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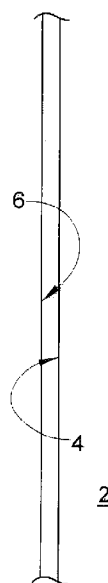
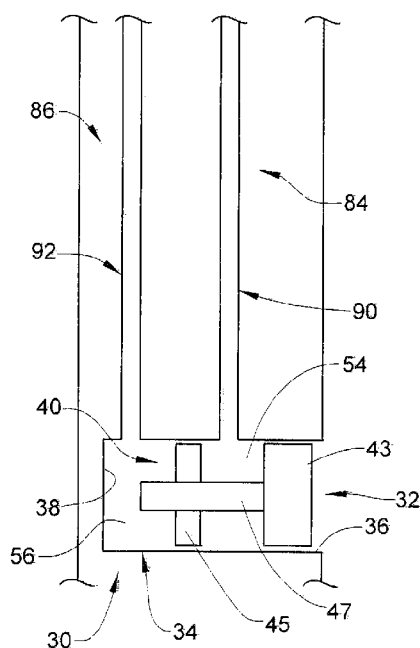
Declarations under Rule 4.17:

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

[Continued on next page]

(54) Title: PRODUCTION FLUID MONITORING SYSTEM INCLUDING A DOWNHOLE ACOUSTIC SENSING SYSTEM HAVING A DOWNHOLE PULSATOR

FIG. 1



(57) Abstract: A downhole acoustic sensing system includes a pulsator device configured and disposed to be arranged in a downhole environment, and a control system operatively connected to the pulsator device. The control system delivers at least one control input to the pulsator device to generate a sinusoidal acoustic signal.



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- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- Published:**
- *with international search report (Art. 21(3))*

PRODUCTION FLUID MONITORING SYSTEM INCLUDING A DOWNHOLE
ACOUSTIC SENSING SYSTEM HAVING A DOWNHOLE PULSATOR

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 14/156645, filed on January 16, 2014, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present invention relates to the art of production fluid monitoring systems and, more particularly, to a production fluid monitoring system including a downhole acoustic sensing system having a downhole pulsator.

[0003] Acoustic devices are used to measure various parameters in a downhole environment. Often times, an acoustic device may be used to determine parameters of a downhole acoustic medium including solids and/or fluids proximate to a drill head. In such cases, the acoustic device may be mounted to the drill string. In many cases, the acoustic device takes the form of a piezo-electric transducer. Piezo-electric transducers may also be mounted to production tubing and operated to transmit and/or receive acoustic signals through the acoustic medium.

SUMMARY

[0004] A downhole acoustic sensing system includes a pulsator device configured and disposed to be arranged in a downhole environment, and a control system operatively connected to the pulsator device. The control system delivers at least one control input to the pulsator device to generate a sinusoidal acoustic signal.

[0005] A production fluid monitoring system includes a pulsator device configured and disposed to be arranged in a downhole environment and a control system operatively connected to the pulsator device. The control system delivers at least one control input to the pulsator device to deliver a sinusoidal acoustic signal through downhole fluids. A data acquisition system is configured and disposed to detect the sinusoidal acoustic signal passing through the downhole production fluids.

[0006] A method of monitoring downhole production fluids includes delivering a positive pressure pulse from a downhole pulsator to form a first portion of a downhole acoustic signal, delivering a negative pressure pulse downhole to form a second portion of the

downhole acoustic signal, passing the acoustic signal through a production fluid, and sensing the acoustic signal to determine a quality of the production fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Referring now to the drawings wherein like elements are numbered alike in the several Figures:

[0008] FIG. 1 is a partial cross-sectional view of a downhole production tubing passing alongside a downhole acoustic device, in accordance with an exemplary embodiment;

[0009] FIG. 2 is a schematic view of a downhole production fluid acoustic sensing system including the downhole acoustic device of FIG. 1;

[0010] FIG. 3 is a view of the downhole acoustic device of FIG. 1 delivering a negative pressure pulse;

[0011] FIG. 4 is a view of the downhole acoustic device of FIG. 1 delivering a positive pressure pulse; and

[0012] FIG. 5 is a graphical representation of an acoustic signal produced by the downhole acoustic device, in accordance with an exemplary embodiment.

