

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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

SECTION MILLING, UNDER REAMING AND SETTING AN INFLATABLE PLUG IN ONE RUN

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 18/468,175, filed on September 15, 2023, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] In the resource recovery industry, fluid sequestration industry and abandonment industry, a borehole can be drilled using a milling device. Once the borehole is milled, it is desirable to form a casing in the borehole, which requires inflating a packer within the borehole to close off a section of the borehole and pouring cement into the section. Currently, a work string including the milling device has to be tripped out of the borehole and another work string that includes the packer is run into the borehole. This extra step of tripping out one string and running in another string costs time and expense. Therefore, there is a need for being able to mill and cement in a single trip.

SUMMARY

[0003] Disclosed herein is a method of performing an operation in a borehole. A work string is conveyed into the borehole, the work string including a milling section and a packer section, wherein the packer section includes a packer and a cover that protects the packer from the borehole. A section of the borehole is milled with the milling section. The packer is moved axially from under the cover to expose the packer to the borehole. The packer is expanded.

[0004] Also disclosed herein is a work string. The work string includes a milling section for milling within a borehole and a packer section including a packer and a cover that protects the packer from the borehole, wherein the packer is configured to move axially from under the cover and expand within the borehole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0006] Figure 1 shows a borehole system in an illustrative embodiment;

[0007] Figure 2 shows the borehole system in another configuration;

[0008] Figure 3 shows a cross-sectional view of a packer section in an embodiment;

[0009] Figure 4 shows a cross-sectional view of the packer section in an alternative embodiment; and

[0010] Figure 5 shows a flowchart of a method for operating the work string, in an illustrative embodiment.

DETAILED DESCRIPTION

[0011] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0012] Referring to Figure 1, a borehole system 100 is shown in an illustrative embodiment. The borehole system 100 includes a work string 102 disposed in a borehole 104 in a subsurface formation 106. The borehole 104 can include a casing 130 therein. The work string 102 includes a tubular 108 extending from a platform 110 located at a surface location 112. The platform 110 includes a rotary table 114 that rotates the tubular 108 and the work string 102 in the borehole 104. The work string 102 can be a drill string in various embodiments. The work string 102 includes bottomhole assembly 116 (BHA) that includes a milling section 118 and a packer section 120. The milling section includes a mill 122 at a bottom end of the work string 102 and an underreamer 124 uphole from the mill 122. In various embodiments, the mill 122 can be used to mill a section of the casing 130 in the borehole 104 and the underreamer 124 can be used to ream the subsurface formation 106 surrounding the borehole 104. The rotary table 114 rotates the work string 102 in order to rotate the mill 122 and/or the underreamer 124.

[0013] The packer section 120 includes a packer 126, which can be an inflatable packer or a high expansion element packer, and a cover 128, such as a sleeve or a shroud, that protects the packer 126 during downhole operations. Such downhole operations include milling and underreaming, during which the work string 102 and packer 126 are rotated. The packer 126 can be moved out from under the cover 128 once the milling and underreaming operations have been completed (and the work string 102 is no longer rotating) and then inflated to seal off a section of the borehole 104. In an embodiment, once the packer 126 has been inflated, cement can be introduced in the sealed off section of the borehole 104 on top of the inflated packer.

[0014] Figure 2 shows the borehole system 100 in another configuration. The milling and/or underreaming have been completed and the work string 102 is rotationally stationary. The packer 126 has been moved axially to an exposed location 202 outside of the cover 128. In various embodiments, the packer 126 is lowered to a location below the cover 128. Once at the exposed location 202, the packer 126 is inflated to close a section of the borehole 104. Once the section is closed, cement can be introduced into the closed section.

[0015] Figure 3 shows a cross-section view 300 of the packer section 120 in an embodiment. The packer section 120 includes a housing 302 and a ball seat 304 located within the housing 302. The housing 302 is generally a hollow tubular or cylindrical shell. The ball seat 304 is coupled to the housing 302 by a rupture device 306. The rupture device 306 can be a shear pin or a shear screw, in various embodiments. The housing 302 includes a ledge 308 on an inside surface of the housing 302 that extends inward from the housing 302. Thus, an inner diameter at the ledge 308 is less than an inner diameter of the housing 302.

