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— *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))*

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

(54) **Title**: FRACTURING SEQUENTIAL OPERATION METHOD USING SIGNAL RESPONSIVE PORTED SUBS AND PACKERS

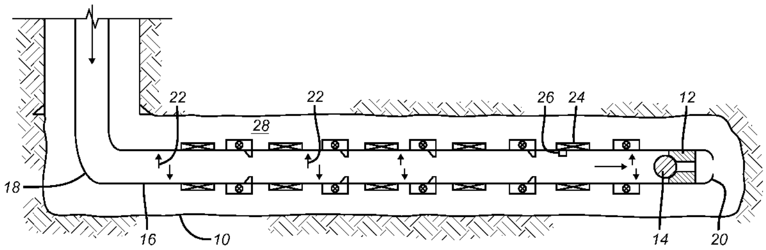

FIG. 1

(57) **Abstract**: The method allows a pressure test of a string with external packers without having the packer setting apparatus exposed to tubing pressure so that at a later time and at a lower pressure than the pressure test pressure, the external packers can be set with annulus pressure opened to a piston that references a low pressure chamber. The packers can be set in any desired order. Thereafter, a circulation sub can be triggered to open to allow the tracking to start. Fracking each interval beyond the first in an uphole direction can be accomplished with pumping ever increasing balls to seats associated with sliding sleeves to open the sleeves in order. In cemented completions, after a pressure test, a ported sub can open on a timer or other signal to allow pumping a combination of a bridge plug and a perforating gun to the desired location.

WO 2015/073701 A1

FRACTURING SEQUENTIAL OPERATION METHOD USING SIGNAL RESPONSIVE PORTED SUBS AND PACKERS

Inventors: Beau R. Wright and Edward T. Wood

FIELD OF THE INVENTION

[0001] The field of this invention is fracking in completions where the liner needs to have a pressure integrity test or internal pressure applied and objects need to be pumped to a desired location through a flow path established after the pressure application.

BACKGROUND OF THE INVENTION

[0002] As regulations regarding completions become more restrictive due to safety and other reasons a need has arisen to perform a pressure integrity test on a string in a variety of circumstances. The string could be cemented and need to have a series of bridge plugs and perforating guns delivered at different depths so that portions can be sequentially perforated and fracked. However, with a need for a pressure test on the tubular there needs to be no openings in the wall open. In order to then be able to pump bridge plugs attached to perforating guns after a pressure test particularly in a horizontal well defined as having an incline of more than 62 degrees from vertical there has to be a wall opening through which circulation or injection can be established where the ported sub that can provide such an opening is configured to stay closed during the pressure test of the string. The problem is that if the ported sub opens in response to applied internal pressure, the needed pressure to get the ported sub to open after the pressure test of the tubular will require subjecting the string to even higher pressures to open. In other fracking systems a series of packers that are spaced apart are set at the same time before any fracking sleeves are opened up. The problem here is that if a pressure test is required on the string and the packer setting ports are still open then the packers will be subjected to higher pressures than the intended setting pressure. This additional setting force on the packers can adversely affect the formation by fracturing at the packers rather than as intended between them. Accordingly it would be advantageous to be able to pressure test the string without the packers set and then set the packers without having to further resort to even higher pressures than the pressure integrity test on the tubular string.

[0003] The method of the present invention relies on ported subs that can be selectively opened with a timer or a signal. In the case of multiple spaced packers, the string can be pressure tested without the packers being set. The setting force for setting the packers can be annulus pressure so that valves can communicate annulus pressure to an actuation piston for the packers to set them with a reference pressure on the opposite side of the piston as being low or atmospheric. The order of setting can be as desired and the valves can respond to a timer or another signal for operation to set the packers in the desired order. Then in order to be able to deliver a succession of balls to different frack sleeves between pairs of packers a ported sleeve valve can be triggered by timers or other signal to open a first access to the formation so that all balls that then need to land on seats and shift sleeves for formation access can be pumped because there will always be a flow path for fluid to carry each ball to its destination.

[0004] Relevant to the art of using timers to shift sleeves or operate other downhole equipment are: WO2009/105128A1;US4709708; 6035880; 3896667; 3570594; US20130062124; 20120138311; 20100200243;20090071642; 20040045724. Also of interest is J.N. McCoy Timer Control of Beam Pump Run Time Reduces Operating Expense presented at the 46th Annual Southwestern Petroleum Short Course, Lubbock, TX April 21-22, 1999.

[0005] Those skilled in the art will better understand the methods of the present invention from a review of the description of the preferred embodiment and the associated drawings while recognizing that the full scope of the invention is to be determined from the appended claims.