DETAILED DESCRIPTION

[0013] Exploration companies routinely drill wells in a medium, indicated at 2 in FIG. 1, in search of natural resources such as natural gas and/or oil. The wells are formed by drilling a bore, indicated generally at 4, into medium 2. Bore 4 extends to a zone or region (not shown) in which a natural resource resides. After forming bore 4, production tubing 6 is inserted downhole into the bore 4. At this point it should be understood that the term “downhole” refers to a zone within medium 2 in which bore 4 is formed. Bore 4 may begin at an exposed earthen or sand surface, or under water. The term “uphole” as used herein refers to a zone or region outside of medium 2.

[0014] In accordance with an exemplary embodiment, a production fluid monitoring system, indicated generally at 14 in FIG. 2, is employed to monitor production fluids passing through production tubing 6. Production fluid monitoring system 14 includes a downhole acoustic sensing system 20 and a data acquisition system 24. Downhole acoustic sensing system 20 includes a pulsator device 30 which, as will be discussed more fully below, delivers an acoustic signal into production fluids passing through production tubing 6.

[0015] Pulsator device 30 may include a piston 32 shiftably mounted in a cylinder 34. Of course, it should be understood that pulsator device 30 may take on a variety of forms

including diaphragms, pumps and the like, capable of delivering a pressure pulse into production fluids passing through production tubing 6. In the exemplary embodiment shown, cylinder 34 extends from a first end 36 exposed to the production fluids to a second, closed end 38 defining a volume 40. Piston 30 includes a first piston element 43 exposed at first end 36 and a second piston element 45 spaced from first piston element 43 by a support rod 47. Second piston element 45 separates volume 40 into a first portion 54 and a second portion 56.

[0016] In accordance with an exemplary embodiment, pulsator device 30 is operatively connected to a control system 70. Control system 70 is connected to a valve 74 which, in turn, may be fluidically coupled to a source of fluid 78 and pulsator device 30. Valve 74 may take the form of a ball valve or other form of fast switching valve. In the exemplary embodiment, shown, valve 74 is fluidically connected to cylinder 34 through a first control input 84 and a second control input 86. First control input 84 takes the form of a first hydraulic line 90 and second control input 86 takes the form of a second hydraulic line 92. Control system 70 operates valve 74 to alternately deliver control signals to pulsator device 30 causing an acoustic signal to pass into the production fluids. The control signals may take the form of pulses of a fluid passing through first and second hydraulic lines 90 and 92. The fluid may be a non-compressible fluid or a compressible fluid.

[0017] In accordance with an aspect of an exemplary embodiment, control system 70 operates valve 74 to deliver a pulse of fluid through first hydraulic line 90 causing piston 32 to move in a first direction towards second end 38 of cylinder 34 creating a negative pressure pulse 96 (FIG. 5) into the production fluid, as shown in FIG. 3. Control system 70 then operates valve 74 to deliver another pulse of fluid into second hydraulic line 92 causing piston 32 to move in a second direction away from second end 38 of cylinder 34 creating a positive pressure pulse 98 (FIG. 5) into the production fluid, as shown in FIG. 4. Control system 70 alternates between sending pulses of fluid to first and second hydraulic lines 90 and 92 creating a sinusoidal acoustic signal 100, as shown in FIG. 5, that is delivered into the production fluid. Of course it should be understood that the sinusoidal signal may represent a summation of sinusoids.

[0018] In accordance with an aspect of an exemplary embodiment, data acquisition system 24 includes a data collection and analysis device 104 operatively connected to a plurality of downhole sensors 108. Downhole sensors 108 may take the form of fiber optic sensors 110 that are arranged at various points along production tubing 6. Acoustic signal(s) 100 passes in an uphole direction and a downhole direction through the production fluids.

Data acquisition system 24 collects and analyzes acoustic signal(s) 100 at various points along production tubing 6 to monitor the production fluids.

