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(54) Title: ONE-TRIP PACKER AND PERFORATING GUN SYSTEM

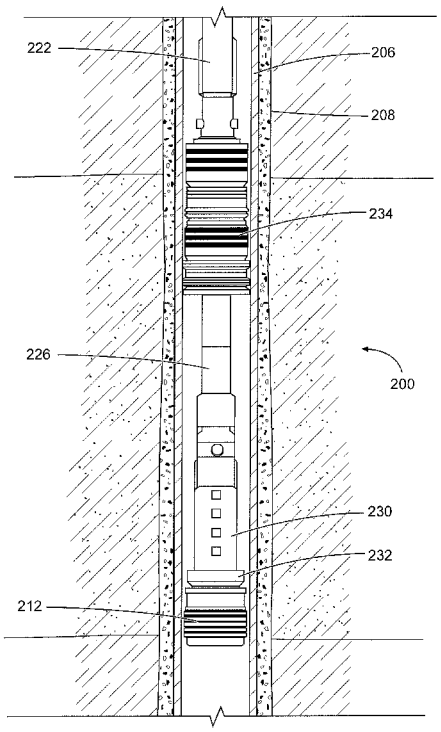


Fig. 2

(57) Abstract: A completion tool for gravel pack and frac pack operations for installing a sump packer and perforating a casing in one trip of a work string. The completion tool is disposed on the end of a work string and includes a perforating gun and a packer attached to the distal end of the completion tool by a coupling. The coupling is such that once the packer is set, the rest of the completion tool can be detached from the packer. After detachment, the completion tool can be repositioned to fire the perforating gun. Positioning of the packer and perforating gun may be accomplished by correlating off of other equipment or by use of logging-while-drilling or measurement-while-drilling equipment incorporated into the completion tool.

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ONE-TRIP PACKER AND PERFORATING GUN SYSTEM

BACKGROUND

In the course of completing a hydrocarbon well, a string of protective casing may be run into the wellbore followed by production tubing inside the casing. The casing is perforated across one or more production intervals to allow formation fluids to enter the casing.

During production of the formation fluid, formation sand may become entrained in the fluid and swept into the production stream. Producing sand is undesirable for multiple reasons. For example, formation sand can lead to significant wear and damage to downstream production equipment, necessitating additional filtration and separating equipment. Sand production can also compromise the integrity of the well because as sand is removed from the formation, the formation becomes increasingly unstable and prone to collapse or subsidence. Removal of sand can also lead to voids along the outside of the casing, reducing the support provided to the casing and increasing the risk of casing collapse.

To control formation sand, operators may perform a gavel pack. This process involves locating a screened section of production tubing at the production interval and packing the annulus between the production tubing and the casing with gravel. The gravel is generally sized to prevent migration of formation sand while still permitting formation fluid to flow into the production tubing.

A similar process, called a frac pack, combines a gravel pack with a fracturing operation. As with standard fracturing operations, a frac pack involves injection of high pressure fluid into the wellbore following perforation. As the fluid enters the formation via the casing perforations, the high pressure of the fluid creates fractures in the formation and causes the fractures to propagate through the formation. The fractures improve production by increasing the available flow paths between the wellbore and the formation. Fluids used in frac pack operations further contain gravel or other granular solids. These solids fill the annulus and the fractures and provide similar filtration effects as the gravel used in gravel pack operations.

Preparing a wellbore interval for a frac or gravel pack operation involves isolating the section by installing a sump packer. The sump packer is installed below the target production interval before perforating the casing and provides a lower boundary for the section being frac or gravel packed.

Typically, the sump packer is inserted into the wellbore using a wireline or work string. Wireline or e-line is generally made of flexible cord or cable, and depends in part on the force of

gravity to insert tools into the wellbore. As a result, wireline is suitable for use only in substantially vertical wells (i.e., wells having less than 45 degrees of deviation) or operations in which the tool can be pumped through the wellbore.

For deviated or horizontal wells, a work string may be required. A work string is generally made of rigid or semi-rigid tubing and can be used to push the packer across deviated or horizontal portions of the wellbore.

Once inserted into the wellbore, the sump packer is correlated on depth using logging-while-drilling or similar equipment and then set, causing the sump packer to engage the wellbore. The e-line or work string is then detached from the packer and withdrawn from the wellbore. Perforating guns are then run into the wellbore to perforate the casing. Similar to the sump packer, the perforating guns may be correlated on depth using logging-while-drilling or similar equipment. Alternatively, the perforating gun may be inserted into the wellbore until it contacts the sump packer, then backed up to the proper position.

Separately running the sump packer and perforating gun can significantly increase rig time. As depths of modern drilling and completion operations increase, rig time stands to increase. Further, in highly deviated wells, the generally faster approach of using wireline to insert the packer and perforating gun is not available.

As a result, there is a need for a completion tool that reduces the number of wireline or work string runs necessary for preparing a wellbore for gravel or frac packing operations.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features.

FIG. 1 is a schematic view of a wellbore having a completed gravel pack operation.

