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(54) Title: REMOTE TOOL POSITION AND TOOL STATUS INDICATION

(57) Abstract: A system is described that is positionable downhole in well-bore for determining a parameter of a downhole tool. The system includes a tubing subassembly and a signal generator positioned in the tubing sub-assembly for outputting, in response to being covered or uncovered by a detectable portion of a downhole tool, a detectable signal for determining a parameter of the downhole tool.

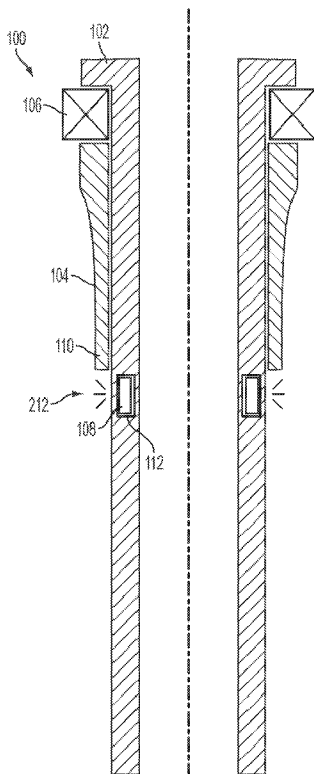
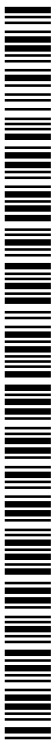


FIG. 2





TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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Remote Tool Position and Tool Status Indication

Technical Field

[0001] The present disclosure relates generally to indication of tool position, movement, and/or functionality in a well completion.

Background

[0002] Oilfield operations may involve the use of various tools in a downhole environment located at a significant distance from a tool operator. During use, tools may need to be positioned in exact locations in a well or may include actuating parts or pieces that need to be actuated in certain ways to complete the desired tasks. It may be desirable to determine a position or status of a tool before performing additional operations. It can be difficult to obtain information about the position and status of tools used downhole, including for example the actuation or movement of parts of a tool.

Brief Description of the Drawings

[0003] Fig. 1 is a cross-sectional view of an embodiment with a downhole tool covering a set of signal generators incorporated in a tubing string according to one example.

[0004] Fig. 2 is a cross-sectional view of the embodiment of Fig. 1 with a downhole tool not covering a set of signal generators incorporated in a tubing string according to one example.

[0005] Fig. 3A is a cross-sectional view of an embodiment with a downhole structure having a closed port and a signal generator according to one example.

[0006] Fig. 3B is a cross-sectional view of the embodiment of Fig. 3A with a downhole structure having a signal generator generating a signal in response to an open port according to one example.

[0007] Fig. 4 is a schematic of an embodiment of a signal generator with a sensor and a signal generation device according to one example.

[0008] Fig. 5 is a schematic of an embodiment of a signal generator with a sensor incorporating a signal generation device according to one example.

[0009] Fig. 6 is a flowchart of an example of a process of using a signal generator according to one embodiment.

[0010] Fig. 7 is a flowchart of an example of a process of using a signal generator according to another embodiment.

[0011] Fig. 8 is a flowchart of an example of a process of using a signal generator according to another embodiment.

[0012] Fig. 9A is a block diagram of an embodiment with a tubing subassembly having two signal generators according to one example.

[0013] Fig. 9B is a block diagram of an alternate embodiment with a tubing subassembly having one signal generator according to one example.

Detailed Description

[0014] One or more signal generators can be provided in a downhole environment to provide recognizable feedback signals to a tool operator as an

indication that the tool has reached a desired position or actuated in the intended fashion. The signals can be generated, transmitted, and received electrically, mechanically, acoustically, or through other signaling methodologies. A signal generator can indicate when a tool has moved to a certain position. A signal generator can provide confirmation that a tool has operated properly or improperly, depending upon the application. The confirmation can be a positive confirmation that the tool, or at least a desired portion of the tool, has actually reached a desired position or configuration, rather than simply that it should be in the desired position or configuration. In some cases, multiple signal generators may be used to provide the desired indication.

