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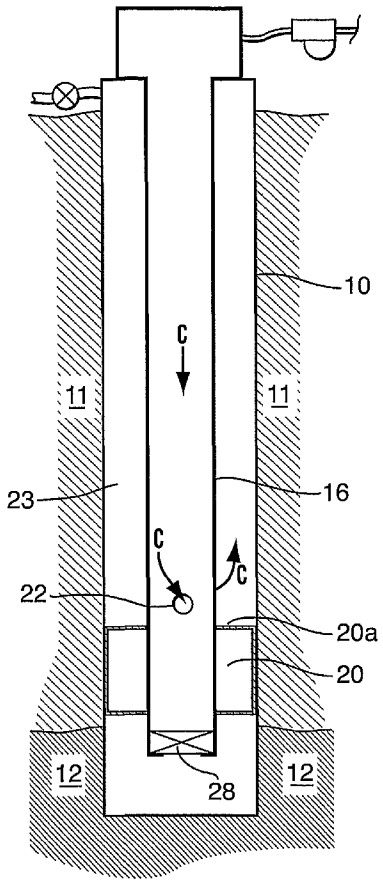
(54) Title: A METHOD FOR DRILLING AND CEMENTING A WELL



(57) Abstract: A method for drilling and cementing a borehole to access at least a portion of a formation of interest, comprising: drilling a borehole using a drill string including an external packer and a drilling assembly to access at least a portion of a formation of interest; using a drilling fluid selected to minimize adverse effects on the at least a portion of the formation of interest when drilling into the at least a portion of the formation of interest; setting the packer to create a seal in the borehole so that (i) an upper drill string/borehole annulus above the packer is isolated from (ii) a lower drill string/borehole annulus below the packer, with the at least a portion of the formation of interest being open to the lower drill string/borehole annulus; and introducing cement above the external packer into the upper drill string/borehole annulus.

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Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A method for drilling and cementing a well

Field

The invention relates to a method for processing a well and, in particular, a method for drilling and cementing a well.

Background

When drilling with casing, a casing string is used as the drill string so that once the well is drilled, the casing string can remain downhole to line the wellbore. This avoids the need for a separate operation to trip in a well bore liner after the well bore is drilled.

In some drilling operations through fragile formations, such as those that have low pressure or that are highly porous, it is desirable to reduce harmful contact with the formation while drilling through it.

Summary

In accordance with one broad aspect, the present invention provides a method for drilling and cementing a borehole to access at least a portion of a formation of interest, comprising: drilling a borehole using a drill string including an external packer and a drilling assembly to access at least a portion of a formation of interest; using a drilling fluid selected to minimize adverse effects on the at least a portion of the formation of interest when drilling into the at least a portion of the formation of interest; setting the packer to create a seal in the borehole so that (i) an upper drill string/borehole annulus above the packer is isolated from (ii) a lower drill string/borehole annulus below the packer, with the at least a portion of the formation

of interest being open to the lower drill string/borehole annulus; and introducing cement above the external packer into the upper drill string/borehole annulus.

In accordance with another broad aspect, the present invention provides a method for drilling and cementing a borehole to access at least a portion of a formation of interest, comprising: drilling a borehole using a drill string including an external packer and a drilling assembly to access at least a portion of a formation of interest, the drilling process including tripping the drilling assembly to surface and reintroducing the drilling assembly during drilling; setting the packer to create a seal in the borehole so that (i) an upper drill string/borehole annulus above the packer is isolated from (ii) a lower drill string/borehole annulus below the packer, with the at least a portion of the formation of interest being open to the lower drill string/borehole annulus; and introducing cement above the external packer into the upper drill string/borehole annulus.

It is to be understood that other aspects of the present invention will become readily apparent to those skilled in the art from the following detailed description, wherein various embodiments of the invention are shown and described by way of illustration. As will be realized, the invention is capable for other and different embodiments and its several details are capable of modification in various other respects, all without departing from the spirit and scope of the present invention. Accordingly the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

Drawings

Referring to the drawings wherein like reference numerals indicate similar parts throughout the several views, several aspects of the present invention are illustrated by way of example, and not by way of limitation, in detail in the figures, wherein:

Figures 1, 2 and 3 show schematically steps in a method according to one aspect of the present invention.

