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(54) **Distributed Sensor Systems and Methods**

(57) A distributed downhole sensor system for a well includes a sensor array comprising. The sensor array includes a plurality of sensors and cable segments. Each sensor is associated with a unique digital address and locatable downhole to capture sensor data simultaneously and output the simultaneously captured sensor data under a first control condition, and a single sensor of the plurality of sensors is configured to capture sensor data independently and output the independently captured sensor data under a second control condition. The cable segments couple the sensors in a line or an array to deliver power to the sensors and provide a communication channel to and from the sensors.

Distributed Sensor Systems and Methods

Background

[0001] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the presently described embodiments. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the described embodiments. Accordingly, it should be understood that these statements are to be read in this light and not as admissions of prior art.

[0002] Oil and gas wells are typically instrumented with various sensors downhole to measure various conditions of the downhole environment and/or well parameters such as temperature, pressure, vibration, cable fault, position and orientation, flow, density, among others. As wells may be very deep, such as 3,000 feet to 10,000 feet or more, the conditions may be different at different depth of the well. Thus, in order to gather data regarding conditions throughout the depth of the well, sensors need to be placed at different depths throughout the well. However, the downhole environment and its lack of easy accessibility present many challenges for instrumenting the well.

[0003] Additionally, instrumenting the well with sensors may add additional time to the well completions process, increasing cost.

US 2005/0194182 Al discloses a method and apparatus for controlling oil well drilling equipment. One or more sensors are distributed in the oil well drilling equipment. Each sensor produces a signal. A surface processor coupled to the one or more sensors via a high speed communications medium receives the signals from the one or more sensors via the high speed communications medium. The surface processor is situated on or near the earth's surface. The surface processor includes a program to process the received signals and to produce one or more control signals. The system includesone or more controllable elements distributed in the oil well drilling equipment. The one or more controllable elements respond to the one or more control signals.

Brief Description of the Drawings

[0004] For a detailed description of the embodiments of the invention, reference will now be made to the accompanying drawings in which:

[0005] FIG. 1 is a schematic view illustrating a production well instrumented with a multi-point sensor line, in accordance with some embodiments;

[0006] FIG. 2 is a schematic view illustrating a production tubing with a multi-point sensor line attached thereto, in accordance with some embodiments;

[0007] FIG. 3 is a detailed view illustrating the sensor line of the multi-point sensor line, in accordance with some embodiments;

[0008] FIG. 4 is an internal view illustrating a sensor of the multi-point sensor line, in accordance with some embodiments; and

[0009] FIG. 5 is a schematic view illustrating deployment of the multi-point sensor line, in accordance with some embodiments.

Detailed Description

[0010] Referring now to the figures, FIG. 1 illustrates an example production well system 100. The well system 100 includes a well 102 formed within a formation 104. The well 102 may be a vertical wellbore as illustrated or it may be a horizontal or directional well. The formation 104 may be made up of several zones which may include oil reservoirs. In certain example embodiments, the well system 100 may include a production tree 108 and a wellhead 109 located at a well site 106. A production tubing 112 extends from the wellhead 109 into the well 102. The production tubing 112 includes a plurality of perforations 126 through which fluids from the formation 104 can enter the production tubing 112 and flow upward into the production tree 108.

[0011] In some embodiments, the wellbore 102 is cased with one or more casing segments 130. The casing segments 130 help maintain the structure of the well 102 and prevent the well 102 from collapsing in on itself. In some embodiments, a portion of the well is not cased and may be referred to as "open hole." The space between the production tubing 112 and the casing 130 or wellbore 102 is an annulus 110. Production fluids enter the annulus 110 from the formation 104 and then enter the production tubing 112 from the

annulus 110. Production fluid enters the production tree 108 from the production tubing 112. The production fluid is then delivered to various surface facilities for processing via a surface pipeline 114.

[0012] It should be appreciated that well system 100 is only an example well system and there are many other well system configurations which may also be appropriate for use.

[0013] A multi-point sensor line 144 is disposed downhole in the wellbore 102. In some embodiments, the sensor line 144 is disposed on the outside of the production tubing 112 along at least a portion of the length of the production tubing 112. In some embodiments, the sensor line 144 is coupled to the production tubing 112 with a plurality of clamps 136 at intervals along the sensor line 144. The sensor line 144 includes a cable 132 with a plurality of sensors. The sensors 134 are configured to take measurements of one or more downhole conditions such as temperature, pressure, moisture, vibration, position and orientation in well, and the like. Accordingly, the sensors 134 may be a temperature sensor, a pressure sensor, a moisture sensor, an accelerometer, and the like. In some embodiments, the sensors 134 may all be temperature sensors, all pressure sensors, or all another type of sensor. In other embodiments, the sensor line 144 includes a mix of different types of sensors. The sensor line 144 may be coupled to an above-surface control system 150 that supplies power to the sensors 134 and receives the data from the sensors 134. The sensor line 144 may reach a lower end 138 of the production tubing 138 or any point between the upper end 140 and the lower end 138. In some embodiments, the sensors 134 are distributed along the length of the production tubing 112 such that one sensor 134 is uphole of another. Thus, the sensors 134 can take measurements at various depths of the well 102.

[0014] FIG. 2 is a detailed view of the production tubing 112 with the sensor line 144 coupled thereto. The sensor line 144 is coupled against the outer surface of the production tubing 112 with clamps 136 or other detainment devices. In some embodiments, the production tubing 112 is made up of a plurality of pipe segments coupled together at the ends 202. The sensor line 144 extends across the joined ends 202 and is coupled by an end clamp 206 which extends across the joined ends 202 of the pipe segments. In some implementations, the production tubing 112 may be instrumented with more than one sensor line 144 or a sensor network.

[0015] FIG. 3 illustrates the sensor line 144 by itself. The sensor line 144 includes a plurality of cable segments 132a, 132b, 132c, 132d and a plurality of sensors 134a, 134b,

134c. In some embodiments, the cable segments 132 and the sensors 134 are coupled linearly and alternatingly. The sensors 134 may be welded to the cable segments 132. The cable 132 may be tubing encapsulated cable or any other type of insulated cable suitable for this application as will be known to one skilled in the art. The number of and distance between the sensors 134a, 134b, 134c can vary depending on the application and desired resolution of the well data. The sensor line 144 can have any appropriate overall length, such as 3,000 feet, 10,000 feet, etc., depending on the application and the well 102. In some embodiments, the connections between the sensors 134a, 134b, 134c and the cable segments 132a, 132b, 132c, 132d may be encased or wrapped with shrink tubing or other means of mechanism reinforcement.