SUMMARY OF THE INVENTION

[0006] The method allows a pressure application in a string with external packers without having the packer setting apparatus exposed to tubing pressure so that at a later time and at a lower pressure than the pressure test pressure, the external packers can be set with annulus pressure opened to a piston that references a low pressure chamber. The packers can be set in any desired order. Thereafter, a port sub can be triggered to open to allow the fracking to start. Fracking each interval beyond the first in an uphole direction can be accomplished with pumping ever increasing balls to seats associated with sliding sleeves to open the sleeves in order. In cemented completions, after a pressure test, a ported sub can open on a timer or other signal to allow pumping a combination of a bridge plug and a perforating gun to the desired location.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 shows a pressure application or test in the string with multiple external packers being unset;

[0008] FIG. 2 is the view of FIG. 1 of the first packer in FIG. 1 being set with a lower pressure than the pressure test pressure of FIG. 1;

[0009] FIG. 3 shows a port being opened with a timer or other signal so that the fracking can start;

[0010] FIG. 4 is the view of FIG. 3 showing how the various landing seats can have a ball pumped to them because of the initially opened port;

[0011] FIG. 5 is the view of FIG. 4 with a first ball pumped to a landing location to initiate fracking in the next zone;

[0012] FIG. 6 is the view of FIG. 5 showing the remaining balls landed so that the fracking in the other intervals can be completed;

[0013] FIG. 7 shows one design of a ported sleeve sub that can be triggered with a timer or a signal in the run in position where the ports are closed;

[0014] FIG. 8 is the view of FIG. 7 in the open position; and

[0015] FIG. 9 is the view of FIGS. 7 and 8 showing an application of such a valve to open a wall port to allow pumping a bridge plug and perforating gun combination with circulation.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] FIG. 1 shows a horizontal borehole **10** having a ball seat **12** on which has landed a ball **14** to allow pressuring up the string **16** that extends from a surface location and past a heel **18** to a toe **20**. Arrows **22** represent internal pressure being applied to pressure test the string **16** usually to a pressure level of about 80% of its working pressure. External packers **24** can be configured to set with tubing pressure or annulus pressure. The access to the setting piston for each packer is sealed off with valves such as schematically illustrated valves **26** that are in the string **16** but can also be on the side of the annulus **28**. These valves are each closed during the pressure test of the string **16**. Thus the pressure test is completed without the packers **24** set and with the setting mechanisms for packer setting isolated from tubing or annulus pressure. After the pressure test is successfully completed the valves **26** associated with each packer **24** can be actuated with a time or with a delivered signal that can arrive with a pumped ball or acoustically or electrically or with pressure pulse patterns or a pressure cycling pattern, an acoustic signal, an electric or magnetic field among other alternatives. With the signals received access to the setting piston or other actuator for each of the packers **24** can be set in the desired sequence. The packers **24** can be hydrostatically set in a known manner by opening a port to hydrostatic pressure on one side of a piston with the opposite side of the piston referencing a variable volume low pressure chamber. In this manner the packers **24** can be set in any desired order depending on timer settings or sequencing of signals. If the valves **26** are in the string **16** then the packer setting mechanism is isolated from tubing pressure during the pressure test so that at a later time when the test pressure is released, the valves **26** can be opened in the desired order and far lower pressures can be used to set the packers than the applied test pressure to test the string. If the valves are in the annulus then they are unaffected by the test pressure on the tubular and again the packers **24** can be opened in any desired order by signaling the valves **26** with timers or through transmitted signals.

[0017] In FIG. 3 the packers **24** are all set and another ported sub **30** is schematically illustrated as opening to provide access to a first interval for fracking to produce fractures **32** in an interval above ball **14**. Once the fractures **32** are made it opens a way to pump down subsequent balls due to the fact that there is always a way to pump fluid to deliver a ball such as **34** to the next seat **36** on which ball **34** is needed to land. Once that happens fractures **38** can be initiated in the next interval by pressure delivered on seated ball **34**. FIGS. 5 and 6 show the process being repeated with progressively larger balls with there always being a way to pump them into position in a horizontal well where the deviation from vertical is defined as at least 62 degrees.