FIG. 2 is a schematic view of a completion tool in accordance with one embodiment inserted into a wellbore

FIG. 3 is a schematic view of the completion tool of FIG. 2 in position to install a sump packer.

FIG. 4 is a schematic view of the completion tool of FIGS. 2 and 3 following firing of a perforation gun.

FIGS. 5A–5B show a cross-sectional view of a portion of the completion tool depicting a first coupling mechanism in an engaged and disengaged position for retaining a sump packer on the completion tool.

FIGS. 6A–6B show a cross-sectional view of a portion of the completion tool depicting a second coupling mechanism in an engaged and disengaged position for retaining a sump packer on the completion tool.

While embodiments of this disclosure have been depicted and described and are defined by reference to exemplary embodiments of the disclosure, such references do not imply a limitation on the disclosure, and no such limitation is to be inferred. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those skilled in the pertinent art and having the benefit of this disclosure. The depicted and described embodiments of this disclosure are examples only, and not exhaustive of the scope of the disclosure.

DETAILED DESCRIPTION

The present disclosure relates generally to completion of hydrocarbon wells and specifically to preparations of a well bore for gravel pack or frac packing operations.

Illustrative embodiments of the present invention are described in detail herein. In the interest of clarity, not all features of an actual implementation may be described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation specific decisions must be made to achieve the specific implementation goals, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of the present disclosure.

To facilitate a better understanding of this disclosure, the following examples of certain embodiments are given. In no way should the following examples be read to limit, or define, the scope of the claims.

In FIG. 1, a casing 106 is cemented into place and lines a wellbore 108. As depicted, the wellbore extends through three distinct layers of a formation 102A, 102B, and 104. The casing 106 includes a series of perforations 110 previously made using a perforating gun. The perforations 110 permit communication of fluids between the surrounding formation 104 and the inside of the casing 106. The perforations 110 correspond to a production interval 111 of the casing 106.

The production interval 111 is delineated from the rest of the wellbore by a sump packer 112, a gravel packer 114, and production tubing 116. The production tubing 116 is hollow and

runs from the gravel packer 114 through the production interval 111, and through the sump packer 112. A screen section 118 of the production tubing 116 permits fluid to communicate into the production tubing 116.

FIG. 1 depicts a cross-section of an example formation in which gravel packing is commonly used. The first formation layer 102A and third formation layer 102B are intended to be made of stable rock having low permeability. The middle layer 104, on the other hand, is a looser formation, consisting of high permeability rock having a high sand content. As a result, middle layer 104 is suitable as a production zone but may be unstable and, absent operator intervention, is prone to sand production.

To prevent production of sand, gravel 120 is inserted inside the casing 106 between the production tubing 116 and the casing 106. As formation fluid flows from the formation 104, through the screen 118, and into the production tubing 116, the gravel 120 acts as a filter, retaining sand that would otherwise enter the production stream.

The gravel used in a given gravel pack operation is determined by the properties of the formation sand. The specific details of gravel selection are known in the art, but generally, gravel is selected based on the size and composition of the formation sand such that the formation sand is prevented from entering the production stream with minimal restriction to formation fluid flow between the formation and the production tubing.

The formation depicted in FIG. 1 is intended to illustrate a common gravel pack application. The characteristics of the formation depicted in FIG. 1 should not be regarded as limiting the scope or applications of this disclosure. Gravel pack operations are suitable for a wide range of formations having varying compositions. Further, gravel pack operations are suitable not only for substantially vertical wells, such as that depicted in FIG. 1, but may also be applied in deviated wells.

The system and methods described in this disclosure may also be applied to combination fracturing and gravel packing operations, commonly referred to as frac pack operations. Preparation of a wellbore for gravel pack and frac pack operations is substantially similar. Both operations involve the general steps of isolating a production zone, perforating the production zone, and filling the space between the wellbore and production tubing with gravel or similar solids that act to retain formation sand.

In frac pack operations, however, the step of filling the wellbore with gravel or solids is combined with a fracturing operation. Specifically, fluid containing gravel or other solids is pumped into the wellbore and into the formation under high pressure. The pressure causes

fractures in the formation and propagation of those fractures. In addition to filling the wellbore, as in a standard gravel pack operation, the gravel or solids in a fracturing operation penetrate into the newly created fractures. Once completed, the gravel or solids perform a similar function as in a gravel pack operation, retaining formation sand while permitting flow of hydrocarbons into a production tubing. By filling the newly created fractures, the gravel or solids also act as a proppant, maintaining the fractures open during the course of production.

FIGS. 2–4 depict the sequence of operation of one embodiment of a completion tool in accordance with this disclosure.

FIG. 2 is a schematic view of a completion tool according to one embodiment. The completion tool 200 is depicted inside a casing 206 cemented in a wellbore 208. The completion tool 200 is further depicted disposed on the end of a work string 222. The work string 222 may be any tubular suitable for inserting the completion tool 200 into the wellbore 208. For example, the work string 222 may be a series of work string segments, a length of coiled tubing, or any combination of similar work string elements.