[0016] FIG. 4 is an internal view of a sensor 134 of the sensor line 144. The sensor 134 includes a housing 401 including a first end 404a and a second end 404b. In some embodiments the housing 401 is made up of a first housing portion 403a and a second housing portion 403b coupled together by a screw 418. The housing 401 contains the sensor components and electronics that enable the functions of the sensor 134. The housing 401 of the illustrated embodiment has a tubular shape, but in other embodiments the housing 401 may have other shapes containing an orifice in which sensor components can be disposed. The housing 401 may be fabricated from metals or metal alloys, or from any other suitable material as will be known to one skilled in the art. In some embodiments, housing 401 may be designed to withstand certain pressure, such as 30,000 psi. The housing 401 higher or lower pressure ratings than 30,000 psi.

[0017] The sensor 134 is coupled to a first cable segment 132a at the first end 404a and to the second cable segment 132b at the second end 404b. Each of the first and second cable segments 132a, 132b includes a conductor 402a, 402b.The conductor 402a, 402b may be a copper conductor or any other suitable type of conductor. The cable segments 132a, 132b may also have a filler material disposed therein that centralizes the conductors 134a, 134b. In some embodiments, the first end 404a of the sensor housing 401 is coupled to the first cable segment 132. Specifically, the first end 404a of the sensor housing 401 may be welded, soldered, or otherwise mechanically coupled to the first cable segment 132. The second end 404b of the sensor housing 401 may be likewise coupled to the second cable segment 132b. When the sensor 134 is coupled to the cable segments 132, the conductors 402 of the cable segments 132 may extend partially into the sensor housing 401. In some embodiments, instead of or in addition to welding the sensor 134 to the

conductors 402, the sensors 134 may be coupled to the conductors 402 through metal-to-metal seals or elastomeric seals.

[0018] In some embodiments, the sensor 134 includes a conductive path 406 disposed therein. The conductive path 406 is electrically coupled to the conductor 402a of the first cable segment 132a at one end and to the conductor 402b of the second cable segment 132 at another end. Thus, the conductor 402a of the first cable segment 132a is electrically coupled to the conductor 402b of the second cable segment 132b. The conductive path 406 may be a wire wrapped around, solder, crimped, and/or potted to the conductors 402 at the ends. In other embodiments, the conductive path 406 may be implemented as a trace on a circuit board or as a piece of conductive material. To which the conductors 402 are soldered or otherwise electrically coupled. In some embodiments, there may additionally be a pressure seal disposed between the cable segments 132 and the ends 404 of the sensor housing 401. The pressure seal provides a barrier, preventing wellbore fluids from entering the sensor 134 and cable segments 132.

[0019] In the embodiment illustrated in FIG. 4, the sensor 134 is a temperature sensor that includes one or more application specific integrated circuits (ASIC). The ASICs may be housed in a multi-chip-module (MCM) 408. The sensor 134 may further include a reference crystal 410, and a temperature crystal 412. The crystals 410, 412 may be quartz crystals. The MCM 408 may include multiple ASICs or integrated circuit connected on a single substrate. The MCM 408 may also hermetically sealed and use a ceramic substrate. The MCM 408 enables telemetry and power conversions for sensor 134. The ASIC 408 is electrically coupled to the internal conductor 406 and draws power therefrom, powering the ASIC 408 and other electrical components of the sensor 134.

[0020] The ASIC 408 is coupled to the reference crystal 410 and the temperature crystal 412. The ASIC 408 calibrates and drives the crystals 410, 412 as well as detects their oscillation frequency. The ASIC 408 may perform some processing on the measured frequency to generate a temperature data that can be sent uphole to the control system 150 via the cable 132. In some embodiments, each sensor 134 in the sensor line 144 may have a unique address. In certain such embodiments, the control system 150 may send a request to one of the sensors 134 requesting a data output. The request contains the address of the requested sensor 134 and only the requested sensor 134 responds with the data. Thus, the control system 150 is able to map received data to the sending sensor 134. The control system 150 may successively poll all of the sensors in this fashion. In some embodiments,

the sensors 134 are configured to send data to the control system 150 via the cable 132 automatically without receiving a specific request from the control system 150. In such embodiments, each sensor 134 may encode their unique address or identifier into the data. Thus, when the control system 150 receives the data from all of the sensors 134, it can parse and/or map each individual data packet to the sending sensor 134. The ASIC 408 may perform analog as well as digital signal processing. In some embodiments, a chassis for the ASIC 408 is integrated with the housing 401. In some cases, all sensors 134 can be configured to take data measurements at the same instance of time using a synchronization scheme. This can be followed by the data being automatically pushed or sensors 134 being addressed individually for data retrieval.

[0021] The ASICs or MCM 408 is an example means for carrying out the processing and other electronic functions of the sensor 134. However, other types and combinations of electronic components and circuit designs can be used to carry out similar functions. Thus the use of ASICs is an enabling example and not a limitation of the present disclosure.

[0022] In some embodiments, the conductive path 406 electrically coupling the first and second cable segments 132a, 132b does not depend on the functionality of the ASIC 408 or any other electronic component in the sensor 134. If the circuitry of the sensor 134 fails and the sensor 134 does not return data, as long as the conductive path 406 is not impeded, power can be delivered through the sensor and to the other sensors 134 in the sensor line 144. In other words, the electronics of the sensor 134 draws power from the conductive path 406 in a parallel manner rather than in a series manner. Thus, the remaining sensors 134 in the sensor line may remain functional if one sensor 134 in the sensor line fails. In some embodiments, the sensors134 includes a temporary or permanent strain relieving mechanism on top and bottom of each sensor 134 to protect the sensor line 144, particularly during deployment and retrieval of the sensor line 144.