[0015] In some embodiments, a signal generator can generate a signal when it is covered by a tool that is properly set or released downhole or that is properly changed position or actuated downhole. The signal can be detected to confirm that the tool has been properly set, released, actuated, or otherwise changed position downhole. In other embodiments, a signal generator can generate a signal when it is uncovered by a tool and can stop generating the signal when it is covered by the tool that is properly set, released, actuated, or otherwise changed positioned downhole. The absence of the signal can be detected to confirm that the tool has been properly set, released, actuated, or otherwise changed position downhole. In an example, a signal generator may provide positive indication of a port being opened by generating a signal when the port is opened. In such an example, the signal generator may provide positive indication of a port being closed by generating a signal continuously until ceasing when the port is closed. In another example, a signal generator

may provide positive indication of a port being opened by generating a signal continuously until ceasing when the port is opened. In such an example, the signal generator may provide positive indication of a port being closed by generating a signal when the port is closed.

[0016] In certain embodiments, the signals generated by the signal generator are transmitted to, and received by, a device associated with the tool operator, thus giving the tool operator feedback about the position and status of the tool.

[0017] These illustrative examples are given to introduce the reader to the general subject matter discussed here and are not intended to limit the scope of the disclosed concepts. The following sections describe various additional features and examples with reference to the drawings in which like numerals indicate like elements, and directional descriptions are used to describe the illustrative aspects but, like the illustrative aspects, should not be used to limit the present disclosure.

[0018] Fig. 1 depicts by cross section an arrangement 100 of downhole equipment according to one embodiment. As used herein, the term “downhole” generally refers to equipment used within a well or borehole and the term “tubing subassembly” refers to any piece of downhole equipment or a part thereof, including a downhole tool. The arrangement 100 includes a tubing string 102, a packer 106, and a tool 104. A tubing string 102 may be positioned within the borehole and may include one or more signal generators 108 positioned proximate the outer diameter (“OD”) of the tubing string 102. The signal generators 108 may be included in a compartment 112 or otherwise situated within the desired piece of downhole equipment. The

compartment 112 may be entirely enclosed by the downhole equipment or may include holes, access panels, or other openings to aid in sensing, signal generation, signal transmission, or access to the signal generator 108. A tool 104 can removably lock onto the OD of the tubing string 102. The arrangement 100 of Fig. 1 is shown with the tool 104 in an unlocked and released state. When in a released state, the tool 104 may include a portion 110 that is located proximate to the OD of the tubing string 102 and to the signal generator 108. The signal generator 108 may include at least one sensor and at least one signal generation device, as described below. The signal generator 108 may detect the proximity of the portion 110 and provide no signal generation. When the portion 110 is in close proximity to the signal generator 108, the signal generator 108 may be considered to be in a "covered" state. The signal generator 108 may detect the proximity of the portion 110 through various positive and negative methods as recited below.

[0019] Fig. 2 depicts by cross section the arrangement 100 of downhole equipment of Fig. 1 with the tool 104 in a set state. The portion 110 may not be in close proximity to the signal generator 108 when the tool 104 is in a set state. The signal generator 108 may be considered to be in an "uncovered state" when the portion 110 is not in close proximity to the signal generator 108. The signal generator 108 may generate a signal 212 when in this uncovered state. The signal 212 may take various forms and may be transmitted in various ways, as described below. In some embodiments, a signal generator 108 may be positioned to detect whether the tool 104 is in a locked state or an unlocked state. Detection of whether the tool 104 is in a

locked state or an unlocked state may be independent of detection of whether the tool 104 is in a set state or a released state.

[0020] Referring to Figs. 1 and 2, the arrangement 100 includes signal generators 108 that can detect the positions of the tool 104 relative to the tubing string 102. In some embodiments, the signal generators 108 may detect the position of any piece of downhole equipment in relation to any other piece of downhole equipment. The signal generators 108 may be located within the tool 104, the packer 106, or on other downhole equipment. The portion 110 sensed by the signal generators 108 may be included on the tubing string 102, the packer 106, or on other downhole equipment.

