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- (54) **Title:** APPARATUS AND METHOD FOR EVALUATING A WELLBORE, IN PARTICULAR A CASING THEREOF

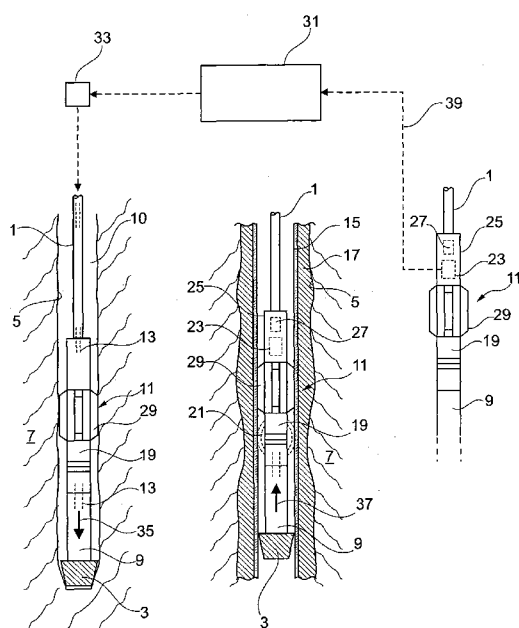


Fig. 1a

Fig. 1b

Fig. 1c

(57) **Abstract:** The apparatus for evaluating a wellbore (5) while drilling comprises a logging tool (11) held on a drill string (1) and is adapted to obtain data from the wellbore (5) while moving the drill string (1) including the logging tool (11) uphole and out of the wellbore (5). The logging tool (11) includes a memory (23) for storing obtained data and an on-board power supply battery (25). A computer (31) being positioned at a surface level of the wellbore (5) is adapted to obtain the data from the memory (23) when the logging tool (11) is also positioned at the surface level. The logging tool (11) is adapted to perform a minimum power-consuming sleep mode with a data obtaining and storing function being disabled and the computer (31) is adapted to transmit a wake-up signal downhole to enable the data obtaining and storing function of the logging tool (11) just prior to tripping out the drill string (1) from the wellbore (5). The wake-up signal preferably is a mud pulse signal sent through the drilling fluid used when drilling the wellbore (5).

- 1 -

Apparatus and Method for Evaluating a Wellbore, in Particular a Casing Thereof

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The invention relates to an apparatus and a method for evaluating a wellbore while drilling, and in particular for evaluating a casing and/or cement in an annulus behind the casing of the wellbore.

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When drilling a wellbore (bore hole) in the field of oil or natural gas production, it is important for the success of the drilling process to have information of the conditions related to the wellbore. In particular, information about the condition of the casing and the bonding of the casing to the cement in the annulus behind it is most valuable, since these parameters effect the further construction of the well. Wear on the casing is important to know for integrity reasons as a burst casing can be costly and potentially may lead to a dangerous well control situation.

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It is commonly known, for example from US 6,041,860, to inspect the wellbore through a wireline logging system comprising a logging or sensing tool which is lowered at the end of a cable into the wellbore. The logging tool is connected through a wireline telemetering system to a computer on the surface level of the wellbore for analyzing the data continuously supplied by the sensing tool to the computer. Before the logging tool can be run into the wellbore, the drilling process must be suspended and the drill string has to be removed, e.g. tripped out. For example, a separate wireline logging run for inspection of the casing takes about 4 to 6 hours and has to be carried out in approximately 50-70 % of the wellbores.

Wireline logging creates problems in case of directional drilling,

- 2 -

since the gravity propelled logging tool may get stuck in the wellbore. In order to avoid this problem, it is known from US 5,589,825 to provide a drill pipe string adjacent to its downhole drill bit or its bottom hole assembly with a drilling sub being capable of receiving a logging tool through the drill pipe string after having suspended the drilling process. The logging tool is sent down to the drilling sub from a surface level position at the drilling platform prior to commencing tripping out the drill pipe string. While moving the drill pipe string uphole, sensors of the logging tool provide data which are stored in a memory of the logging tool. The position of the logging tool with respect to the wellbore is sensed by the computer on the surface level. After the drilling sub has tripped out of the wellbore, the logging tool is recovered from the drilling sub and is connected to the computer for communicating the data stored in the memory to the computer for evaluating the data versus depths or tripping out time.