Detailed Description of Various Embodiments of the Invention

The detailed description set forth below in connection with the appended drawings is intended as a description of various embodiments of the present invention and is not intended to represent the only embodiments contemplated by the inventor. The detailed description includes specific details for the purpose of providing a comprehensive understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without these specific details.

In a method according to the invention, a borehole can be drilled to access a formation of interest. A formation of interest herein is that which is desired to be protected from harmful fluid contact therewith. A formation of interest may therefore include a fragile formation, such as one that has a low pressure or one that is highly porous. The formation of interest may be in various states such as a newly accessed formation or a depleted formation.

The borehole may be drilled with a drill string and a drilling assembly including an external packer which, when desired, may be positioned and may be set to seal the borehole relative to the formation of interest so that the drill string/borehole annulus above the packer is isolated from the drill string/borehole annulus below the packer. A drilling fluid may be used that is selected to minimize adverse effects on the formation. Thereafter, cement may be added above the packer.

The invention relates in one embodiment to a method of drilling, casing, and cementing a wellbore where the casing is carried along with or used as at least a portion of the drill string, an external casing packer is carried on the casing and may be set to form a seal in the annulus between the casing and the borehole after drilling of at least a portion of that borehole and before cement is introduced. Cement may be pumped into the annulus between the casing and the borehole above the packer after the packer creates a seal in the casing/borehole annulus, so that a potentially damaging hydrostatic head of liquid (packer setting fluid and/or cement) is substantially prevented from being communicated to a formation of interest positioned relative to, which is generally below, the packer.

The borehole can be drilled into or through a formation of interest, of which at least a portion thereof is desired to be protected. The packer may be positioned and may be set to seal the borehole relative to the formation of interest. For example, the packer may be positioned above any portion of the formation of interest that is sought to be protected to isolate the casing/borehole annulus above the packer from that portion of the formation of interest, which may be open to the casing/borehole annulus below the packer.

A drilling fluid may be used that is selected to minimize adverse effects to the formation such as, for example, by drilling the borehole substantially without putting a damaging hydrostatic pressure head on the formation of interest and/or avoiding the use of fluids that adversely chemically react with the materials of the formation of interest. Such a drilling fluid may be for example, underbalanced relative to the formation of interest to thereby have a lower hydrostatic pressure than the pressure of the formation of interest or of a chemical state or composition selected to substantially avoid an adverse affect on the formation of the interest. In one embodiment, for example, a foam-type drilling fluid may be used. In another embodiment, a gaseous-based drilling fluid may be used, which may be substantially dry. For example, a low density, compressible drilling fluid can be used including, for example, air, nitrogen, natural gas, or a mixture of any of these fluids. In one embodiment, a drilling fluid comprised substantially entirely of air may be useful.

In another embodiment, consideration may also be given to the method by which the packer is set so that the formation is not damaged by this action. The packer may be set by setting the casing down in the borehole, by hydraulic actuation or by inflation. If a compressible fluid is used as the drilling fluid, consideration may be given to methods for setting the packer since compressible fluids may not be capable of use to set a packer. If it is not desirable to set the drill string down on bottom, then care may be necessary to avoid exposing the formation of interest to a damaging packer setting fluid. For example, some packers require the use of non-compressible, higher density, liquid-based fluids to hydraulically set them. In such an embodiment, once the casing point is reached the low density compressible fluid used for drilling may be replaced with the non-compressible, higher density, liquid-based fluid, such as, for example,

water or mud, that may be used to inflate the packer. In such a method, it may be necessary to ensure that the higher density liquid does not damage the formation of interest. Such damage might be caused, for example, by exposing the formation of interest to the hydrostatic head of the higher density, packer-setting fluid.