[0021] Fig. 3A depicts by cross section a part of downhole equipment 300 according to a second embodiment. The downhole equipment 300 may include a body section 302 having a port 308. Fig. 3A is a partial view showing only a portion of the piece of downhole equipment 300 on one side of a centerline 310 of a borehole. The port 308 may be opened or closed by an actuatable member 304, shown here in a closed configuration. The body section 302 includes a signal generator 306 located proximate the inner diameter ("ID") of the downhole equipment 300 and within a compartment 312. When the actuatable member 304 is in a closed configuration, the actuatable member 304 is not in close proximity to the signal generator 306, and the signal generator 306 may be considered to be in an "uncovered" state. When in an uncovered state, the signal generator 306 may generate no signal.

[0022] Fig. 3B depicts by cross section the part of downhole equipment 300 of Fig. 3A with the signal generator 306 in a "covered" state. The

downhole equipment 300 includes a body section 302 having a port 308. The port 308 is shown here in an open configuration with the actuatable member 304 being in close proximity to the signal generator 306. In this state, the signal generator 306 may be considered to be in a “covered” state. When in a covered state, the signal generator 306 may generate a signal 332, as described below. It will be understood that the signal 332 may take various forms and may be transmitted in various ways, as recited below.

[0023] Referring to Figs. 3A and 3B, the part of downhole equipment 300 includes a signal generator 306 that can detect the position of an actuatable member 304 relative to body section 302. In some embodiments, the actuatable member 304 may be configured for purposes other than opening or closing a port. In some embodiments, a signal generator 306 can detect the position or movement of other types of actuatable members, such as actuatable members that can engage pieces, lock pieces, extend tools, retract tools, extend surfaces, retract surfaces, or any other function that involves a movable part. Signal generators 306 may be positioned such that the signal generators 306 become “covered” or “uncovered” whenever actuatable members, such as those outlined above, change positions to or from a desired position. In some embodiments, the signal generator 306 may be located within the actuatable member 304 or on other downhole equipment and may detect the proximity of certain portions of other downhole equipment, such as portions of the body section 302.

[0024] Fig. 4 is a block diagram of an embodiment of a signal generator 400. The signal generator 400 may include a sensor 402 in communication with a signal generation device 404. The sensor 402 and signal generation

device 404 may be collocated within a single housing or may be located in separate housings. As used herein, any description of the location of a signal generator 400 within a piece of downhole equipment may be interpreted as describing the location of the sensor 402 of the signal generator 400. A signal generator 400 may include more than one sensor 402 and more than one signal generation device 404.

[0025] The sensor 402 may be electrical, magnetic, mechanical, or other type of sensor. For example, the sensor 402 may be a magnetic sensor (e.g., reed switch or hall effect sensor), a pressure sensor (e.g., piezo element or a strain gauge), an optical sensor (e.g., photodetector), a chemical sensor, an electrical sensor (e.g., inductive sensor or capacitive sensor), a flow sensor, a radiation sensor, or an acoustic sensor (e.g., sonar).

[0026] The sensor 402 may be configured to detect being covered or uncovered by a desired portion of downhole equipment. In some embodiments, a "detection event" occurs when the sensor 402 is covered. In some embodiments, a "detection event" occurs when the sensor 402 is uncovered.

[0027] The position and placement of the sensor 402 may depend on the type of sensor 402 used. In some embodiments, the sensor 402 may interact with a source 406 to properly detect a detection event. The type of source 406 selected to effectuate the sensor 402 may depend on the sensor 402 used. For example, a magnetic sensor may require a source that is a magnet; an optical sensor may require a source that is a light source (e.g., light emitting diode), and a radiation sensor may require a source with measurable radioactive decay. The source 406 may be located external to, or

incorporated in the signal generator 400. In some embodiments, the source 406 may be incorporated into the portion of downhole equipment for which detection is desired, such as within an actuatable member or other detectable portion.