[0019] At this point it should be understood that the exemplary embodiments describe a system for delivering pressure pulses into production fluids passing through production tubing in a resource collection system. The pressure pulses form an acoustic source that may be monitored to determine various attributes of the production fluid. The timing, duration, period and frequency of the pressure pulses may be varied depending upon desired sensing parameters. For example, a low frequency acoustic signal may be desirable when sensing deep downhole. It should also be understood that while described as a hydraulically actuated piston responding to two control signals, the present invention may employ a single control signal. A second control may be provided by a spring that is compressed by the piston in response to the single control signal. Further, other systems including electric and magnetic may be used to drive the piston.

[0020] It should be further understood that the control system may be provided uphole to provide technicians with greater control of the acoustic signal. For example, in contrast to current acoustic sources used during drilling which operate continuously, the pulsator device of the present invention may be operated only during select periods. Periodic, as opposed to continuous operation, may extend an overall service life of the downhole acoustic sensing system. Moreover, by mounting the control system and the valve uphole, maintenance may be performed to further extend service life. However, it should be understood that both the valve and the control system may be arranged downhole.

[0021] While one or more embodiments have been shown and described, modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.

CLAIMS:

1. A downhole acoustic sensing system (20) comprising:
a pulsator device (30) configured and disposed to be arranged in a downhole environment; and
a control system (70) operatively connected to the pulsator device (30), the control system (70) delivering at least one control input (84) to the pulsator device (30) to generate a sinusoidal acoustic signal (100).
2. The downhole acoustic sensing system (20) according to claim 1, wherein the pulsator device (30) comprises a piston (32).
3. The downhole acoustic sensing system (20) according to claim 2, wherein the at least one control input (84) includes a first control input (84) configured and disposed to drive the piston (32) in a first direction and a second control input (86) configured to drive the piston (32) in a second direction substantially opposite the first direction.
4. The downhole acoustic sensing system (20) according to claim 3, further comprising: a hydraulic line (90) operatively connected to the control system (70) and fluidically connected to the piston (32), the at least one control input (84) comprising a non-compressible fluid (78) passing through the hydraulic line (90).
5. The downhole acoustic sensing system (20) according to claim 4, wherein the at least one control input (84) comprises a non-compressible fluid (78) passing through the hydraulic line (90).
6. The downhole acoustic sensing system (20) according to claim 2, further comprising: a valve (74) fluidically connected between the control system (70) and the pulsator device (30), the valve (74) selectively delivering the first and second control input (84,86).
7. The downhole acoustic sensing system (20) according to claim 1, wherein the control system (70) is configured and disposed to be arranged uphole and connected to the pulsator device (30) through at least one hydraulic line (90).
8. A production fluid monitoring system (14) comprising:
a pulsator device (30) configured and disposed to be arranged in a downhole environment;
a control system (70) operatively connected to the pulsator device (30), the control system (70) delivering at least one control input (84) to the pulsator device (30) to deliver a sinusoidal acoustic signal (100) through downhole production fluids (78); and

a data acquisition system (24) includes at least one downhole sensor (108) configured and disposed to detect the sinusoidal acoustic signal (100) passing through the downhole production fluids (78).

9.The production fluid monitoring system (14) according to claim 8, wherein the pulsator device (30) comprises a piston (32).

10.The production fluid monitoring system (14) according to claim 9, wherein the at least one control input (84) includes a first control input (84) configured and disposed to drive the piston (32) in a first direction and a second control input (86) configured to drive the piston (32) in a second direction substantially opposite the first direction.

11.The production fluid monitoring system (14) according to claim 10, further comprising: a hydraulic line (90) operatively connected to the control system (70) and fluidically connected to the piston (32), the at least one control input (84) comprising a non-compressible fluid (78) passing through the hydraulic line (90).

12.The production fluid monitoring system (14) according to claim 11, wherein the at least one control input (84) comprises a non-compressible fluid (78) passing through the hydraulic line (90).

13.The production fluid monitoring system (14) according to claim 9, further comprising: a valve (74) fluidically connected between the control system (70) and the pulsator device (30), the valve (74) selectively delivering the first and second control inputs (84,86).

14.The production fluid monitoring system (14) according to claim 8, wherein the control system (70) is configured and disposed to be arranged uphole and connected to the pulsator device (30) through at least one control input (84).