For drilling, the casing may be used as at least a portion of the drill string or carried along with the drill string. In so doing, a drilling assembly may be used that proceeds ahead of the bottom end of the casing and creates a borehole with an ID greater than the casing so that the casing can be advanced behind the drilling assembly. One such drilling assembly includes, for example, a pilot bit and an underreamer. The drilling assembly and other components may be sized appropriately to be retrieved and reintroduced through the casing periodically during drilling and/or retrieved after drilling is completed. Alternately, the drilling assembly may be intended to be left downhole.

The drilling assembly or casing may include or be capable of accepting seals or valves which are selectively openable/closable to permit closing of the lower end of the casing, when desired, to control the passage of fluids out through the drilling assembly and out of the bottom end of the casing. Such seals or valves may be provided by a launchable plug, selectively closeable seals in the drilling assembly, etc. In addition, the casing may include ports or valves or require the formation of ports for providing an opening through the casing above the packer to permit introduced cement to pass into the annulus above the packer. For example, a selectable port sub, a cementing stage tool, or perforating methods may be employed for selectively opening a port above the packer. In one embodiment, a port may be provided that is opened by rotating an upper portion of the casing relative to a lower end of the casing that is held stationary by engagement of the borehole wall through the inflated packer.

In the method, it may be desirable to hold the introduced cement in the casing/borehole annulus and possibly also in the lower casing ID until the cement sets. In one method, for example, it may be desirable to create a seal adjacent the casing bottom end to prevent cement from U-tubing from the annulus back into the casing ID. In one embodiment, a seal is created adjacent the bottom of the casing to

contain cement in the lower region of the casing and/or in the annulus. In one embodiment, a check valve may be provided in the casing wall up hole of the external casing packer, which permits flow from the casing ID to the casing/borehole annulus, but acts against reverse flow. In another embodiment, a cement introduction tool including a seal formable between the tool and the casing ID to prevent flow of the introduced cement upwardly past the cement introduction tool may be employed in the casing. Cement may be introduced through the tool below the seal into the casing ID and into the casing/borehole annulus. In yet another embodiment, a wiper plug may be held in place above the cement to prevent U-tubing.

Thereafter, the casing may be cleaned out and the borehole below the packer may be treated, further drilled, produced in any of various ways.

Figure 1 illustrates generally a first step in one possible method according to the invention wherein a borehole 10 may be drilled, cased and cemented after drilling while protecting at least a portion of a formation of interest 12 against damage by contact with a hydrostatic head of fluid, such as may be generated by some drilling fluids, packer setting fluids and/or cement.

In the illustrated embodiment, a casing string 16 is used as the drill string and a drilling assembly 18 is mounted at the distal end of the casing string to form the borehole ahead of the casing string. Periodically during drilling, the drilling assembly may be tripped to surface for inspection, repair or replacement and may be returned downhole to continue drilling. Such a process is facilitated by use of casing as the drill string to surface. By use of casing as a drill string, the drilling, casing and cementing of the borehole may be completed without a requirement to ever trip the casing out of the well. In particular, the casing may be used as the drill string and then left down hole to case the borehole.

The lower end of the casing may include an external casing packer 20 that may be energized by any of various means including for example by inflation with water, mud or cement (as shown in the Figures), by direct compression of the drill string, or by indirect compression as by use of a hydraulically powered piston, to create a seal about the casing at the position of the packer, which in this embodiment is adjacent

the casing's lower end. The casing may also include at least one port 22 (shown closed in Figure 1) that can be opened, when desired, to allow fluid such as, for example, cement to be pumped from the interior of the casing to the exterior annulus 23, which is that open area between the casing and borehole 10. Port 22 may be positioned in the casing uphole of the external casing packer.