[0018] The method described above addresses two potential problems when the string requires a pressure test. First, the packers are not set first before the pressure test on the string. Instead, the pressure test is run with the packers unset and their setting mechanism shielded from string test pressures or annulus pressure. Furthermore, with the packers unset the risk of creating fractures at set packer locations is removed as can happen when the higher test pressure for the string is allowed to act on the setting pistons of the already set packers to further set them to enough of a degree where they can actually initiate or greatly extend fractures in undesirable locations. The ideal situation is that the fractures initiate between the barriers rather than at the barriers. With the packers unset during the pressure test there is no risk of initial or additional fractures forming at the packer locations. When the packers are then ready to set after the pressure test, they can be set with tubing pressure that is at far lower pressures than the tubing test pressures previously used during the pressure test. If annulus pressure is to be used to set the packers then the same result obtains as the setting pressure in the annulus when the setting mechanism of the packers is exposed to such pressures is far lower than the tubing pressure during the pressure test. The setting ports are selectively made accessible to tubing or annulus pressure with timer or signal triggered valves as described above so that the packers can be set in any desired order. With the packers set another port is opened either by timer or signal to expose the lowest interval for fracking. This initial fracking of the lowermost zone allows there to be created a flow path that allows pumping of each of the progressively increasing in diameter subsequent balls to be pumped into a horizontal borehole to be quickly landed on a respective ball seat so that the intervals can be sequentially fractured in a bottom up order. This valve that operates on a timer or through a transmitted signal solves the problem of having ports closed during the pressure test and avoiding to run the pressure even higher than the pressure test pressure to get the ports to open after the pressure test ends. Instead, the circulation sub is triggered to open with time or with a transmitted or other signal so that the initial opening solves the problem of how to pump the sequential array of balls to a horizontal formation for the fracking of the zone from bottom up where there is also a need for a pressure integrity test before the fracking starts. Overpressures of the string as would occur with a pressure actuated circulation sub that had to open only after a pressure test of the string are avoided.

[0019] FIGS. 7 and 8 illustrate a known design for a ported sub that acts with pressure at an inlet **40** that can be opened with pressure acting on a rupture disc blocking the opening so that the piston **42** is stroked against a low pressure or atmospheric chamber **44**. Even if there is cement in the annulus, the opening of ports **46** allows access to the formation for pumping down into a horizontal bore equipment such as a bridge plug with an attached perforating gun **53**. This is illustrated in FIG. 9 where a circulation valve or port **50** is blocked with an assembly that responds to a timer or another signal to open at a time after a string pressure test so that stages of bridge plugs **52** and perforating guns **53** can be pumped into the wellbore with displaced fluid having a path into the formation after penetrating the cement in the surrounding annulus that may or may not have set up by that time. As each gun is fired in its interval the access that was cut off to the formation fracked below the just set bridge plug is opened again with the firing of the gun above the just set bridge plug. In this sense the pressure test can take place first followed by opening a port with a timer or other signal that allows the first assembly of bridge plug and perforating gun to be pumped into position. Thereafter it is just each newly made perforation 7 that enables pumping down the next assembly into a horizontal run in a borehole.

[0020] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below:

We claim:

1. A completion method, comprising:

running in a string into a deviated borehole;

closing off a lower end of a passage through said string when said string is properly positioned;

blocking off at least one wall access port with a first signal responsive device;

applying pressure to said string with said wall access port isolated from pressure applied during said pressure application;

opening said wall access port after said pressure application with a signal other than sustained pressure in said string.

2. The method of claim **1**, comprising:

providing at least one external packer on said string.

3. The method of claim **2**, comprising:

conducting said pressure application with said packer unset.

4. The method of claim **3**, comprising:

setting said packer with a second signal responsive device that selectively provides access to a setting mechanism associated with said at least one external packer.

5. The method of claim **4**, comprising:

setting said packer with pressure in said string after providing a signal to said second signal responsive device.

6. The method of claim **4**, comprising:

setting said packer with pressure in a surrounding annulus about said string after providing a signal to said second signal responsive device.

7. The method of claim **4**, comprising:

using said open wall access port for initial fracturing below said packer after said packer is set.

8. The method of claim **7**, comprising:

providing a plurality of said at least one packer in a spaced relation to each other with each packer having an associated ball seat attached to a sliding sleeve;

using said open wall access to allow pumping of a ball to said associated ball seat closest to said open wall access port with fluid going through said wall access port as said ball lands on said closest seat and opens another wall access port uphole while isolating said wall access port that was initially opened.

9. The method of claim **1**, comprising:

using a timer for said signal.

10. The method of claim **1**, comprising:

delivering an object near said signal responsive device to deliver said signal.

11. The method of claim **1**, comprising:

using at least one of a pressure cycling pattern, an acoustic signal, an electric or magnetic field as said signal.

12. The method of claim **1**, comprising:

delivering a bridge plug and a perforating gun by pumping with flow going into said opened wall access port.