15.The production fluid monitoring system (14) according to claim 14, wherein the at least one control input (84) comprises a first hydraulic line (90) configured to deliver a first control input (84) and a second hydraulic line (92) configured to deliver a second control input (86).

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FIG. 1

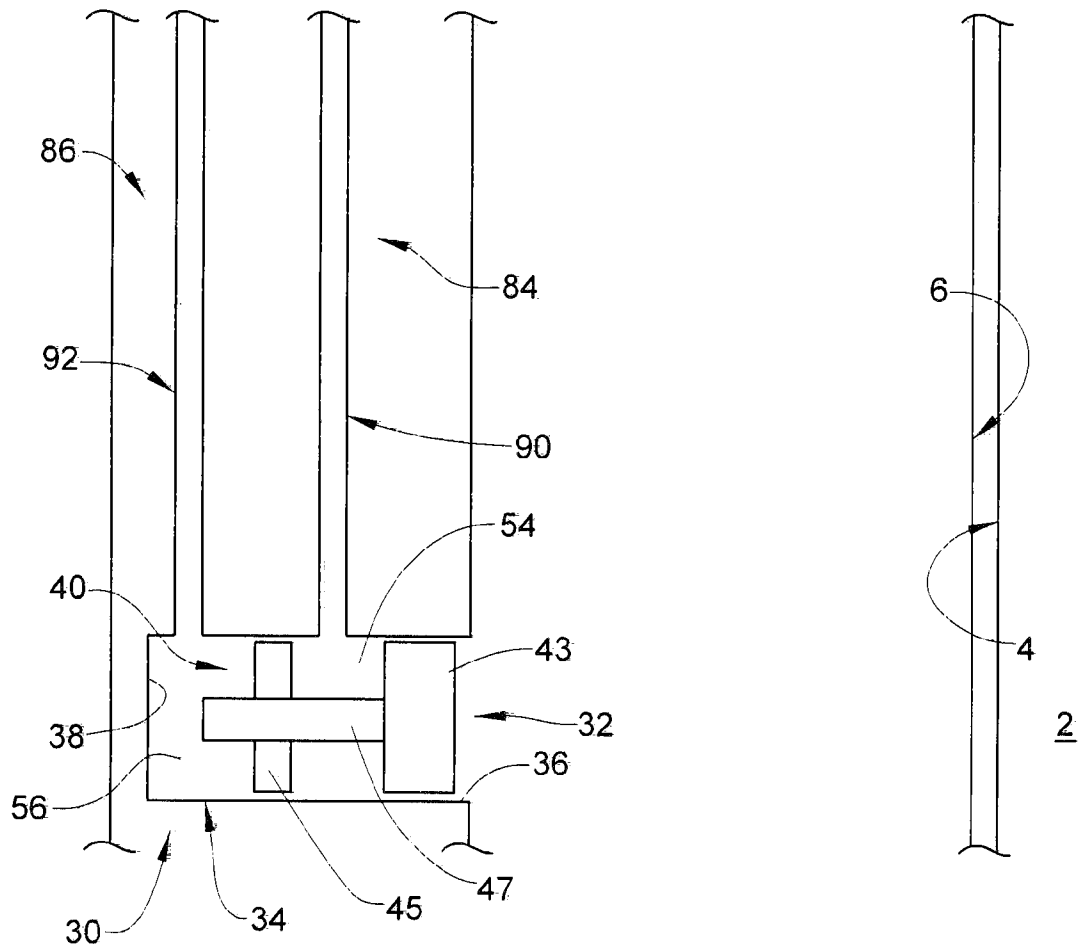
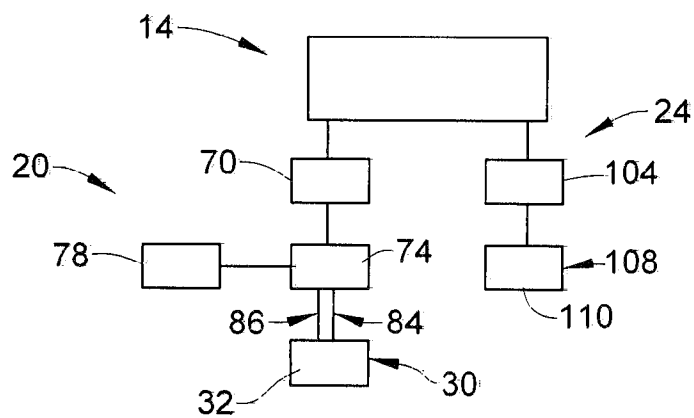