Since the logging tool known from US 5,589,825 is run downhole through the drill pipe string, the uphole end of the drill pipe string has to be cleared for inserting the logging tool by disconnecting the circulating head of the drilling rig to open the upper end of the drill pipe string, and in case of directional drilling, the logging tool may also get stuck in the drill pipe string.

From US 7,275,597 B2, it is known to take record measurements at a plurality of selected points along a downhole tool string. The equipment installed in the tool string comprises a plurality of electronic devices, each being separately powered by a battery. The electronic devices relay their data to a surface level computer via a two-way telemetry system, through which individual power state switching instructions are also transmitted from the surface level computer to the downhole electronic devices. The system known from US 7,275,597 B2 needs a complicated transmission system.

It is an object of the invention to provide an apparatus and a method for evaluating a wellbore in a less time consuming manner and with less constructional expense than hitherto.

- 3 -

According to the invention, the apparatus for evaluating a wellbore while drilling comprises:

- a drill string including a downhole drilling tool;
- 5 - a logging tool held on the drill string at a downhole position thereof, wherein the logging tool is adapted to obtain data from the wellbore while moving the drill string including the logging tool uphole and out of the wellbore, and wherein the logging tool includes a memory for storing obtained data and an on-board power supply battery; and
- 10 - a computer being positioned at a surface level of the wellbore and being adapted to obtain the data from the memory when the logging tool is also positioned at the surface level.

The improvement according to the invention is characterized in
15 that the logging tool is adapted to perform a minimum power-consuming sleep mode with a data obtaining and storing function being disabled and the computer is adapted to transmit a wake-up signal downhole to enable the data obtaining and storing function of the logging tool.

20 Contrary to the logging system known from US 5,589,825 the logging tool is mounted to the drill string prior to the start of moving the drill string downhole and the start of the drilling operation. During drilling, the logging tool is run downhole with the data obtaining and storing function remaining in a deactivated state and the logging tool remaining in its sleep
25 mode, in which the power consumption of electronic components of the logging tool is at a marginal minimum thus only negligibly discharging the battery. The battery has a capacity sufficient to withstand also longer drilling periods. Since contrary to the logging tool system known from US 5,589,825, the uphole end of the drill string does not need to be accessible for inserting
30 the logging tool so that a coiled drill pipe string associated with a bottom hole assembly drilling tool can be used in a preferred embodiment of the invention.

- 4 -

If the drilling operation is stopped for tripping out the drill string, the surface level computer transmits a wake-up signal downhole to the logging tool immediately before the drill string including the logging tool starts to be moved out of the wellbore. The surface level computer controls or measures the position of the drill string relatively to a reference point of the wellbore to provide for a time dependency or a distance dependency of the data obtained and stored by the logging tool during tripping out of the wellbore.

Depending on the parameters to be measured, the logging tool can comprise individual measuring devices including at least an acoustic device or an ultrasonic device or an infrared device or a radio-frequency device, but also a tactile device like a calliper or a camera for optical viewing may be included. Preferably the measuring device provides data not only continuously along the wellbore but also azimuthally around the wall of the wellbore in a 360° manner, such that with a single trip of the logging tool the complete surface of the wellbore can be scanned.

The logging tool preferably is adapted to obtain data for evaluating the wall conditions of the wellbore, in particular for evaluating the condition of a casing, for example a metal casing cemented in the wellbore and the bonding of the cement in the annulus behind the casing. Logging tools for casing inspection capable of recording the thickness and integrity of the casing and the extent of corrosion the casing has undergone are known. So it is known to evaluate the casing thickness and other parameters by means of acoustic, electrical or mechanical techniques. Logging tools providing a representation of the integrity of the cement, in particular whether the cement adheres solidly to the outside of the casing, are also known. Typically, these tools are of a sonic type. Magnetic resonance logging tools also may be used for evaluating the casing and the cement. These technologies use a sequence of pulses which are sent out from a transmitter/receiver unit while the reflected wave is recorded.