[0023] The sensor line 144 is substantially fabricated previous to deployment downhole. In some embodiments, the sensor line 144 may be wrapped around a spool, wherein it is stowed until coupled to the production tubing 112 and deployed downhole. FIG. 5 is a schematic view of a run in hole (RIH) operation in which a multi-point sensor line 144 is being deployed. A RIH operation is performed to land a production tubing 112 into the well 102, through which production fluids are brought uphole from the well and delivered to surface facilities. The RIH operation is generally performed after the well is drilled and cased. The production tubing 112 is generally made up of a plurality of pipe segments

coupled together to form the production tubing 112. During the RIH operation, one pipe segment is lowered partially into the well and suspended at one end at the surface. Another pipe segment is lifted above the first pipe segment from a rig 504 and coupled to the first pipe segment, forming a pipe string. The pipe string is then lowered further into the well 102. Additional pipe segments are added to the pipe string in this manner until the desired depth is reached.

[0024] The prefabricated sensor line 144 is coupled to the production tubing 112 as the production tubing 112 is being put together and lowered into the well 102. Specifically, in some embodiments, the sensor line 144 is coupled to the pipe string at one or more points above ground. When the tubing string is lowered, the sensor line 144 is lowered into the well as well. In some embodiments, the sensor line 144 is unspooled from a spool 502 as it is lowered downhole. The sensor line 144 is continuously unspooled and coupled to the pipe string and lowered downhole. In some embodiments, the sensor line 144 is coupled to the production tubing 112 via clamps or other coupling means. The sensor line 144 may be clamped to the production tubing 112 at various intervals, such as 30 feet. In some embodiments, the sensor line 144 may also be joined to pup joints in addition to the production tubing 112.

[0025] Once the production tubing 112 is installed in the well, the sensor line 144 is coupled to an above-ground control system 150. The sensor line 144 can then be powered and operated. As the sensor line 144 is prefabricated prior to deployment downhole, the process of deploying the sensor line 144 (e.g., coupling the sensor line 144 to the production tubing 112), does not add significant time to the RIH operation.

[0026] In addition to the embodiments described above, many examples of specific combinations are within the scope of the disclosure, some of which are detailed below:

Example 1: A distributed downhole sensor system for a well, comprising:

a sensor array comprising:

a plurality of sensors, wherein each sensor is associated with a unique digital address and locatable downhole to capture sensor data simultaneously and output the simultaneously captured sensor data under a first control condition, and wherein a single sensor of the plurality of sensors is configured to capture sensor data independently and output the independently captured sensor data under a second control condition; and

cable segments coupling the sensors in a line or an array to deliver power to the sensors and provide a communication channel to and from the sensors.

Example 2: The system of example 1, further comprising a control device coupled to the sensor array to power the sensors and receive data from the sensors.

Example 3: The system of example 1, wherein a failure of one of the sensors does not affect the functionality of any other sensor.

Example 4: The system of example 1, wherein the sensors are configured to draw power from the cable segments in an electrically parallel manner.

Example 5: The system of example 4, wherein each sensor comprises a conductor to electrically couple the sensor to the cable segments.

Example 6: The system of example 1, wherein the plurality of sensors comprises temperature sensors, pressure sensors, or both.

Example 7: The system of example 1 or 6, wherein the plurality of sensors comprises one or more quartz based sensor.

Example 8: The system of example 1, wherein the first control condition comprises a request for simultaneously captured sensor data from the sensors, and wherein the second control condition comprises a request for sensor data from a single sensor.

Example 9: The system of example 1, wherein the sensors comprise strain relieving mechanisms.

Example 10: A method of deploying a distributed sensor system downhole in a well, comprising:

providing a prefabricated sensor array, the prefabricated sensor array comprising a plurality of sensors coupled together via cable segments;

coupling the prefabricated sensor line to a production tubing;

lowering the production tubing into the well; and

lowering the production tubing further into the well, wherein the second portion of the prefabricated sensor line is uphole of the first portion of the prefabricated sensor line.

Example 11: The method of example 10, further comprising:

coupling the prefabricated sensor line to a control system; and

providing power to the plurality of sensors from the control system.

Example 12: The method of example 10, wherein the failure of one of the plurality of sensors does not affect the functionality of any other sensor in the plurality of sensors.

Example 13: The method of example 10, wherein the plurality of sensors comprises a temperature sensor, a pressure sensor, or both.

Example 14: The method of example 10 or 13, wherein the plurality of sensors comprises one or more quartz based sensor.

Example 15: A method of operating a distributed sensor system, comprising:

simultaneously capturing sensor data with a plurality of sensors in a sensor array under a first control condition, wherein the plurality of sensors are disposed at various depths downhole and coupled together via cable segments;

transmitting the simultaneously captured sensor data uphole via the cable segments under the first control condition;

independently capturing sensor data with a single sensor in the sensor array under a second control condition; and

transmitting the independently captured sensor data uphole via the cable segments under the second control condition .

Example 16: The method of example 15, wherein each sensor is associated with a unique digital address.

Example 17: The method of example 16, wherein the first control condition comprises receiving a request for simultaneous sensor data from the plurality of sensors; and

wherein the second control condition comprises receiving a request for an independent sensor data from the single sensor.

Example 18: The method of example 16, wherein the sensor data comprises temperature data, pressure data, or both.

Example 19: The method of example 16, wherein the first control condition comprises preprogrammed instructions to output simultaneous sensor data from the plurality of sensors; and

wherein the second control condition comprises preprogrammed instructions to output an independent sensor data from the single sensor.

Example 20: The method of example 17, wherein the plurality of sensors includes one or more quartz based sensor.

[0027] This discussion is directed to various embodiments of the invention. The drawing figures are not necessarily to scale. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. Although one or more of these embodiments may be preferred, the embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. It is to be fully recognized that the different teachings of the embodiments discussed may be employed separately or in any suitable combination to produce desired results. In addition, one skilled in the art will understand that the description has broad application, and the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to intimate that the scope of the disclosure, including the claims, is limited to that embodiment.