[0028] In some embodiments, the portion of downhole equipment for which detection is desired may be the source. In one embodiment, the actuatable member or other detectable portion may provide sufficient pressure to the sensor 402 to generate a detection event.

[0029] In some embodiments, emissions from a source 406 may be reflected off the portion of downhole equipment for which detection is desired. In one embodiment, a sensor 402 that is an optical sensor may trigger a detection event when it detects light from a source 406 reflected off of an actuatable member or other detectable portion. In another embodiment, a sensor 402 that is an acoustic sensor may trigger a detection event when it detects sound waves from a source 406 reflected off of an actuatable member or other detectable portion. The source 406 may be included within the signal generator 400, located proximate the signal generator 400, or located elsewhere.

[0030] In some embodiments, the sensor 402 may require clear line of sight to the actuatable member or other detectable portion in order to properly detect a detection event. Such clear line of sight may include holes or other openings between a compartment in which the sensor is located and the actuatable member or other detectable portion.

[0031] The signal generation device 404 may be any device capable of generating a detectable signal that may be ultimately received by a tool

operator, a processor, or another receiver. The signal generation device 404 may generate detectable signals which are acoustic, electrical, or other in nature. As used herein, an electrical signal includes signals by wire and wireless (e.g., radio frequency). In certain embodiments, the signal generation device 404 is acoustic in nature and produces a discernible acoustic signal that is transmitted from the signal generator 400 to a tool operator or piece of receiving equipment. Such transmission may be through any combination of tubular conduction (e.g., mechanical conduction of acoustic signals through the tube string), hydrophonic conduction (e.g., picking up acoustic signals from a hydrophone located within functional distance of the signal generator 400, such as in nearby water), or other acoustic conduction means. A signal generation device 404 that generates acoustic signals may be primarily mechanical in nature (e.g., a mechanical hammer that creates noise by hammering an object), primarily electrical in nature (e.g., an electrical circuit driving an acoustic transducer to generate an acoustic sound), or other.

[0032] The signal generation device 404 may include elements capable of producing electrical signals that are transmitted to a tool operator or other receiver in various ways, such as by wire or wirelessly. In some embodiments, the signal generation device 404 sends a wireless signal that is repeated by one or more repeating elements positioned in the borehole. In such embodiments, these repeating elements may be unique repeating devices or may be other signal generation devices 404 configured to also operate as repeaters. These electrical signals may ultimately reach the control rig. These signals may result in display elements on a annunciator

panel or computer screen, or any other method, visual or otherwise, of indicating the presence of an electrical signal to a tool operator.

[0033] In some embodiments, one or more signal generators 400 or one or more sensors 402 may be used. In such embodiments, each signal generator 400 may be capable of sending a signal that includes information about which sensor 402 detected a detection event. In some embodiments, multiple sensors 402 may be included in a single signal generator 400. Such information may include a serial number or other identifying information about the sensor 402 or signal generator 400. In such embodiments, the tool operator or other receiver may be able to discern which of multiple signal generators 400 or multiple sensors 402 detected a detection event. In embodiments where the signal generation device 404 is acoustic in nature, identifying information may be transmitted by producing acoustic patterns unique to particular sensors 402 or signal generators 400.

[0034] Fig. 5 depicts a block diagram of an alternate embodiment of a signal generator 500 including a sensor 502 incorporating a signal generation device 504. This sensor 502 may act to both sense the proximity of the portion of downhole equipment for which detection is desired and produce a signal. In some embodiments, the sensor 502 is a mechanical device that produces an acoustic noise when it interacts with the portion of downhole equipment for which detection is desired (e.g., a spring-biased clapper that claps the tubing string when uncovered). In such embodiments, the signal is the acoustic noise.

[0035] Fig. 6 is a block diagram depicting an example of using the a signal generator according to an embodiment. A sensor detects a covering or

uncovering of the sensor at 602. Upon detecting the detection event at 602, the signal generation device may generate a detectable signal at 604.