In the present method, a borehole is drilled through a formation 11 including formation of interest 12 using casing as the drill string and including external packer 20. Drilling into at least a portion of the formation of interest is accomplished using a drilling fluid (arrows A) that is substantially inert to the formation of interest, with consideration as to the properties of the formation of interest. For example, in one embodiment, drilling proceeds using a fluid, such as air or foam, that has a lower hydrostatic pressure than the pressure of the formation of interest. Of course, other drilling fluids can be used until it is desired to protect the formation of interest or a portion thereof against damage or further damage by that drilling fluid. For example, if desired the operator may wish to drill without consideration as to the effects of the drilling fluid on the formation until it is determined that the formation of interest or a depth of interest has been reached. Thereafter, the operator may wish to cement the well or otherwise displace the previous drilling fluid to permit initiation of a method according to the present invention using a drilling fluid selected to minimize adverse effects on the formation of interest for a period of time during drilling.

Once drilling has been achieved to a desired depth, in the illustrated embodiment, drilling assembly 18 may tripped out of the casing and external casing packer 20 may be set to isolate an upper portion of the casing/borehole annulus from a lower portion of the casing/borehole annulus, the lower portion of the casing/borehole annulus being that portion open to the portion of the formation to be protected. If it is desired to hydraulically set packer 20, care may be taken to avoid exposing the selected portion of the formation of interest to the hydrostatic head of the hydraulic setting fluid. For example, Figure 2 shows one such method wherein packer 20 is hydraulically settable. To set the packer, the drilling fluid is displaced with a hydraulic setting fluid without exposing the formation of interest to the hydrostatic pressure of the hydraulic setting fluid. In this method, a plug 28 is installed to seal the lower end of the casing

string before the hydraulic setting fluid is introduced. For example, in one method, drilling fluid may be bled off, a plug 28 may be introduced to the casing string and a circulating head 30 may be installed at surface. Hydraulic packer setting fluid 32, such as water may be introduced above the plug to displace the plug downwardly (arrow B). Care may be taken to avoid causing the plug to land in an uncontrolled or damaging fashion at the bottom of the casing string and/or care may be taken to avoid creation of problematic trapped pockets of drilling fluid. For example, drilling fluid backpressure may be controlled to control the displacement of the plug and/or the state of the hydraulic packer setting fluid may be controlled to control the pressure and/or density of the fluid 32 above the plug. This, for example, may involve pumping the plug to separate the hydraulic packer setting fluid from the drilling fluid and to prevent the higher density hydraulic packer setting fluid from passing through the bit. While pumping the higher density fluid, some procedure may be useful to control the rate at which the heavier density fluid falls in the casing. The controlling step may include, for example, any of holding backpressure on the annulus, using a flow-restricting nozzle at the bit, and/or pumping water above a plug with a positive displacement pump that is rigged up so that no air can be sucked into the casing. As the hydrostatic pressure of the fluid in the casing exceeds the hydrostatic pressure in the annulus with consideration to back pressure and annular friction, the more dense fluid may tend to fall faster. By controlling the rate that water is pumped into the casing and preventing air from being sucked in, the hydrostatic head can be controlled by letting the water flash to low temperature steam. Of course, if such a method is used for introducing hydraulic packer setting fluid 32, the casing may need to be designed with sufficient collapse pressure to withstand this process.

Once the plug lands, introduction of hydraulic packer setting fluid 32 may be continued to gradually bring the hydrostatic pressure up to the full hydrostatic head of the liquid setting fluid. The setting fluid then may be manipulated, as by pressuring up, to set the packer. Packer 20 in the illustrated embodiment is hydraulically settable and may include a check valve for permitting hydraulic inflation thereof. As such, once the packer is set, the check valve may maintain the packer in the inflated state.

Once packer 20 is set, as shown in Figure 3, port 22 may be opened so that cement can then be introduced to the annulus between the casing and the borehole above the casing packer. Port 22 may be opened by various means, as noted previously. In one embodiment, port 22 may be part of a mechanism providing opening of the port by rotation of an upper casing portion relative to a lower casing portion. Since in this embodiment the bottom casing portion is anchored by the packer, the port may be opened by rotating the upper casing portion while the lower portion of the casing remains stationary. Thereafter, hydraulic packer-setting fluid 32 and cement may be displaced through the casing string and annulus (arrows C). The cement may be introduced to cement the casing in the well bore.