- 5 -

In a preferred embodiment, the logging tool comprises a centralizer for guiding the logging tool coaxial with the wellbore to improve the measuring accuracy.

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The wake-up signal sent by the surface level computer to activate the logging tool immediately prior to the tripping out operation is a simple pulse signal comprising at least one pulse, preferably a predetermined series of pulses, which are sent by means of a mud pulse system via the drilling fluid (mud) used during the drilling operation. Additionally or alternatively, an acoustical or electrical pulse signal may be transmitted via the metal pipes of the drill string. Also the acoustical or electrical may consist of a single pulse or preferably of a predetermined sequence of pulses. The logging tool comprises a receiver which is responsive to the pulse signal and activates the data obtaining and storing function in response to the detection of the pulse signal defining the wake-up signal.

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The logging tool preferably is mounted to the drill string adjacent the drilling tool, and further preferably is in the form of a drill pipe section detachably mounted to the drill string. The logging tool has a through channel guiding the flow of drilling fluid to the drilling tool.

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In a preferred embodiment, the logging tool is a modular unit comprising at least a sensing module and a battery module. The memory preferably is part of the battery module such that the battery module including the memory may be detached from the logging tool for transmitting the data stored in the memory to the surface level computer.

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The invention further relates to a method for evaluating a wellbore while drilling, comprising the steps of:

- mounting a logging tool to a drill string having a drilling tool, wherein the logging tool has a function to obtain and store data sensed

- 6 -

within the wellbore,

- commanding the logging tool into a minimum power-consuming sleep mode to disable the data obtaining and storing function,

- moving the drill string including the logging tool in its sleep
5 mode downhole while drilling the wellbore,

- stopping drilling the wellbore and transmitting a wake-up signal downhole to the logging tool from a computer positioned at a surface level of the wellbore to enable the data obtaining and storing function of the logging tool,

- tripping the drill string including the enabled logging tool out of
10 the wellbore while the logging tool is obtaining and storing data sensed within the wellbore, and

- transmitting the data stored in the logging tool to the computer after the logging tool has reached the surface level of the wellbore.

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Preferably, the method is carried out by means of an apparatus according to the invention as explained above.

In the following the invention will be described with reference to
20 the accompanying drawing which shows a preferred embodiment an apparatus for evaluating a casing of a wellbore and/or cement in an annulus behind the casing.

Fig. 1a shows a section through a wellbore with the apparatus
25 drilling the wellbore;

Fig. 1b shows the apparatus during a tripping out operation in a cased section of the wellbore; and

Fig. 1c shows the apparatus above the surface level of the wellbore.

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Fig. 1a shows a drill pipe string 1 with a drilling tool 3 at its downhole end while drilling a wellbore 5 into a formation 7. The drill pipe string 1 may consist of a plurality of tubular pieces, but also may be in the

- 7 -

form of a coiled tubing. The drilling tool 3 can be in the form of a drill bit, but the drill bit preferably is associated to a bottom hole assembly 9 to provide for rotational driving and/or directional drilling. Drilling fluid or mud is circulated downhole to the drilling tool 3 through the drill pipe string 1 and uphole through an annulus 10 between the drill pipe string 1 and the wellbore 5. Adjacent the bottom hole assembly 9, a logging tool 11 is attached to the drill pipe string 1. The logging tool 11 forms a unit which mechanically connects the bottom hole assembly 9 to the drill pipe string 1 and has a through channel 13 guiding the drilling fluid from the drill pipe string 1 to the drilling tool 3.