[0036] In some embodiments, the signal generator may log the detection event in an internal memory at 606. Such a log may include time information, location information, and any other information available to the sensor. Such a log may be accessed at a later time, as described further below. In alternate embodiments, the signal generator may not log any information and no internal memory may be present.

[0037] Fig. 7 is a block diagram depicting an example of using a signal generator according to an alternate embodiment. A sensor detects whether it is covered at 702. If the sensor is covered, the signal generator begins generating a detectable signal at 704. 704 may continue indefinitely while the sensor remains covered. Whenever the sensor is no longer covered at 702, the signal generator may cease generating a detectable signal at 706.

[0038] In some embodiments, the sensor may instead detect whether it is no longer covered at 702.

[0039] In some embodiments, 704 and 706 may be switched, such that the signal generator does not generate a detectable signal while the sensor is covered, but generates a detectable signal whenever the sensor is not covered. In such embodiments, a signal generator may produce a detectable signal continuously as a tool is being inserted into the downhole space until the tool has reached the desired position, at which point the signal generator will cease generating a detectable signal.

[0040] Fig. 8 is a block diagram depicting an example of preparing a piece of downhole equipment for use with a signal generator according to an

embodiment. The position of the sensor may be determined based on the desired detection event at 800. 800 may include preparing a piece of downhole equipment with a structure capable of covering or uncovering a signal generator. 800 may further include preparing any holes or other openings necessary for operation of the sensor. 800 may also include determining an existing structure that may be used to cover or uncover a signal generator. Once the position of the sensor has been determined, the sensor may be incorporated into the downhole equipment at the determined position at 802.

[0041] In some embodiments the signal generator may be accessed after it has been incorporated into the downhole equipment at 804. Such access may be for retrieval of saved or logged data in the signal generator, for repairs such as sensor replacement or battery replacement, for programming, or for other purposes. In some embodiments, the signal generator would be removable from the piece of downhole equipment. In some embodiments, the signal generator would be included within an accessible recess in the downhole equipment. In some embodiments, the signal generator would be accessible for data collection and/or recharging without removing the signal generator from the piece of downhole equipment. Such access may be achieved through physical connection through ports on the piece of downhole equipment, through wireless (e.g., radio frequency or inductive communications), or other means. In some embodiments, the signal generator may be permanently or semi-permanently included in the downhole equipment and may not be accessible without destroying the signal generator

or the downhole equipment. In some embodiments, the signal generator is not accessed after it has been incorporated into the downhole equipment.

[0042] Fig. 9A is a block diagram of an embodiment with a tubing subassembly having two signal generators according to one example. A tubing subassembly 900 is shown having a first signal generator 902 and a second signal generator 906. Upon being covered and/or uncovered (e.g., a first detection event), the first signal generator 902 can generate a first signal 904. Upon being covered and/or uncovered (e.g., a second detection event), the second signal generator 906 can generate a second signal 908. The second signal 908 can be unique and discernibly different from the first signal 904. The first signal generator 902 and second signal generator 906 can be placed such that the first signal 904 and second signal 908 are generated in response to different parameters of the tubing subassembly, such as a position, an actuation, a set state, a released state, a locked state, or an unlocked state. The first signal 904 and second signal 908 can each be electrical or acoustic in nature.

[0043] In one aspect, the tubing subassembly can be a ported sleeve where both the first and second signal generators 902, 906 generate no signals when the port is opened, the first signal generator 902 generates a first signal 904 when the port is closed, and the second signal generator 906 generates a second signal 908 when the port is closed and the tubing subassembly is in a locked state.

[0044] Fig. 9B is a block diagram of an alternate embodiment with a tubing subassembly having one signal generator according to one example. A tubing subassembly 910 is shown having a signal generator 912. Upon

being covered and/or uncovered, the signal generator 912 can generate either a first signal 904 or a second signal 908. The second signal 908 can be unique and discernibly different from the first signal 904. The signal generator 902 can generate the first signal 904 in response to one parameter of the tubing subassembly and can generate the second signal 908 in response to another parameter of the tubing subassembly. Parameters of the tubing subassembly can include a position, an actuation, a set state, a released state, a locked state, or an unlocked state.