Thereafter, the formation of interest below the packer may be accessed in any of various ways and for various purposes. If it is desired to further drill into the formation of interest, it may be of interest to undertake such further drilling using a drilling fluid selected to minimize adverse effects on the formation of interest.

Thus, as shown, by use of the present invention at least a selected portion of a formation of interest 12 may be protected against damage by contact with a hydrostatic head of drilling fluid and by contact with cement by using a drilling fluid selected to minimize adverse effects on the formation of interest, when drilling into it, and by selecting the external casing packer to be set above the formation of interest. If the packer is settable by use of hydraulic fluid, in one aspect of the present invention, the selected portion of the formation of interest 12 may also be protected against damage by contact with that packer setting fluid.

Obviously, any portion of the formation of interest that is above the upper end 20a of the packer once it is set will be exposed to the effects of the packer setting fluid and cement after it moves through port 22 into the annulus above the packer. If it is desired to completely avoid damage to the formation of interest by contact with a hydrostatic head of drilling fluid or cement, it may be useful set the packer so that its upper end (as shown) is completely above the formation of interest.

The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications

to those embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein, but is to be accorded the full scope consistent with the claims, wherein reference to an element in the singular, such as by use of the article "a" or "an" is not intended to mean "one and only one" unless specifically so stated, but rather "one or more". All structural and functional equivalents to the elements of the various embodiments described throughout the disclosure that are know or later come to be known to those of ordinary skill in the art are intended to be encompassed by the elements of the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 USC 112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or "step for".

We claim:

1. A method for drilling and cementing a borehole to access at least a portion of a formation of interest, comprising: drilling a borehole using a drill string including an external packer and a drilling assembly to access at least a portion of a formation of interest; using a drilling fluid selected to minimize adverse effects on the at least a portion of the formation of interest when drilling into the at least a portion of the formation of interest; setting the packer to create a seal in the borehole so that (i) an upper drill string/borehole annulus above the packer is isolated from (ii) a lower drill string/borehole annulus below the packer, with the at least a portion of the formation of interest being open to the lower drill string/borehole annulus; and introducing cement above the external packer into the upper drill string/borehole annulus.

2. The method for drilling and cementing a borehole of claim 1 wherein the drilling fluid generates a hydrostatic pressure lower than the pressure in the formation of interest.

3. The method for drilling and cementing a borehole of claim 1 wherein the drilling fluid is substantially gaseous.

4. The method for drilling and cementing a borehole of claim 1 wherein the drilling fluid includes air.

5. The method for drilling and cementing a borehole of claim 1 wherein the drilling fluid includes foam.

6. The method for drilling and cementing a borehole of claim 1 wherein the external packer is set substantially without exposing the at least a portion of the formation of interest to a damaging hydrostatic head of fluid.

7. The method for drilling and cementing a borehole of claim 1 wherein the external packer is set by compression of the drill string.

8. The method for drilling and cementing a borehole of claim 1 wherein the external packer is set by use of a liquid-based fluid and the step of setting the

external packer includes: sealing a lower end of the drill string and introducing a liquid-based fluid to hydraulically set the external packer.

9. The method for drilling and cementing a borehole of claim 8 wherein the step of sealing the lower end of the drill string includes displacing a plug through the drill string to a position at a lower end of the drill string.

10. The method for drilling and cementing a borehole of claim 1 wherein the step of introducing cement above the external packer includes opening a port through the drill string to access the upper drill string/borehole annulus.

11. The method for drilling and cementing a borehole of claim 1 wherein the drill string is at least in part formed of wellbore casing and wherein the method further comprises leaving the drill string downhole to case the wellbore.

12. The method for drilling and cementing a borehole of claim 11 wherein the drilling assembly is periodically retrieved and reintroduced through the wellbore casing during drilling.

