(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 October 2015 (29.10.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/163902 A1

(51) International Patent Classification:
E21B 23/01 (2006.01) *E21B 43/10* (2006.01)

(21) International Application Number:
PCT/US2014/035401

(22) International Filing Date:
25 April 2014 (25.04.2014)

(25) Filing Language: English

(26) Publication Language: English

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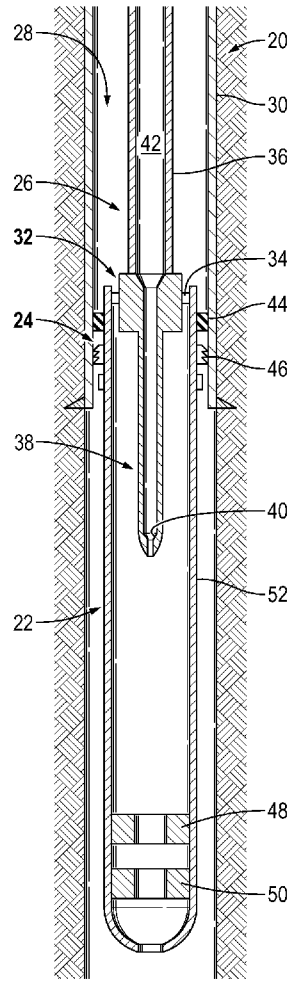
(54) Title: LINER HANGER SYSTEM

FIG. 1



(57) Abstract: A technique facilitates downhole operations, such as cementing operations. The technique utilizes a running string having a hydraulically actuated setting tool. A liner is suspended from the running string via a releasable mechanism. A liner hanger assembly is coupled with the liner and mechanically linked with the hydraulically actuated setting tool. Hydraulic actuation of the setting tool causes mechanical actuation of the liner hanger assembly. The structure enables use of a liner hanger assembly which does not have a hydraulic actuation piston.

WO 2015/163902 A1

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

LINER HANGER SYSTEM

BACKGROUND

[0001] A liner hanger is used to hang a liner within host casing. A liner comprises a tubular, e.g. a casing, which joins the host casing at a downhole location. The host casing may extend upwardly to a surface location. Generally, liner hangers are either mechanically or hydraulically actuated. Mechanical liner hangers often are used for shallow or less deviated applications and hydraulic liner hangers tend to be used for deep or more deviated applications. Hydraulic liner hangers generally have a cylinder and piston which tend to present a weak point in terms of resisting burst and collapse pressures.

SUMMARY

[0002] In general, a methodology and system employ a running string having a hydraulically actuated setting tool. A liner is suspended from the running string via a releasable mechanism. A liner hanger assembly is coupled with the liner and mechanically linked with the hydraulically actuated setting tool. Hydraulic actuation of the setting tool causes mechanical actuation of the liner hanger assembly. The structure enables use of a liner hanger assembly which does not use a hydraulic actuation piston.

[0003] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like

elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0005] Figure 1 is a schematic illustration of an example of a liner and liner hanger deployed downhole into a wellbore by a running string, according to an embodiment of the disclosure;

[0006] Figure 2 is a schematic cross-sectional view of an example of a portion of the running string, liner, and liner hanger, according to an embodiment of the disclosure;

[0007] Figure 3 is a schematic cross-sectional view of an example of a portion of the running string which comprises a setting tool and extends down to the liner hanger illustrated in Figure 2, according to an embodiment of the disclosure; and

[0008] Figure 4 is a schematic cross-sectional view of an example of a cement wiper plug seated in a landing collar to enable pressuring up of the system for setting the liner hanger, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0009] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0010] The present disclosure generally relates to a methodology and system comprising a liner hanger assembly formed with a liner hanger and a liner hanger packer element. In this embodiment, a hydraulic actuation piston is located on the running string

rather than in the liner hanger. During a cementing operation, the running string is coupled to a liner hanger assembly and run downhole into a wellbore. Cement is then pumped into a surrounding annulus. After pumping the cement downhole, the liner hanger assembly is actuated via a hydraulic actuation system contained in the running string rather than in the liner hanger assembly.