FIG. 2



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FIG. 3

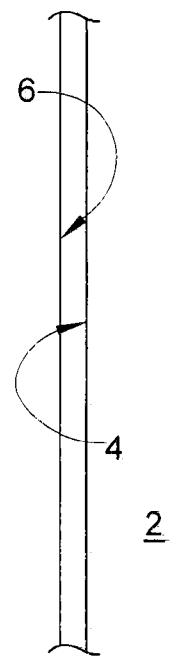
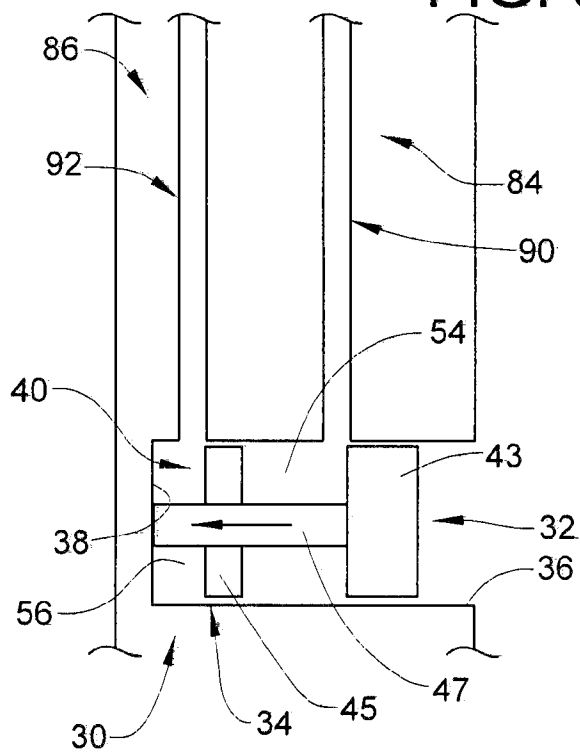
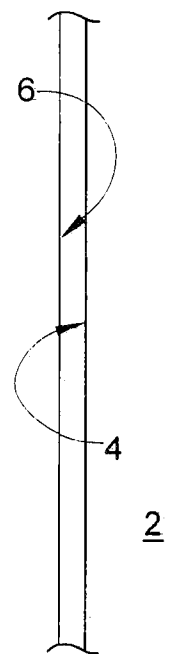
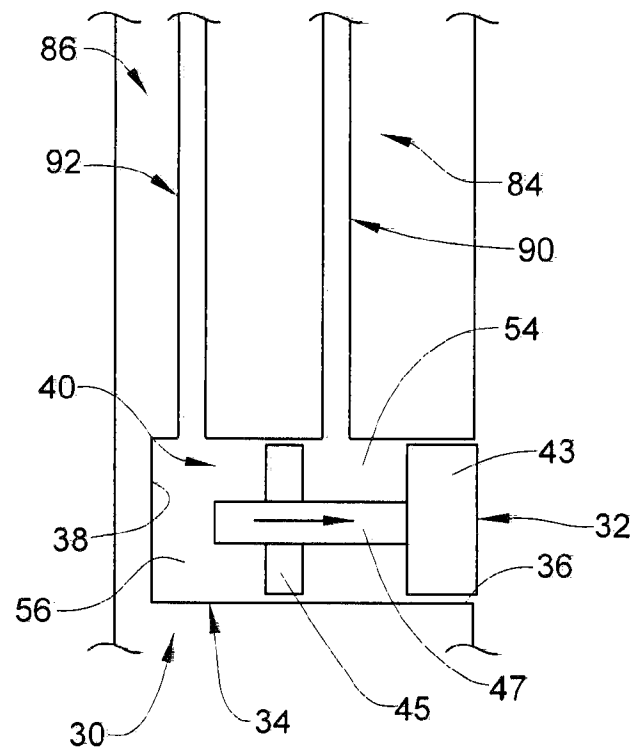
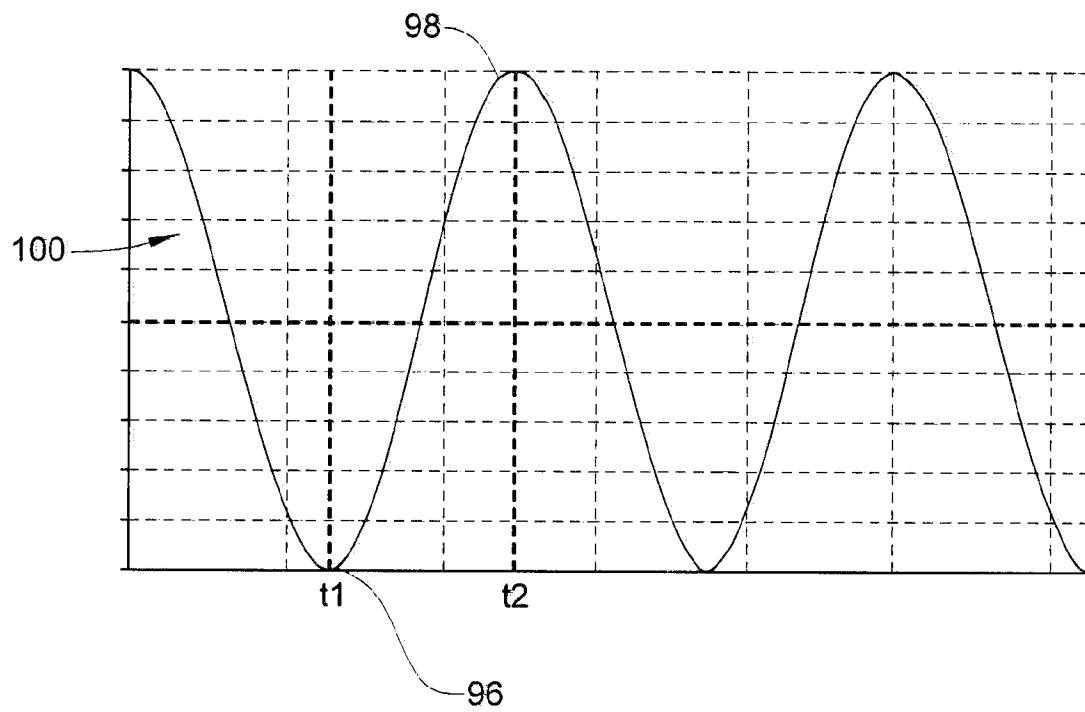


