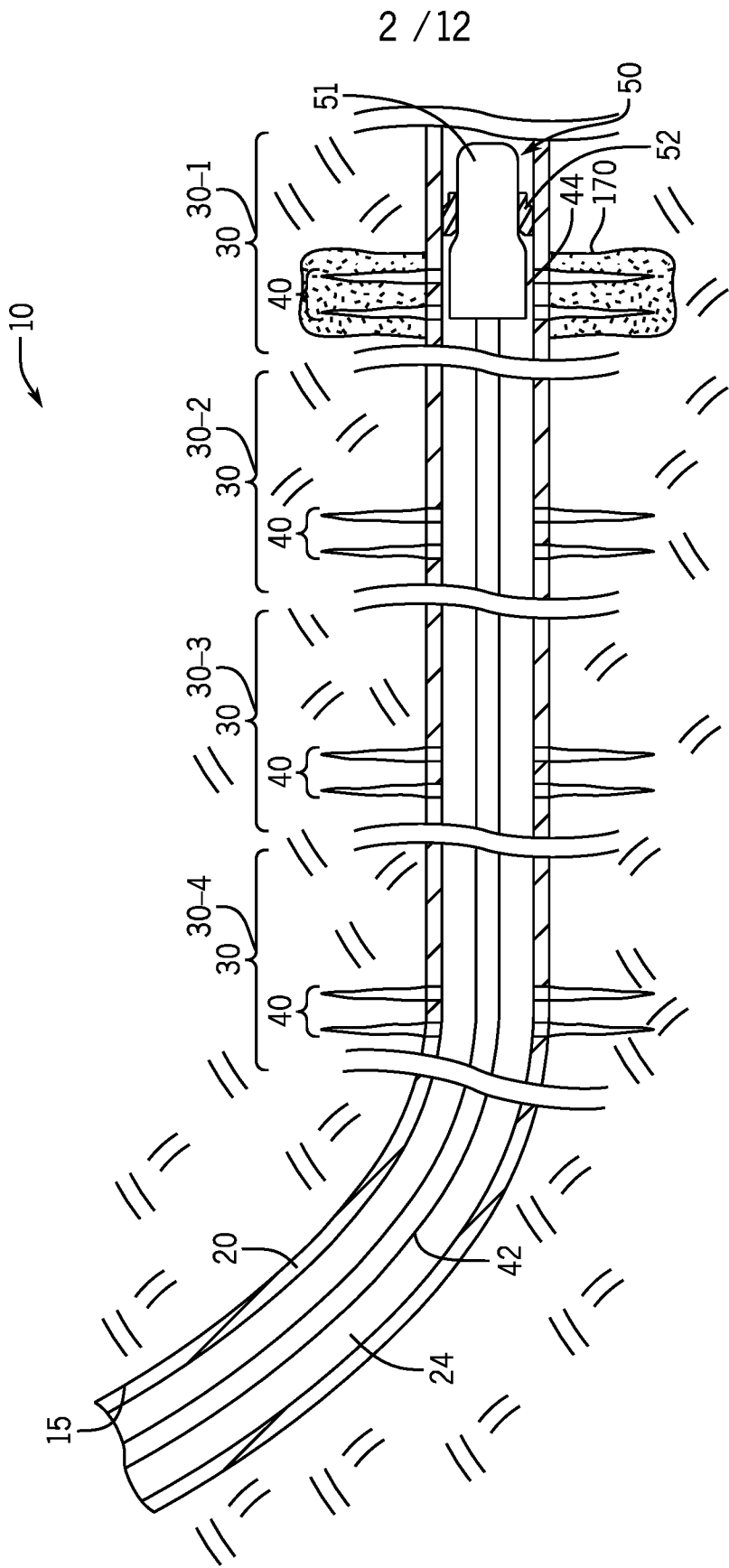


FIG. 2

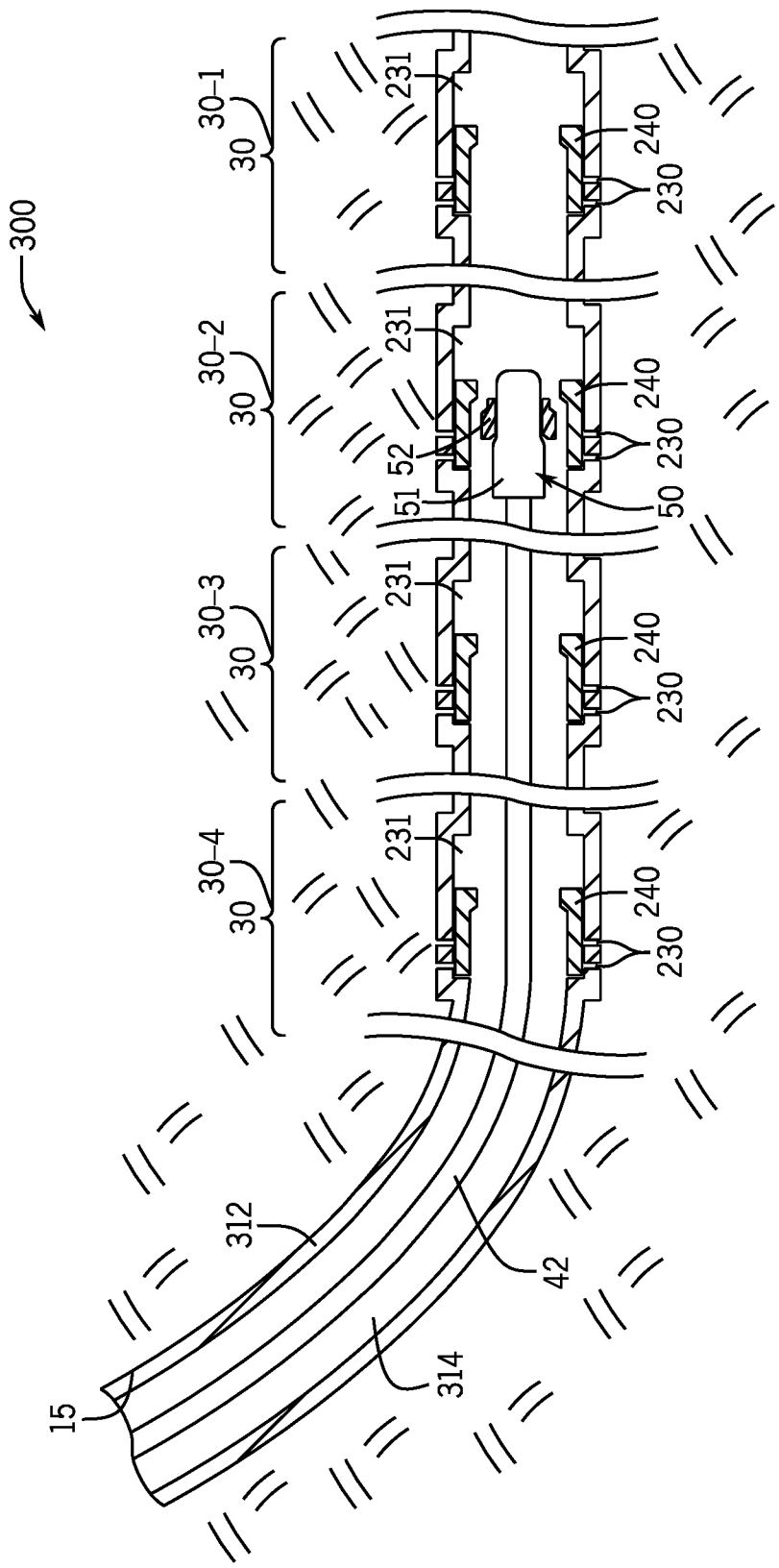


FIG. 3A

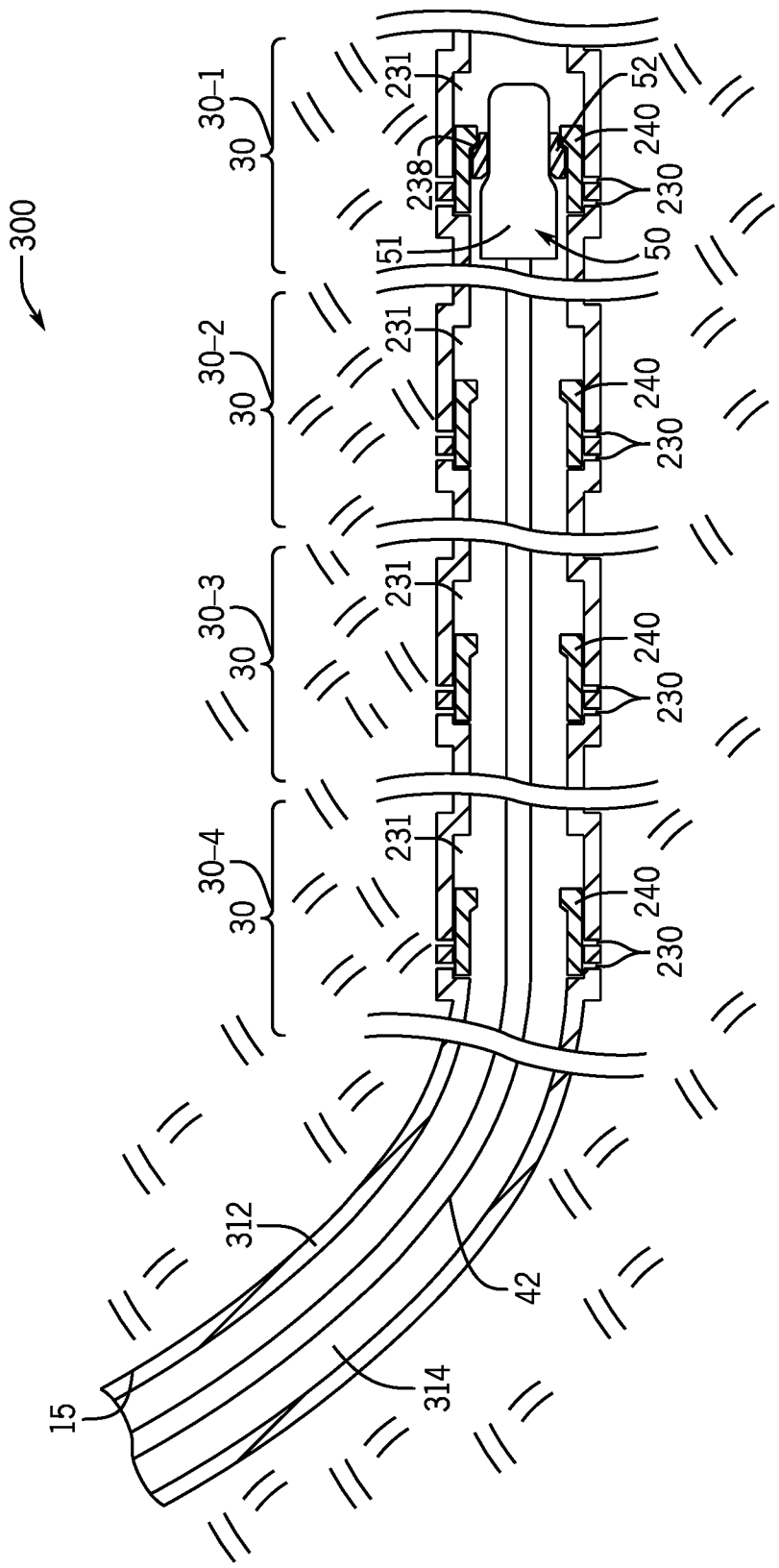