[0016] The ball seat 304 includes a lower portion 310. The packer 126 is disposed on the ball seat 304 at the lower portion 310. The ball seat 304 is configured to receive a ball 320 that is dropped from the surface location 112. Once the ball 320 lands at the ball seat 304, a fluid pressure builds up on the back side (i.e., uphole side) of the ball 320, creating a downhole force on the ball seat 304 that exceeds a rupture threshold of the rupture device 306. Once the rupture device 306 is ruptured, the ball seat 304 moves downward, thereby moving the lower portion 310 and the packer 126 out from under the cover 128 to a location at which it is exposed to the borehole. A ridge 312 on the ball seat 304 catches the ledge 308 to stop further motion of the ball seat 304.

[0017] Figure 4 shows a cross-sectional view 400 of the packer section 120 in an alternative embodiment. The packer section 120 includes a housing 402 and a piston 404 that moves axially within the housing 402. The piston 404 can be part a telescoping sub 406 that is capable of moving with respect to the housing 402. A first end 408 of the piston 404 is in fluid communication with a hydraulic chamber 410. The packer 126 is disposed on the piston 404 at a location 412 distal from the first end 408. A hydraulic pump 414 increases a pressure of hydraulic fluid within the hydraulic chamber 410 to move the piston 404 in a downward direction 416 to thereby move the packer 126 out from under the cover 128 to an exposed location. The hydraulic pump 414 can be activated by a signal from a controller 420. In an embodiment, the controller 420 can be an operator or user at a surface location. In an alternative embodiment, the controller 420 can be a downhole timing device, which can be battery-operated.

[0018] Figure 5 shows a flowchart 500 of a method for operating the work string, in an illustrative embodiment. In box 502, the work string is conveyed into the borehole. The work string 102 includes the milling section and the packer section with the packer underneath the cover or protected from the environment by the cover. In box 504, a section of the casing is milled using the mill of the milling section with the packer underneath the cover. Alternatively, or additionally, the formation is underreamed by the underreamer of the milling section with the packer underneath the cover. In box 506, the packer is moved axially from underneath the cover to an exposed location along the work string 102. In box 508, the packer is expanded to seal off a section of the borehole 104. An inflatable packer can be inflated, while a high expansion element packer can be activated to expanded outward.

[0019] Set forth below are some embodiments of the foregoing disclosure:

[0020] Embodiment 1. A method of performing an operation in a borehole. A work string is conveyed into the borehole, the work string including a milling section and a packer section, wherein the packer section includes a packer and a cover that protects the packer from the borehole. A section of the borehole is milled with the milling section. The packer is moved axially from under the cover to expose the packer to the borehole. The packer is expanded.

[0021] Embodiment 2. The method of any previous embodiment, wherein milling the borehole further comprises rotating the work string.

[0022] Embodiment 3. The method of any previous embodiment, wherein the milling section further comprises an underreamer, the method further comprising expanding the borehole with the underreamer with the packer under the cover.

[0023] Embodiment 4. The method of any previous embodiment, further comprising moving the packer axially via at least one of: (i) activating a hydraulic pump; (ii) dropping a ball through the work string; and (iii) a signal from a battery-operated timing device.

[0024] Embodiment 5. The method of any previous embodiment, wherein the packer is disposed on a telescoping sub and moving the packer further comprises moving the telescoping sub.

[0025] Embodiment 6. The method of any previous embodiment, further comprising milling the borehole and inflating the packer in a same run.

[0026] Embodiment 7. The method of any previous embodiment, wherein the work string further comprises a bottomhole assembly and the packer is disposed on the bottomhole assembly.

[0027] Embodiment 8. The method of any previous embodiment, wherein the cover is one of: (i) a sleeve; and (ii) a shroud.

[0028] Embodiment 9. A work string. The work string includes a milling section for milling within a borehole and a packer section including a packer and a cover that protects the packer from the borehole, wherein the packer is configured to move axially from under the cover and expand within the borehole.

[0029] Embodiment 10. The work string of any previous embodiment, further comprising a rotary table for rotating the work string for milling withing the borehole.