As best can be seen from Fig. 1b, the logging tool 11 is adapted to evaluate a tubular casing 15 which is cemented by cement 17 provided in the annulus behind the casing 15 to the wellbore 5. Additionally or alternatively, the logging tool 11 may be adapted to evaluate the bonding of the cement 17 to the casing 15. To sense corrosion or other defects of the casing 15 or the integrity of the cement 17, the logging tool 11 comprises a sensor unit 19 capable of evaluating physical properties of the casing 15 and the cement 17. For example, the sensor unit 19 determines the thickness and integrity of the casing 15 and the extent of corrosion. Further, it evaluates whether the cement 17 adheres solidly to the outside of the casing 15, or contains hollow portions. As explained below, the sensor unit 19 measures the physical parameters continuously along the wellbore 5 while the logging tool 11 is moving out of the wellbore 5. Further, the sensor unit 19 senses the physical parameters continuously azimuthally, e.g. around 360° and thus scans the whole body of the casing 15 and/or the cement 17.

In the preferred embodiment shown in the drawing, the sensor unit 19 comprises a transmitter/receiver which periodically transmits a pulse signal as indicated at 21 in Fig. 1b of a supersonic wave or an electromagnetic wave, which is reflected by the casing 15 and/or the cement 17. The reflected wave is received by the transmitter/receiver of the sensor unit 19 and is stored in a memory 23 of a communication unit 25 of the logging

- 8 -

tool 11. The communication unit 25 is an electronic device and includes a battery 27 as a power supply for the communication unit 25 and the sensor unit 19.

5 To improve the measuring accuracy of the sensor unit 19, the logging tool 11 is provided with a centralizer 29 which guides the logging tool 11 coaxially with respect to the casing 15.

10 The communication unit 25 including the memory 23 as well as the sensor unit 19 are capable of being operated in a sleep mode, in which the power consumption of the electronic components is at a marginal minimum, and in which the data sensing and storing function of the sensor unit 19 and the memory 23 is disabled, i.e. deactivated. The communication unit 25 is adapted to receive a wake-up signal generated by a mud pulse
15 generator 33 in response to a command of the computer 31. The mud pulse signal is transmitted through drilling fluid fed through the drill pipe string 1 to the drilling tool 3. The wake-up signal comprises at least one pulse, preferably a predetermined sequence of pulses which is recognized by the communication unit 25 to activate or switch on the sensing and storing
20 function of the logging tool 11.

 Before commencing the drilling operation, the computer 31 switches the logging tool 11 into the sleep mode, and thereafter the wellbore 5 is drilled down to a desired depth (arrow 35). After having stopped drilling
25 and just before starting to pull out the drill pipe string 1 from the wellbore 5, the computer 31 commands the mud pulse generator 33 to transmit the wake-up signal to the communication unit 25 to activate the sensing and storing function of the logging tool 11. While the drill pipe string 1 and the logging tool 11 are continuously moved out of the wellbore 5 (arrow 37 in
30 Fig. 1b), the memory 23 stores data continuously provided by the sensor unit 19. The computer 31 measures the position of the logging tool 11 with respect to a reference point of the wellbore 5 through measuring the position of the drill pipe string 1 or the elapsed time interval since the start of the

- 9 -

tripping out movement to provide for a continuous log of the physical parameters of the casing 15 and/or the cement 17. It is to be noted that no data are transmitted to the computer 31 from the communication unit 25 during the tripping operation. After the logging tool 11 has reached the
5 surface level of the computer 31, a communication link 39, e.g. in the form of a cable, is established between the communication unit 25 and the computer 31 to read out stored data from the memory 23. The computer 31 evaluates the casing 15 and the cement 17 depending on the data thus obtained.

10 In the embodiment explained above, the wake-up signal is transmitted in the form of a mud pulse signal. Alternatively or additionally, an acoustical or electrical wake-up signal can be transmitted through the metal body of the drill pipe string 1.

15 The logging tool 11 is a modular construction, which comprises at least a sensing module and a battery module to allow replacement for example of the sensor unit 19 by another type of sensing unit, for example a calliper-type sensing unit. The battery module allows quick replacement of a discharged battery. Additionally the communication unit 25 including the
20 memory 23 also forms a module to which the battery module may be attached. The logging tool 11 per se is detachably mounted to the drill pipe string 1.

