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[Continued on next page]

- (54) **Title:** PACKER ASSEMBLY WITH MOORING RING FOR ENHANCED ANCHORING

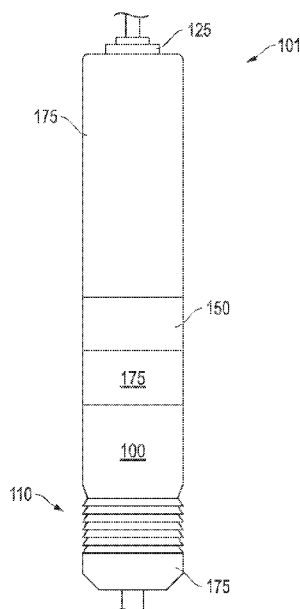


FIG. 1

(57) **Abstract:** A packer assembly including a slip for anchoring and a mooring ring for enhancing the anchoring. The slip is configured with teeth for penetrating into a well tubular during anchoring whereas the mooring ring is configured with an outer surface for frictional engagement with the well tubular during anchoring. Thus, a degree of anchoring forces may be distributed through the mooring ring as opposed to through the isolated narrow region of the slip alone. Once more, the anchoring forces distributed through the mooring ring are translated in a penetration free manner relative the well tubular.



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PACKER ASSEMBLY WITH MOORING RING FOR ENHANCED ANCHORING

BACKGROUND

[0001] Exploring, drilling and completing hydrocarbon and other wells are generally complicated, time consuming, and ultimately very expensive endeavors. As a result, over the years, a significant amount of added emphasis has been placed on well monitoring and maintenance. By the same token, perhaps even more emphasis has been directed at initial well architecture and design. All in all, careful attention to design, monitoring and maintenance may help maximize production and extend well life. Thus, a substantial return on the investment in the completed well may be better ensured.

[0002] In the case of well design, architecture and subsequent maintenance, there is often the need to isolate high pressure regions of a cased or lined well with a packer assembly which anchors in place and seals off a region of the well. For example, isolation for the sake of targeted production from a particular region of a well is quite common. However, as well depths continue to become greater and greater, so do well pressures. Thus, the likelihood exists that the well may exceed 20,000 feet in depth, for example, with an architecture targeting an isolated region for production that exceeds 10,000-15,000 PSI. By the same token, a host of interventional applications may also be undertaken which have the effect of introducing such dramatically high pressures in a well. For example, perforations may be formed into the wall of the well at a given location by way of a perforating application which involves isolating the location with a packer assembly. Thus, the packer assembly is subjected to such high pressures introduced by way of the adjacent explosive perforating application.

[0003] Faced with such dramatically high pressures, packer assemblies utilize slips to engage and anchor at the wall of the well with a substantial amount of force. For example, the slips may include teeth which forcibly extended outward into an anchoring biting engagement with the tubular defining the well (i.e. the casing or liner). The amount of force imparted by the slips of the packer assembly during such setting may exceed 100,000 PSI. At the same time, however, ratings for such tubulars defining the well may, at times, be below the force imparted by the packer. For example in the case of casing tubular, ratings often run across a range of 50,000-150,000 PSI. As a result, the potential exists for the casing tubular to sustain damage by the forcibly expanded packer assembly during setting.

[0004] In many cases, however, concern over damage on the casing tubular by slips of a packer assembly is mitigated by the realization that the casing is generally reinforced and held in place by cement. That is, a thick layer of cement is generally present between the casing tubular and the formation. Thus, while the force of the slips may sometimes exceed the casing tubular rating, as a practical matter, ballooning or deformation damage to the casing may be prevented due to the reinforced environment of the casing.

[0005] Unfortunately, such damage is not always avoidable due to the presence of cementing. For example, the packer assembly may be set at a location in the well that is above the cement level. This often occurs in circumstances where the operator is unaware of the true height of the cement level due to challenges in estimating the level. Furthermore, as a simple matter of cost, casing tubulars are often installed and utilized bare, without any cementing. Indeed, where the tubular defining the well is a liner as opposed to casing, this would be the norm.

[0006] In circumstances where discrete slips are forcibly expanded beyond the rating of the well defining tubular, and cement is not present, ballooning or deforming

of the tubular is to be expected. Plastically deforming a casing in this manner may be quite costly to the operator. In a worst case scenario, the well may be entirely lost. That is, given the cost of a workover in light of the expected productivity of the well, in spite of the likely millions of dollars lost, it may be more cost-effective to abandon the well and even complete another, rather than to engage in workover efforts. On the other hand, where a workover is deemed worth attempting, it remains a costly option in a variety of ways. For example, although costly, it may be possible to remove and replace the damaged section of casing restoring it to full performance. Alternatively, the casing may be patched in a manner that reduces the diameter of the wellbore at the patch location but is generally a bit less expensive. Regardless, even where the less costly patching is undertaken, it is likely to involve several days worth of downtime at a cost of several hundred thousand dollars.