[0030] Embodiment 11. The work string of any previous embodiment, wherein the milling section further comprises a mill for milling the borehole and an underreamer for expanding a section of the borehole with the packer under the cover.

[0031] Embodiment 12. The work string of any previous embodiment, further comprising a device for moving the packer axially, wherein the device is one of: (i) hydraulic pump; and (ii) a ball seat.

[0032] Embodiment 13. The work string of any previous embodiment, further comprising a telescoping sub that moves axially, wherein the packer is disposed on the telescoping sub.

[0033] Embodiment 14. The work string of any previous embodiment, wherein the work string further comprises a bottomhole assembly and the packer is disposed on the bottomhole assembly.

[0034] Embodiment 15. The work string of any previous embodiment, wherein the packer is one of: (i) an inflatable packer; and (iii) a high expansion element packer.

[0035] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Further, it should be noted that the terms “first,” “second,” and the like herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. The terms “about”, “substantially” and “generally” are intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application. For example, “about” and/or “substantially” and/or “generally” can include a range of $\pm 8\%$ of a given value.

[0036] The teachings of the present disclosure may be used in a variety of well operations. These operations may involve using one or more treatment agents to treat a

formation, the fluids resident in a formation, a borehole, and / or equipment in the borehole, such as production tubing. The treatment agents may be in the form of liquids, gases, solids, semi-solids, and mixtures thereof. Illustrative treatment agents include, but are not limited to, fracturing fluids, acids, steam, water, brine, anti-corrosion agents, cement, permeability modifiers, drilling muds, emulsifiers, demulsifiers, tracers, flow improvers etc. Illustrative well operations include, but are not limited to, hydraulic fracturing, stimulation, tracer injection, cleaning, acidizing, steam injection, water flooding, cementing, etc.

[0037] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited.

CLAIMS

What is claimed is:

1. A method of performing an operation in a borehole (104), characterized by: conveying a work string (102) into the borehole (104), the work string (102) including a milling section (118) and a packer section (120), wherein the packer section (120) includes a packer (126) and a cover (128) that protects the packer (126) from the borehole (104); milling a section of the borehole (104) with the milling section (118); moving the packer (126) axially from under the cover (128) to expose the packer (126) to the borehole (104); and expanding the packer (126).
2. The method of claim 1, wherein milling the borehole (104) further comprises rotating the work string (102).
3. The method of claim 1, wherein the milling section (118) further comprises an underreamer (124), the method further characterized by expanding the borehole (104) with the underreamer (124) with the packer (126) under the cover (128).
4. The method of claim 1, further characterized by moving the packer (126) axially via at least one of: (i) activating a hydraulic pump (414); (ii) dropping a ball (320) through the work string (102); and (iii) a signal from a battery-operated timing device.
5. The method of claim 1, wherein the packer (126) is disposed on a telescoping sub (406) and moving the packer (126) further comprises moving the telescoping sub (406).
6. The method of claim 1, further characterized by milling the borehole (104) and inflating the packer (126) in a same run.
7. The method of claim 1, wherein the work string (102) further comprises a bottomhole assembly (116) and the packer (126) is disposed on the bottomhole assembly (116).
8. The method of claim 1, wherein the cover (128) is one of: (i) a sleeve ; and (ii) a shroud.
9. A work string (102), characterized by:
a milling section (118) for milling within a borehole (104); and
a packer section (120) including a packer (126) and a cover (128) that protects the packer (126) from the borehole (104), wherein the packer (126) is configured to move axially from under the cover (128) and expand within the borehole (104).
10. The work string (102) of claim 9, further characterized by a rotary table (114) for rotating the work string (102) for milling withing the borehole (104).

11. The work string (102) of claim 9, wherein the milling section (118) further comprises a mill (122) for milling the borehole (140) and an underreamer (124) for expanding a section of the borehole (104) with the packer (126) under the cover (128).

12. The work string (102) of claim 9, further characterized by a device for moving the packer (126) axially, wherein the device is one of: (i) hydraulic pump (414); and (ii) a ball seat (304).