[0011] The present system and methodology provide a liner hanger system with robust mechanical properties, e.g. high-strength with respect to burst and collapse pressures. The construction thus mitigates the tendency to move toward heavier wall casing to resist such pressures. In various well applications, the construction enables use of a hydraulic liner hanger without an actuator cylinder or piston which could otherwise provide a weak point with respect to resisting burst and collapse pressures. The hydraulics may be placed in the running/setting tool, thus allowing the mechanical properties of the hydraulic liner hanger to match the mechanical properties of the casing below.

[0012] Referring generally to Figure 1, an embodiment of a well system 20 is illustrated as comprising a liner 22 having a liner hanger assembly 24 forming a liner hanger bottom hole assembly. The liner 22 is releasably coupled with a running string 26 which delivers the liner 22 and liner hanger assembly 24 downhole into a wellbore 28. In this example, the liner 22, liner hanger assembly 24, and running string 26 are deployed down into wellbore 28 through a casing 30, e.g. a host casing. The running string 26 extends into the liner 22 and is engaged with the liner 22 via a running/setting tool assembly 32 having a coupling mechanism 34 by which the running/setting tool assembly 32 is engaged with liner 22. The coupling mechanism 34 may be part of a running tool and designed to mechanically engage, frictionally engage, or otherwise engage an interior of the liner 22. The running string 26 may further comprise a tubing 36, such as a drill pipe, coupled with the running/setting tool assembly 32 for deploying the liner 22 downhole.

[0013] The running string 26 also may comprise a tail pipe 38 extending from running tool 22 on an opposite side of running/setting tool 32 relative to tubing 36. In the example illustrated, the tailpipe 38 comprises a seat 40 designed and oriented to sealingly receive a dropped object. For example, the seat 40 may comprise a ball seat against which a dropped ball may seal when dropped down through an interior 42 of running string 26.

[0014] The liner 22 may have a variety of sizes, lengths, constructions, and/or components depending on the specifics of a given application. Additionally, the liner 22 may be used in cooperation with many types of components suited for a given application. For example, the liner hanger assembly 24 may comprise a liner top packer 44 which is set via, for example, a setting sleeve upon application of pressure along interior 42. The liner hanger assembly 24 also may comprise a hydraulically actuated hanger mechanism 46 which may include slips constructed to engage an interior of casing 30 and to suspend liner 22 from casing 30.

[0015] Examples of other components comprise a landing collar 48 and float equipment 50. The landing collar 48 and float equipment 50 may be positioned along an interior of a downhole end of liner tubing 52 which forms the liner 22. Landing collar 48 provides a landing for a cement wiper plug, as described in greater detail below, to facilitate setting of liner hanger assembly 24. Other components may be added and/or substituted to accommodate specific applications.

[0016] Referring generally to Figure 2, a partial cross-sectional view of an embodiment of liner hanger assembly 24 is illustrated as coupled with liner tubing 52 of liner 22. In this example, liner hanger assembly 24 comprises hanger mechanism 46 which may be in the form of a slip or a plurality of slips 54. The slips 54 are selectively actuated outwardly to engage in inner surface of casing 30. Each slip 54 may be actuated outwardly by forcing the slip to move longitudinally against an inclined surface. For example, each slip 54 may comprise an inclined surface 56 positioned against a corresponding inclined surface 58 of a ramp 60 mounted along liner tubing 52. In the

embodiment illustrated, the lower slip 54 is positioned between the lower ramp 60 and an abutment 62 affixed to liner tubing 52. Similarly, the upper slip 54 is positioned between the upper ramp 60 and an abutment end 64 of a tieback receptacle 66. In some applications, the ramps 60 and abutment 62 may be mounted along a mandrel 67, e.g. a packer mandrel, which is an extension of liner tubing 52 or coupled with liner tubing 52.

[0017] As the liner hanger assembly 24 is longitudinally contracted along a longitudinal axis A, the slips 54 are moved toward each other in a longitudinal direction. The longitudinal contraction moves inclined surfaces 56 along corresponding inclined surfaces 58, thus forcing the slips 54 in a radially outward direction until they are securely engaged with the surrounding casing 30 so as to suspend liner 22. In other words, the slips 54 are forced in a radially outward direction as abutment 62 and abutment end 64 are shifted toward each other by setting/running tool assembly 32.