13. The method for drilling and cementing a borehole of claim 1 wherein the external packer is set with its upper end above the formation of interest.

14. A method for drilling and cementing a borehole to access at least a portion of a formation of interest, comprising: drilling a borehole using a drill string including an external packer and a drilling assembly to access at least a portion of a formation of interest, the drilling process including tripping the drilling assembly to surface and reintroducing the drilling assembly during drilling; setting the packer to create a seal in the borehole so that (i) an upper drill string/borehole annulus above the packer is isolated from (ii) a lower drill string/borehole annulus below the packer, with the at least a portion of the formation of interest being open to the lower drill string/borehole annulus; and introducing cement above the external packer into the upper drill string/borehole annulus.

15. The method for drilling and cementing a borehole of claim 14 wherein the drill string is at least in part formed of wellbore casing and wherein the

method further comprises leaving the drill string downhole to case the wellbore.

16. The method for drilling and cementing a borehole of claim 14 wherein the drilling proceeds during at least a period of time prior to setting the packer using a drilling fluid hydrostatic pressure lower than the pressure in the formation of interest.

17. The method for drilling and cementing a borehole of claim 14 wherein prior to setting the packer, the method further comprises: retrieving the drilling assembly to surface; and sealing the bottom of the drill string.

18. The method for drilling and cementing a borehole of claim 14 wherein after cementing, the method further comprises: drilling using a drilling fluid hydrostatic pressure lower than the pressure in the formation of interest.

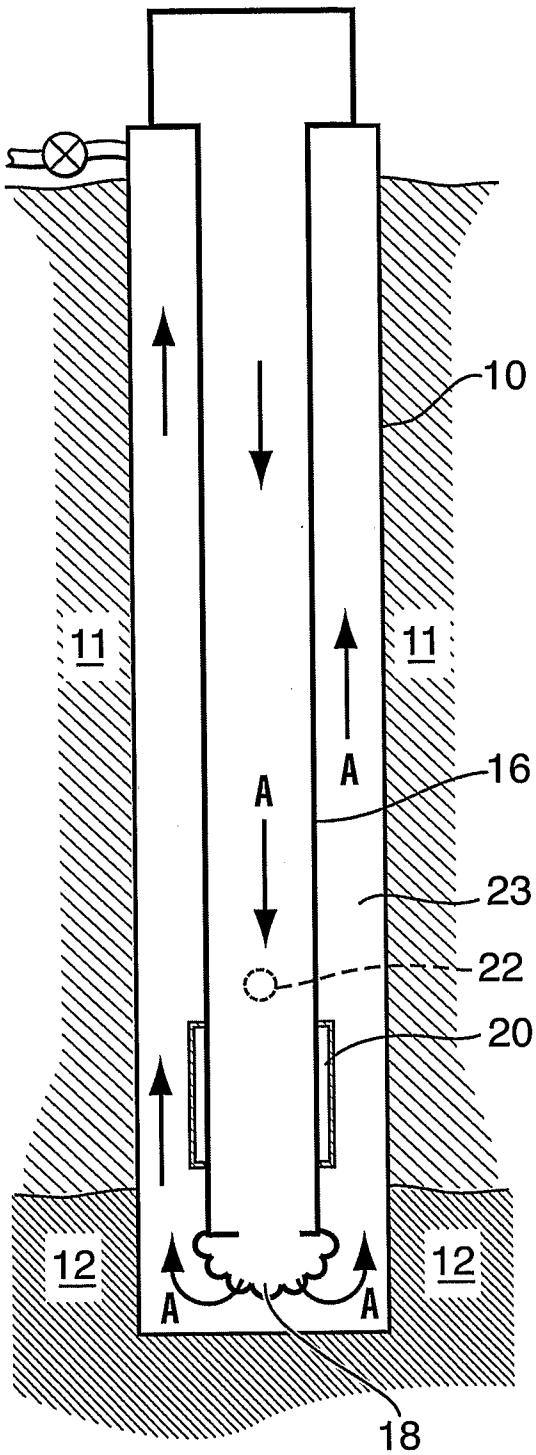
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FIG. 1