13. The work string (102) of claim 9, further characterized by a telescoping sub (406) that moves axially, wherein the packer (126) is disposed on the telescoping sub (406).

14. The work string (102) of claim 9, wherein the work string (102) further comprises a bottomhole assembly (116) and the packer (126) is disposed on the bottomhole assembly (116).

15. The work string (102) of claim 9, wherein the packer (126) is one of: (i) an inflatable packer; and (iii) a high expansion element packer.

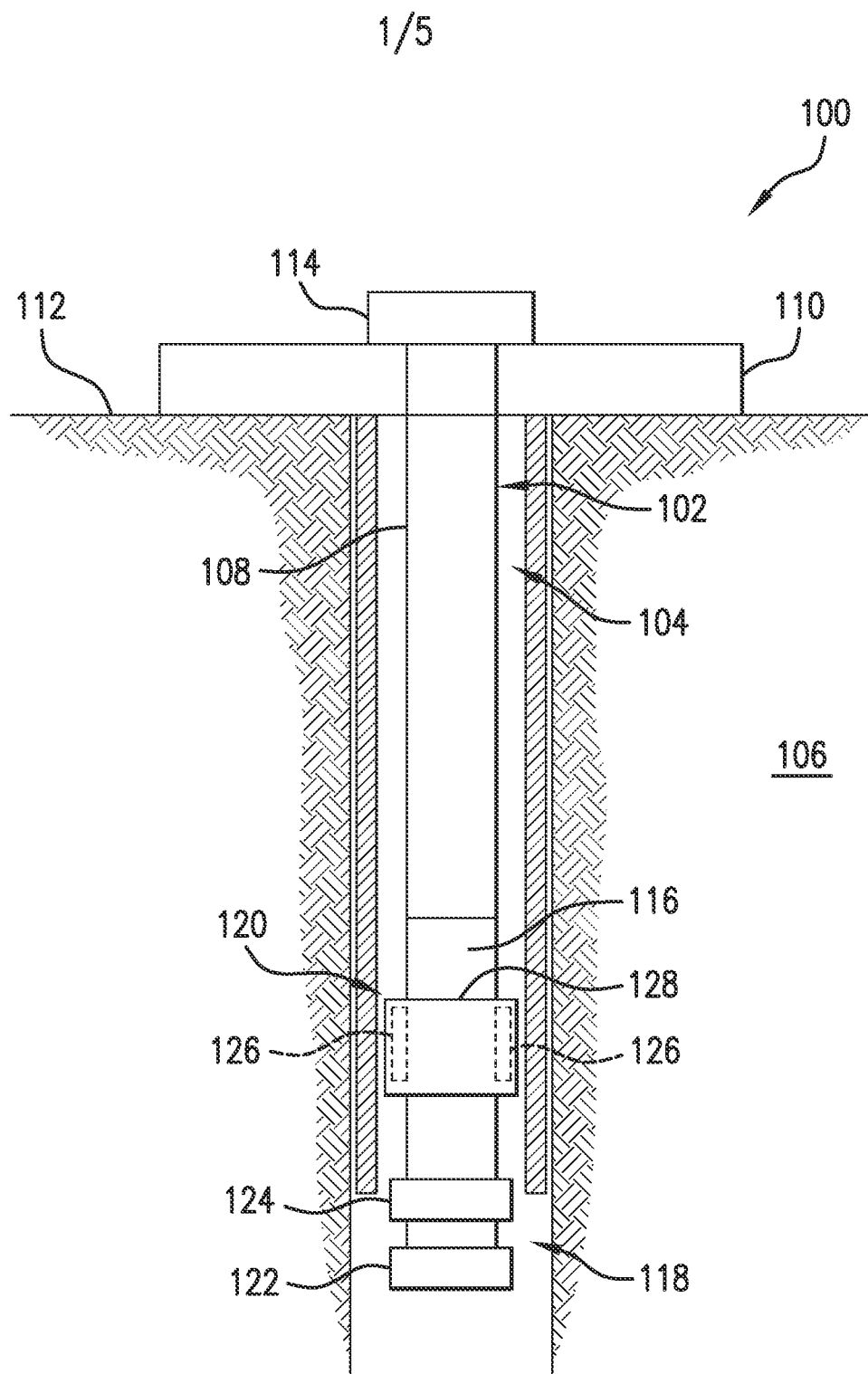


FIG. 1

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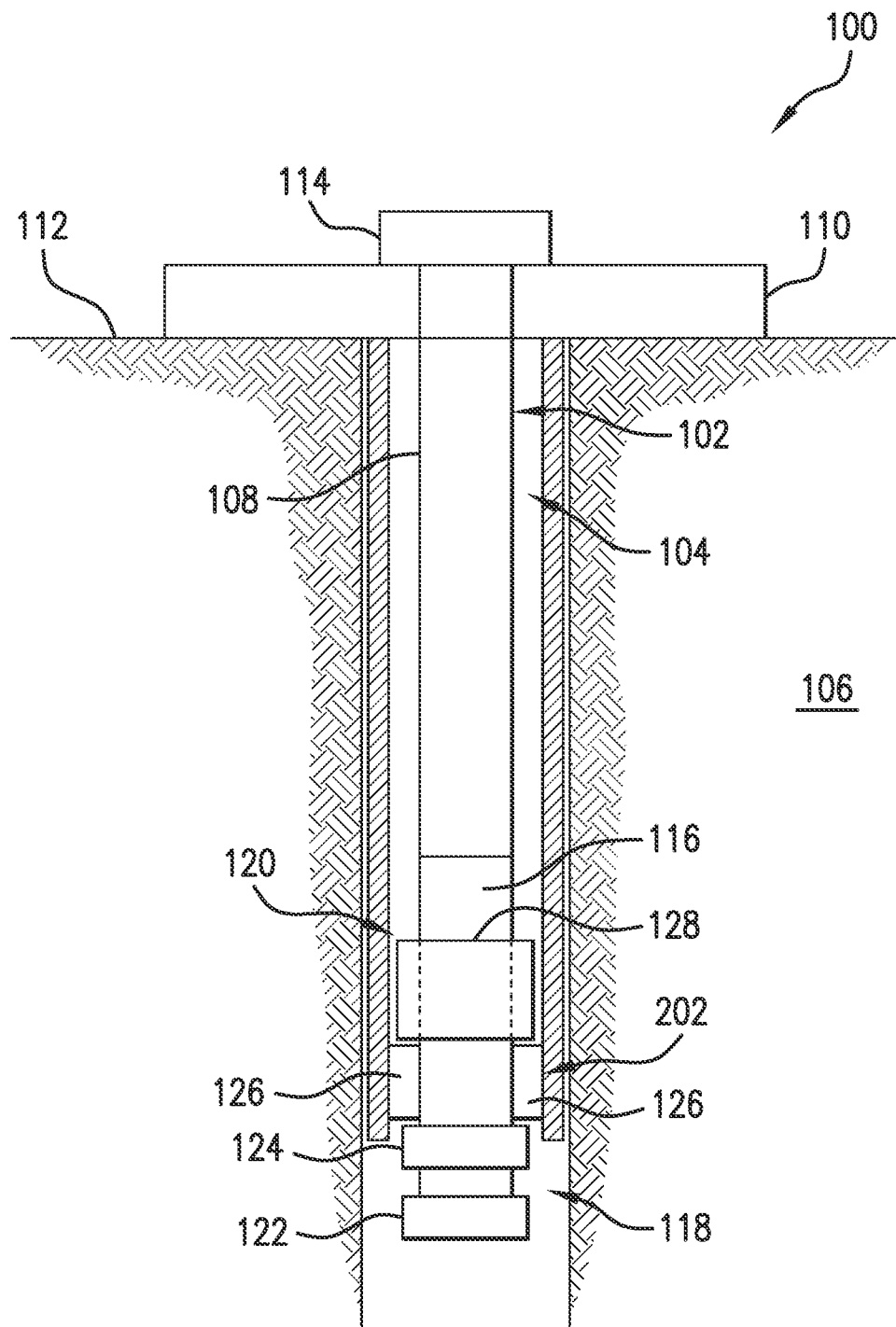