FIG. 3B

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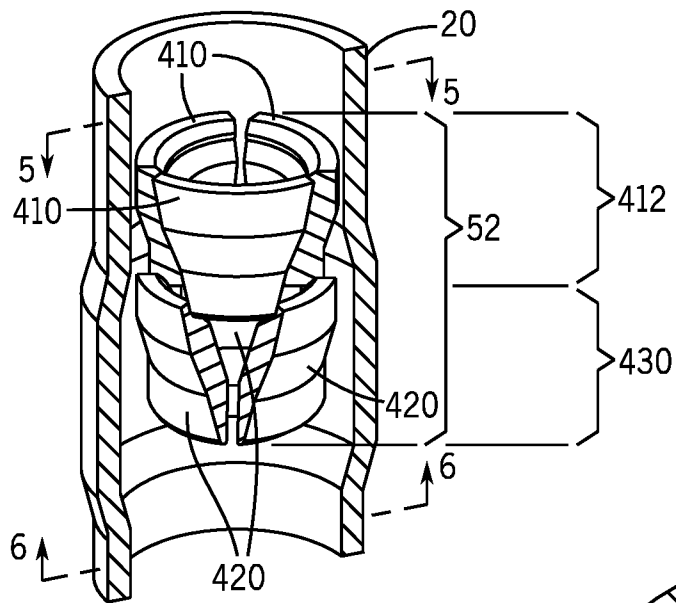