[0045] In one aspect, the tubing subassembly can be a ported sleeve where the signal generator 912 generates no signals when the port is opened, generates a first signal 904 when the port is closed, and generates a second signal 908 when the port is closed and the tubing subassembly is in a locked state.

[0046] In one aspect, the signal generator 912 can include a first sensor 914 and a second sensor 916. Such a signal generator 912 can generate a first signal 904 in response to a first sensor 914 being covered or uncovered (e.g., a first detection event), and can generate a second signal 908 in response to a second sensor 916 being covered or uncovered (e.g., a second detection event).

[0047] In one aspect, the signal generator 912 can include only a first sensor 914. The signal generator 912 can be configured to discern between the first sensor 914 being covered in different manners and generate a first signal 904 when covered in a first manner (e.g., a first detection event) and generate a second signal 908 when covered in a second manner (e.g., a second detection event).

[0048] In one aspect, the signal generator 912 can be configured to discern between the first sensor 914 being covered by a first source 918 and a second source 920. In one aspect, the first sensor 914 may be a magnetic sensor and the first source 918 may have a magnetic field strength that is discernibly different from that of a second source 920. In another aspect, the first sensor 914 may be a sonar sensor and the first source 918 may have a discernibly different sonar response than that of the second source 920.

[0049] The foregoing description of the aspects, including illustrated aspects, of the disclosure has been presented only for the purpose of illustration and description and is not intended to be exhaustive or to limit to the precise forms disclosed. Numerous modifications, adaptations, and uses thereof will be apparent to those skilled in the art without departing from the scope of this disclosure.

Claims

What is claimed is:

1. A system positionable downhole in wellbore, the system comprising:
a tubing subassembly; and
a signal generator positioned in the tubing subassembly for outputting, in response to being covered or uncovered by a detectable portion of a downhole tool, a detectable signal for determining a parameter of the downhole tool.
2. The system of claim 1, wherein the signal generator includes one or more signal generators in the tubing subassembly, at least one signal generator being operable for outputting, in response to being covered or uncovered by the detectable portion of the downhole tool, a second detectable signal that is different than the detectable signal to determine a change in the parameter or to determine a second parameter of the downhole tool.
3. The system of claim 1, wherein the parameter of the downhole tool is a position, an actuation, a set state, a released state, a locked state, or an unlocked state.

4. The system of claim 1, wherein:
the signal generator includes a sensor for detecting being covered or uncovered by the detectable portion; and
the sensor is a pressure sensor, an electrical sensor, an acoustic sensor, or an optical sensor.
5. The system of claim 4, wherein the sensor is a sonar sensor.
6. The system of claim 1, wherein the signal generator generates an acoustic signal that is conducted through a tubing string.
7. The system of claim 1, wherein the signal generator generates an electrical signal.
8. The system of claim 7 additionally comprising a repeating element located between the signal generator and a control rig that repeats the electrical signal.
9. The system of claim 7, additionally comprising a memory, wherein the detectable signal is a log entry in the memory.

10. The system of claim 1, wherein:

- the tubing subassembly includes a compartment therein;
- the signal generator is positioned in the compartment;
- the signal generator includes an acoustic sensor for detecting being covered or uncovered by the detectable portion;
- the downhole tool is a separate part from the tubing subassembly;
- the compartment is positioned such that the detectable portion covers the acoustic sensor when the downhole tool is in a released state; and
- wherein the signal generator is operable for outputting an acoustic signal into a wellbore environment.

11. A downhole notification method comprising:

- detecting a detection event by a signal generator positioned within a tubing subassembly, the detection event corresponding to a covering or uncovering of the signal generator by a detectable portion of a downhole tool;
- generating a detectable signal, by the signal generator, in response to the detecting.