FIG.2

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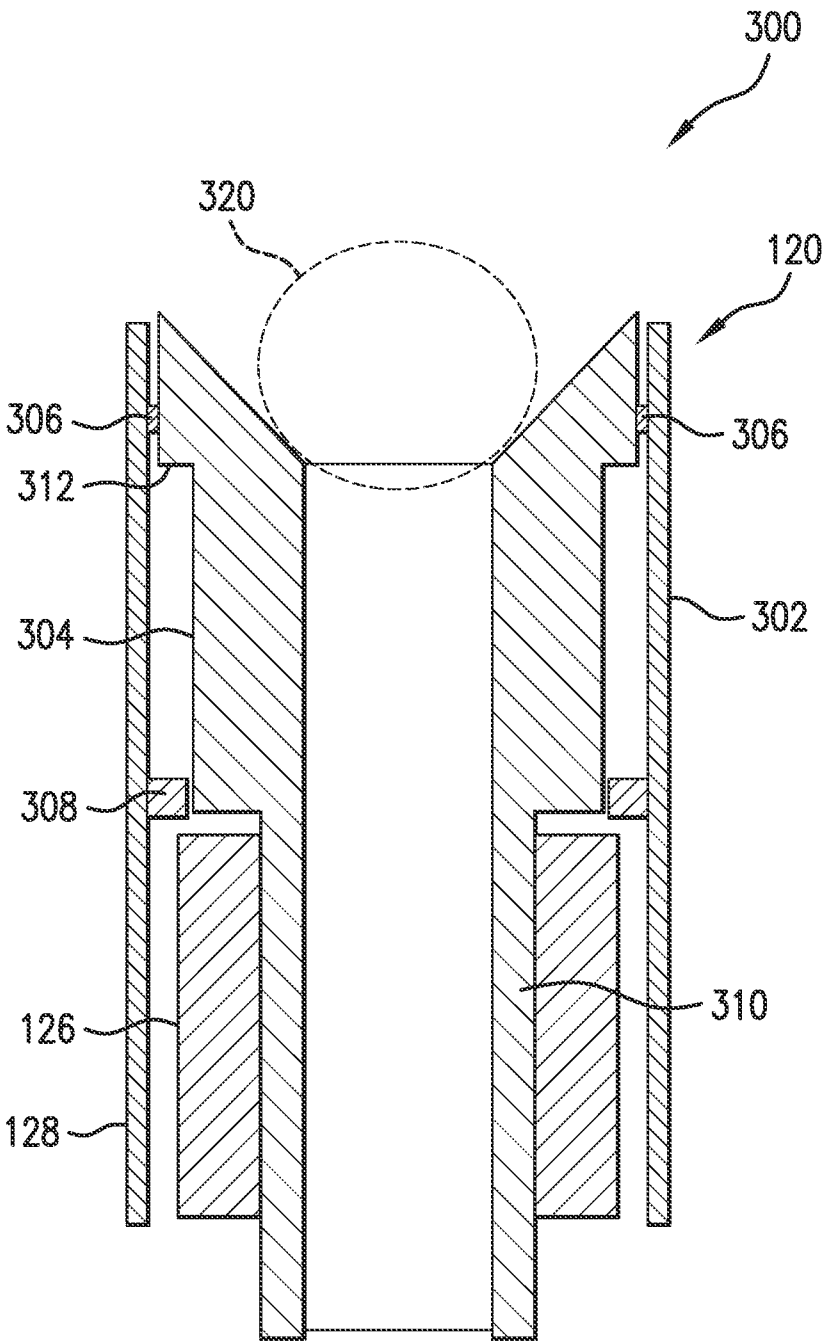