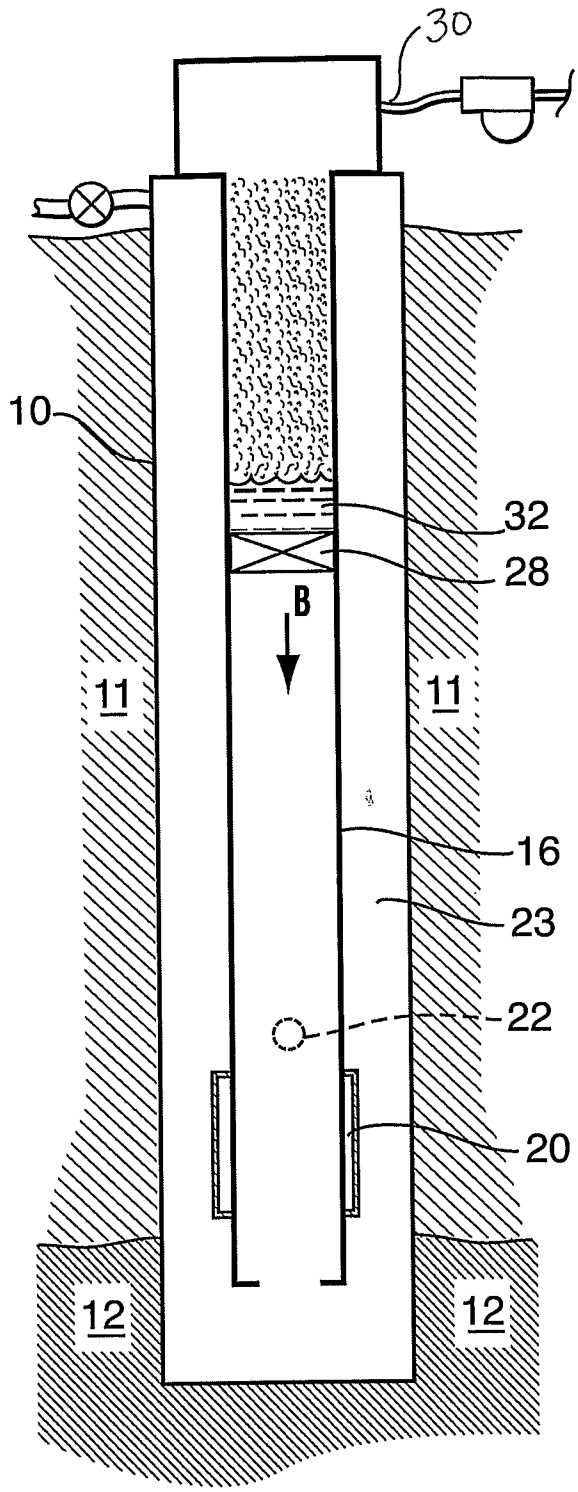
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FIG. 2