[0007] In light of the costs involved, efforts have been undertaken to help lessen the likelihood of plastically deforming well defining tubular with packer assembly slips. For example, rather than utilize a single slip with all anchoring forces focused around a narrow ring of a few inches that makes up the slip, packer assemblies have been developed which utilize more than one slip. The slips may be spaced apart and simultaneously set. This would allow the anchoring forces that are translated through to the well defining tubular to be distributed over multiple slips. Thus, in theory, the amount of forces imparted through any one of the slips might be reduced without compromise to the overall anchoring ability of the packer assembly. Unfortunately, the ability to simultaneously anchor slips with precision remains a challenge. Instead, it is much more likely that the slips will set in sequence with the first set slip absorbing all anchoring forces alone followed by anchoring of subsequent slips as the initially set slip begins to fail. In all probability, the operator has exchanged a functional packer assembly prone to damage the casing for one that is more likely to fail to anchor.

SUMMARY

[0008] A packer assembly is provided with a mandrel having a slip thereabout for anchoring the assembly against a tubular in a well. The assembly also includes a mooring ring about the mandrel that is adjacent the slip. The ring includes an outer surface for engaging the tubular in a penetration-free manner to enhance a distribution of anchor forces along the assembly during the anchoring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Fig. 1 is a side vertical view of an embodiment of a packer assembly utilizing a slip and a mooring ring for enhanced anchoring.

[0010] Fig. 2A is an overview of an oilfield with a well accommodating the packer assembly of Fig. 1 therein.

[0011] Fig. 2B is an enlarged view of the packer assembly taken from 2-2 of Fig. 2A.

[0012] Fig. 3A is a perspective view of an embodiment of a mooring ring for enhancing the anchoring of a packer assembly.

[0013] Fig. 3B is a perspective view of an embodiment of a slip for interacting with the mooring ring of Fig. 3A in anchoring a packer assembly.

[0014] Fig. 4A is a side cross-sectional view of the packer assembly of Fig. 1 prior to setting in the well of Fig. 2A.

[0015] Fig. 4B is a perspective view of an actuator cone of Fig. 4A for setting the mooring ring and the slip of the assembly.

[0016] Fig. 5 is a flow-chart summarizing an embodiment of deploying and utilizing a packer assembly with a mooring ring in a well.

DETAILED DESCRIPTION

[0017] Embodiments herein are described with reference to certain types of packer assemblies. For example, a mechanical packer is shown which is utilized downhole for

a temporary isolation. However, a variety of different types of packer assemblies may take advantage of the unique anchoring embodiments detailed herein. For example, a more permanent packer assembly utilized with production tubing may utilize such anchoring features. So long as the packer assembly includes a slip for tubular penetration type anchoring in combination with a mooring ring for distributing and enhancing anchoring forces in a non-penetrating fashion, appreciable benefit may be realized.

[0018] Referring now to Fig. 1, a side vertical view of an embodiment of a packer assembly 101 is shown. The assembly 101 may be utilized to provide fluid isolation at a location in a well tubular. In the embodiment shown a head 125 of the assembly 101 is provided for securing to wireline or other form of downhole conveyance. The head 125 in turn is coupled to a housing structure 175 that ultimately transitions into a seal element 150 for providing fluid isolation and a slip 110 for anchoring the assembly 101 in place within a well tubular. In addition, a mooring ring 100 is provided for enhancing this anchoring as detailed below.

[0019] The assembly 101 might most commonly be anchored in a well defined by a tubular in the form of a casing of stainless steel or other suitable material. Alternatively, a liner, production tubing or other form of tubular may serve as a platform for anchoring of the assembly 101. Regardless of the type of well tubular, the slip 110 is outfitted with teeth for biting into the well tubular for sake of the noted anchoring. In the embodiment shown, the teeth are provided in a series of expandable ring forms. However, in other embodiments, the teeth may be of a more individual projection-like nature.

[0020] The assembly 101 of Fig. 1 is also outfitted with a seal element 150 as indicated above. The seal element 150 may be of an elastomeric material that is suitable for downhole use and which may be compressibly expanded into sealing

engagement with the well tubular. Thus, the above noted fluid isolation may be achieved via a slip 110 which anchors the assembly 101 in place in combination with a seal element 150 which fluidly seals the location.

[0021] In addition to the slip 110 and the seal element 150, the assembly 101 of Fig. 1 is also outfitted with a mooring ring 100 for enhanced anchoring. That is, rather than imparting anchoring forces nearly exclusively through the slip 110, a mooring ring 100 is provided to uniquely engage the tubular. So, for example, rather than utilize another slip alone as a manner by which to distribute anchoring forces along the assembly 101, the mooring ring 100 frictionally engages the tubular during anchoring without biting into the adjacent tubular. In this way, the mooring ring 100 may take on a degree of the anchoring load by way of surface friction at the interface of the ring 100 and tubular, without measurably affecting the ability of the slip 110 to be set and anchor.

[0022] Unlike use of a second slip alone, the use of the mooring ring 100 assures a distribution of forces during anchoring. That is, the possibility is avoided of sequentially loading multiple slips in a manner that might only sequentially move anchoring forces from one slip to another as a previously anchored slip begins to fail. Since the mooring ring 100 distributes anchoring forces but does not bite into the tubular, the possibility of such sequential anchor loading and failure is substantially eliminated.