13. The method of claim **12**, comprising:

setting said bridge plug to close off said wall access port;

releasing said gun from said plug and repositioning said gun uphole;

firing said gun to provide a new access location through the wall of said string;

delivering another bridge plug and perforating gun by pumping to said new access location.

14. The method of claim **12**, comprising:

fracking through said wall access port before said delivering.

15. The method of claim **12**, comprising:

using a timer for said signal.

16. The method of claim **12**, comprising:

delivering an object near said signal responsive device to deliver said signal.

17. The method of claim **12**, comprising:

using at least one of a pressure cycling pattern, an acoustic signal, an electric or magnetic field as said signal.

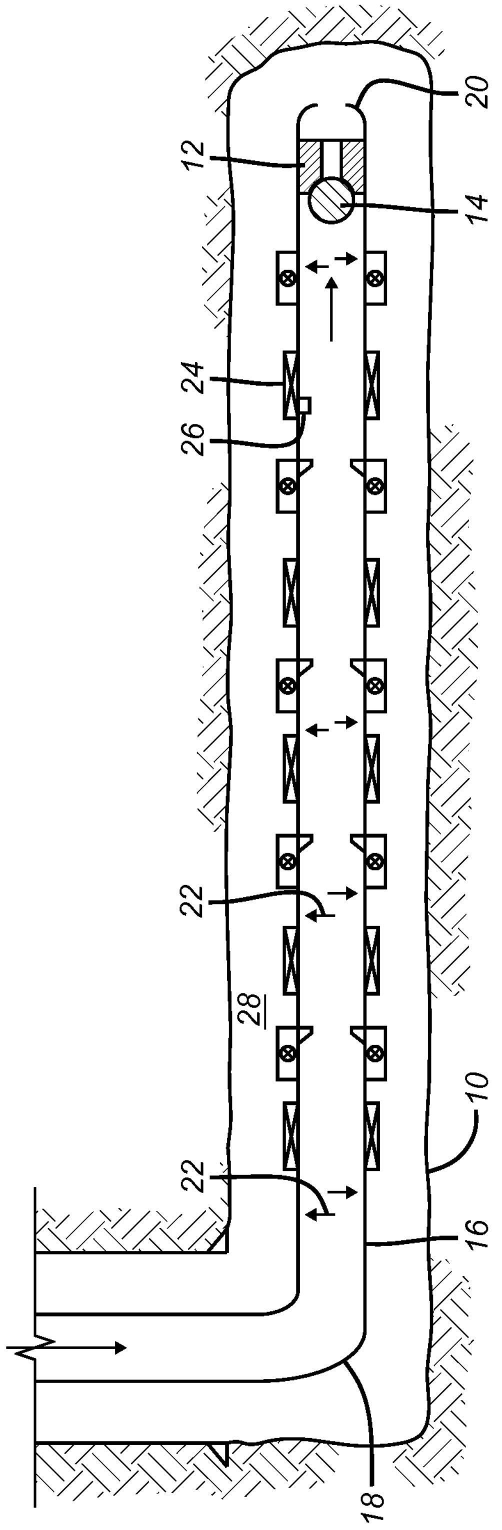

FIG. 1

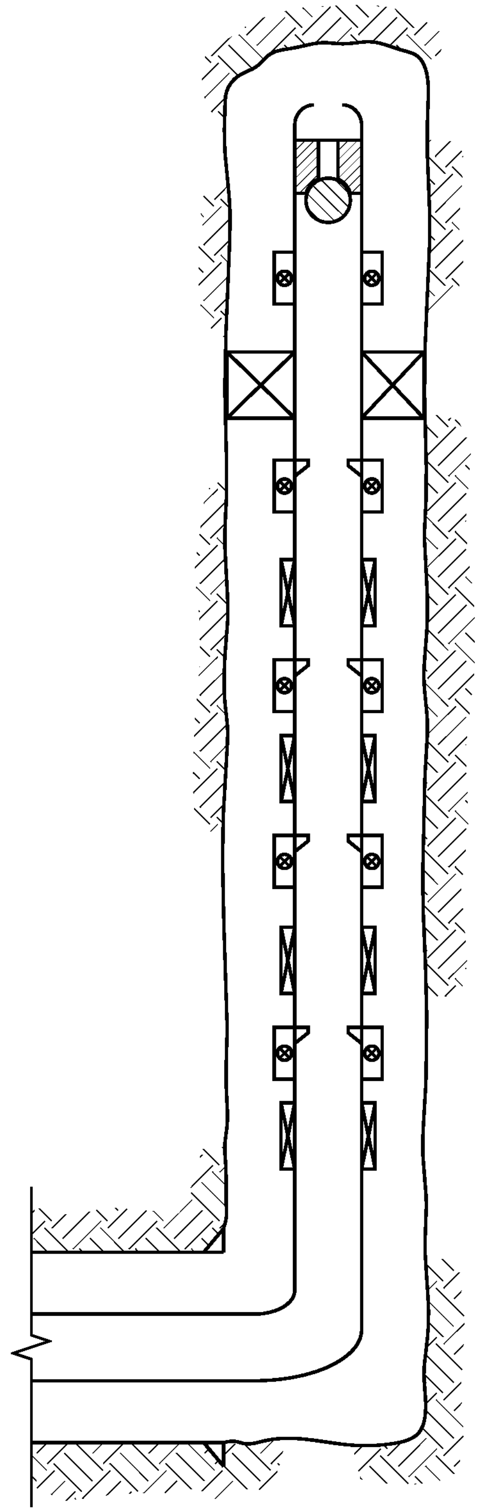

FIG. 2

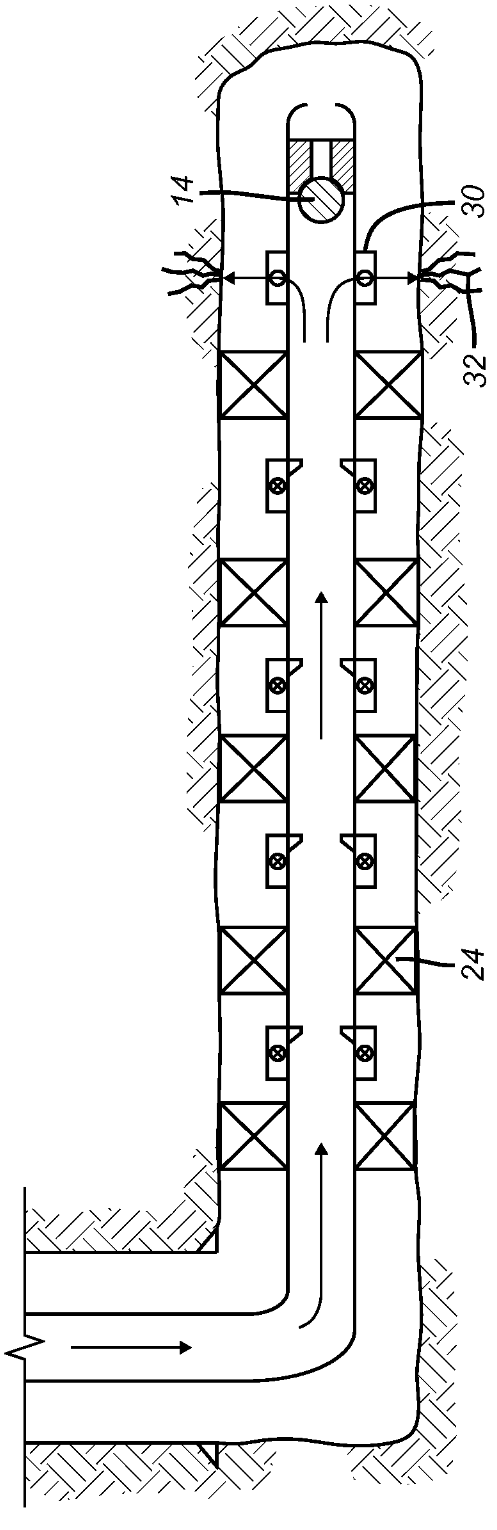

FIG. 3

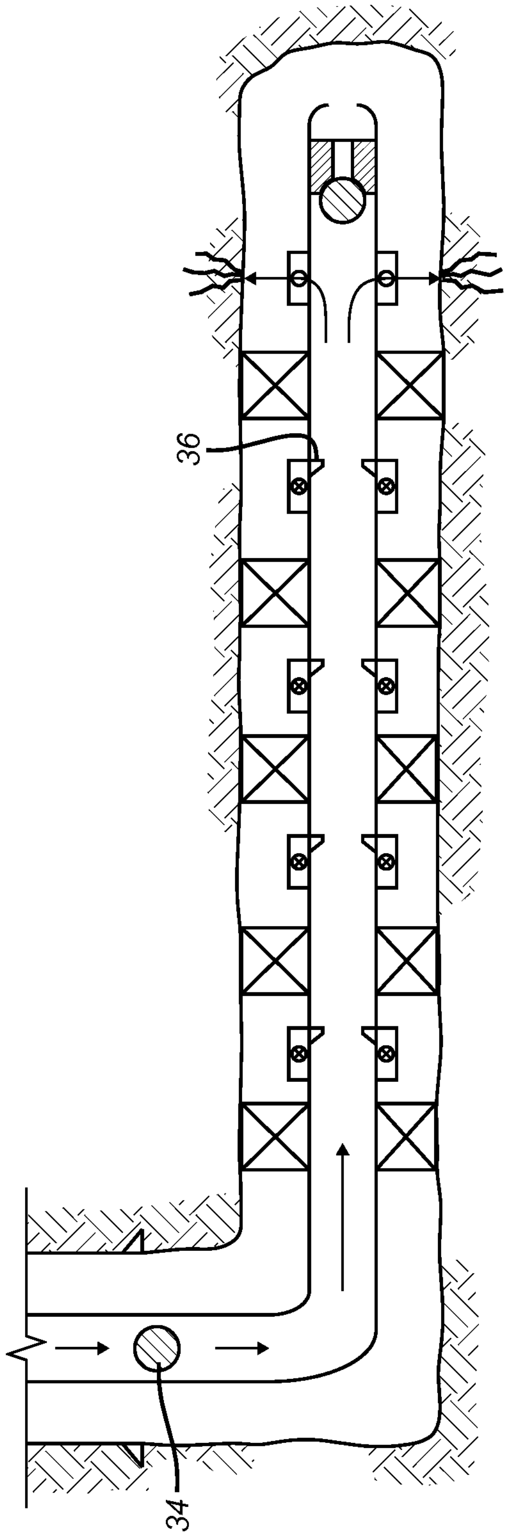

FIG. 4

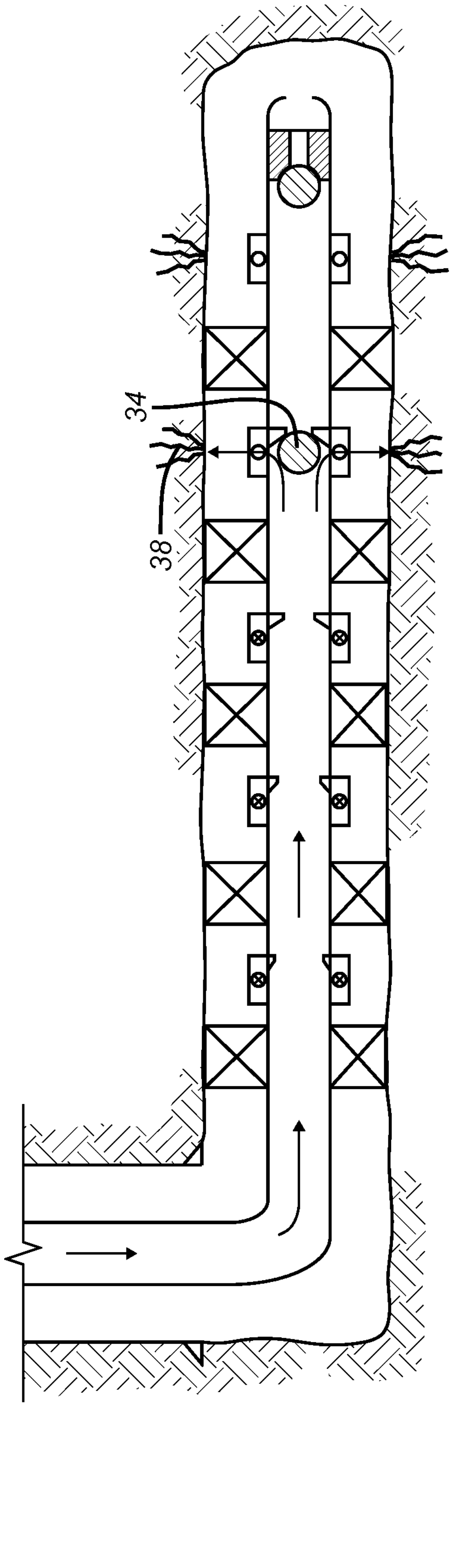