[0018] The liner hanger assembly 24 also may comprise a packer/packing element 68 which may be actuated into sealing engagement with the inner surface of the surrounding casing 30. Depending on the application, the packing element 68 may be the sealing element of liner top packer 44 or it may form an additional sealing element separate from liner top packer 44. In the example illustrated, packing element 68 is positioned between ramps 60 so that longitudinal contraction of liner hanger assembly 24 also serves to move ramps 60 toward each other, thus squeezing the packing element 68 in a longitudinal direction. The longitudinal squeezing of packing element 68 forces the packing element to expand in a radially outward direction into engagement with the surrounding casing 38. The packing element 68 may be sufficiently radially expanded to form a secure seal with the inner surface of the surrounding casing 30.

[0019] During movement downhole and while setting liner hanger assembly 24, the liner 22 is securely attached to running string 26 by setting/running tool assembly 32 via a running tool 70 comprising coupling mechanism 34. Running tool 70 may be constructed as a sliding sleeve or other suitable structure. In this example, setting/running tool assembly 32 further comprises a setting tool 72 coupled to running

tool 70, as illustrated in Figure 3. As illustrated in both Figures 2 and 3, the tieback receptacle 66 is constructed for relative movement with respect to running tool 70 to enable setting of liner hanger assembly 24.

[0020] The running tool 70 comprises a connector 74 which couples a piston 76 with tieback receptacle 66. In the illustrated embodiment, the liner hanger assembly 24 does not have an actuation piston. Instead, setting tool 72 of running string 26 comprises actuation piston 76 coupled with a cylinder 78 which is slidably mounted along a pressure stop 80 and along running tool 70. Movement of piston 76 and cylinder 78 is used to selectively transition the liner hanger assembly 24 from an un-actuated position (see Figure 2) to an actuated position in which slips 54 and packing element 68 engage casing 30.

[0021] The interior of cylinder 78 is in fluid communication with interior 42 of running string 26 via a port 82. By applying sufficient pressure to the fluid in interior 42, the actuation piston 76 is hydraulically actuated to shift liner hanger assembly 24 into engagement with casing 30. As pressure is increased on fluid within running string 26, the fluid flows through port 82 and into cylinder 78 between piston 76 and pressure stop 80 to drive piston 76 and cylinder 78 in a direction represented by arrow 83. The movement of piston 76 under hydraulic pressure causes corresponding movement of tieback receptacle 66 along liner tubing 52 of liner 22. This relative movement longitudinally squeezes slips 54 between abutment 62 and abutment end 64, thus forcing both slips 54 and packing element 68 in a radially outward direction until fully engaged with the surrounding surface of casing 30. In this manner, the hydraulic actuation is achieved via setting tool 72 mounted on running string 26 rather than incorporating an actuation piston and cylinder/chamber into liner hanger assembly 24.

[0022] In some applications, e.g. cementing applications, a cement plug 84 may be used both for application of pressure to move the cement into the surrounding annulus and to create a seal for pressuring up interior 42 to actuate liner hanger assembly 24. As illustrated in Figure 4, the cement plug 84 may be designed to sealingly engage landing

collar 48 when the cement plug 84 is pumped downhole to push cement into the annulus. In this example, the cement plug 84 comprises a landing feature 86 constructed to land in an form a seal with landing collar 48 or with another suitable landing receptacle. Depending on the application, cement plug 84 may comprise a variety of other features, such as a liner wiper plug 88 and a drill pipe plug 90.

[0023] However, other objects, e.g. balls or darts, also may be dropped downhole to form the seal which enables pressure to be applied along interior 42 of running string 26 when actuating liner hanger assembly 24. Such objects may be designed to sealingly engage landing collar 48, seat 40 of tailpipe 38, or another suitable sealing surface which allows pressure to be increased along interior 42. Pressure relief may be provided to avoid excess pressure buildup along interior 42. For example, a burst disc or other suitable pressure relief feature may be located along running string 26.

[0024] In some applications, the liner hanger assembly 24, including packing element 68, and liner 22 are constructed as a bottom hole assembly. The running string 26 comprises setting tool 72 and running tool 70, however the running string 26 may comprise a variety of other components and features. Examples of such components include upper and lower pack offs, sliding sleeves, integral ball seats, and/or other components provided for a specific application.

[0025] The embodiment illustrated in Figures 2-4 places hydraulics in the running string 26 and provides the liner hanger assembly 24 with simple slips 54 and packing element 68. The slips 54 are constructed to withstand axial loads in both directions along axis A when set, and the packing element 68 securely seals the interface between liner 22 and host casing 30. The construction and arrangement of components facilitates a variety of operations, including cementing operations.