FIG. 3

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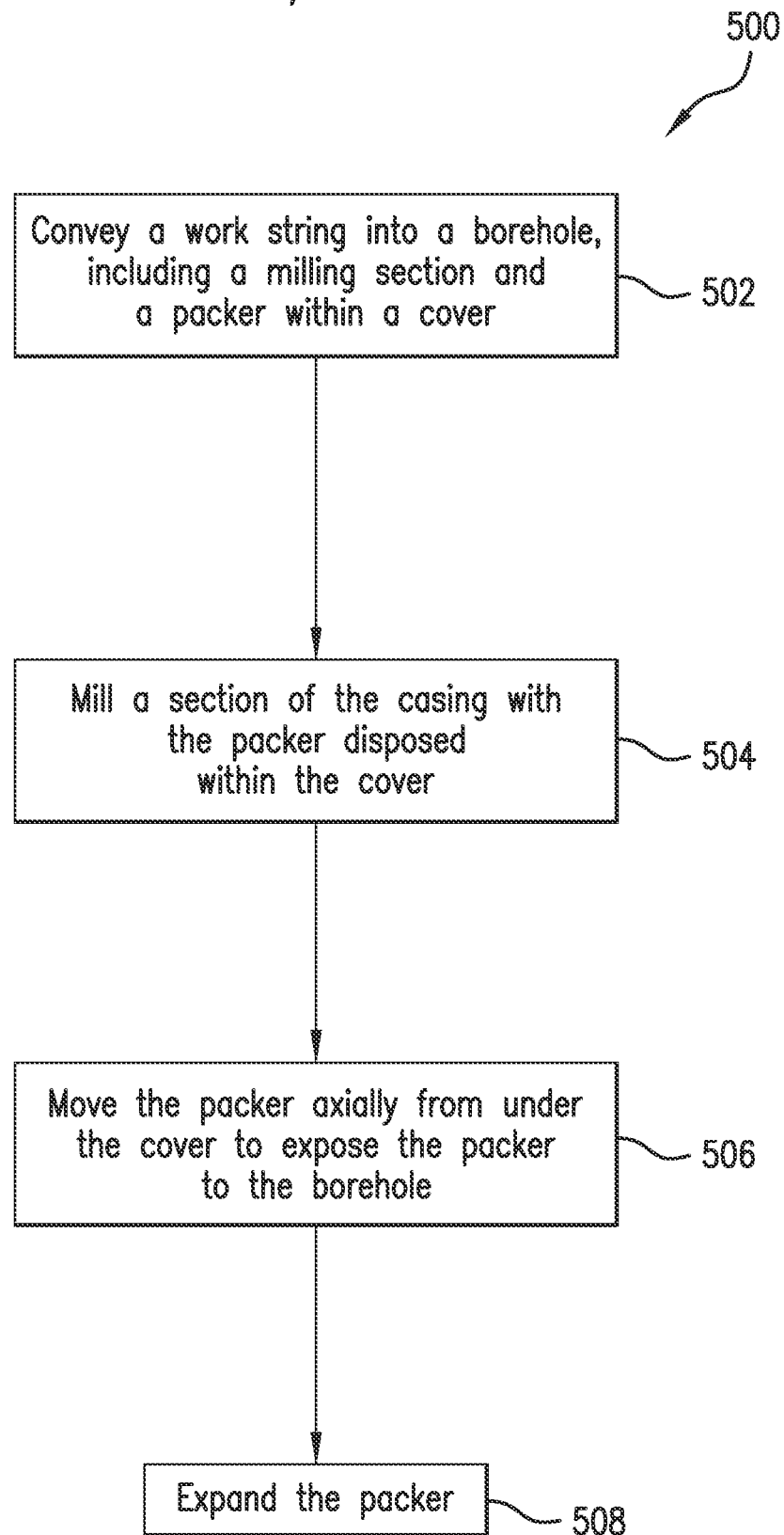