To facilitate one-trip sump packer installation and perforation, the completion tool 200 includes a hydrostatic-set sump packer 212 connected beyond the distal end of a perforating gun 230. Hydrostatic-set sump packers, like sump packer 212, are generally configured to activate when exposed to a predetermined hydrostatic pressure. Activation expands one or more flexible, elastomeric packer elements, causing the elements to engage the inner surface of the casing or wellbore and fixing the packer in place.

The sump packer 212 is connected to the completion tool 200 by a coupling 232. As will be discussed later in this disclosure, the coupling 232 is configured so that the sump packer 212 is detachable from the rest of the completion tool 200 once the sump packer 212 is anchored or set in the casing 206.

As depicted in FIG. 2, the completion tool 200 is inserted into the casing 206 by the work string 222. Positioning of the completion tool within the wellbore 208 may be assisted by a navigation sub 226 containing logging-while-drilling (LWD) or measurement-while-drilling (MWD) equipment. Depending on the specific equipment within the navigation sub 226, the position of the completion tool 200 may be determined based on various measurements, including but not limited to position and orientation of the navigation sub 226 and properties of the surrounding formation.

The sump packer 212 is then positioned and set within the wellbore, as shown in Fig. 3. The sump packer 212 is positioned below the intended production interval to form a lower

boundary of the gravel or frac pack operation. Once in position, fluid is pumped into the work string 222 and into the casing 206 through a ported sub 228, increasing the hydrostatic pressure within the casing 206 until the setting pressure of the sump packer 212 is reached. When the setting pressure is reached, the sump packer 212 sets, expanding to engage the inner surface of the casing 206 and becoming fixed within the casing 206.

As depicted in FIG. 4, after the sump packer 212 is set, the coupling 232 is disengaged, detaching the sump packer 212 from the rest of the completion tool 200. Once detached from the sump packer 212, the completion tool 200 can be repositioned within the casing 206 to align the perforating gun 230 with a target production zone. Repositioning the completion tool 200 may be accomplished using the navigation sub 226 or by simply retracting the completion tool 200 a known distance from the set sump packer 212.

FIGS. 2–4 include a second packer 234 disposed on the completion tool 200 and located above the perforating gun 230. In embodiments having a second packer, the second packer may be mechanically set. Such packers depend on twisting or thrusting of the work string to set the packer. Once operations are complete, a substantially opposite movement of the work string may be used to disengage the packer.

The second packer 234 is optional but may be used to isolate the production zone. Isolating the production zone is useful during the steps of setting the packer and firing the perforating gun, which may be hydrostatically activated in certain embodiments. The hydrostatic pressure necessary to set the packer and/or fire the perforating gun is achieved by pumping fluid into the wellbore. Isolating the production zone using the second packer minimizes the volume necessary to be filled in order to build pressure within the production zone and as a consequence, minimizes the time required to set the packer or fire the perforating gun.

Coupling of the sump packer 212 to the completion tool 200 can be accomplished using various approaches. For example, FIGS. 5A and 5B are cross-sectional views of a portion of one embodiment of a completion tool in which a sump packer 512 is connected to the completion tool using shearing members. In FIGS. 5A and 5B, the shearing members are depicted as shear pins 534A, B. Other types of shearing members include shear screws and shear sleeves, and any type of shearing member may be used alone or in combination with any other type of shearing member.

The shear pins 534A, B extend from the sump packer 512 into a coupling 532 disposed on the end of a perforating gun 530. Once the sump packer 512 is set and engages the inner

surface of the casing, the completion tool is retracted, as depicted in FIG. 5B, causing the shear pins to shear and detaching the sump packer 512 from the completion tool.

FIGS. 6A and 6B are cross-sectional views of a portion of a second embodiment of a completion tool in which a sump packer 612 is connected to a coupling 632 of the completion tool using a threaded connection 634. In this embodiment, once the sump packer 612 is set and engages the inner surface of the casing, the coupling 632 may be detached from the packer 612 by disengaging the threaded connection 634 by rotating and withdrawing the work string on which the completion tool is disposed.

Other methods for coupling the sump packer to the completion tool may also be implemented. For example, in one embodiment, magnets located on the coupler and on the inside of the packer may couple the sump packer to the completion tool. In another embodiment, the shear pins depicted in FIG. 5A may be replaced with pins that retract into either the sump packer or coupling. The pins may retract based on hydrostatic pressure, spring force, or electromagnetic force, such as with a solenoid.

Although numerous characteristics and advantages of embodiments of the present invention have been set forth in the foregoing description and accompanying figures, this description is illustrative only. Changes to details regarding structure and arrangement that are not specifically included in this description may nevertheless be within the full extent indicated by the claims.

WHAT IS CLAIMED IS:

1. A completion tool comprising:

a proximal end for connecting to a work string;

a distal end opposite the proximal end;

a perforating gun disposed between the distal end and the proximal end; and

a packer detachably attached to the distal end by a coupling disposed between the perforating gun and the packer; wherein

the packer is detachable from the distal end by setting the packer and disengaging the coupling.