- 10 -

Claims

1. Apparatus for evaluating a wellbore while drilling, the apparatus
5 comprising:
- a drill string (1) including a downhole drilling tool (3);
 - a logging tool (11) held on the drill string (1) at a downhole position thereof, wherein the logging tool (11) is adapted to obtain data from the wellbore (5) while moving the drill string (1) including the logging tool (11) uphole and out of the wellbore (5) and wherein the logging tool (11) includes a memory (23) for storing obtained data and an on-board power supply battery (25); and
 - a computer (31) being positioned at a surface level of the wellbore (5) and being adapted to obtain the data from the memory (23) when
10 the logging tool (11) also is positioned at the surface level,
- characterized in that the logging tool (11) is adapted to perform a minimum power consuming sleep mode with a data obtaining and storing function being disabled and the computer (31) is adapted to transmit a wake-up signal downhole to enable the data obtaining and
15 storing function of the logging tool (11).
2. Apparatus according to claim 1, wherein the logging tool (11) is adapted to evaluate a casing (15) and/or cement (17) in an annulus behind the casing (15) along the wellbore (5).
20
3. Apparatus according to one of claims 1 or 2, wherein the logging tool (11) comprises a centralizer (29) for guiding the logging tool (11) coaxial with the wellbore (5).
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4. Apparatus according to any one of claims 1 to 3, wherein the wake-up signal is a mud pulse signal transmitted via drilling fluid and/or an acoustical or electrical pulse signal transmitted via the drill string (1).
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- 11 -

5. Apparatus according to any one of claims 1 to 4, wherein the logging tool (11) is mounted to the drill string (1) adjacent the drilling tool (3).
- 5 6. Apparatus according to any one of claims 1 to 5, wherein the logging tool (11) is in the form of a drill pipe section detachably mounted to the drill string (1) and having a through channel (13) for drilling fluid.
- 10 7. Apparatus according to any one of claims 1 to 6, wherein the logging tool (11) is a modular unit comprising at least a sensing module (19) and a battery module (25).
- 15 8. Method for evaluating a wellbore while drilling, comprising the steps of:
- mounting a logging tool (11) to a drill string (1) having a drilling tool (3), wherein the logging tool (11) has a function to obtain and store data sensed within the wellbore (5);
 - commanding the logging tool (11) into a minimum power consuming sleep mode to disable the data obtaining and storing function,
 - 20 - moving the drill string (1) including the logging tool (11) in its sleep mode downhole while drilling the wellbore (5),
 - stopping drilling and transmitting a wake-up signal downhole to the logging tool (11) from a computer (31) positioned at a surface level
 - 25 of the wellbore (5) to enable the data obtaining and storing function of the logging tool (11),
 - tripping the drill string (1) including the enabled logging tool (11) out of the wellbore (5) while the logging tool (11) is obtaining and storing data sensed within the wellbore (5), and
 - 30 - transmitting the data stored in the logging tool (11) to the computer (31) after the logging tool (11) has reached the surface level of the wellbore (5).

- 12 -

9. Method according to claim 8, wherein the step of obtaining and storing data while tripping out the drill string (1) includes the step of obtaining data for evaluating a casing (15) and/or cement (17) in an annulus behind the casing (15) along the wellbore (5).

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10. Method according to one of claims 8 or 9, wherein the step of tripping out the drill string (1) from the wellbore (5) includes the step of centralizing the logging tool (11) coaxially to the wellbore (5).

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11. Method according to any one of claims 8 to 10, wherein the step of transmitting the wake-up signal includes the step of transmitting a mud pulse signal via drilling fluid and/or an acoustical or electrical pulse signal via the drill string (1).