FIG. 4

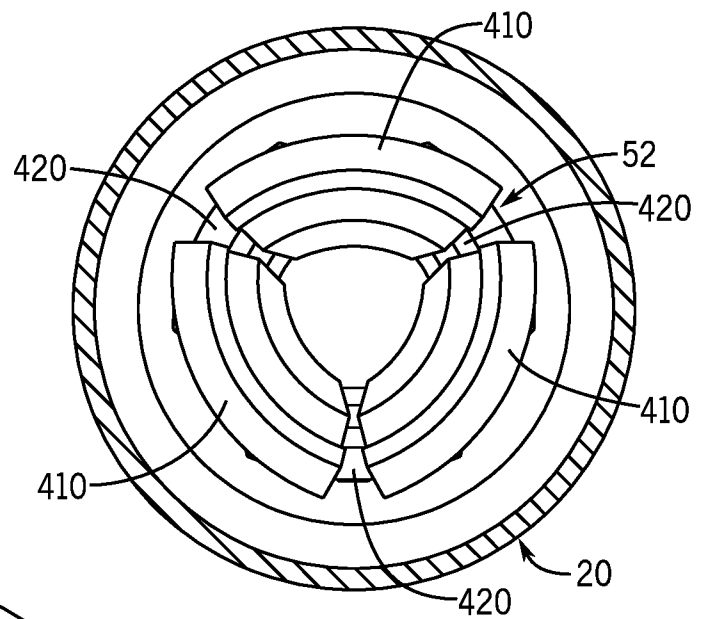


FIG. 5

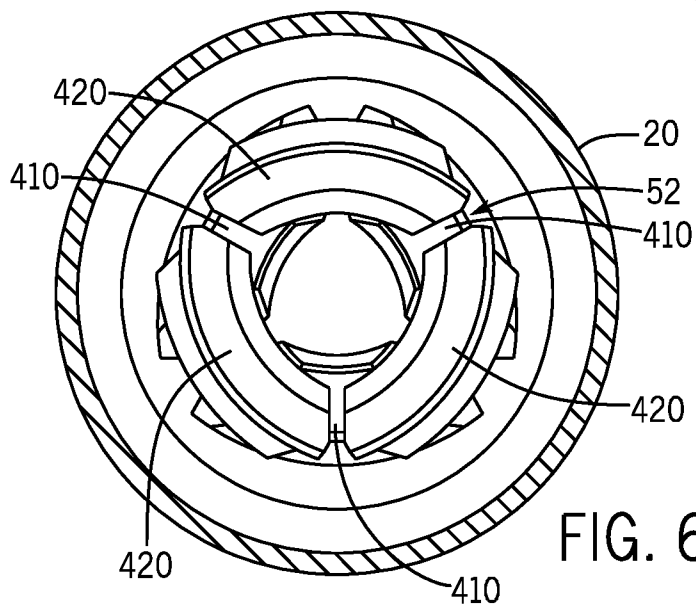


FIG. 6

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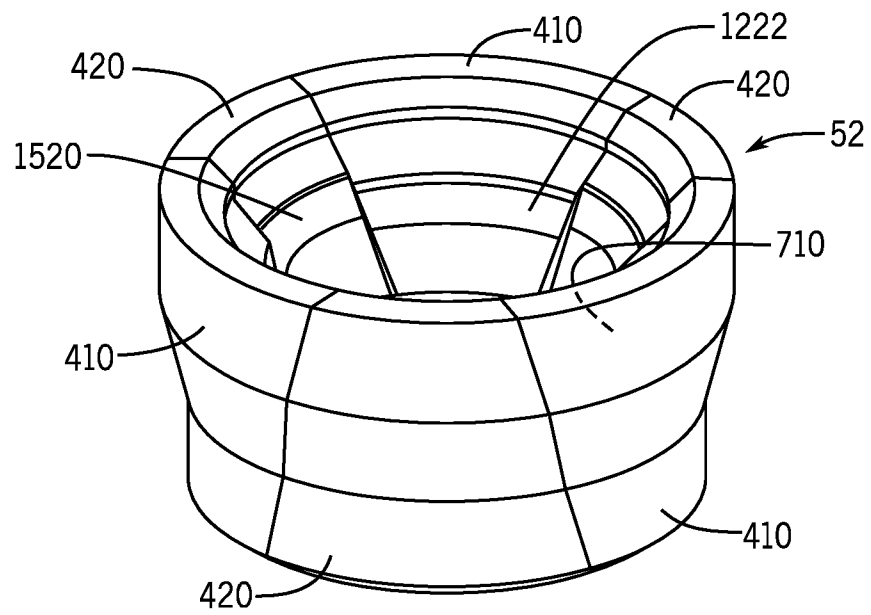


FIG. 7

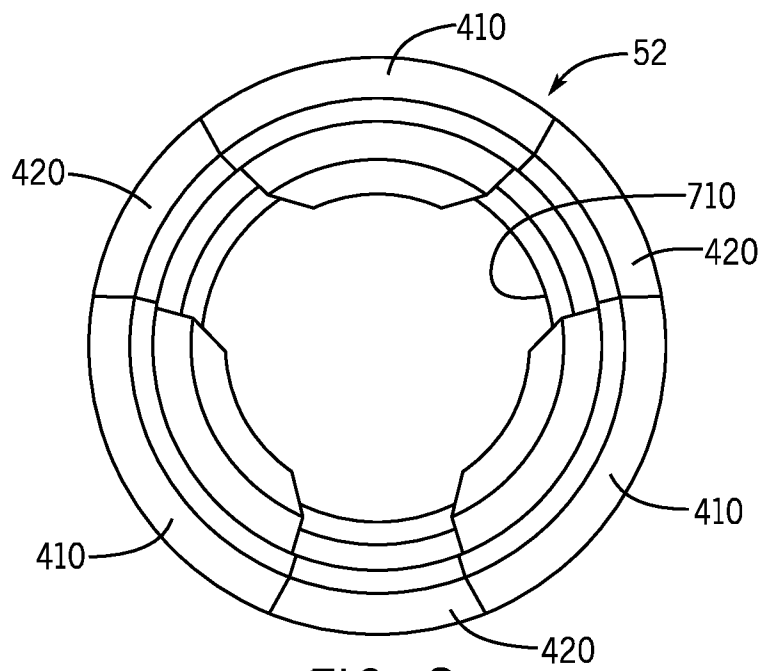


FIG. 8

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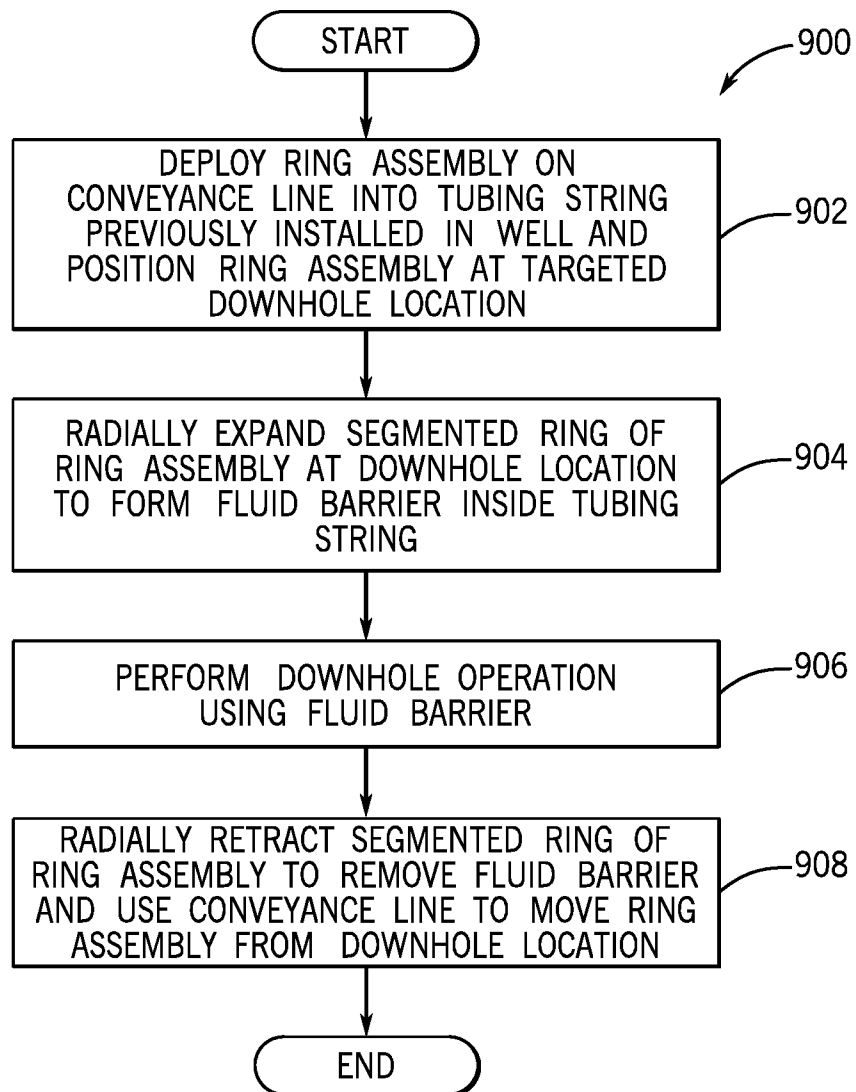