12. The method of claim 11, wherein the signal generator includes one or more signal generators, additionally comprising:

- detecting a second detection event by at least one signal generator corresponding to the at least one signal generator being covered or uncovered by the detectable portion; and
- generating a second detectable signal that is different than the detectable signal.

13. The method of claim 11, wherein the signal generator is positioned such that the detecting correlates to a position of the downhole tool, an actuation of the downhole tool, a set state of the downhole tool, a release state of the downhole tool, a locked state of the downhole tool, or an unlocked state of the downhole tool.

14. The method of claim 11, wherein:

the detecting is performed by a sensor of the signal generator, the sensor being a pressure sensor, an electrical sensor, an acoustic sensor, or an optical sensor.

15. The method of claim 14, wherein the sensor is a sonar sensor and the detecting is performed by sonar.

16. The method of claim 11, wherein the detectable signal includes information indicative of an identification of the signal generator, a location of the signal generator, or state of the downhole tool.

17. The method of claim 11, additionally comprising:

logging the detection event in a memory.

18. The method of claim 11, additionally comprising:

relaying the detectable signal through a repeater to a control rig.

19. A system positionable downhole in wellbore, the system comprising:
a tubing subassembly having a compartment;
a signal generator, having a sensor and a signal generation device, for determining a parameter of a downhole tool; wherein:

the sensor is positioned in the compartment for detecting being covered or uncovered by a detectable portion of the downhole tool, the sensor being a pressure sensor, an electrical sensor, an acoustic sensor, or an optical sensor;

the signal generation device is operatively coupled to the sensor for generating an acoustic signal or an electrical signal in response to the sensor being covered or uncovered by the detectable portion; and

the parameter of the downhole tool is a position, an actuation, a set state, a released state, a locked state, or an unlocked state.

20. The system of claim 19, wherein:

the tubing subassembly is a tubing string;

the compartment includes an opening to an outer diameter of the tubing string;

the detectable portion is a portion of the downhole tool locatable about the outer diameter of the tubing string; and

the sensor is located such that it is coverable by the downhole tool when the downhole tool is in a released position.