[0028] Certain terms are used throughout the description and claims to refer to particular features or components. As one skilled in the art will appreciate, different persons may refer to the same feature or component by different names. This document does not intend to distinguish between components or features that differ in name but not function, unless specifically stated. In the discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to... ." Also, the term "couple" or "couples" is intended to

mean either an indirect or direct connection. In addition, the terms "axial" and "axially" generally mean along or parallel to a central axis (e.g., central axis of a body or a port), while the terms "radial" and "radially" generally mean perpendicular to the central axis. The use of "top," "bottom," "above," "below," and variations of these terms is made for convenience, but does not require any particular orientation of the components.

[0029] Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present disclosure. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[0030] Although the present invention has been described with respect to specific details, it is not intended that such details should be regarded as limitations on the scope of the invention, except to the extent that they are included in the accompanying claims.

Further disclosure is provided in the following numbered paragraphs:

1. A distributed downhole sensor system for a well, comprising:

a sensor array comprising:

a plurality of sensors, wherein each sensor is associated with a unique digital address and locatable downhole to capture sensor data simultaneously and output the simultaneously captured sensor data under a first control condition, and wherein a single sensor of the plurality of sensors is configured to capture sensor data independently and output the independently captured sensor data under a second control condition; and

cable segments coupling the sensors in a line or an array to deliver power to the sensors and provide a communication channel to and from the sensors.

2. The system of 1, further comprising a control device coupled to the sensor array to power the sensors and receive data from the sensors.

3. The system of 1, wherein a failure of one of the sensors does not affect the functionality of any other sensor.

4. The system of 1, wherein the sensors are configured to draw power from the cable segments in an electrically parallel manner.

5. The system of 4, wherein each sensor comprises a conductor to electrically couple the sensor to the cable segments.

6. The system of 1, wherein the plurality of sensors comprises temperature sensors, pressure sensors, or both.

7. The system of 1 or 6, wherein the plurality of sensors comprises one or more quartz based sensor.

8. The system of 1, wherein the first control condition comprises a request for simultaneously captured sensor data from the sensors, and wherein the second control condition comprises a request for sensor data from a single sensor.

9. The system of 1, wherein the sensors comprise strain relieving mechanisms.

10. A method of deploying a distributed sensor system downhole in a well, comprising:

providing a prefabricated sensor array, the prefabricated sensor array comprising a plurality of sensors coupled together via cable segments;

coupling the prefabricated sensor line to a production tubing;

lowering the production tubing into the well; and

lowering the production tubing further into the well, wherein the second portion of the prefabricated sensor line is uphole of the first portion of the prefabricated sensor line.

11. The method of 10, further comprising:

coupling the prefabricated sensor line to a control system; and

providing power to the plurality of sensors from the control system.

12. The method of 10, wherein the failure of one of the plurality of sensors does not affect the functionality of any other sensor in the plurality of sensors.

13. The method of 10, wherein the plurality of sensors comprises a temperature sensor, a pressure sensor, or both.

14. The method of 10 or 13, wherein the plurality of sensors comprises one or more quartz based sensor.

15. A method of operating a distributed sensor system, comprising:

simultaneously capturing sensor data with a plurality of sensors in a sensor array under a first control condition, wherein the plurality of sensors are disposed at various depths downhole and coupled together via cable segments;

transmitting the simultaneously captured sensor data uphole via the cable segments under the first control condition;

independently capturing sensor data with a single sensor in the sensor array under a second control condition; and

transmitting the independently captured sensor data uphole via the cable segments under the second control condition .

16. The method of 15, wherein each sensor is associated with a unique digital address.

17. The method of 16, wherein the first control condition comprises receiving a request for simultaneous sensor data from the plurality of sensors; and

wherein the second control condition comprises receiving a request for an independent sensor data from the single sensor.

18. The method of 16, wherein the sensor data comprises temperature data, pressure data, or both.

19. The method of 16, wherein the first control condition comprises preprogrammed instructions to output simultaneous sensor data from the plurality of sensors; and

wherein the second control condition comprises preprogrammed instructions to output an independent sensor data from the single sensor.

20. The method of 17, wherein the plurality of sensors includes one or more quartz based sensor.

Conclusies:

1. Werkwijze voor het plaatsen van een verdeeld sensorsysteem in een boorgat, omvattende:

het voorzien van een geprefabriceerde sensorlijn (144), waarbij de geprefabriceerde sensorlijn (144) meerdere sensoren (134; 134a-134c) omvat die samen zijn gekoppeld via kabelsegmenten (132a-132d);

het koppelen van de geprefabriceerde sensorlijn met een productieleiding (112);

het naar beneden brengen van de productieleiding (112) in het boorgat; en

het verder naar beneden brengen van de productieleiding (112) in het boorgat, waarbij het tweede deel van de geprefabriceerde sensorlijn zich boven het eerste deel van de geprefabriceerde sensorlijn bevindt.

