



- (51) **International Patent Classification:**
E21B 17/00 (2006.01) *E21B 17/02* (2006.01)
- (21) **International Application Number:**
PCT/US2014/065361
- (22) **International Filing Date:**
13 November 2014 (13.11.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
14/079,019 13 November 2013 (13.11.2013) US
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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, 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, ST, 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).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

- (54) **Title:** COMPLETION SYSTEMS INCLUDING AN EXPANSION JOINT AND A WET CONNECT

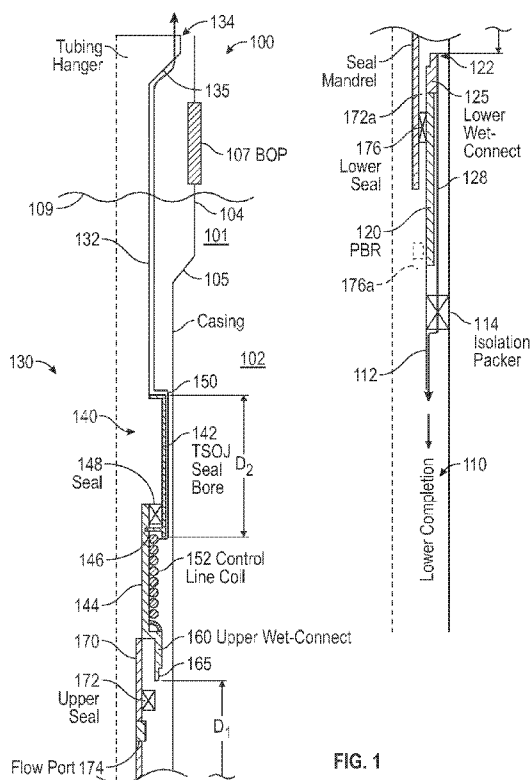


FIG. 1

- (57) **Abstract:** A production string for use in a wellbore is disclosed that in a non-limiting embodiment includes a lower section that includes a first tubular having a first connection device at a top end thereof, and an upper section that includes a second tubular that sealingly slides against the first tubular, a second connection device associated with the second tubular configured to engage with the first connection device, and an expansion joint above the second tubular.



— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))* — *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Published:

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

COMPLETION SYSTEMS INCLUDING AN EXPANSION JOINT AND A WET CONNECT

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Application No. 14/079019, filed on November 13, 2013, which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Disclosure

[0001] This disclosure relates generally to a completion system wherein a production string for the production of hydrocarbons may include an expansion joint for accommodating variations in the length of the production string and a wet connect.

2. Background of the Art

[0002] Wells or wellbores are drilled in subsurface formations for the production of hydrocarbons (oil and gas). Modern wells can extend to great well depths, sometimes more than 2,500 meters. Hydrocarbons are trapped in various traps in the subsurface formations at different depths. The areas of the formation that contain the hydrocarbons are referred to as reservoirs or hydrocarbon-bearing formations or production zones. The wellbore is lined with a casing and the annulus between the casing and the wellbore is filled with cement. Perforations are made through the casing and the formation to allow the hydrocarbons to flow from the production zones into the wellbore. A production string is placed inside the casing to lift the hydrocarbons from the wellbore to the surface. A production string typically includes a lower completion section that includes various devices, such as sand screens, valves, packers, etc. in front of each zone and an upper completion section that typically includes a long tubing made by connecting or joining pipe sections, each about 30 feet in length. A liner hanger is placed on top of the tubing to attach or hang the tubing inside the casing at a selected location below the surface level. To deploy the production string, the lower completion section is deployed in the wellbore. The upper completion section is then lowered into the wellbore and attached to the top of the lower completion section. Operators determine the length of the upper completion section needed to hang the liner hanger at the selected location in the casing and to connect the upper completion section to the lower completion section. For deep wellbores, the tubing length can exceed 1,500 meters (about 15,000 feet). Due to the weight of the tubing, play in the tubing joints and for the expansion

of the tubing after installation, an expansion joint is provided in the tubing to accommodate for such the tubing length changes.

[0003] The disclosure herein provides a completion system wherein a production string includes a device that can accommodate relatively large tubing length variations during deployment and an expansion joint for accommodating variations in length after deployment.