FIG. 4



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FIG. 5



A. CLASSIFICATION OF SUBJECT MATTER**E21B 43/12(2006.01)i, E21B 47/00(2006.01)i, G01V 1/40(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 43/12; E21B 47/06; F04B 49/00; E21B 41/00; E21B 47/14; E21B 23/00; G01V 1/40; E21B 47/00

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:pulsator, control, sinusoidal, acoustic, piston, hydraulic, non-compressible fluid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004-0026076 A1 (GOODWIN et al.) 12 February 2004 See paragraphs [0046], [0071]-[0072]; claims 1, 6-7; and figures 2, 10.	1-15
A	US 2008-0314137 A1 (PROETT et al.) 25 December 2008 See paragraphs [0034], [0041]-[0045]; and figures 1, 2C.	1-15
A	WO 2005-024177 A1 (SCHLUMBERGER HOLDINGS LIMITED et al.) 17 March 2005 See page 4, line 10 - page 5, line 5; and figure 1.	1-15
A	US 5281100 A (DIEDERICH, RICHARD E.) 25 January 1994 See column 2, line 16 - column 3, line 25; and figure 1.	1-15
A	US 5115880 A (SALLAS et al.) 26 May 1992 See column 2, line 40 - column 3, line 6; and figure 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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date

US 5115880 A

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None