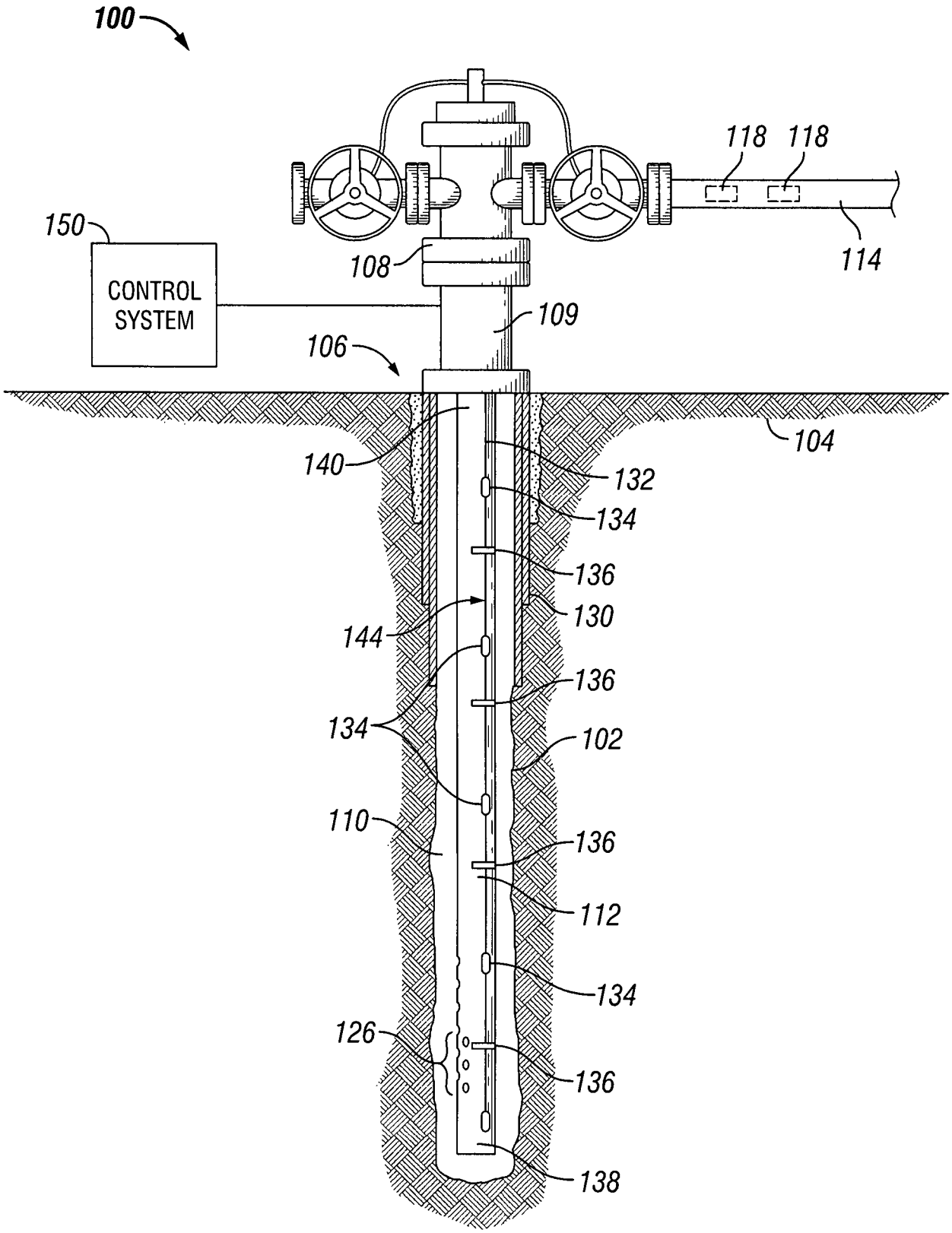
2. Werkwijze volgens conclusie 1, verder omvattende:

het koppelen van de geprefabriceerde sensorlijn (144) met een controlesysteem (150); en het leveren van stroom aan de meerdere sensoren (134; 134a-134c) vanuit het controlesysteem (150).

3. Werkwijze volgens conclusie 1, waarbij de storing van een van de meerdere sensoren (134; 134a-134c) geen invloed heeft op de functionaliteit van enige andere sensor in de meerdere sensoren (134; 134a-134c).

4. Werkwijze volgens conclusie 1, waarbij de meerdere sensoren (134; 134a-134c) een temperatuursensor, een druksensor, of beide, omvatten.

5. Werkwijze volgens conclusie 1 of 4, waarbij de meerdere sensoren (134; 134a-134c) een of meerdere op kwarts gebaseerde sensoren omvatten.


100
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CONTROL SYSTEM
108
114
109
106
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134
126
136
138

FIG. 1

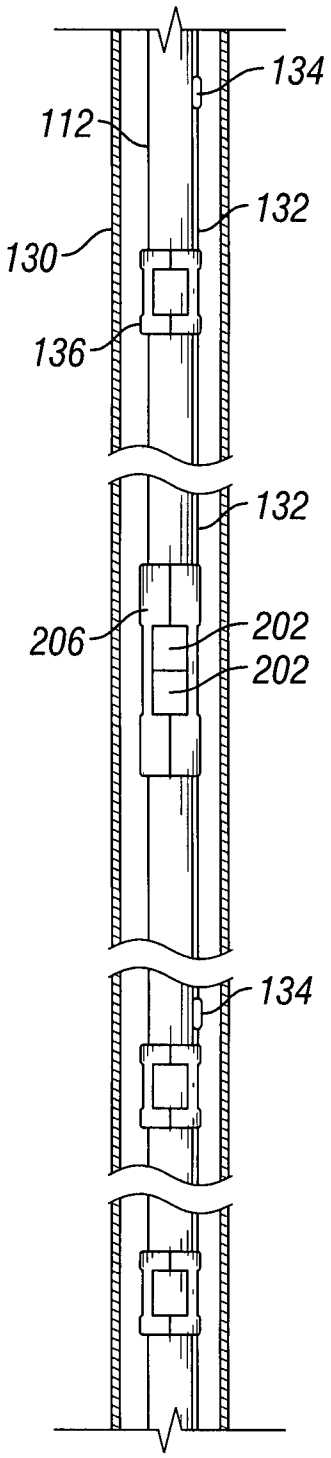
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FIG. 2

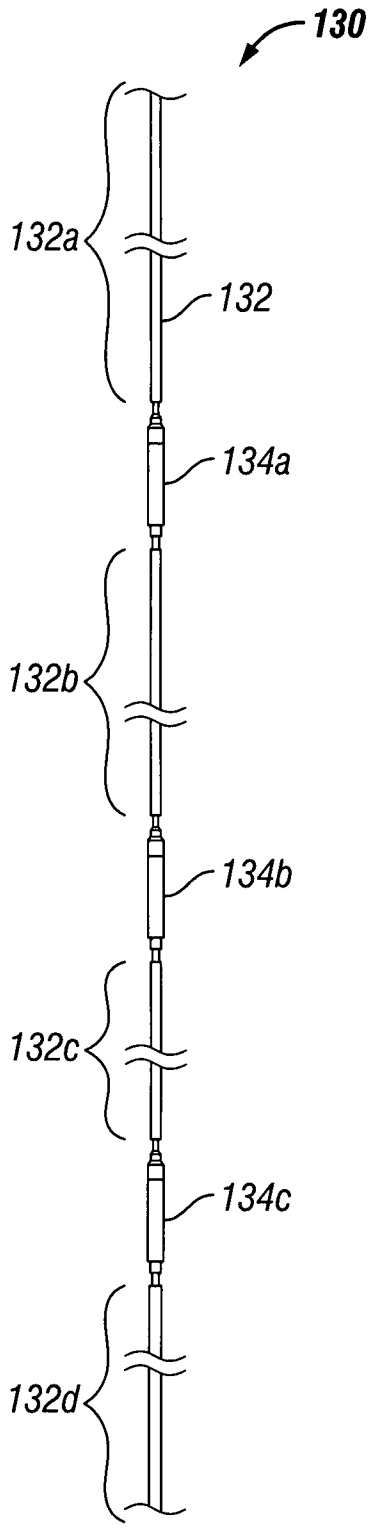
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FIG. 3