SUMMARY

[0004] In one aspect, a production string for use in a wellbore is disclosed that in a non-limiting embodiment includes a lower section that includes a first tubular having a first connection device at a top end thereof, and an upper section that includes a second tubular that sealingly slides against the first tubular, a second connection device associated with the second tubular configured to engage with the first connection device, and an expansion joint above the second tubular.

[0005] In another aspect, a method of completing a well is disclosed that in one non-limiting embodiment includes: providing a production string that includes a lower section having a first tubular having a first connection device at a top end thereof; deploying the lower section in the well; providing an upper section that includes a second tubular that sealingly slides against the first tubular, a second connection device above the second tubular configured to engage with the first connection device, and an expansion joint above the second connection device; lowering the upper section to connect the first connection device to the second connection device by sealingly sliding the second tubular against the first tubular and; lowering the upper section after connecting the first connection device to the second connection device using the expansion joint to set the upper section in the well.

[0006] Examples of the more important features of a well completion system are summarized rather broadly in order that the detailed description thereof that follows may be better understood, and in order that the contributions to the art may be appreciated. There are, of course, additional features that will be described hereinafter and which will form the subject of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a detailed understanding of the apparatus and methods disclosed herein, reference should be made to the accompanying drawings and the detailed description thereof, wherein like elements are generally given same numerals and wherein:

FIG. 1 shows a production string wherein a lower section of the production string containing a lower portion of a wet connect has been deployed in the wellbore and an upper section of the production string is in the process of being deployed in the wellbore.

DETAILED DESCRIPTION OF THE DRAWINGS

[0008]FIG. 1 is a line diagram of a non-limiting embodiment of a production string or production assembly 100 for deployment in a wellbore 101 formed in a formation 102. The wellbore 101 is shown lined with a casing 104 that includes a landing 105 near the top of the casing 101. A blow-out-preventor 107 is deployed above the mud line 109 over the casing 101 to prevent blow-outs as is well known in the art. The production string 100 includes a lower string or completion section (also referred to herein as the “lower section”) 110 and an upper completion string or upper completion section (also referred to herein as the “upper section”) 130. The lower section 110 may include devices known in the art to facilitate the production of hydrocarbons from the formation to the surface. Any suitable lower completion system may be utilized for the purposes of this disclosure and is thus not shown in detail herein. The lower completion section 110 is isolated from the upper completion section 140 by an isolation packer 114. The lower completion section 110 includes a tubular 112 that has a polished bore receptacle (“PBR”) 120 at the top of the tubular and a wet connect carrier 122 having a lower wet connect 125 on top of the PBR 120. A control line (also referred to as the “communication line” or “communication link”) 128 is run from the wet connect 125 to a circuit or control unit (not shown) in the lower completion section 110 for transmitting signals between the control circuit and the lower wet connect 125.

[0009]The upper section 130 includes a tubular 132 that has a tubing hanger 134 at its upper end. The tubing hanger 134 has a landing 135 that lands on or hangs on to the landing 105 in the casing 104 when the upper section 130 is deployed in the casing 101. The upper section 130 contains an expansion joint (that may be a telescoping space out joint or TSOJ) 140 connected to the bottom end of the tubular 132. In one aspect, the expansion joint 140 includes a seal bore 142. The seal bore 142 is connected to a tubular 144 via a shear device 146, such as a shear pin. A seal 148 provides a seal between the seal bore 142 and the tubular 144. An upper wet connect carrier 160 having an upper wet connect 165 is connected to the lower end of the tubular 144. In one aspect, a control line 150 may be run from the surface along the tubular 132 and then along the seal bore 142 and then coiled around the tubular 144, as shown by coil 152. The communication line 150 terminates at the upper wet connect 165. The tubular 144 is then connected to mandrel 170 that has an upper seal 172, a flow port

174 and a lower seal 176. As is known in the art, the casing 101 and the production string 100 are filled with a fluid, such as drilling fluid, to provide a hydrostatic pressure in the casing greater than the formation pressure along the length of the wellbore to prevent the fluid from the formation 104 to enter into the production string 100.