[0023] Referring now to Figs. 2A and 2B, the packer assembly 101 of Fig. 1 is shown in use in a downhole environment. Specifically, Fig. 2A depicts an overview of an oilfield 201 with a well 280 accommodating the assembly 101 of Fig. 1 therein. In this embodiment, the well 280 may extend several thousand feet below a well head 260, traversing various formation layers 290, 295 before reaching a location for isolation. The assembly 101 may be utilized for fluid isolation at the location in advance of a high

pressure application such as perforating. Thus, given the depth and introduction of a high pressure application above the assembly 101 which may exceed 100,000 PSI, substantial anchoring forces may be imparted through the slip 110 and mooring ring 100. In this way, the assembly 101 may be held in place and the seal element 150 maintain fluid isolation during the application.

[0024] With specific reference now to Fig. 2B, an enlarged view of the packer assembly 101 taken from 2-2 of Fig. 2A is shown with the seal element 150 fluidly isolating the well 280. Further, the packer assembly 101 is shown set by the teeth of the slip 110 wedgeably penetrating to a degree into the tubular casing 285 which defines the well 280.

[0025] As shown in Fig. 2A, an outer surface of the mooring ring 100 is also in contact with the casing 285 to provide a frictional interface 200 therewith. Indeed, in the embodiment shown, the frictional interface 200 is formed in advance of anchoring through the slip 110. Thus, anchor forces are not just distributed through the narrow region of the slip 110 but also to a degree through the ring 100 in advance of fully setting the slip 110. As a practical matter, this means that 50 – 150,000 PSI of force is not directed through the slip 110 alone but instead distributed across a larger region of the casing 285. As a result, the likelihood of plastically deforming the casing 285 and slip failure is reduced if not eliminated entirely. This may be particularly beneficial in circumstances where cement 287 is not present or the tubular is a thinner liner as opposed to the depicted casing 285.

[0026] Referring now to Figs. 3A and 3B, perspective views of an embodiment of the mooring ring 100 and the slip 110 are shown. As depicted in Fig. 2B above, in this embodiment, these features 100, 110 are positioned adjacent one another and configured for cooperative setting. For example, the mooring ring 100 is provided with a slip-setting surface 301 which interfaces a slip incline surface 302. Thus, as detailed

further below, when the mooring ring 100 is expanded and/or forcibly pressed down at its own ramped surface 325, this may translate forces to the slip-setting 301 and incline 302 surfaces for setting of the slip 110. Although, as described further below, forces acting upon the incline surface 302 may also be provided by way of a setting cone.

[0027] With specific reference to the embodiment of Fig 3A, radial expansion of the mooring ring 100 is promoted through use of slits 350. This allows the region around the ramped surface 325 to move outward similar to collet fingers in response to a setting cone being forcibly driven toward the surface 325. In one embodiment, slits 350 and collet fingers may be exchanged for keys or other expandable components configured to be released from the mooring ring 100 during setting and captured at the interface 200 between the surface 300 and the casing 285 of Fig. 2B to further enhance anchoring. That is, with added reference to Fig. 2B, the outer surface 300 of the ring 100 may be expanded into the interface 200 with the casing 285. In another embodiment, this surface 300 may be knurled or otherwise patterned, roughened or coated with a high-friction coating so as to enhance the anchor-type engagement between the surface 300 and the casing 285 at the interface 200.

[0028] With specific reference to Fig. 3B, the perspective view of the slip 110 shown reveals an embodiment where individual projection-like teeth 310 are utilized in place of the more expandable ring form as shown in Figs. 1 and 2B above. Nevertheless, expansion of the slip 110 still translates into partial penetration of these teeth 310 into casing 285 to attain anchoring as shown in Fig. 2B. Indeed, in the embodiment shown, forces imparted through the incline surface 302 as described above may result in the release of a shear plate 375 to allow the slip 110 to behave as a C-ring. Thus, the slip 110 may further expand into more anchored engagement with the casing 285 of Fig. 2B.

[0029] Continuing with reference to Figs. 3A and 3B, even in embodiments shown herein, where anchoring is aided by the mooring ring 100, the slip 110 would still provide the primary anchoring function. For example, the mooring ring 100 may take on between about 10% and about 50% of the transferred anchoring load whereas the slip 110 would take on about 50% to 90% of the load.

[0030] Referring now to Fig. 4A, a side cross-sectional view of the packer assembly 101 of Fig. 1 is shown prior to setting in the well 280 of Fig. 2A. In this view, the mooring ring 100 is visible just above the slip 110 as detailed above. However, in other embodiments, the mooring ring 100 may be located elsewhere in relation to the slip 110. For example, so long as the outer surface 300 of the mooring ring 100 begins to engage the casing 285 as shown in Fig. 2B in advance of the complete anchoring of the slip 110, there is no particular requirement that the ring 100 actually play a role in setting of the slip 110. Although, as noted above and shown in Fig. 4A, the embodiment depicted includes a slip-setting surface 301 which plays a role in setting the slip 110 via the incline surface 302 of the slip 110.