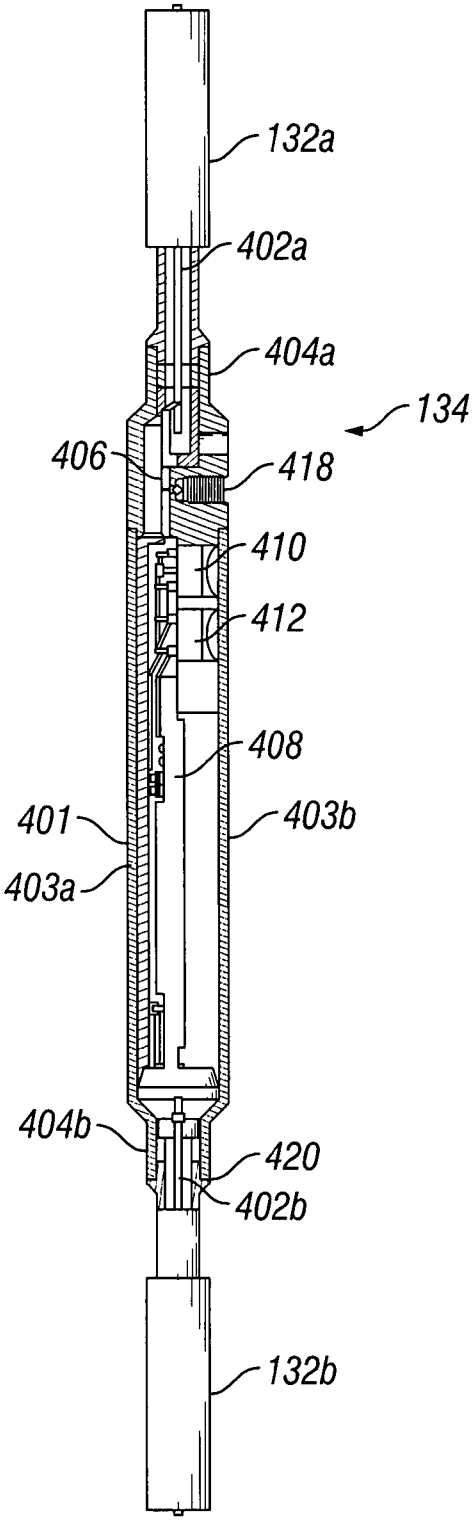
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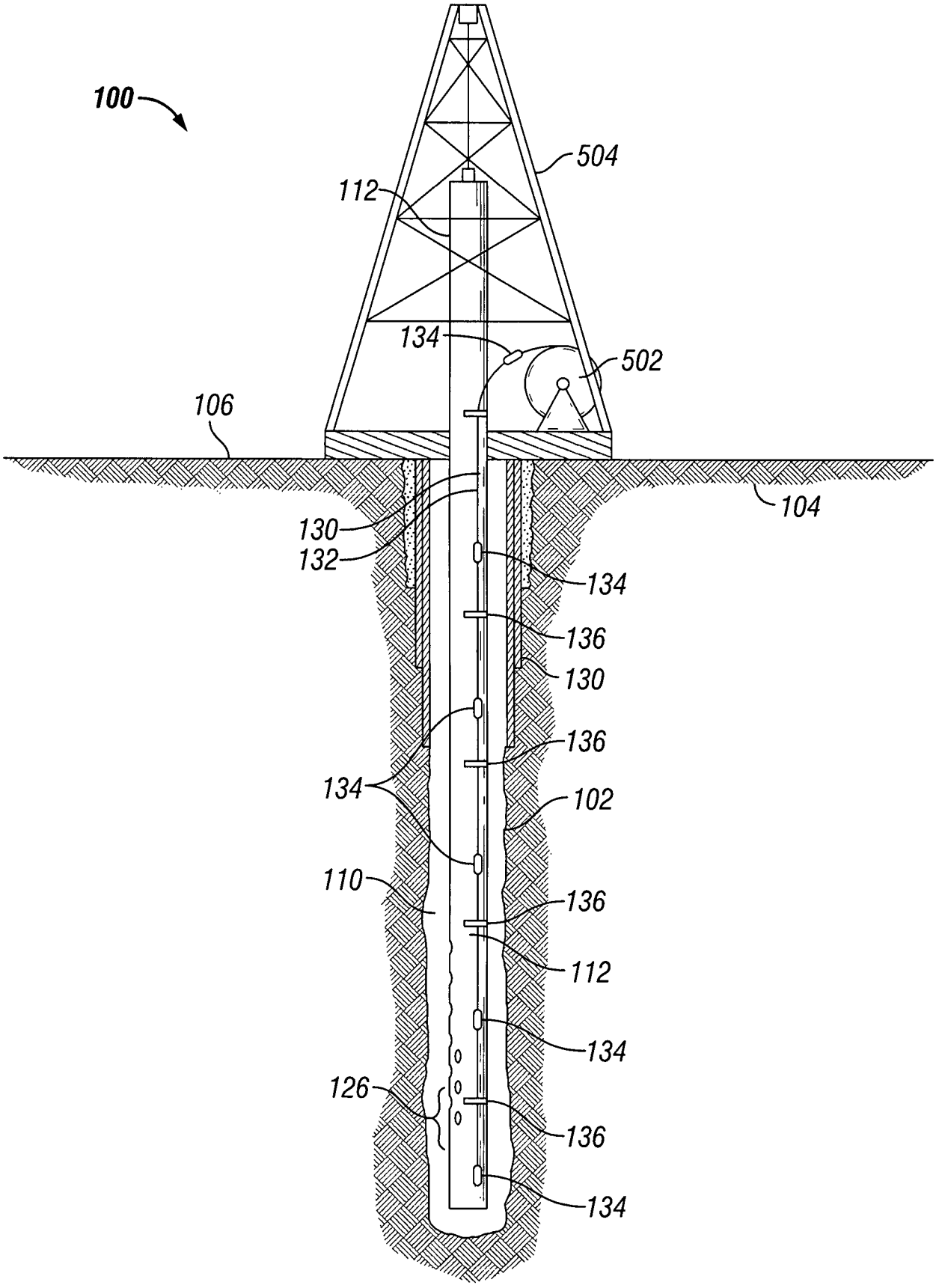
FIG. 4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504
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134
502
106
104
130
132
134
136
130
136
134
102
110
136
112
134
126
136
134