[0010] To connect the upper section 130 to the lower section and to connect the upper wet connect 165 to the lower wet connect 125, the tubular 132 is lowered to cause the lower seal 176 to engage with the PBR 120. When the lower seal 176 engages with the PBR 120, as shown in FIG. 1, pressure inside the upper section 130 increases, which produces a spike in the pressure measured at the surface. This enables an operator to know that the lower seal has engaged with the PBR 120. To connect the upper wet connect 165 to the lower wet connect 125, the flow port 174 allows fluid circulation to clean the area between the upper wet connect 165 and the lower wet connect 125. The upper section 130 is then lowered so that the upper wet connect 165 mates with the lower wet connect 125. Mating of the upper and lower wet connects 165 and 125 provides communication between the surface and the lower completion section 110. Mating of the upper and lower wet connects 165 and 125 prevents the upper section 130 to further move downward. The weight of the upper section 130 is not sufficient to break the shear device 146. At this stage, the lower seal 176 is at a location 176a and the upper seal 172 has engaged with the PBR as shown by location 172a. In addition, the landing 135 of the tubing hanger 134 is still above the landing 105 of the casing 101. The distance "D1" between the lower wet connect 125 and the upper wet connect 165 is selected so that when the wet connects 125 and 165 mate, the landing 135 will remain above the landing 105 by a known distance. The tubular 132 is then pushed downward to break the shear device 142, which enables the seal bore 142 of the TSOJ 140 to move along the tubular 144 via the seal 146, which compresses the coil 152. The distance "D2" is greater than the distance needed to place the landing 135 onto the landing 105 after breaking the shear device 144. The communication link containing the links 128 and 150 may include one or more hydraulic lines, electrical lines (conductors), fiber optic lines and/or any other type of communication links known in the art. Various types of wet connects are known in the art and any suitable wet connect and communication link may be utilized for the purposes of this disclosure.

[0011] Thus, in one non-limiting embodiment, the disclosure provides a completion system wherein a production string includes a lower completion section and an upper completion section. In one aspect, a lower wet connect carrier is placed at the top of a PBR above the lower completion section. A first control line is run from the lower wet connect

carrier through an isolation packer to the lower completion section. The upper completion section includes an extended mandrel with two sets of seals (an upper seal set and a lower seal set) below an upper wet connect carrier, with a flow port placed below the upper seal set. When the upper completion section is lowered into the wellbore, the lower seal set engages with the PBR and the pressure spike is read at the surface. The Flow Port allows for circulation between the lower wet connect and the upper wet connect. The upper string is then lowered so that the upper seal set engages with the PBR and the upper wet connect fully mates (engages) with the lower wet connect. A TSOJ with a coiled control line is placed above the upper connect carrier with a higher shear force than is required to mate the upper wet connect with the lower wet connect. The TSOJ is sheared and moved downward to set the liner hanger in the casing. The coil and the TSOJ allow for tube movement throughout the life of the well.

[0012] A long production string can require the use of a long expansion joint to allow for the make-up of a tubing hanger made by joining pipe sections and for additional 'play' in the string, such as due to the weight of the tubing. The production string 100 provides a first stroke (distance D1) via the mandrel to deploy the upper section 130 of the production string 100 (to connect the upper and lower wet connects) and a second stroke (distance D2) via the telescopic expansion joint 140 to set the liner hanger 134 in the casing 101. The production string 100 further provides coiled control lines (fiber optic, hydraulic, or electric) around the telescopic member 144 to allow for the compression of the control line during deployment of the production string 100 and for contraction and expansion of the production string 100 thereafter. Use of both a PBR and an expansion joint 140 allows for the full required stroke without requiring control line coil to cover the distance. In one aspect, the first stroke may be substantially greater than the second stroke. For a total stroke of 120 feet, in one embodiment, the first stroke may be about 100 feet and the second stroke may be about 40, the combination thereby providing sufficient safety margin for correctly landing the liner hanger and also providing for the expansion of the production string over the life of the well.

[0013] The foregoing disclosure is directed to the certain exemplary embodiments and methods. Various modifications will be apparent to those skilled in the art. It is intended that all such modifications within the scope of the appended claims be embraced by the foregoing disclosure. The words "comprising" and "comprises" as used in the claims are to be interpreted to mean "including but not limited to". Also, the abstract is not to be used to limit the scope of the claims.