[0026] In an operational example, the liner 22 is run to a target depth via running string 26 and then preparations for a cementing operation are initiated. A predetermined volume of cement is then pumped downhole through the running string 26, through the

liner 22, and into a surrounding annulus with the aid of cement plug 84. Proper placement of the cement may be confirmed by pressuring up against, i.e. bumping, the cement plug 84. If the cement plug 84 (or other suitable sealing element) is sufficiently sealed, pressure is then increased along interior 42 of running string 26 and within liner 22 to set the liner hanger assembly 24. The pressure is increased sufficiently to drive piston 76 and tieback receptacle 66 along running tool 70 so as to move slips 54 along corresponding ramps 60 and to squeeze packing element 68 until the slips 54 and packing element 68 securely engaged the surrounding casing 30. If the ability to build pressure is not achieved by bumping the cement plug 84, then contingent balls, plugs, or other sealing elements may be dropped downhole for engagement with a suitable landing collar or other seat.

[0027] Proper setting of the liner hanger assembly 24 may be confirmed when slips 54 and packing element 68 become securely engaged with casing 30. After confirmation that the liner hanger assembly 24 has been properly set, the running tool 70 may be released from liner 22. Once released, the running string 26 may be retrieved back to the surface. The setting/running tool 32 may be constructed with contingent release mechanisms to ensure the running string 26 can be retrieved to the surface even if primary release techniques do not function as planned.

[0028] By moving the hydraulic components away from the liner hanger 46 and overall liner hanger assembly 24, there are no weak points in the liner hanger in terms of burst and collapse pressures. The liner hanger assembly 24 is thus able to match the mechanical properties of the liner 22 suspended below. Additionally, the potential for hydraulic leaks in the packing element 68 of liner hanger assembly 24 is removed because there are no holes or seals in the system. The construction also avoids reductions in the outside diameter of mandrel 67 (or other similar structure) that would otherwise be employed to enable operation of a cylinder and piston in the liner hanger assembly. The liner hanger assembly 24 may be mounted on a mandrel, e.g. mandrel 67, having the same outside diameter as the liner tubing 52 extending below.

[0029] In cementing applications, the structure of liner hanger assembly 24 and running string 26 enable the packing element 68 to be set after the cementing operation. Setting packing element 68 after cementing facilitates improved equivalent circulating density (ECD) because the cement does not have to flow past set slips. Instead, the cement flows past a smooth outside diameter around the slips 54 and packing element 68, thus improving cementing pressures.

[0030] The structure also enables reduction in the number of external components on the liner hanger assembly 24, including the top packer 44. The reduction in components increases the reliability and durability of the overall system. In fact, the liner hanger and liner top packer can basically be reduced to a liner hanger packer, e.g. packing element 68, which removes one connection between the conventional liner hanger and liner top packer. This simplification further reduces the potential for hydraulic leaks in the system.

[0031] By utilizing cement plug 84 to establish setting pressure, the structure also removes the technique of blowing ball seats prior to cementing operations. Because pressures associated with blowing the ball seat are avoided, the potential for fracturing weak formations due to surge pressures is reduced. In some applications, fractured formations are to be avoided because they can lead to loss of circulation and can compromise cement placement.

[0032] The structure of the overall well system 20 facilitates operations in a variety of deep water environments. The structure provides higher burst and collapse protection along with greater durability and dependability. However the system is also particularly useful with unstable formations and to ensure proper cement placement in a wide variety of deep water environments and other well related environments.

[0033] It should be further noted that liner 22, liner hanger assembly 24, and/or running string 26 may be constructed in a variety of configurations with many types of components depending on a given downhole application. The system and methodology

may be employed in vertical and/or deviated, e.g. horizontal, wellbores. Additionally, the configuration of the liner hanger slips, packing element, liner top packer, landing collars, seats, pack offs, cement plugs and/or other components of the overall system may be adjusted to accommodate structural, environmental, and/or operational parameters.

[0034] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

CLAIMS

What is claimed is:

1. A system for use in a wellbore, comprising:

a liner hanger assembly without an actuation piston, the liner hanger assembly having a liner hanger mechanism and a liner hanger packing element;

a liner coupled with the liner hanger assembly; and

a running string extending into and releasably coupled with the liner, the running string having a setting tool which is hydraulically actuatable to set the liner hanger mechanism and the liner hanger packing element.