FIG. 9

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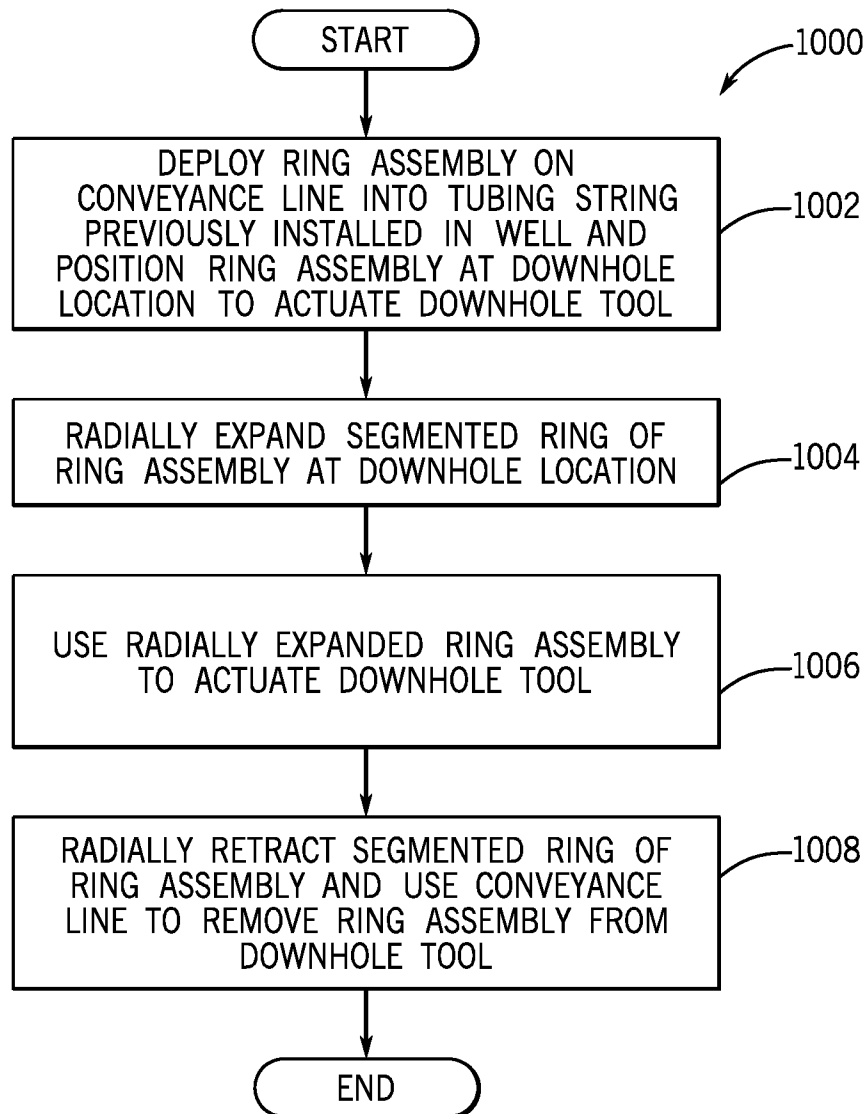