2. The completion tool of claim 1, wherein

the work string includes at least one of the group of a segmented work string and coiled tubing.

3. The completion tool of claim 1, wherein

the packer includes a hydrostatic packer.

4. The completion tool of claim 1, wherein

the packer is detachably attached to the coupling by at least one shearing member.

5. The completion tool of claim 1, wherein

the packer is detachably attached to the coupling by a threaded connection.

6. The completion tool of claim 1, further comprising

at least one of the group of a logging-while-drilling tool and a measurement while drilling tool.

7. The completion tool of claim 1, further comprising

a second packer disposed between the proximal end and the perforating gun.

8. A system for completing a wellbore, comprising

a work string;

a completion tool disposed on the work string, the completion tool comprising:

a proximal end for connecting to a work string;

a distal end opposite the proximal end;

a perforating gun disposed between the distal end and the proximal end; and

a packer detachably attached to the distal end by a coupling disposed between the perforating gun and the packer; wherein

the packer is detachable from the distal end by setting the packer and disengaging the coupling.

9. The system of claim 8, wherein
the packer includes a hydrostatic packer.
10. The system of claim 8, wherein
the packer is detachably attached to the coupling by at least one shearing member.
11. The system of claim 8, wherein
the packer is detachably attached to the coupling by a threaded connection.
12. The system of claim 8, further comprising
one of the group of a logging-while-drilling tool and a measurement while drilling tool..
13. The system of claim 8, further comprising
a second packer disposed between the proximal end and the perforating gun.
14. A method of installing a packer in a wellbore, comprising
positioning a completion tool within the wellbore, the completion tool comprising
a proximal end for connecting to a work string;
a distal end opposite the proximal end;
a perforating gun disposed between the distal end and the proximal end; and
a packer detachably attached to the distal end by a coupling disposed between the perforating gun and the packer; wherein
the packer is detachable from the distal end by setting the packer and disengaging the coupling;
setting the packer within the wellbore; and
detaching the packer by disengaging the coupling.
15. The method of claim 14, wherein
the completion tool is inserted into the wellbore on a work string, the work string including at least one of the group of a segmented work string and coiled tubing.
16. The method of claim 14, wherein
the packer includes a hydrostatic packer and setting the packer is performed by increasing hydrostatic pressure within the wellbore.
17. The method of claim 14, further comprising
setting a second packer, the second packer being disposed between the proximal end and the perforating gun.

18. The method of claim 14, wherein

the packer is coupled to the perforating gun by at least one shearing member, and

the step of detaching the perforating gun from the packer comprises

retracting the perforating gun, causing the at least one shearing member to shear.

19. The method of claim 14, wherein

the packer is coupled to the perforating gun by a threaded connection, and

the step of detaching the perforating gun from the packer comprises

rotating the perforating gun, causing the threaded connection to disengage.

20. The method of claim 14, wherein

the completion tool further comprises at least one of the group of a logging-while-drilling tool and a measuring-while-drilling tool and data from the logging-while-drilling tool is used to position the completion tool within the wellbore.