2. The system as recited in claim 1, wherein the liner hanger mechanism comprises a plurality of slips.

3. The system as recited in claim 2, wherein the liner hanger packing element is disposed between longitudinally movable slips of the plurality of slips.

4. The system as recited in claim 1, wherein the running string comprises a hydraulic actuation piston operable via pressurized fluid supplied along an interior of the running string.

5. The system as recited in claim 1, wherein the running string comprises a liner running tool releasably coupled with the liner.

6. The system as recited in claim 1, wherein the running string comprises a tail pipe having a seat.

7. The system as recited in claim 4, were the hydraulic actuation piston is coupled with a tieback receptacle which is moved to actuate the liner hanger mechanism and the liner hanger packing element.

8. The system as recited in claim 7, wherein movement of the tieback receptacle via the hydraulic actuation piston mechanically forces a plurality of slips to move in a radially outward direction and into engagement with a surrounding casing.

9. The system as recited in claim 1, wherein the liner comprises a landing collar for receiving a cement plug, the cement plug creating a sealed interior which may be pressurized to actuate the setting tool.

10. A method, comprising:

providing a liner hanger assembly with a hanger mechanism and a packing element;

coupling the liner hanger assembly, a liner, and a running string;

running the liner hanger assembly and liner downhole into a wellbore via the running string;

pumping cement through the running string and into a surrounding annulus; and

after pumping the cement, hydraulically actuating a setting tool on the running string to mechanically set the hanger mechanism and the packing element against a surrounding casing.

11. The method as recited in claim 10, wherein providing comprises providing the liner hanger assembly with the hanger mechanism in the form of a plurality of mechanically actuatable slips.

12. The method as recited in claim 11, further comprising locating the packing element between slips of the plurality of mechanically actuatable slips such that longitudinal movement of the mechanically actuatable slips causes radial expansion of the packing element.

13. The method as recited in claim 10, wherein hydraulically actuating comprises moving an actuator piston.

14. The method as recited in claim 13, wherein moving the actuator piston comprises moving a tieback receptacle which is operatively coupled with the hanger mechanism to mechanically actuate the hanger mechanism.

15. The method as recited in claim 10, wherein pumping cement comprises pumping a cement plug downhole through the running string.

16. The method as recited in claim 15, further comprising using the cement plug to create a seal which enables an interior of the running string to be sufficiently pressurized for actuation of the setting tool.

17. The method as recited in claim 10, further comprising utilizing a mandrel within the hanger mechanism and the packing element and providing the mandrel with an outside diameter substantially equal to an outside diameter of the liner.

18. A system for use in a wellbore, comprising:

a running string having a hydraulically actuated setting tool;

a liner suspended from the running string via a releasable running tool; and

a liner hanger assembly coupled with the liner and mechanically linked with the hydraulically actuated setting tool such that hydraulic actuation of the hydraulically actuated setting tool on the running string causes mechanical actuation of a liner hanger mechanism and a liner hanger packing element of the liner hanger assembly.

19. The system as recited in claim 18, wherein the liner hanger mechanism comprises a pair of slips and the liner hanger packing element is disposed longitudinally between the pair of slips.

20. The system as recited in claim 19, wherein actuation of the hydraulically actuated setting tool moves the pair of slips longitudinally closer to each other which forces the pair of slips and the liner hanger packing element to transition in a radially outward direction and into engagement with a surrounding casing.