FIG. 5

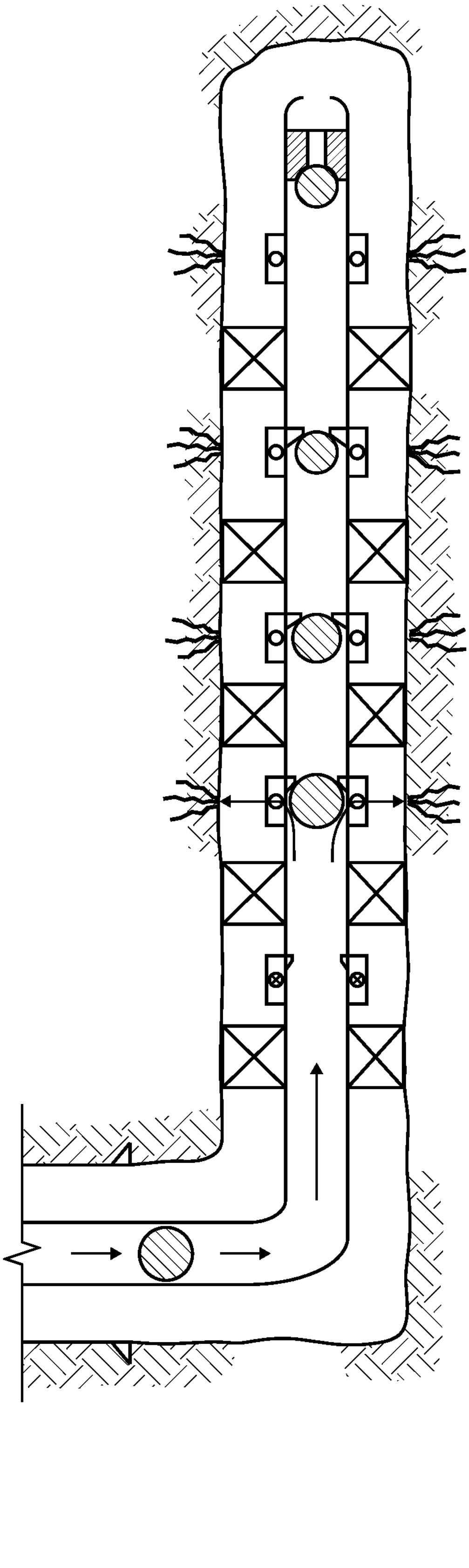

FIG. 6

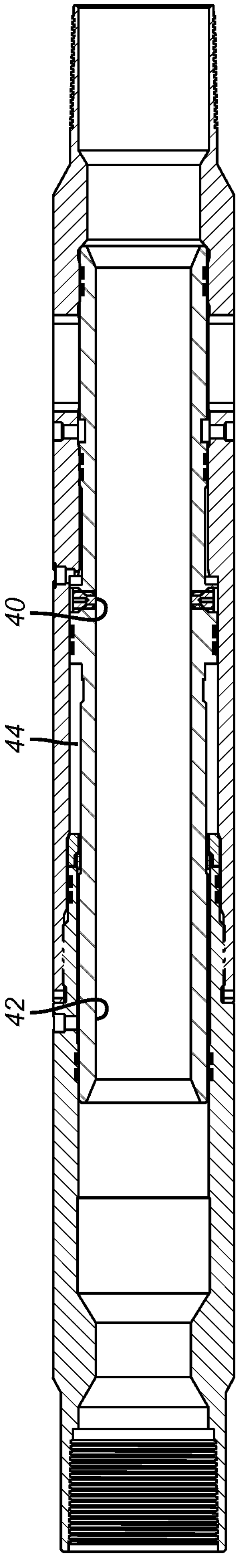

FIG. 7

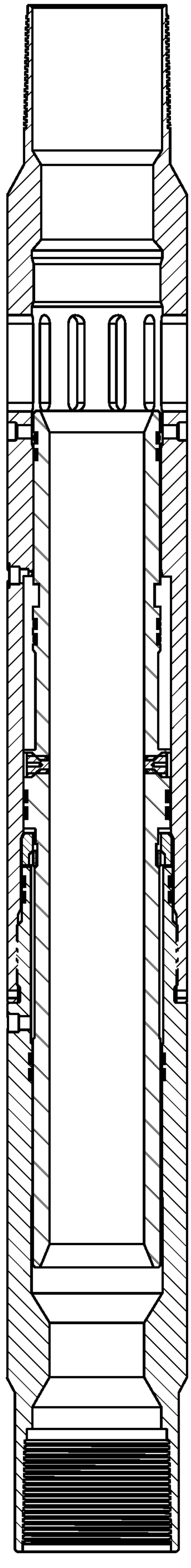

FIG. 8

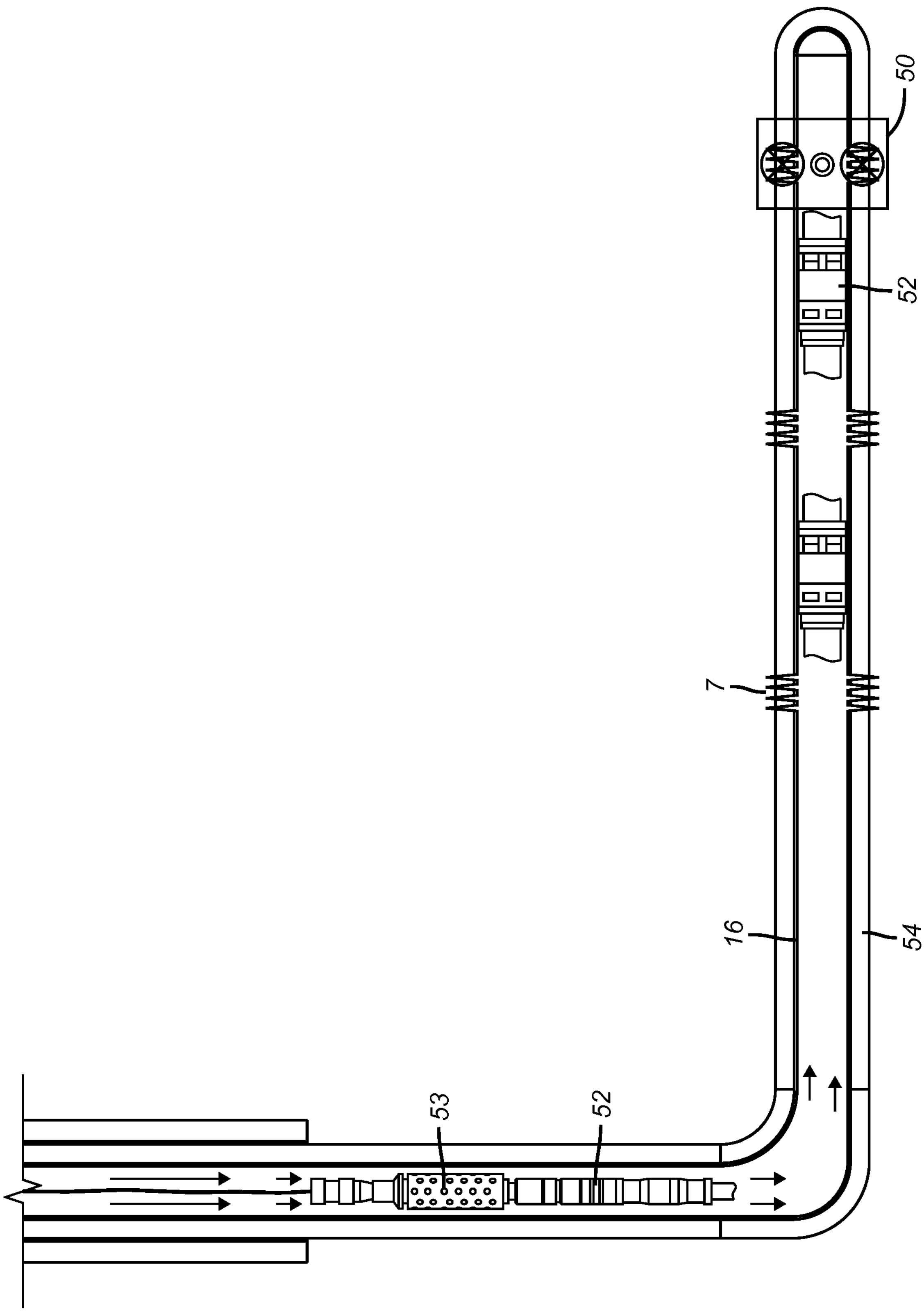

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/065508

A. CLASSIFICATION OF SUBJECT MATTER

E21B 43/26(2006.01)i, E21B 43/247(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 43/26; E21B 34/06; E21B 43/04; E21B 34/00; E21B 33/124; E21B 33/12; E21B 43/247

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, string, passage, wall access port, pressure, signal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012-0006562 A1 (SPEER et al.) 12 January 2012 See paragraphs [0003], [0005], [0017], [0019]-[0020], [0041], [0045]; claim 19; and figures 1, 3A-3B.	1-17
Y	EP 1225302 A2 (HALLIBURTON ENERGY SERVICES, INC.) 24 July 2002 See paragraph [0050]; and figure 4.	1-17
Y	US 2001-0018977 A1 (KILGORE, MARION D.) 06 September 2001 See paragraphs [0040], [0044], [0073]; and figures 4, 8.	3-8
A	US 2013-0146291 A1 (O`MALLEY, EDWARD J.) 13 June 2013 See paragraphs [0002], [0014]-[0015]; and figures 1-2, 6.	1-17
A	US 2013-0206425 A1 (MAZYAR et al.) 15 August 2013 See paragraphs [0001]-[0002], [0012]; and figures 1A-1B.	1-17

☐ 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
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"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
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 February 2015 (24.02.2015)	**24 February 2015 (24.02.2015)**

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