[0031] Both the mooring ring 100 and the slip 110 are located about a central supportive structure in the form of a mandrel 475 for the packer assembly 101. However, in the embodiment shown, a setting cone 400 is located between the mooring ring 100 and the mandrel 475. This cone 400 is morphologically tailored to set both the ring 100 and the slip 110. Specifically, the setting cone 400 includes a mooring-setting incline 405 and a slip-setting incline 402, each of which may be tailored in terms of the degree of incline relative the mooring ring 100 and slip 110 to determine the amount of radial stress that is translated to each feature (100, 110) as the cone 400 is moved downward as described below.

[0032] Specifically, the cone 400 is configured to move downward such that the mooring-setting incline 405 acts upon the mooring ring 100 at its ramped surface 325 to

begin anchoring. The continued downward movement of the cone 400 results in its slip-setting incline 402 acting upon the slip 110 to complete anchoring. Indeed, as described above, this may include imparting enough force through the slip 110 to break apart a shear plate 375 and allow further radial expansion of the slip 110 for biting into a casing 285 as depicted in Fig. 2B.

[0033] With added reference to Fig. 4B, a perspective view of the setting cone 400 is shown. The upper end of this cone 400 may be acted upon through conventional means, such as by a hydraulically driven actuator 425 as shown in Fig. 4A in order to attain the downward thrust sufficient for setting of the mooring ring 100 and slip 110 as detailed above. Indeed, a predetermined amount of anchoring forces may be imparted through the actuator 425 in this manner. Due to the distribution of these forces through the anchoring ring 100 and subsequently the slip 110, the predetermined amount of forces may be set at a relatively high level, perhaps well over 150,000 PSI, without undue concern over ballooning or other damage to the surrounding well tubular (i.e. casing 285 as shown in Fig. 2B).

[0034] Referring now to Fig. 5, a flow-chart summarizing an embodiment of deploying and utilizing a packer assembly with a mooring ring in a well is shown. In a very straight forward fashion, embodiments detailed hereinabove involve the positioning of a packer assembly in a well as shown at 525. Then, in a sequential manner, a mooring ring is set such that a surface thereof begins to engage a well tubular as shown at 550. This occurs in a frictional manner without any teeth of the mooring ring penetrating the tubular (e.g. casing). Thus, a degree of anchoring forces are distributed through the mooring ring before the slip is set as indicated at 575. As a result, the biting engagement of the slip does not absorb all of the anchoring forces in play. Rather, a predetermined amount of such forces may be distributed elsewhere through the mooring ring.

[0035] Embodiments described hereinabove provide devices and techniques to aid in anchoring of a packer assembly in manners that minimize the likelihood of plastically deforming well tubulars such as casing. This is achieved in a manner that does not require the use of multiple slips which are prone to sequentially anchor and fail. Thus, the operator need not decide between a packer assembly likely to damage the casing versus one that is unlikely to effectively anchor.

[0036] The preceding description has been presented with reference to presently preferred embodiments. Persons skilled in the art and technology to which these embodiments pertain will appreciate that alterations and changes in the described structures and methods of operation may be practiced without meaningfully departing from the principle, and scope of these embodiments. For example, embodiments of packer assemblies may utilize multiple slips in combination with one or more mooring rings as detailed herein. Furthermore, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

CLAIMS

We Claim:

- 1 1. A packer assembly for use at a location in a well tubular, the assembly
2 comprising:
3 a seal element about a mandrel for sealing engagement with the well tubular at
4 the location;
5 a slip about the mandrel with teeth for penetrating into the well tubular for
6 anchoring of the assembly at the location; and
7 a mooring ring about the mandrel adjacent the slip, the ring having an outer
8 surface for frictional engagement with the tubular at an interface therewith to enhance a
9 distribution of anchor forces along the assembly during the anchoring.
- 1 2. The assembly of claim 1 wherein the well tubular is one of a casing, a liner, and
2 production tubing.
- 1 3. The assembly of claim 1 wherein at least a portion of the mooring ring is of a
2 slit and collet configuration for radial expansion into the frictional engagement with the
3 tubular.
- 1 4. The assembly of claim 1 wherein at least a portion of the mooring ring
2 comprises releasable keys for positioning at the interface to enhance the frictional
3 engagement with the well tubular.
- 1 5. The assembly of claim 1 wherein the slip is a first slip, the assembly further
2 comprising a second slip.

1 6. The assembly of claim 5 wherein the mooring ring is a first mooring ring, the
2 assembly further comprising a second mooring ring.

1 7. The assembly of claim 1 further comprising a setting cone positioned between
2 the mooring ring and the mandrel, the setting cone interfacing the slip for driving the
3 teeth thereof into the penetrating of the well tubular for the anchoring and interfacing
4 the mooring ring for the enhancing of the anchoring.

1 8. The assembly of claim 7 further comprising an actuator to impart a
2 predetermined force on the setting cone for shifting thereof to achieve the interfacing of
3 the slip for the penetrating and the interfacing of the mooring ring for the enhancing.

1 9. The assembly of claim 8 wherein the predetermined force is over about 150,000
2 PSI.