FIG. 10

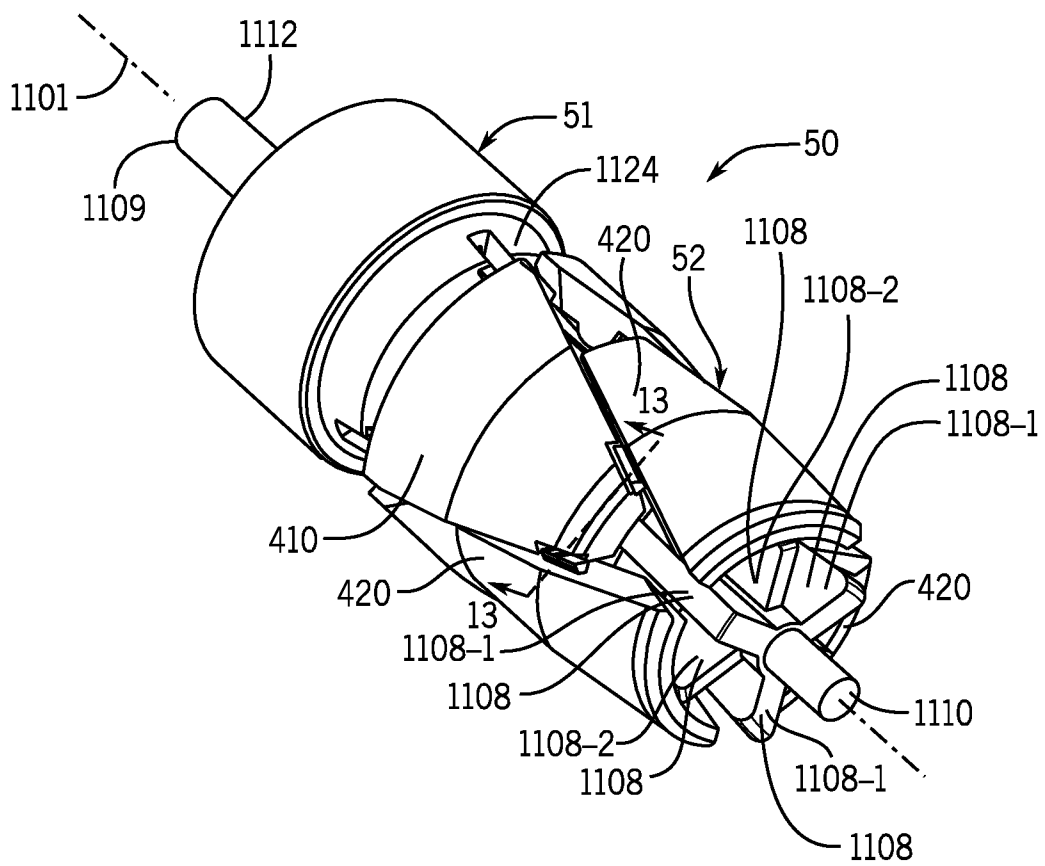


FIG. 11

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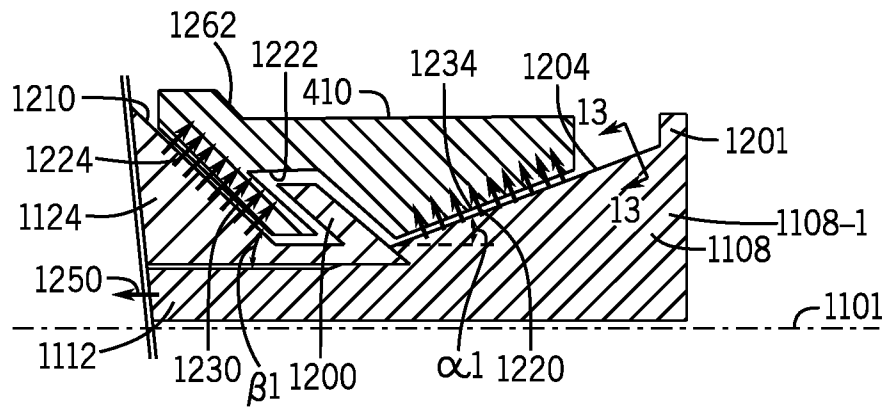