FIG. 5

Abstract

A distributed downhole sensor system for a well includes a sensor array comprising. The sensor array includes a plurality of sensors and cable segments. Each sensor is associated with a unique digital address and locatable downhole to capture sensor data simultaneously and output the simultaneously captured sensor data under a first control condition, and a single sensor of the plurality of sensors is configured to capture sensor data independently and output the independently captured sensor data under a second control condition. The cable segments couple the sensors in a line or an array to deliver power to the sensors and provide a communication channel to and from the sensors.

Rijksdienst voor Ondernemend Nederland

OCTROOIAANVRAAG NR.:
NO 139998
NL 1042671

ONDERZOEKSRAPPORT

BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

RELEVANTE LITERATUUR

Categorie[1]	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren	Van belang voor conclusie(s) nr:	Classificatie (IPC)
X	US 2005/194182 A1 (RODNEY PAUL F [US] ET AL) 8 september 2005 (2005-09-08) * alineas [0010], [0011], [0014], [0015], [0018], [0019], [0030], [0037], [0038]; figuur 1 * -----	1-5	INV. E21B47/01 E21B47/12 E21B17/00
A	US 2013/120154 A1 (GLEITMAN DANIEL [US]) 16 mei 2013 (2013-05-16) * alineas [0015], [0018], [0026], [0037] * -----	1-5	
A	US 6 480 000 B1 (KONG FAN-NIAN [NO] ET AL) 12 november 2002 (2002-11-12) * kolom 5, regel 1 - regel 21 * * kolom 6, regel 46 - kolom 7, regel 9 * -----	1-5	
A	WO 03/083248 A2 (UNION OIL CO [US]; PINTO C JASON [US]) 9 oktober 2003 (2003-10-09) * bladzijde 2, regel 32 - regel 38 * -----	1-5	
A	WO 2010/068643 A1 (SCHLUMBERGER CA LTD [CA]; SCHLUMBERGER SERVICES PETROL [FR]; SCHLUMBER) 17 juni 2010 (2010-06-17) * alineas [0024], [0025] * -----	1-5	Onderzochte gebieden van de techniek E21B
A	WO 2016/040140 A1 (HALLIBURTON ENERGY SERVICES INC [US]) 17 maart 2016 (2016-03-17) * alinea [0026] * -----	1-5	

Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:

Plaats van onderzoek:	Datum waarop het onderzoek werd voltooid:	Bevoegd ambtenaar:
München	27 april 2018	Schneiderbauer, K

[1] CATEGORIE VAN DE VERMELDE LITERATUUR

X: de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur
Y: de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht
A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
O: niet-schriftelijke stand van de techniek
P: tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur
T: na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
E: eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
D: in de octrooiaanvraag vermeld
L: om andere redenen vermelde literatuur
&: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

EPO FORM 1503 (P04149)

AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK, UITGEVOERD IN DE OCTROOIAANVRAGE NR.

NO 139998
NL 1042671

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooischriften genoemd in het rapport.
De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door het Bureau voor de Industriële eigendom gegarandeerd; de gegevens worden verstrekt voor informatiedoeleinden.

27-04-2018

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 2005194182 A1	08-09-2005	BR PI0508369 A	31-07-2007
		CA 2558162 A1	06-10-2005
		CA 2867817 A1	06-10-2005
		CN 1965249 A	16-05-2007
		CN 101832130 A	15-09-2010
		CN 101832131 A	15-09-2010
		GB 2428820 A	07-02-2007
		GB 2448256 A	08-10-2008
		US 2005194182 A1	08-09-2005
		US 2011290559 A1	01-12-2011
		WO 2005091899 A2	06-10-2005
US 2013120154 A1	16-05-2013	AU 2005224600 A1	29-09-2005
		BR PI0508362 A	24-07-2007
		BR PI0508448 A	24-07-2007
		CA 2558332 A1	29-09-2005
		EP 1735642 A2	27-12-2006
		GB 2428096 A	17-01-2007
		NO 335639 B1	12-01-2015
		US 2005194185 A1	08-09-2005
		US 2005200498 A1	15-09-2005
		US 2009260876 A1	22-10-2009
		US 2011253447 A1	20-10-2011
		US 2013120154 A1	16-05-2013
		US 2013213128 A1	22-08-2013
		WO 2005086691 A2	22-09-2005
		WO 2005091019 A1	29-09-2005
US 6480000 B1	12-11-2002	AU 5538199 A	17-01-2000
		BR 9911194 A	06-02-2001
		GB 2355538 A	25-04-2001
		NO 982827 A	20-12-1999
		US 6480000 B1	12-11-2002
		WO 0000850 A1	06-01-2000
WO 03083248 A2	09-10-2003	AU 2003224768 A1	13-10-2003
		WO 03083248 A2	09-10-2003
WO 2010068643 A1	17-06-2010	EP 2376743 A1	19-10-2011
		US 2009182509 A1	16-07-2009
		WO 2010068643 A1	17-06-2010
WO 2016040140 A1	17-03-2016	EP 3175084 A1	07-06-2017
		US 2016273335 A1	22-09-2016
		US 2018058189 A1	01-03-2018
		WO 2016040140 A1	17-03-2016

EPO FORM P0459

Algemene informatie over dit aanhangsel is gepubliceerd in de 'Official Journal' van het Europees Octrooibureau nr 12/82 blz 448 ev

AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK, UITGEVOERD IN DE OCTROOIAANVRAGE NR.