CLAIMS

1. A production string for use in a wellbore, comprising:
a lower section that includes a first tubular having a first connection device at a top end thereof; and
an upper section that includes:
a second tubular that sealingly slides against the first tubular;
a second connection device associated with the second tubular configured to engage with the first connection device; and
an expansion joint above the second tubular.
2. The production string of claim 1, wherein the second tubular includes at least two seals that are spaced apart from each other and configured to sealingly engage with the first tubular.
3. The production string of claim 2, wherein a seal in the at least two seals is positioned below the first connection device when the first and second connection devices engage with each other.
4. The production string of claim 1 or 2, wherein the first connection device includes a first part of a wet connect and the second connection device includes a second part of the wet connect.
5. The production string of any of the claims claim 1-4, wherein the expansion joint includes a telescoping device having a first member connected to a second member via a shear device.
6. The production string of claim 5, wherein the first member sealingly slides against the second member when the shear device is disengaged.
7. The production string of claim 6, wherein the upper section includes a first communication link that runs from a surface location to the second connection device and is coiled around the second member of the expansion joint.
8. The production string of claim 7, wherein the lower section includes a second communication link that runs from the first connection device to location in the lower section.
9. The production string of claim 1 further comprising a tubing having a liner hanger at a first end thereof and wherein the expansion joint is connected to second end of the tubing.

10. A production string for use in a wellbore, comprising:

- a lower section that includes a lower wet connect on a top end of a first tubular and a first communication link that runs from the lower wet connect to a selected location in the lower section; and
- an upper section that includes:
 - a tubing;
 - an expansion joint attached to a bottom end of the tubing, the expansion joint including a telescoping device having a telescoping member configured to slide against a second tubular member, wherein the telescoping member is restrained from sliding against the second tubular member by a shear device;
 - an upper wet connect below the expansion joint;
 - a mandrel below the upper wet connect, wherein the mandrel is configured to sealingly slide against the first tubular; and
 - a second communication link that runs from a selected location above the expansion joint to the upper wet connect, wherein a portion of the second communication link is coiled around the telescoping member.

11. The production string of claim 10, wherein:

- the tubing includes a liner hanger at a top end of the tubing and a first landing for placement on a second landing in a casing in the wellbore;
- the mandrel includes a lower seal and an upper seal; and wherein
- the liner hanger positions above a blow-out-preventor on the wellbore when the lower seal engages with the first tubular; and
- the liner hanger positions below the blow-out-preventor when the upper wet connect mates with the lower wet connect and before placement of the first landing onto the second landing.

12. A method of completing a well, comprising:

- providing a production string that includes a lower section having a first tubular having a first connection device at a top end thereof;
- deploying the lower section in the well;
- providing an upper section that includes a second tubular that sealingly slides against the first tubular, a second connection device above the second tubular configured to engage with the first connection device, and an expansion joint above the second connection device;
- lowering the upper section to connect the first connection device to the second connection device by sealingly sliding the second tubular against the first tubular and;

lowering the upper section after connecting the first connection device to the second connection device using the expansion joint to set the upper section in the well.