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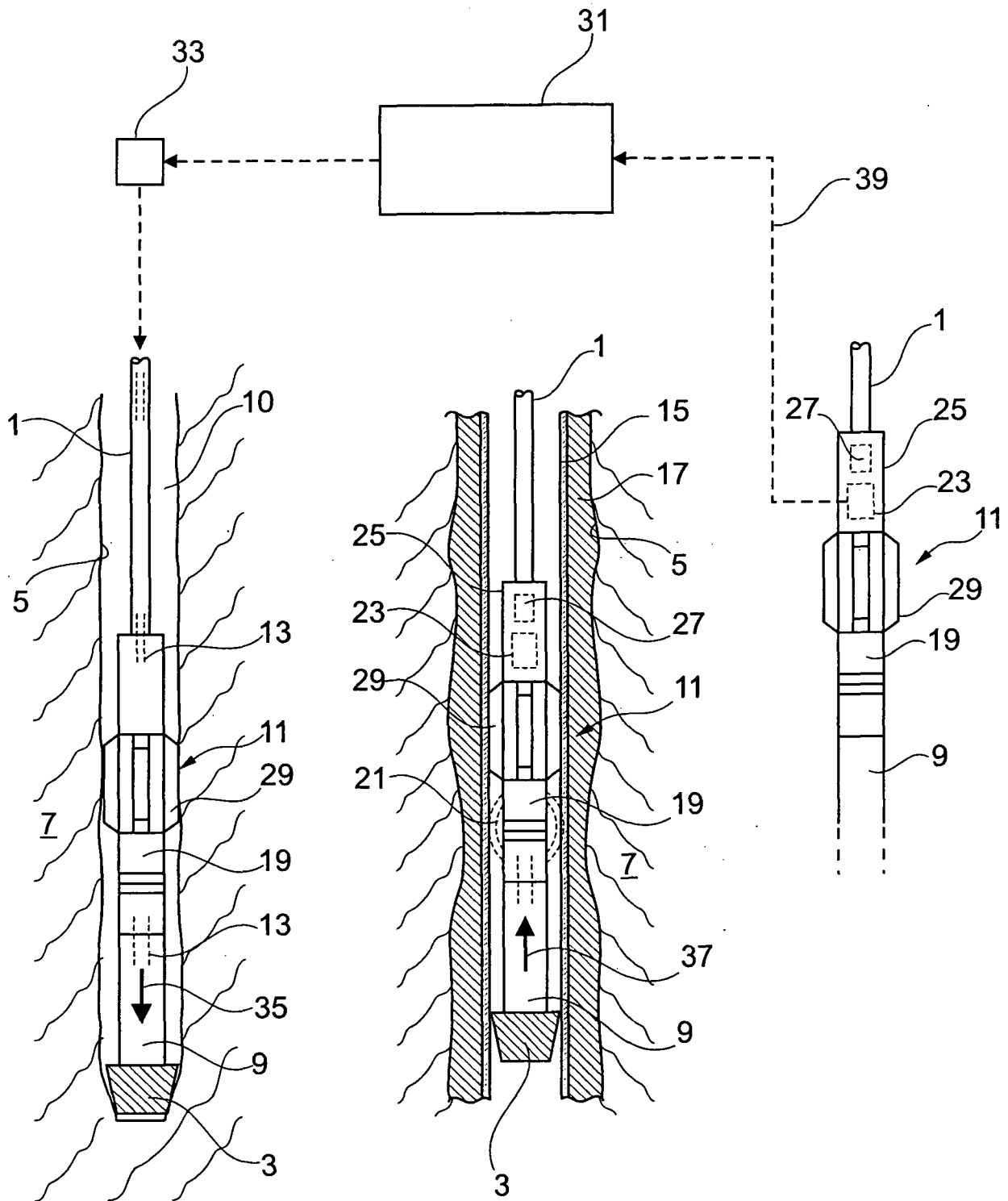


Fig. 1a

Fig. 1b

Fig. 1c

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/002424

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B47/00 E21B47/12

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

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	abstract	2,9
X	US 5 160 925 A (DAILEY PATRICK E [US] ET AL) 3 November 1992 (1992-11-03) column 23, line 49 - column 25, line 34 column 4, line 5 - line 10	1,4-8,11
X	US 5 153 832 A (ANDERSON TERRY O [US] ET AL) 6 October 1992 (1992-10-06) abstract; figure 1	1,6-8
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

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15/12/2009

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/002424

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No

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