FIG. 1

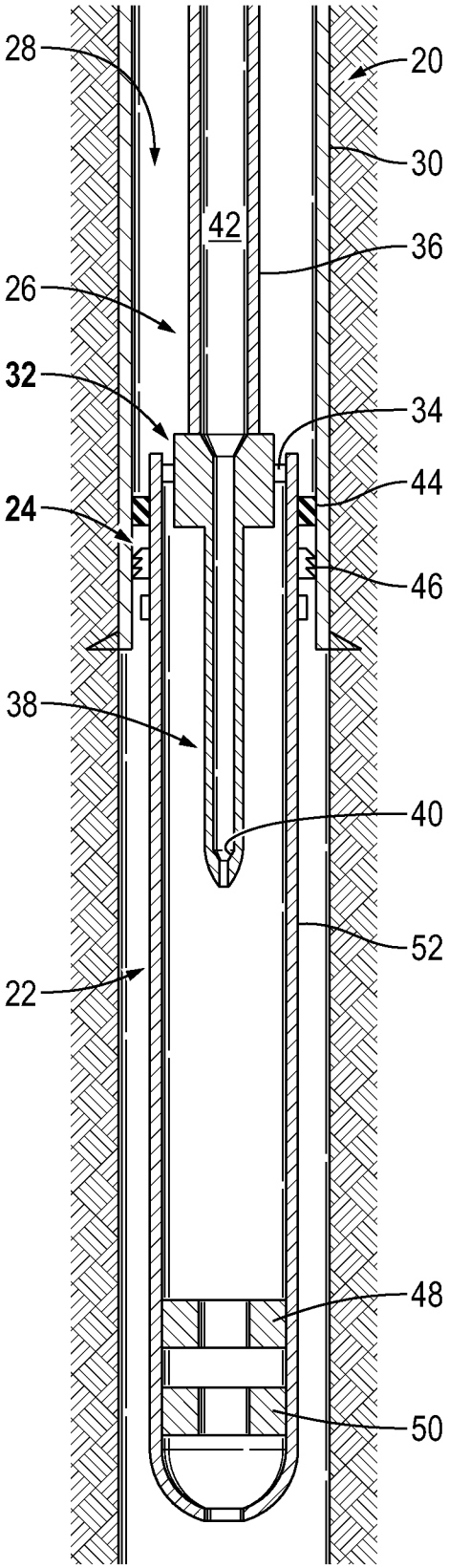

FIG. 4

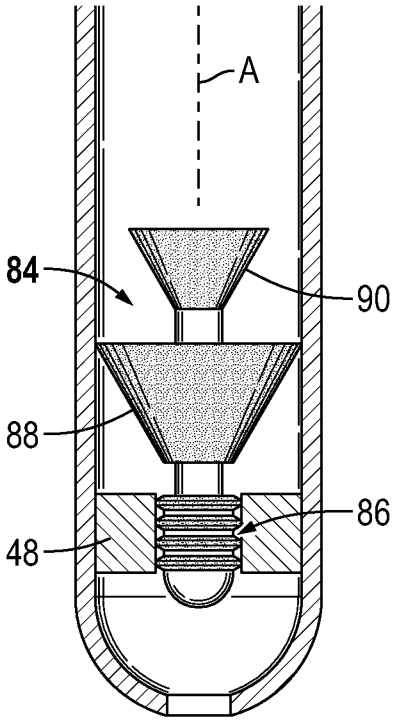

FIG. 2

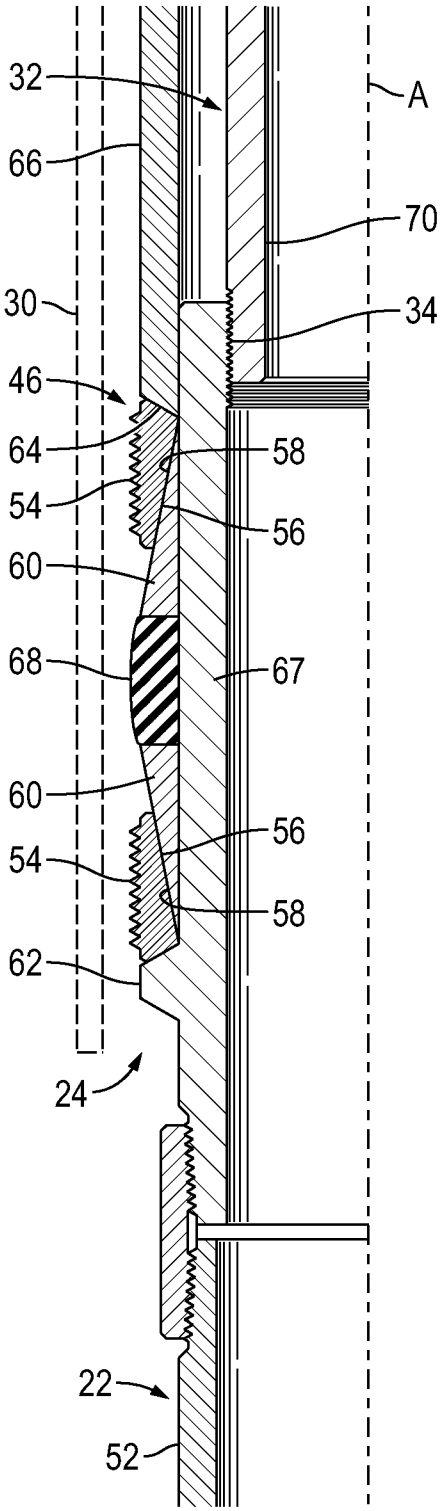
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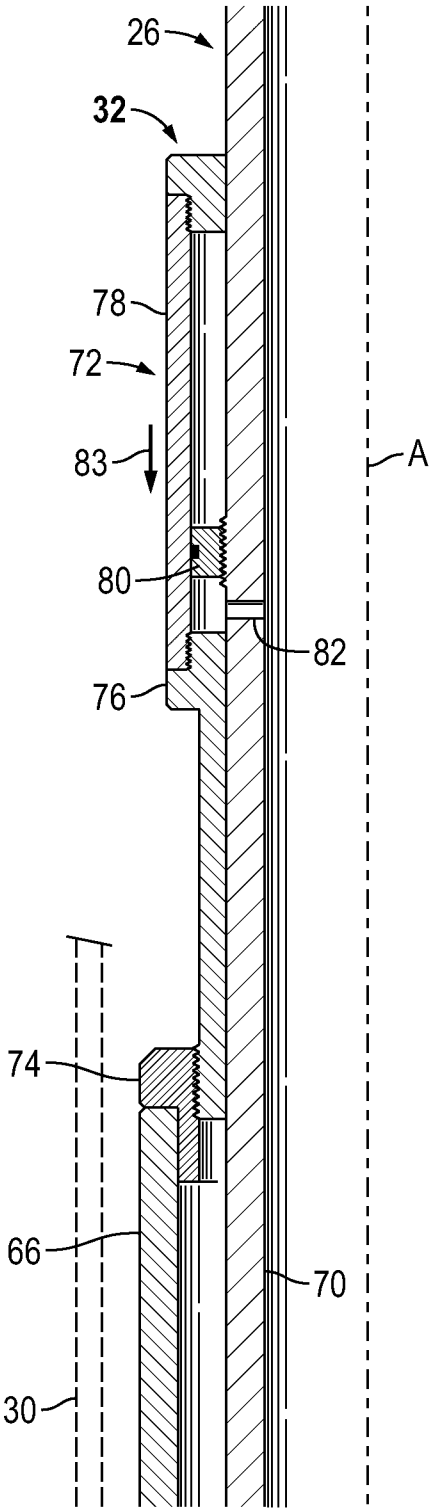
FIG. 3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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/035401

A. CLASSIFICATION OF SUBJECT MATTER

E21B 23/01(2006.01)i, E21B 43/10(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 23/01; E21B 23/08; E21B 23/04; E21B 25/06; E21B 23/06; E21B 43/00; E21B 33/12; E21B 34/12; E21B 23/00; E21B 43/10

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: liner hanger assembly, liner, running string, setting tool, hydraulic, wellbore, and packing element

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4972908 A (BRADDICK, BRITT O.) 27 November 1990 See column 3, line 19 - column 4, line 2; column 6, line 54 - column 7, line 52 and figures 1-5.	1,5,10,17-18
Y		2-4,6-9,11-16 ,19-20
Y	US 2013-0056200 A1 (MARTINEZ et al.) 07 March 2013 See paragraphs [0025],[0030],[0033]-[0034] and figures 1B,3A-3C.	2-4,7-8,11-14 ,19-20
Y	US 5884702 A (YOKLEY et al.) 23 March 1999 See column 5, lines 3-8; column 8, lines 28-42 and figures 1,2A.	6,9,15-16
A	US 5826652 A (TAPP, WILLIAM T.) 27 October 1998 See column 2, line 55 - column 3, line 13 and figures 1b,2d.	1-20
A	US 5411099 A (BRADDICK, BRITT O.) 02 May 1995 See abstract, claim 1 and figure 2A.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"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	Date of mailing of the international search report
16 January 2015 (16.01.2015)	**19 January 2015 (19.01.2015)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. ++82 42 472 3473

Authorized officer
HWANG, Chan Yoon
Telephone No. +82-42-481-3347

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2014/035401

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