1 10. A mooring ring for enhancing anchoring of a packer assembly in a well tubular,
2 the ring positioned adjacent a slip of the assembly for biting engagement with the
3 tubular and comprising an outer surface for frictional engagement with the tubular.

1 11. The ring of claim 10 wherein the outer surface is one of knurled, patterned,
2 roughened and frictionally coated to enhance the frictional engagement.

1 12. The ring of claim 10 wherein between about 10% and about 50% of forces for
2 the anchoring of the packer assembly are translated therethrough.

1 13. A method of enhancing anchoring of a packer assembly in a well tubular, the
2 method comprising:

3 deploying the packer assembly into the well tubular;
4 translating anchoring forces through a mooring ring of the assembly for
5 frictionally engaging a surface thereof with the well tubular; and
6 setting a slip of the assembly into biting engagement with the well tubular.

1 14. The method of claim 13 further comprising fluidly isolating the well tubular
2 with a seal element of the packer assembly in sealing engagement with the well tubular.

1 15. The method of claim 13 wherein the translating of the anchoring forces through
2 the mooring ring comprises radially expanding the mooring ring into the engaging of
3 the surface with the well tubular.

1 16. The method of claim 15 wherein the radially expanding of the mooring ring
2 comprises driving a setting cone of the assembly into interface with the mooring ring.

1 17. The method of claim 16 further comprising utilizing a hydraulically powered
2 actuator for the driving of the setting cone.

1 18. The method of claim 16 further comprising using the setting cone for the setting
2 of the slip.

1 19. The method of claim 18 wherein the setting of the slip with the setting cone
2 begins after the radially expanding of the mooring ring is initiated by the setting cone.

- 1 20. The method of claim 13 wherein the setting of the slip comprises:
- 2 releasing a shear plate of the slip; and
- 3 radially expanding the slip to radially expand teeth thereof for the biting
- 4 engagement.

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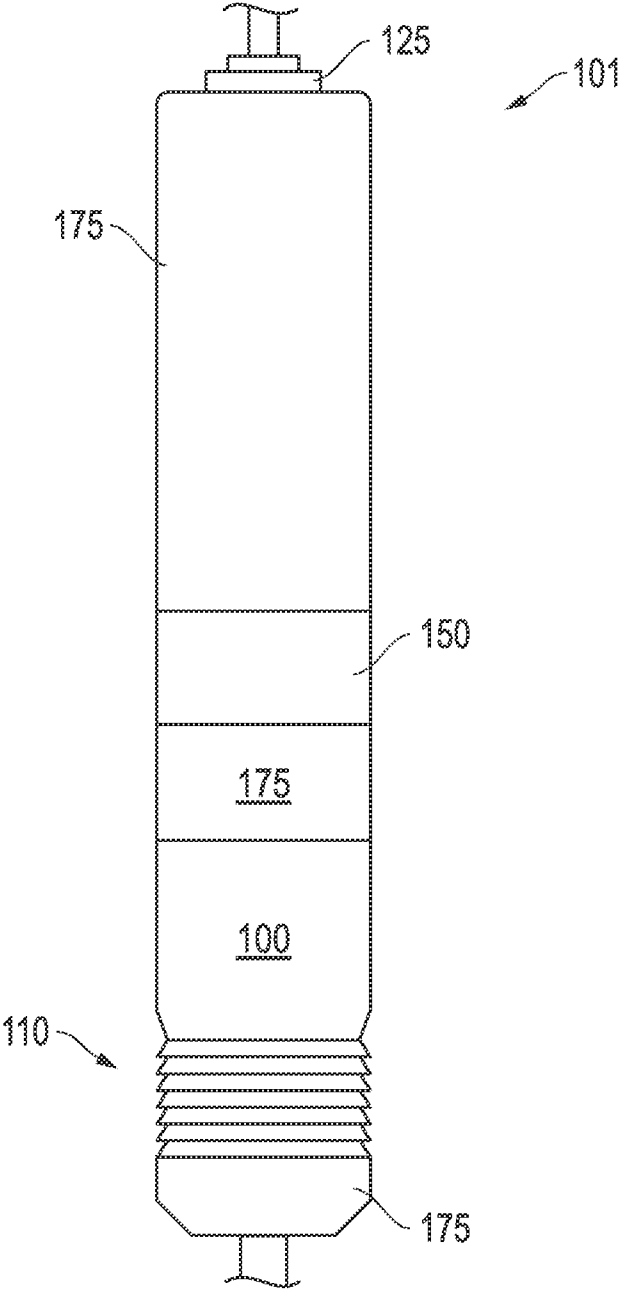