FIG. 12A

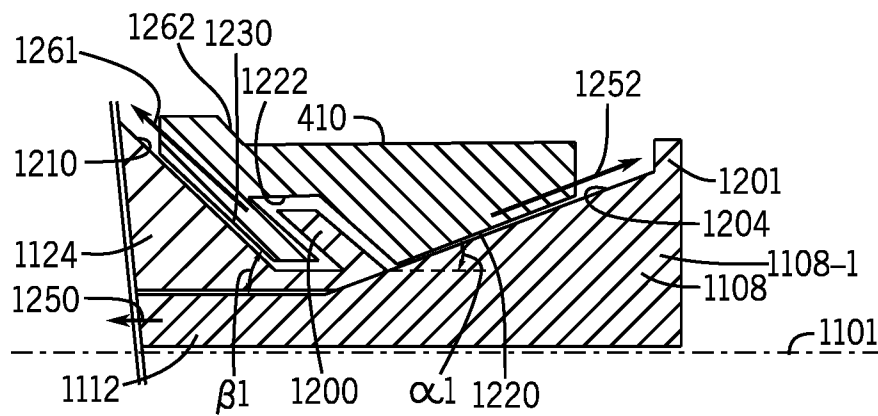


FIG. 12B

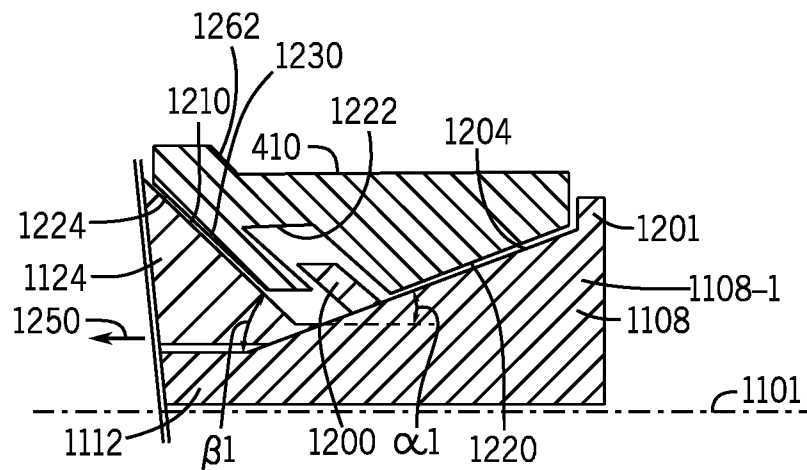


FIG. 12C

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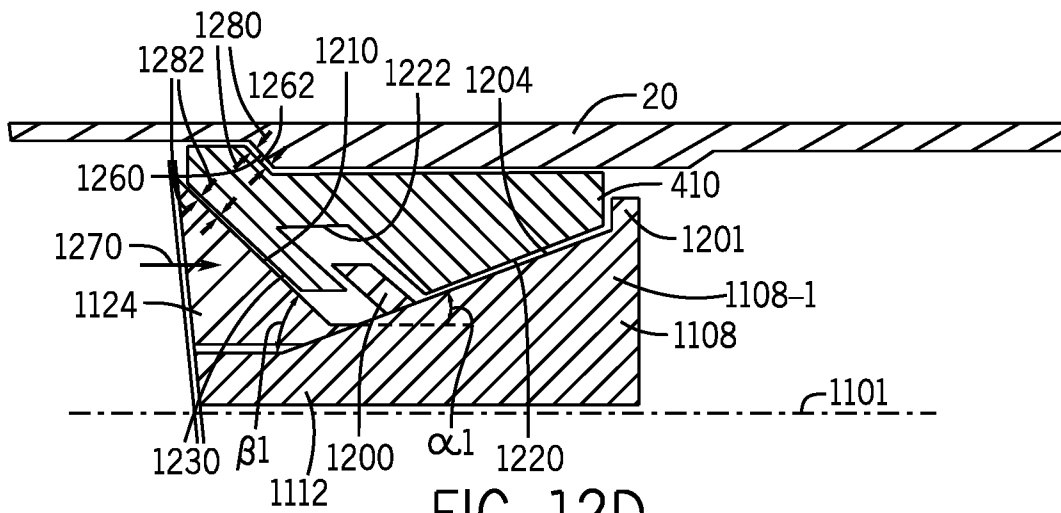