13. The method of claim 12, wherein the first connection device and the second connection device each is a wet connect.

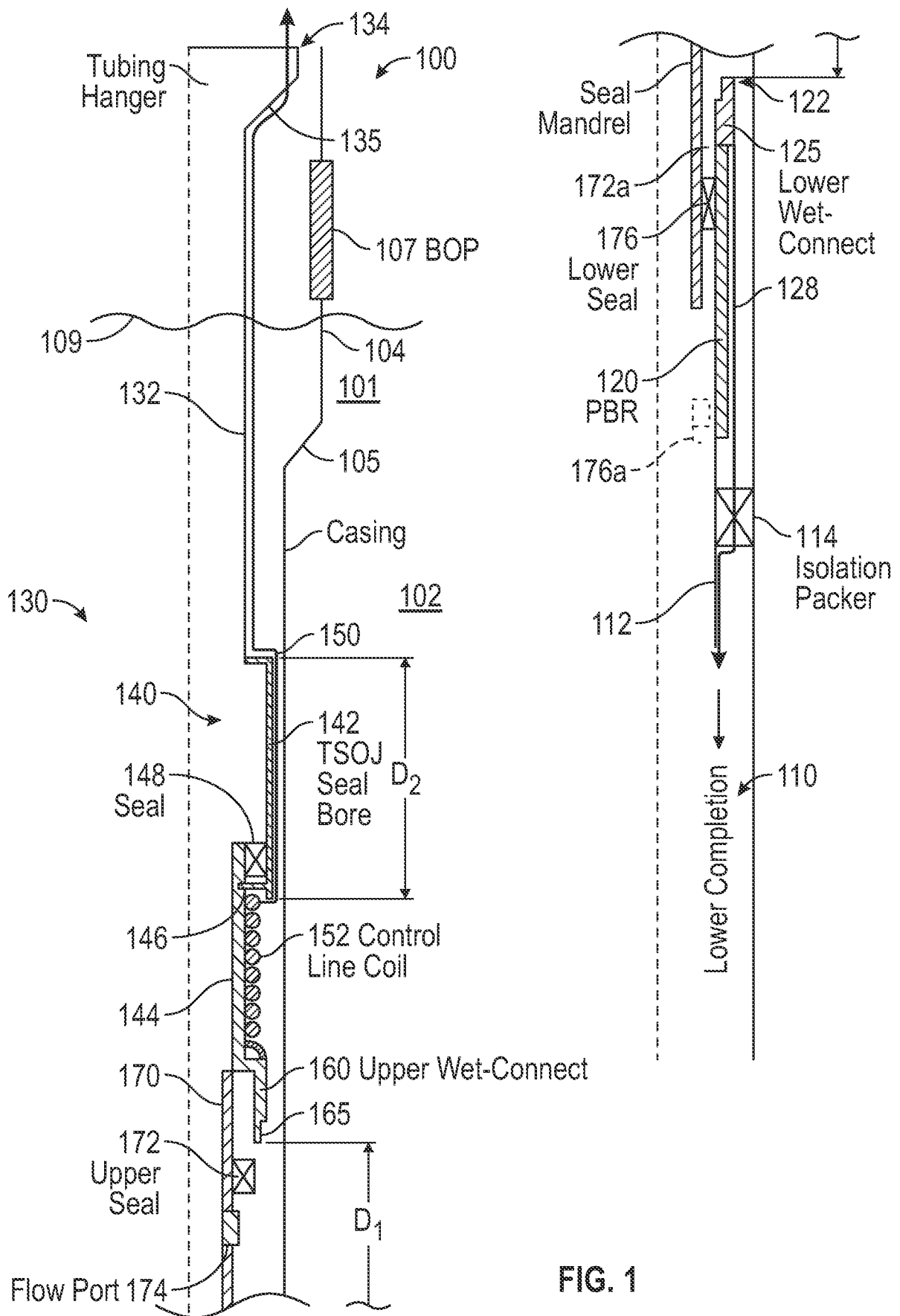
14. The method of claim 12 or 13 further comprising:

running a first communication link from the first connection device to a location in the lower section; and

running a second communication link from the second connection device to a location above the expansion joint.

15. The method of claim any of the claims 12-14, wherein the production string further comprises a mandrel having a port that provides fluid communication between the first connection device and the second connection device when the second tubular is in a sealing arrangement with the first tubular.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/065361**A. CLASSIFICATION OF SUBJECT MATTER****E21B 17/00(2006.01)i, E21B 17/02(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 17/00; E21B 19/16; E21B 43/02; E21B 23/00; E21B 43/10; E21B 33/035; E21B 34/10; E21B 17/02

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: production string, wellbore, section, tubular, connection device, expansion joint

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0048307 A1 (PATEL, DINESH R.) 28 February 2013 See paragraphs [0020]-[0022], [0026]-[0033]; claim 1; and figures 1-4, 7-9.	1-4, 12-14
Y		9-11
Y	WO 2007-119052 A1 (READ WELL SERVICES LIMITED) 25 October 2007 See page 8, lines 29-30; page 10, lines 3-6; and figures 5a, 7-8.	9-11
Y	EP 2287439 A1 (WOODSIDE ENERGY LIMITED) 23 February 2011 See paragraph [0011]; and figure 3.	11
A	US 2008-0029274 A1 (RYTLEWSKI et al.) 07 February 2008 See paragraphs [0061]-[0064]; and figure 4.	1-4, 9-14
A	US 2006-0260818 A1 (MEIJER et al.) 23 November 2006 See paragraphs [0037]-[0040]; and figures 1-3.	1-4, 9-14



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

"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

16 March 2015 (16.03.2015)

Date of mailing of the international search report

16 March 2015 (16.03.2015)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORTInternational application No.
PCT/US2014/065361**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 6-8
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 6-8 are not clear because they refer to claim 5, which do not comply with PCT 6.4(a). Therefore, claims 6-8 do not meet the requirement of PCT Article 6.
3. ☒ Claims Nos.: 5,15
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/065361

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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