FIG. 1

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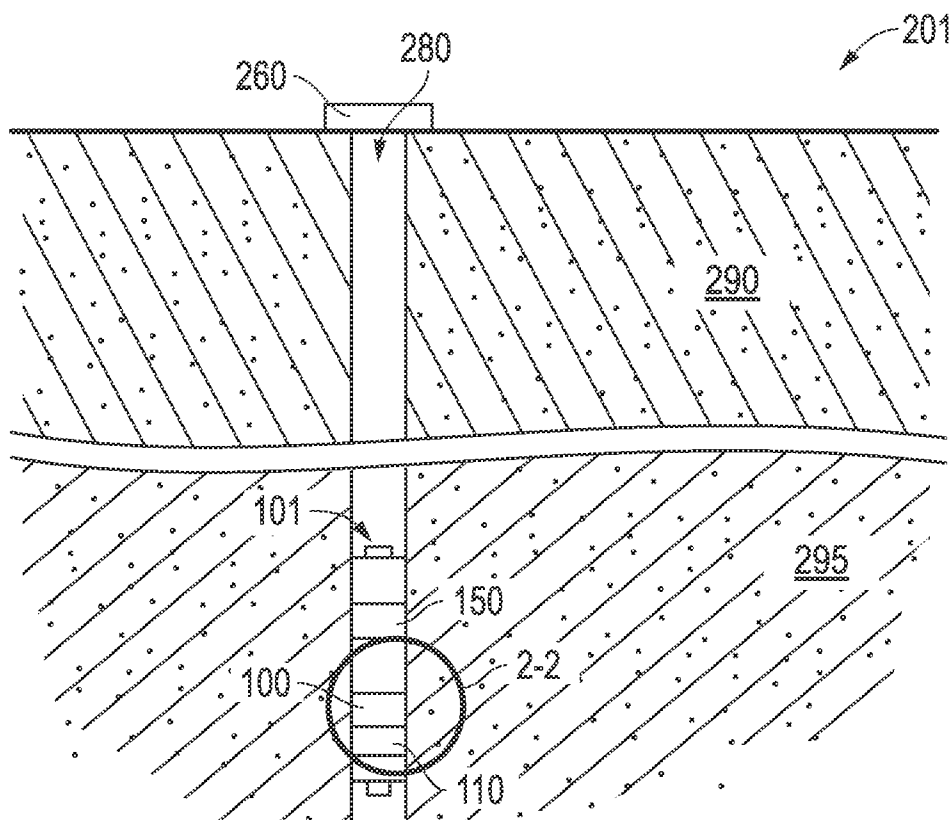