NO 139998
NL 1042671

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooischriften genoemd in het rapport.
De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
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27-04-2018

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
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EPO FORM P0459

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SCHRIFTELIJKE OPINIE

DOSSIER NUMMER	INDIENINGSDATUM	VOORRANGSDATUM	AANVRAAGNUMMER
NO139998	29.03.2017	28.04.2016	NL1042671

CLASSIFICATIE
INV. E21B47/01 E21B47/12 E21B17/00

AANVRAGER
Halliburton Energy Services, Inc.

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- ☒ Onderdeel I Basis van de schriftelijke opinie
- ☐ Onderdeel II Voorrang
- ☐ Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk
- ☐ Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding
- ☒ Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid
- ☐ Onderdeel VI Andere geciteerde documenten
- ☒ Onderdeel VII Overige gebreken
- ☐ Onderdeel VIII Overige opmerkingen

DE BEVOEGDE AMBTENAAR
Schneiderbauer, K

Aanvraag nr.:

SCHRIFTELIJKE OPINIE

NL1042671

Onderdeel I Basis van de Schriftelijke Opinie

1. Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.

2. Met betrekking tot **nucleotide en/of aminozuur sequenties** die genoemd worden in de aanvraag en relevant zijn voor de uitvinding zoals beschreven in de conclusies, is dit onderzoek gedaan op basis van:

   a. type materiaal:

   ☐ sequentie opsomming

   ☐ tabel met betrekking tot de sequentie lijst

   b. vorm van het materiaal:

   ☐ op papier

   ☐ in elektronische vorm

   c. moment van indiening/aanlevering:

   ☐ opgenomen in de aanvraag zoals ingediend

   ☐ samen met de aanvraag elektronisch ingediend

   ☐ later aangeleverd voor het onderzoek

3. ☐ In geval er meer dan één versie of kopie van een sequentie opsomming of tabel met betrekking op een sequentie is ingediend of aangeleverd, zijn de benodigde verklaringen ingediend dat de informatie in de latere of additionele kopieën identiek is aan de aanvraag zoals ingediend of niet meer informatie bevatten dan de aanvraag zoals oorspronkelijk werd ingediend.

4. Overige opmerkingen:

Aanvraag nr.:

SCHRIFTELIJKE OPINIE

NL1042671

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja:	Conclusies 5
	Nee:	Conclusies 1-4
Inventiviteit	Ja:	Conclusies
	Nee:	Conclusies 1-5
Industriële toepasbaarheid	Ja:	Conclusies 1-5
	Nee:	Conclusies

2. Citaties en toelichting:

Zie aparte bladzijde

Onderdeel VII Overige gebreken

De volgende gebreken in de vorm of inhoud van de aanvraag zijn opgemerkt:

Zie aparte bladzijde

Reference is made to the following documents:

D1	US 2005/194182 A1 (RODNEY PAUL F [US] ET AL) 8 september 2005 (2005-09-08)
D2	US 2013/120154 A1 (GLEITMAN DANIEL [US]) 16 mei 2013 (2013-05-16)
D3	US 6 480 000 B1 (KONG FAN-NIAN [NO] ET AL) 12 november 2002 (2002-11-12)
D4	WO 03/083248 A2 (UNION OIL CO [US]; PINTO C JASON [US]) 9 oktober 2003 (2003-10-09)
D5	WO 2010/068643 A1 (SCHLUMBERGER CA LTD [CA]; SCHLUMBERGER SERVICES PETROL [FR]; SCHLUMBER) 17 juni 2010 (2010-06-17)
D6	WO 2016/040140 A1 (HALLIBURTON ENERGY SERVICES INC [US]) 17 maart 2016 (2016-03-17)

Re Item V

1.) The subject-matter of independent claim 1 is not new over the teachings of D1.

D1 describes:

Werkwijze voor het plaatsen van een verdeeld sensorsysteem in een boorgat, omvattende:

i) het voorzien van een geprefabriceerde sensorreeks, waarbij de geprefabriceerde sensorreeks meerdere sensoren omvat die samen zijn gekoppeld via kabelsegmenten;

-> downhole sensor modules 170 (paragraph 10 and figure 1) which are coupled by communication media 190 (which can be a cable: paragraph 11)

ii) het koppelen van de geprefabriceerde sensorlijn met een productieleiding;

-> first sentence of paragraph 10

iii) het naar beneden brengen van de productieleiding in het boorgat;

-> figure 1

iv) en het verder naar beneden brengen van de productieleiding in het boorgat, waarbij het tweede deel van de geprefabriceerde sensorlijn zich boven het eerste deel van de geprefabriceerde sensorlijn bevindt.

-> figure 1: sensor line with sensor modules 170 consists of at least two parts from which one is located above the other.

2.) The dependent claims.

The subject-matter of claims 2-4 is disclosed in D1 and therefore not new. In particular:

2. Werkwijze volgens conclusie 1, verder omvattende:
het koppelen van de geprefabriceerde sensorlijn met een controlesysteem; en het leveren van stroom aan de meerdere sensoren vanuit het controlesysteem.

-> processor 185; paragraph 11

3. Werkwijze volgens conclusie 1, waarbij de storing van een van de meerdere sensoren geen invloed heeft op de functionaliteit van enige andere sensor in de meerdere sensoren.

-> paragraph 18; sensors can be addressed individually for sensing their data uphole

4. Werkwijze volgens conclusie 1, waarbij de meerdere sensoren een temperatuursensor, een druksensor, of beide, omvatten.

-> paragraph 10: WOB sensors

The subject-matter of claim 5 is standard knowledge for a skilled worker and therefore not inventive:

5. Werkwijze volgens conclusie 1 of 4, waarbij de meerdere sensoren een of meerdere op kwarts gebaseerde sensoren omvatten.

Re Item VII

The relevant background art disclosed in D1 is not mentioned in the description, nor is this document identified therein.

Independent claim 1 is not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble and the remaining features being included in the characterising part.

The features of claims 1-5 are not provided with reference signs placed in parentheses.