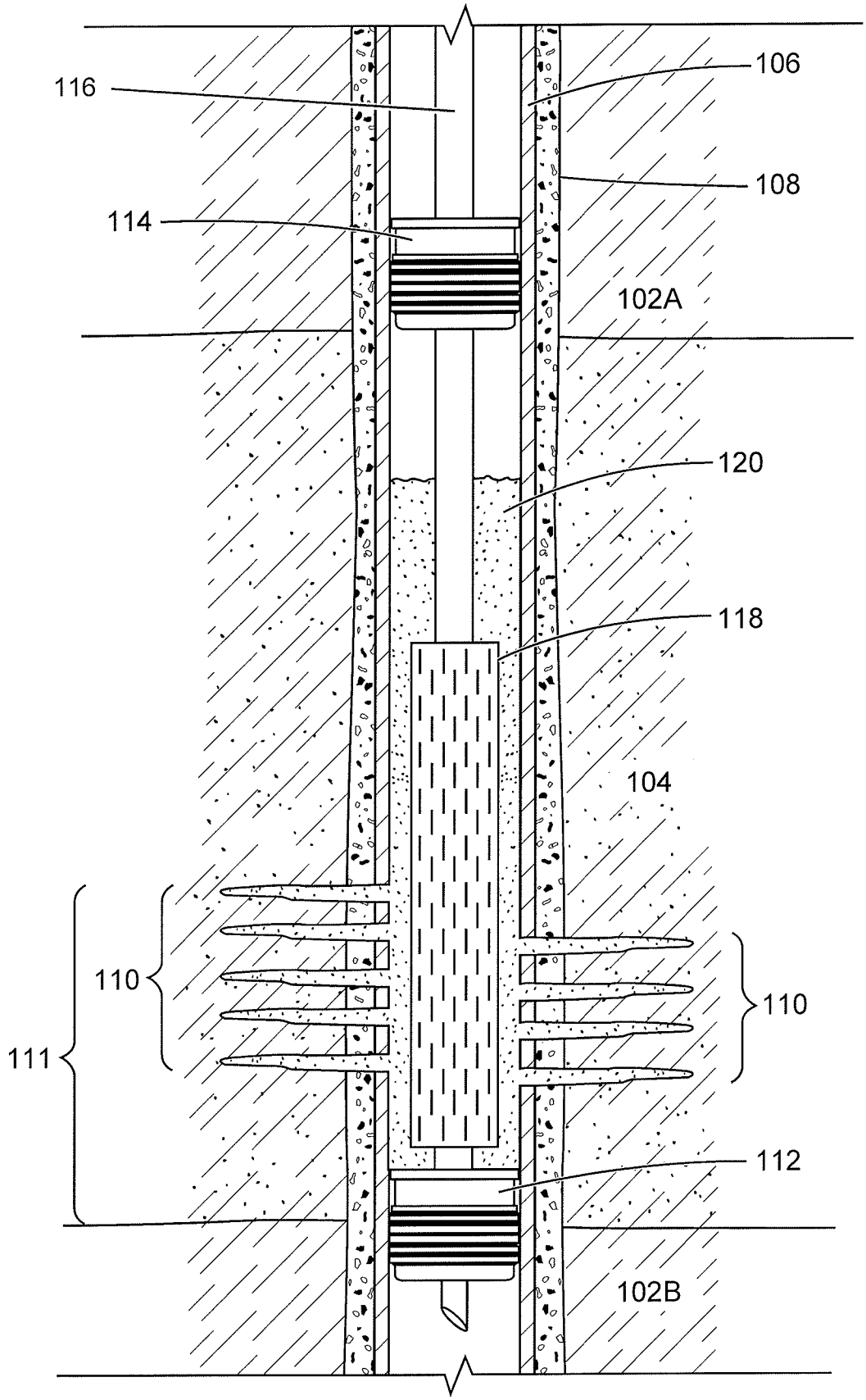


Fig. 1

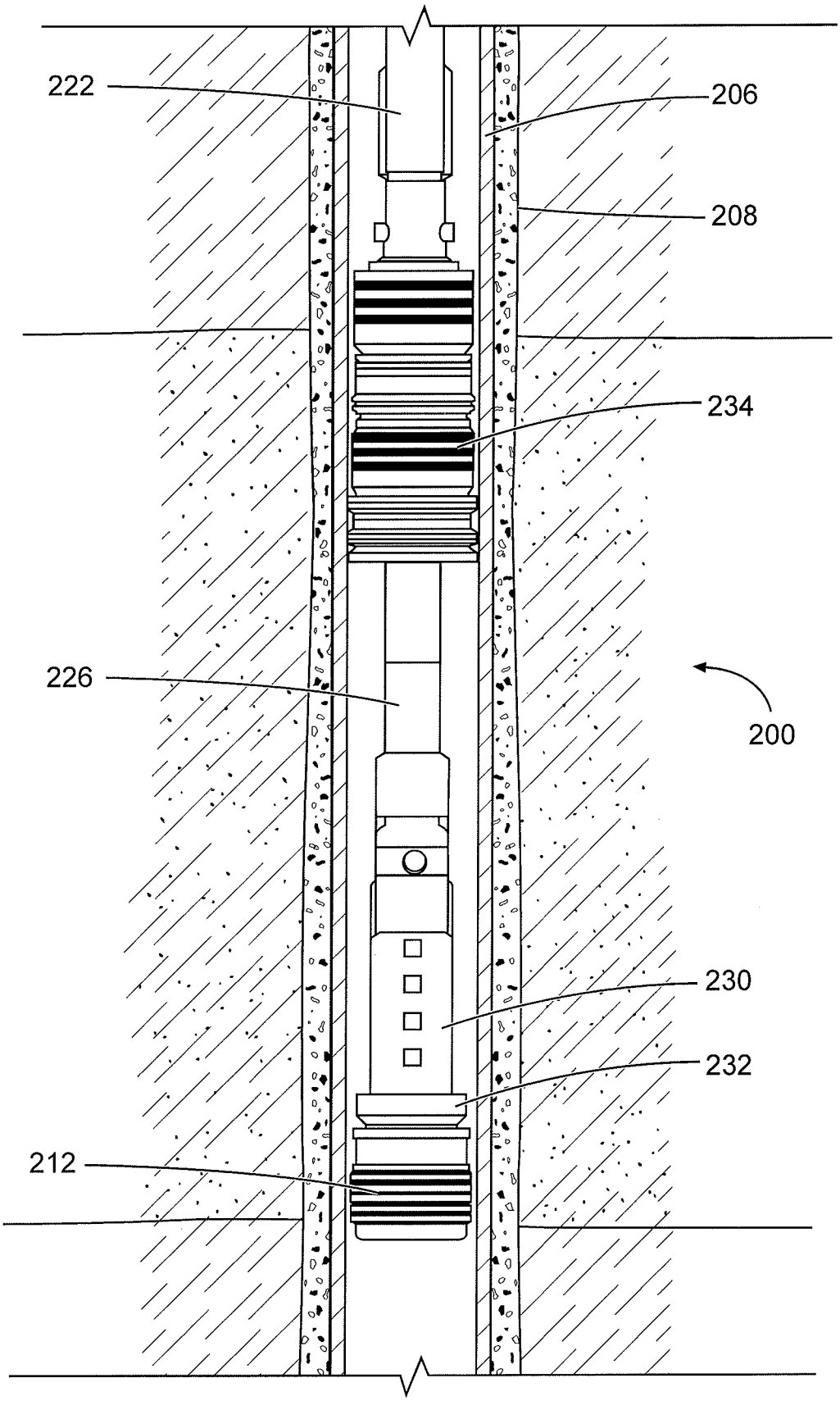


Fig. 2

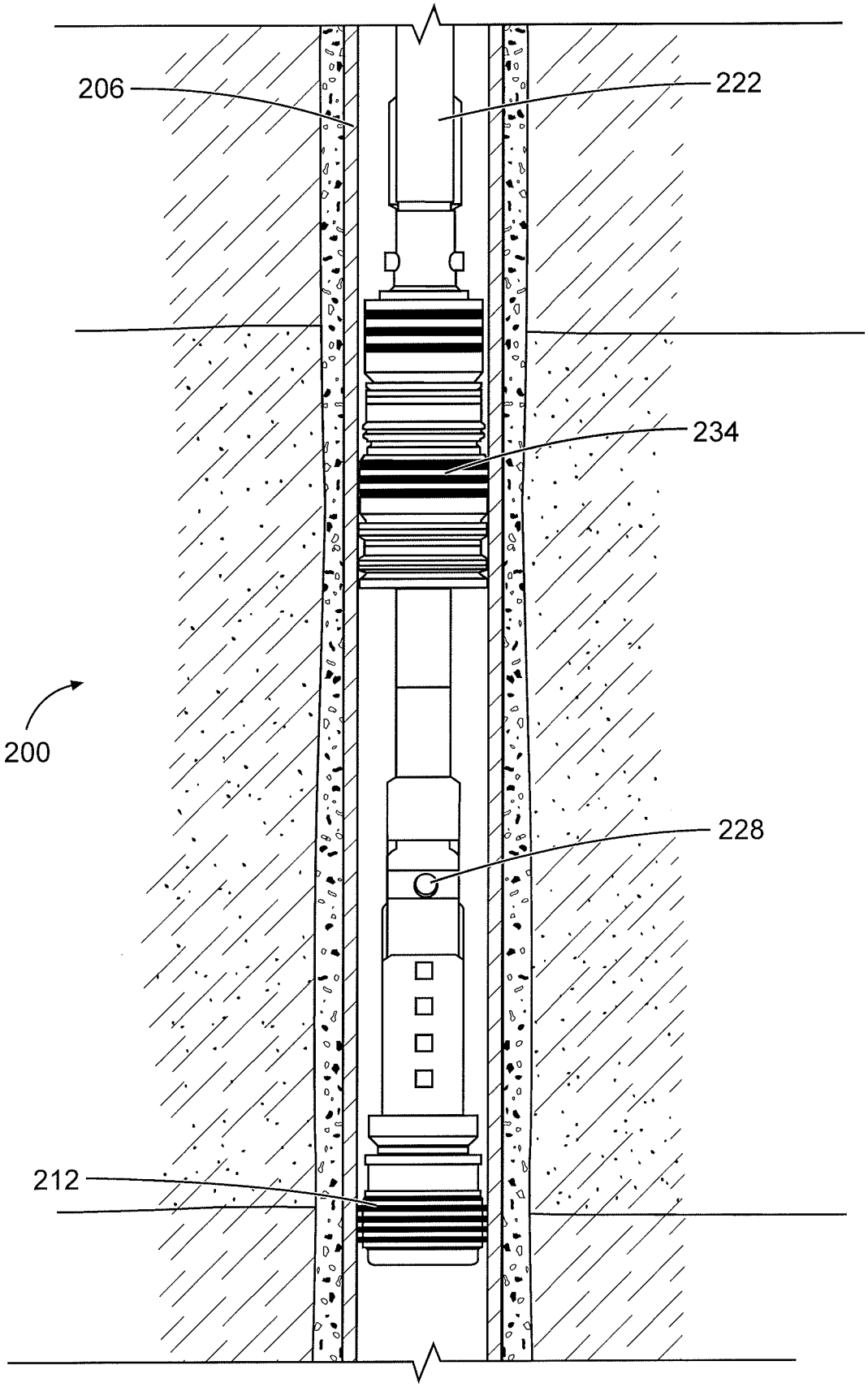


Fig. 3

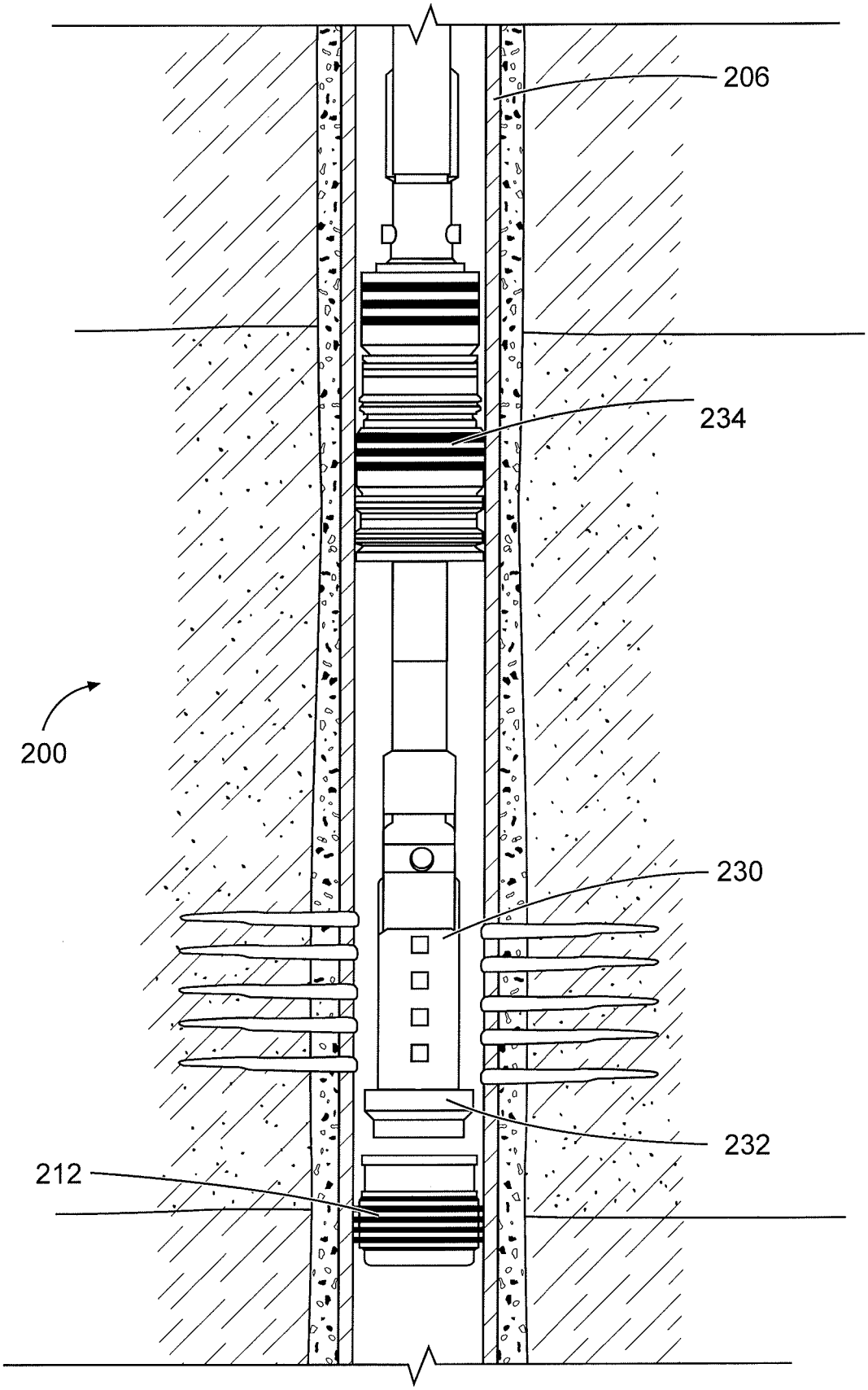


Fig. 4

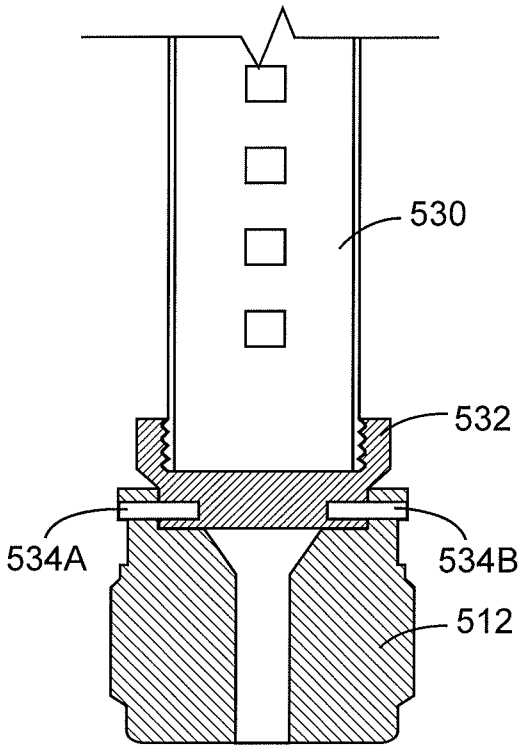


Fig. 5A

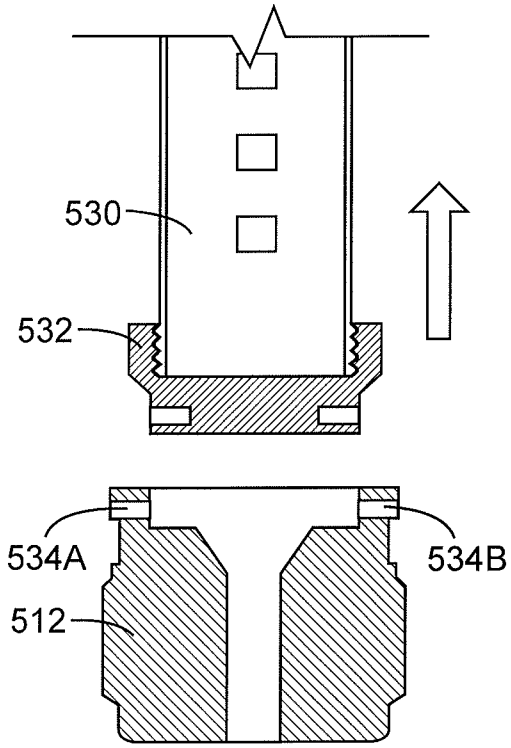


Fig. 5B

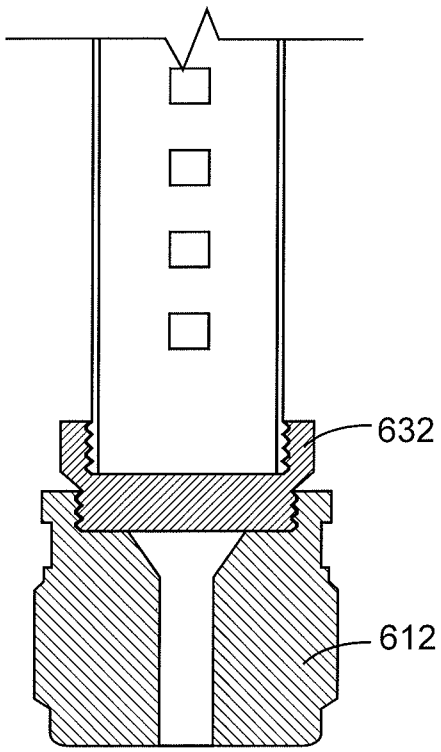


Fig. 6A

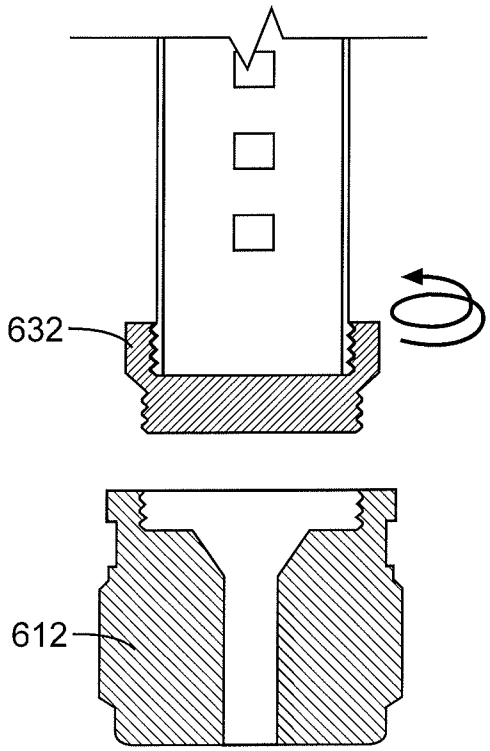


Fig. 6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/045269

A. CLASSIFICATION OF SUBJECT MATTER

E21B 33/12(2006.01)i, E21B 37/08(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B 33/12; E21B 43/112; E21B 33/16; E21B 43/08; E21B 43/11; E21B 37/08

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: completion, work string, perforating gun, packer, detachable, shear, thread, measurement, and coupling

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0314591 A1 (HALES et al.) 25 December 2008 See paragraphs [0019],[0024],[0043]-[0072]; claims 1,7; and figures 1-4.	1-4,6-10,12-18,20
Y		5,11,19
Y	US 6206100 B1 (GEORGE et al.) 27 March 2001 See column 5, lines 26-40 and figures 2-4.	5,11,19
A	EP 0796980 B1 (SCHLUMBERGER LIMITED et al.) 25 February 2004 See paragraphs [0052]-[0059] and figures 13A-14D.	1-20
A	US 2008-0066902 A1 (BULLARD, GERALD) 20 March 2008 See paragraphs [0052]-[0053] and figures 7-9.	1-20
A	US 2009-0194277 A1 (BURNETT et al.) 06 August 2009 See paragraphs [0007]-[0065] and figures 3a-3d.	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
"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)
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"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
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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2015 (18.03.2015)	**19 March 2015 (19.03.2015)**

Name and mailing address of the ISA/KR
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2014/045269

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