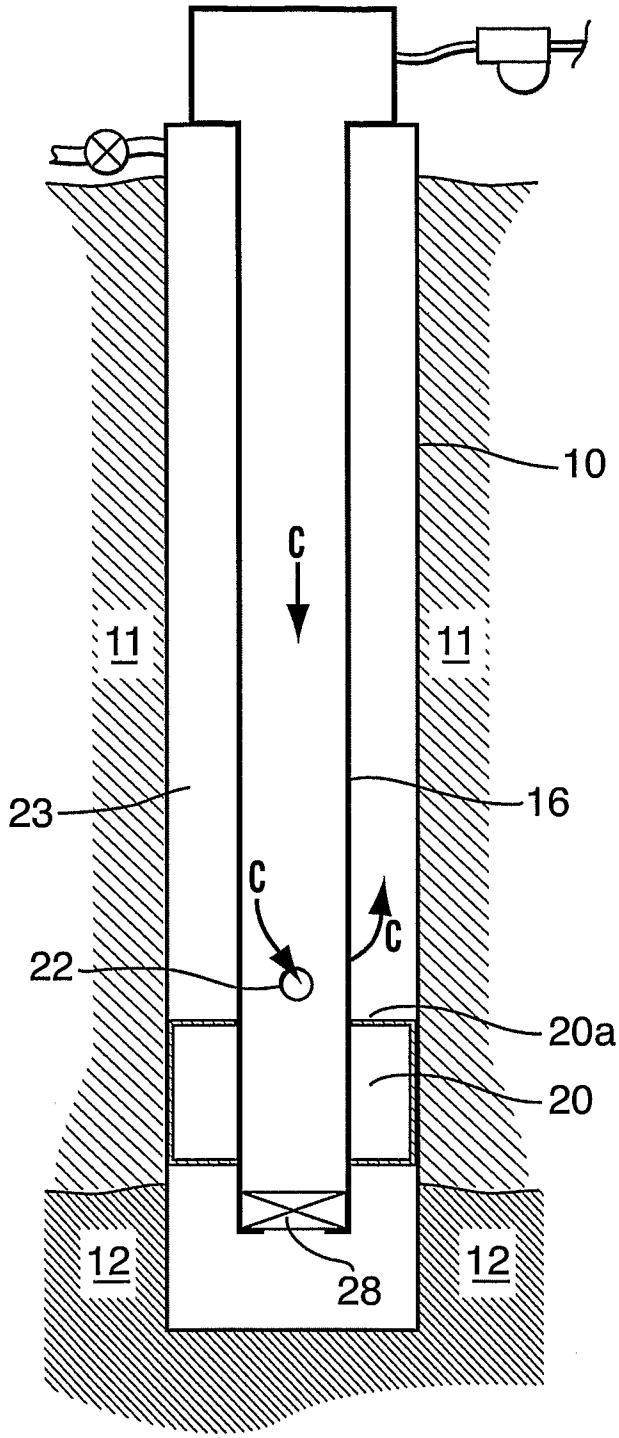

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2006/001189

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***E21B 23/06*** (2006.01) , ***E21B 33/14*** (2006.01)
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)
IPC: ***E21B 23/ALL*** (2006.01) , ***E21B 33/ALL*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None.

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Delphion, Esp@cenet, Canadian Patent Database - keywords: Drill*, cement*, borehole, formation, drill string, packer, drilling fluid/liquid, setting near packer, seal, annulus, tripping

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6799635 B2 (HALLIBURTON ENERGY SERVICES, INC.) 5 October 2004 (05-10-2004), see entire document;	14, 15, and 17
Y		1-13, 16, and 18
X	US 5595246 A (BAKER HUGHES INC.) 21 January 1997 (21-01-1997), see entire document;	14, 15, and 17
Y		1-13, 16, and 18
Y	US 5010966 A (CHALKBUS, INC.) 30 April 1991 (30-04-1991), see column 1, lines 4-7 and 26-30;	1, 2, 6-13, 16, and 18
Y	US 5249635 A (MARATHON OIL COMPANY) 5 October 1993 (05-10-1993), see abstract;	1 and 3-13
A	US 5024273 A (DAVIS-LYNCH, INC.) 18 June 1991 (18-06-1991), see entire document.	1-18

[ ] Further documents are listed in the continuation of Box C.

[X] 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

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Date of the actual completion of the international search	Date of mailing of the international search report
6 November 2006 (06-11-2006)	10 November 2006 (10-11-2006)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001(819)953-2476	Derek Jackson 819- 934-4259

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US6799635 B2	05-10-2004	US7086479 B2	08-08-2006
US5595246 A	21-01-1997	AU4924396 A US5746274 A WO9625582 A2	04-09-1996 05-05-1998 22-08-1996
US5010966 A	30-04-1991	NONE	
US5249635 A	05-10-1993	NONE	
US5024273 A	18-06-1991	NONE	