FIG. 2A

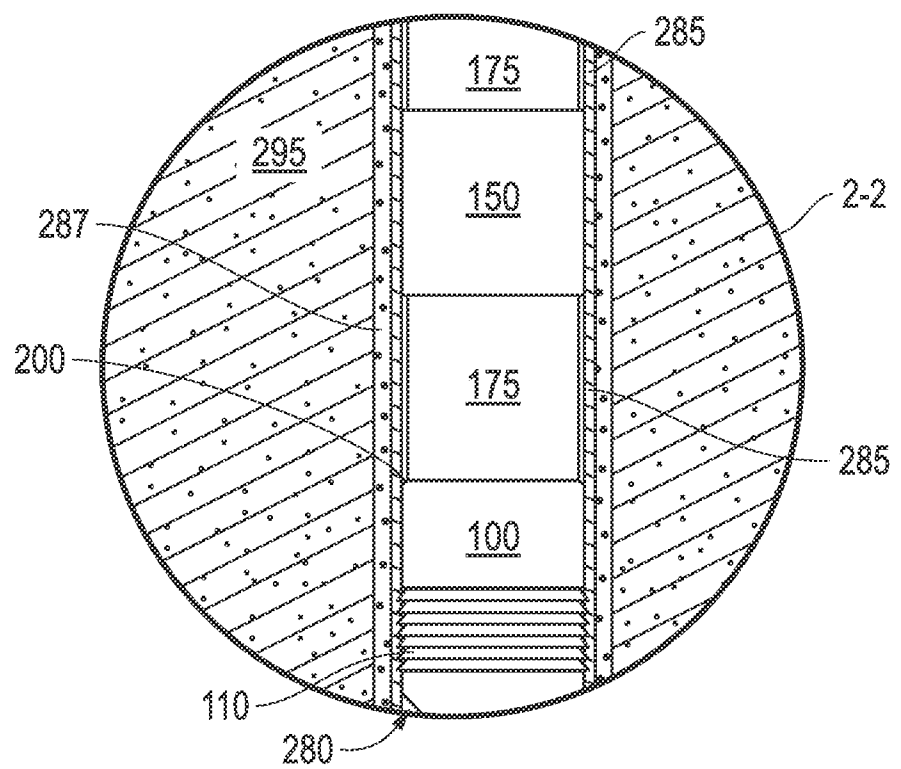


FIG. 2B

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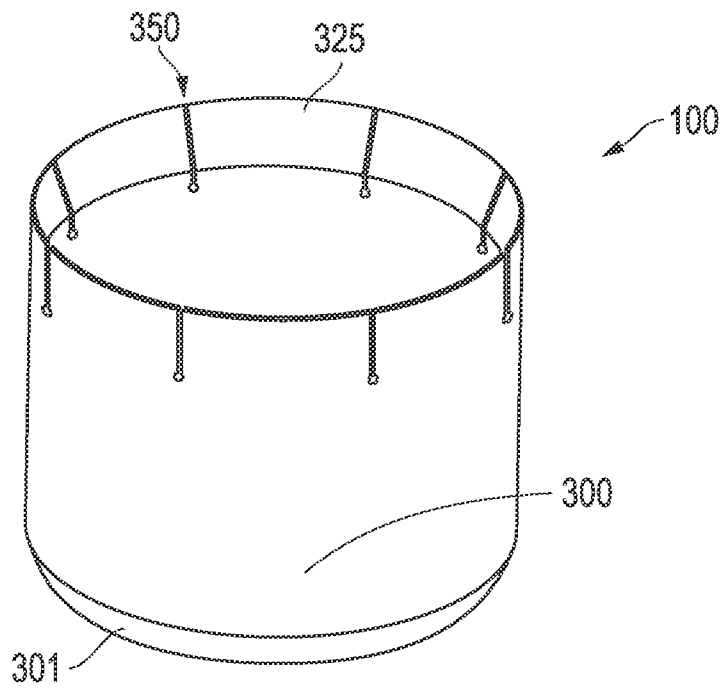


FIG. 3A

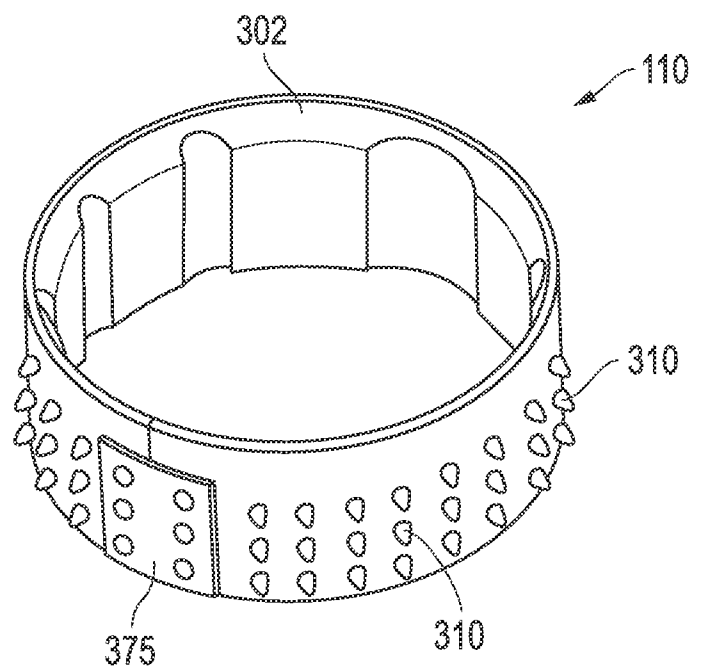


FIG. 3B

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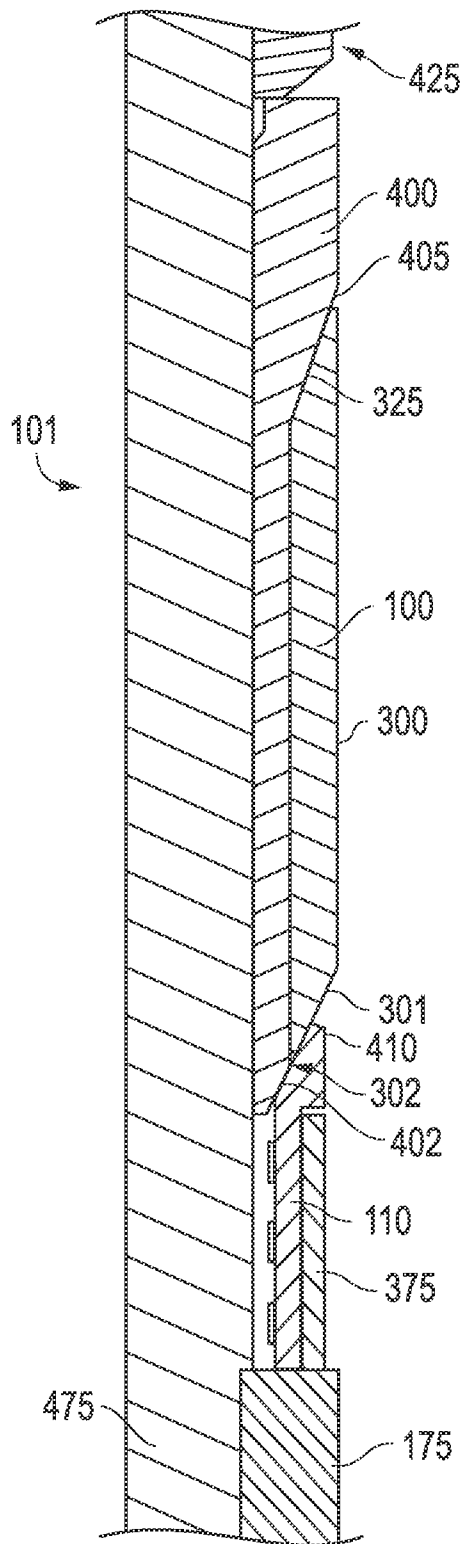