FIG.5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/046850

A. CLASSIFICATION OF SUBJECT MATTER E21B 29/00(2006.01)i; E21B 33/127(2006.01)i; E21B 34/14(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 29/00(2006.01); E02D 3/12(2006.01); E02D 5/18(2006.01); E21B 33/12(2006.01); E21B 33/127(2006.01); E21B 33/138(2006.01); E21B 34/14(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: borehole, work string, milling section, packer section, cover, ball, hydraulic pump, underreamer		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2019-0249512 A1 (SAUDI ARABIAN OIL COMPANY) 15 August 2019 (2019-08-15) paragraphs [0020]-[0037], claim 1, and figures 1-2	1-15
Y	US 2008-0236835 A1 (RAYSSIGUIER et al.) 02 October 2008 (2008-10-02) abstract, paragraphs [0025]-[0040], and figures 1-A, 1-B, 4	1-15
Y	US 2017-0101847 A1 (WELLTEC A/S) 13 April 2017 (2017-04-13) paragraphs [0065], [0078] and figures 1-2	10
A	US 4545702 A (SANO et al.) 08 October 1985 (1985-10-08) column 7, line 37 - column 10, line 59 and figures 1-9	1-15
A	US 2002-0011333 A1 (WARD, CHRISTOPHER D.) 31 January 2002 (2002-01-31) paragraphs [0092]-[0108] and figures 1-2	1-15
☐ 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 “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 26 December 2024		Date of mailing of the international search report 26 December 2024
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer PARK, Tae Wook Telephone No. +82-42-481-3405

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/046850

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2019-0249512	A1	15 August 2019	CN	111712615	A	25 September 2020
				EP	3752708	A1	23 December 2020
				EP	3752708	B1	09 November 2022
				SA	520412463	B1	09 July 2023
				US	10961807	B2	30 March 2021
				WO	2019-157481	A1	15 August 2019
US	2008-0236835	A1	02 October 2008	AT	E344377	T1	15 November 2006
				BR	PI0514862	A	24 June 2008
				CA	2578367	A1	16 March 2006
				EP	1635035	A1	15 March 2006
				EP	1635035	B1	02 November 2006
				MX	2007002707	A	16 May 2007
				NO	20071412	L	06 June 2007
				US	7896067	B2	01 March 2011
				WO	2006-027120	A1	16 March 2006
US	2017-0101847	A1	13 April 2017	AU	2015-261996	A1	22 December 2016
				AU	2015-261996	B2	21 December 2017
				BR	112016025140	A2	15 August 2017
				BR	112016025140	B1	16 November 2022
				CA	2948083	A1	26 November 2015
				CN	106460482	A	22 February 2017
				EP	2947259	A1	25 November 2015
				EP	3146144	A2	29 March 2017
				EP	3146144	B1	04 December 2024
				MX	2016014495	A	23 January 2017
				MY	177423	A	15 September 2020
				RU	2016147665	A	20 June 2018
				RU	2016147665	A3	24 December 2018
				RU	2712903	C2	31 January 2020
				SA	516380228	B1	21 July 2022
				US	10253591	B2	09 April 2019
				WO	2015-177122	A2	26 November 2015
				WO	2015-177122	A3	19 May 2016
US	4545702	A	08 October 1985	DE	3323332	A1	12 January 1984
				DE	3323332	C2	24 March 1988
				FR	2529612	A1	06 January 1984
				FR	2529612	B1	05 September 1986
				GB	2126268	A	21 March 1984
				GB	2126268	B	31 July 1985
				IT	1163632	B	08 April 1987
				JP	02-035087	B2	08 August 1990
				JP	03-048963	B2	26 July 1991
				JP	59-008821	A	18 January 1984
				JP	59-008822	A	18 January 1984
				JP	59-106616	A	20 June 1984
				JP	59-195918	A	07 November 1984
				JP	62-009693	B2	02 March 1987
				NL	8302373	A	01 February 1984
US	2002-0011333	A1	31 January 2002	AU	6470298	A	20 October 1998

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/046850

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
		AU 728437 B2	11 January 2001
		CA 2284639 A1	01 October 1998
		CA 2284639 C	29 January 2008
		CA 2523039 A1	01 October 1998
		CA 2523039 C	21 April 2009
		DK 1012443 T3	15 May 2006
		EP 1012443 A1	28 June 2000
		EP 1012443 A4	05 July 2000
		EP 1012443 B1	11 January 2006
		ID 20104 A	01 October 1998
		ID 20105 A	01 October 1998
		NO 321471 B1	15 May 2006
		NO 994684 L	16 November 1999
		US 6148912 A	21 November 2000
		US 6189612 B1	20 February 2001
		US 6296056 B1	02 October 2001
		US 6427785 B1	06 August 2002
		US 6427785 B2	06 August 2002
		WO 98-42948 A1	01 October 1998