FIG. 12D

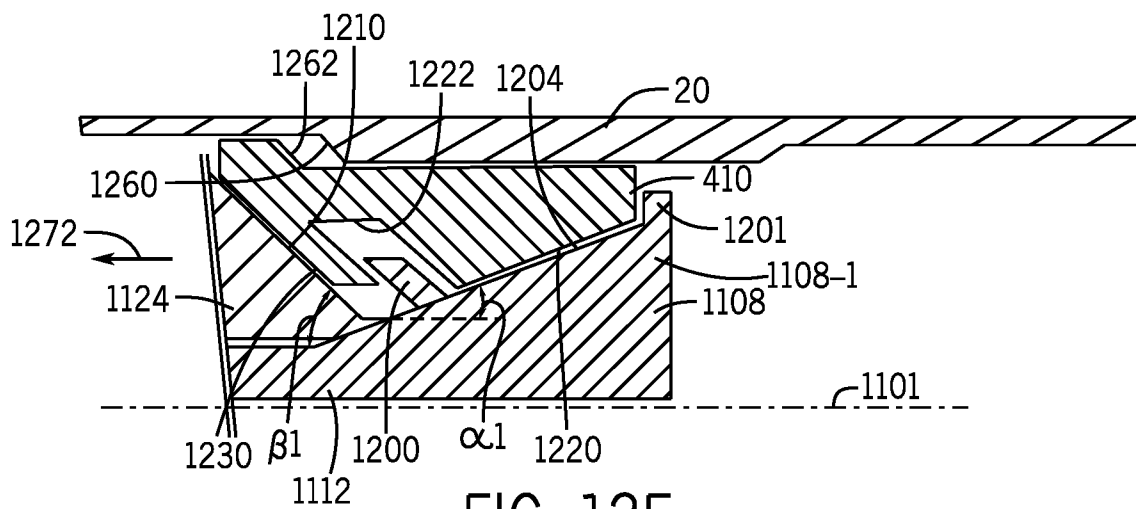


FIG. 12E

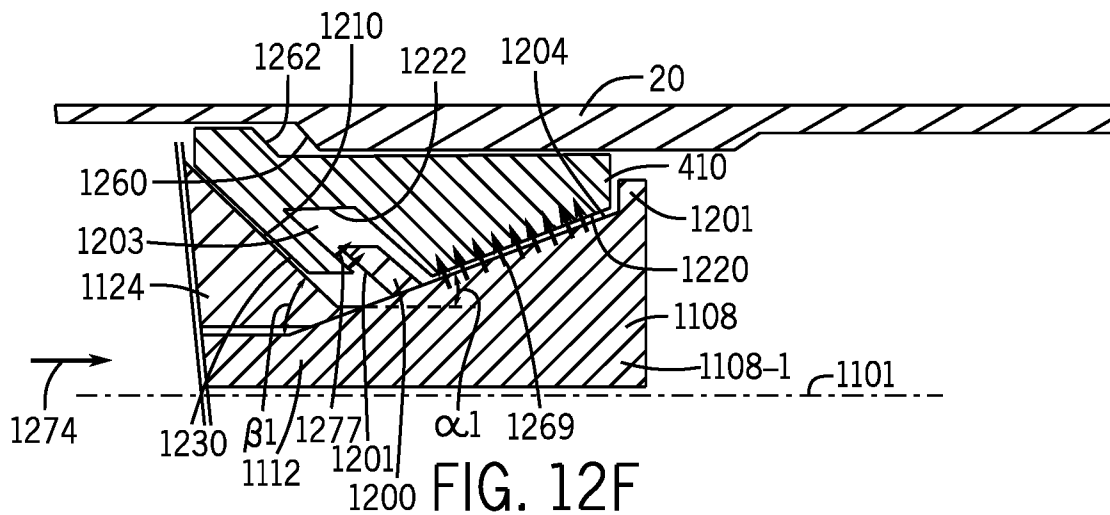


FIG. 12F

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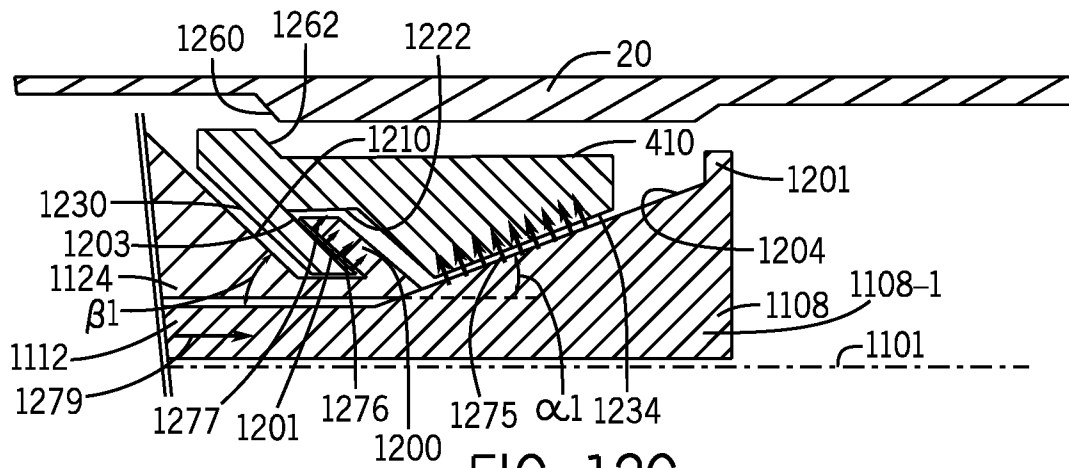


FIG. 12G

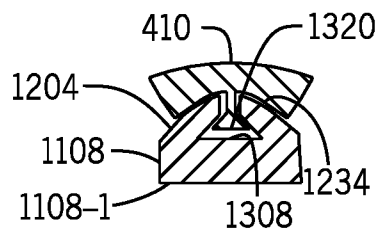


FIG. 13

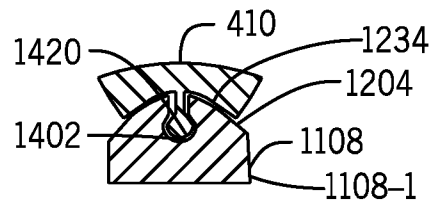


FIG. 14

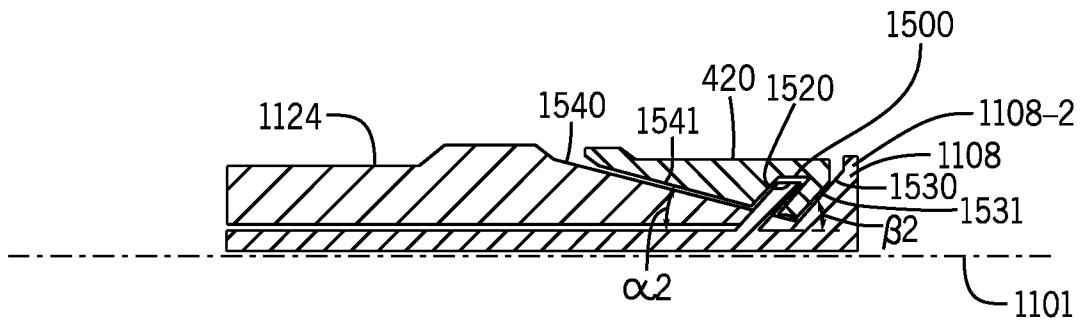


FIG. 15A

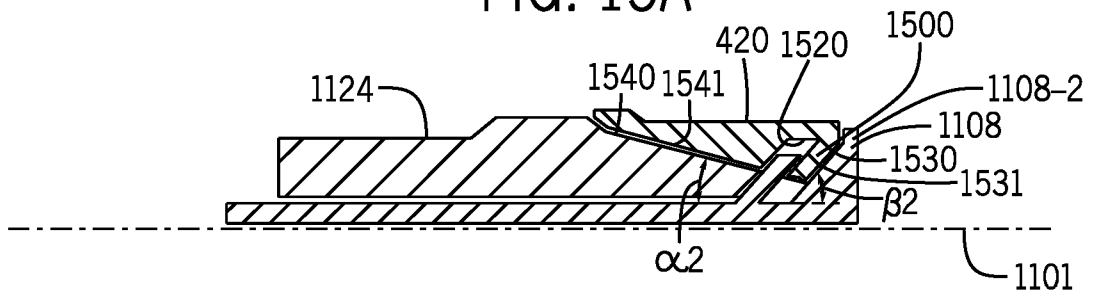


FIG. 15B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/065689**A. CLASSIFICATION OF SUBJECT MATTER****E21B 33/12(2006.01)i, E21B 23/00(2006.01)i, E21B 43/11(2006.01)i, E21B 43/25(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 33/12; E21B 33/128; E21B 41/00; E21B 29/00; E21B 43/11; E21B 23/00; E21B 43/25

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: wellbore, subterranean, tubing string, ring assembly, expand, contract, conveyance line, fluid barrier, rod and mandrel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0216758 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION) 07 August 2014 See paragraphs [0047]-[0100] and figures 1-23.	1-20
A	US 2011-0088891 A1 (STOUT, GREGG W.) 21 April 2011 See paragraphs [0021]-[0033] and figures 1-6.	1-20
A	US 2010-0186947 A1 (BISHOP et al.) 29 July 2010 See paragraphs [0014]-[0018] and figures 1-5.	1-20
A	US 2013-0062063 A1 (BAIHLY et al.) 14 March 2013 See paragraphs [0009]-[0035] and figures 1-7.	1-20
A	US 2013-0048314 A1 (VANLUE, DUKE) 28 February 2013 See paragraphs [0070]-[0186] and figures 2A-14B.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

29 March 2016 (29.03.2016)

Date of mailing of the international search report

29 March 2016 (29.03.2016)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/065689

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Information on patent family members

International application No.

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