FIG. 4A

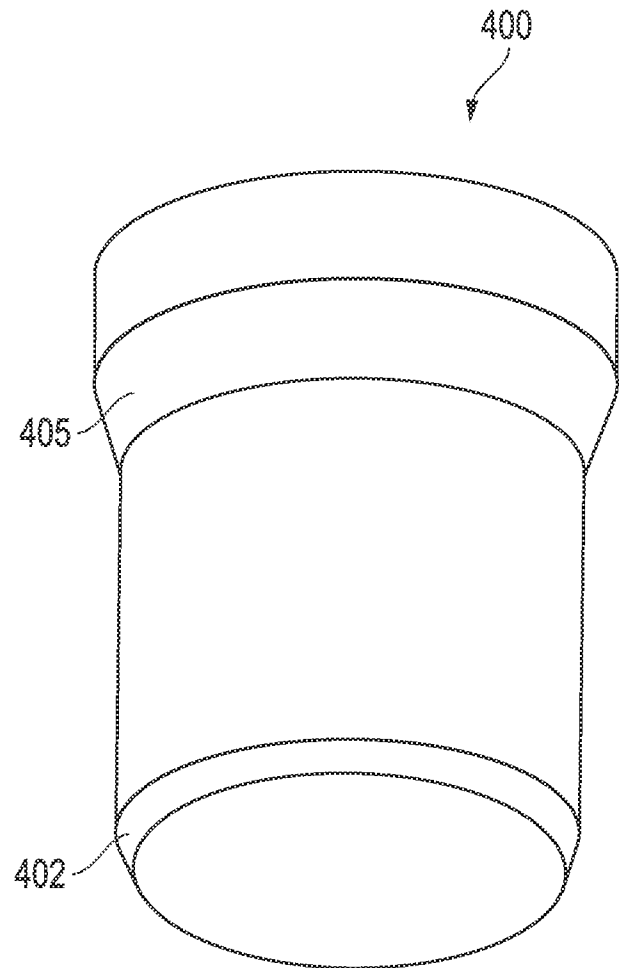


FIG. 4B

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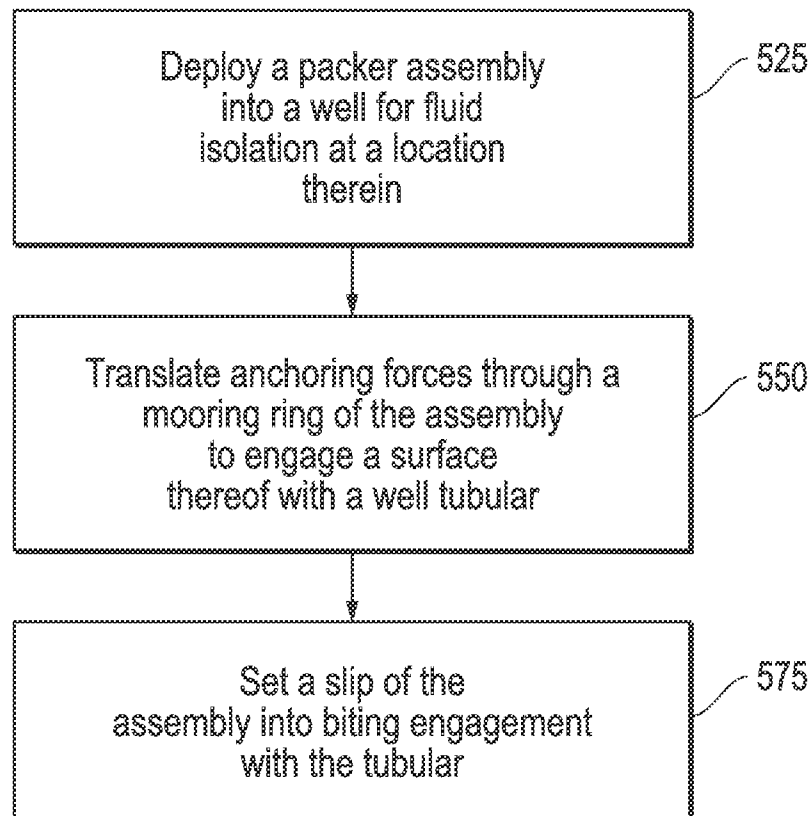


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/017250**A. CLASSIFICATION OF SUBJECT MATTER****E21B 33/12(2006.01)i, E21B 34/06(2006.01)i, E21B 23/00(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
E21B 33/12; E21B 23/04; E21B 23/00; E21B 34/06Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:packer, mooring ring, anchoring, seal element, slip, and frictional engagement**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7124831 B2 (TURLEY et al.) 24 October 2006 See column 1, lines 25-33, column 4, line 35 - column 6, line 39, column 7, lines 60-67, and figures 3, 5-6.	1-3, 5-6, 10-15
A		4, 7-9, 16-20
A	US 2013-0186616 A1 (XU et al.) 25 July 2013 See paragraph [0030] and figure 6.	1-20
A	US 5819846 A (BOLT, JR., DONALD B.) 13 October 1998 See column 6, line 8 - column 7, line 8 and figures 1-9.	1-20
A	US 2012-0080202 A1 (GREENLEE et al.) 05 April 2012 See paragraphs [0054]-[0063] and figure 6.	1-20
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Further documents are listed in the continuation of Box C.



See patent family annex.

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