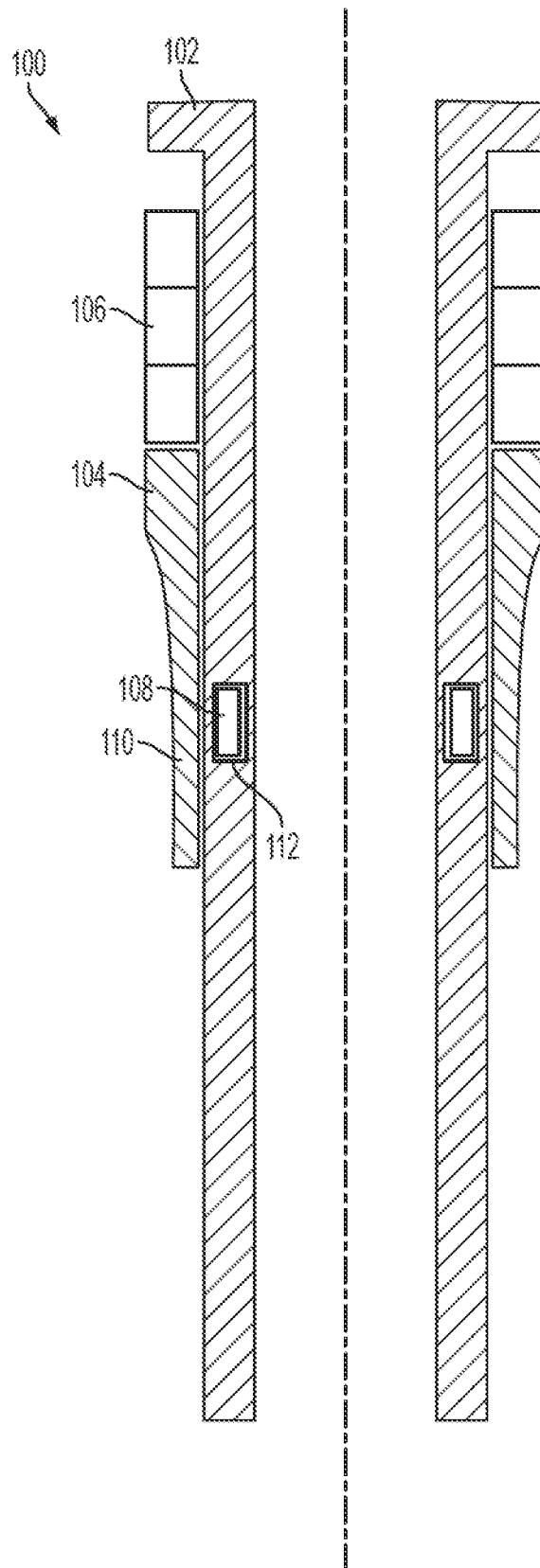


FIG. 1

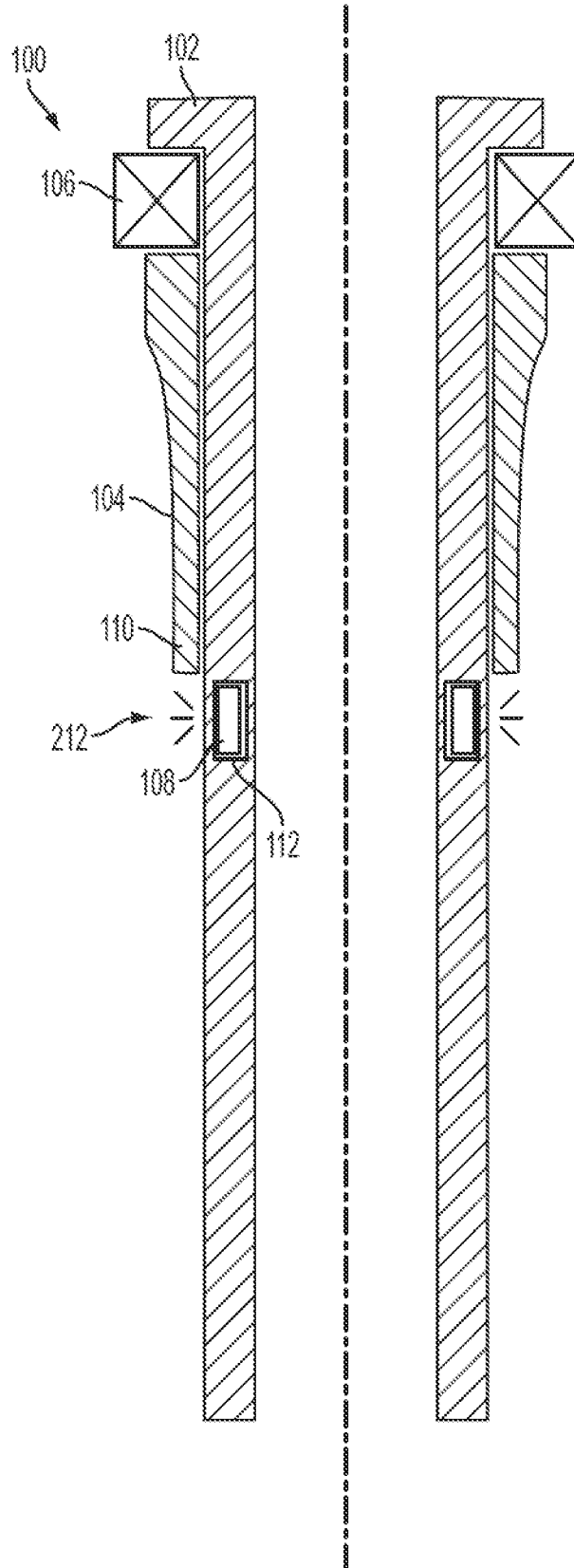


FIG. 2

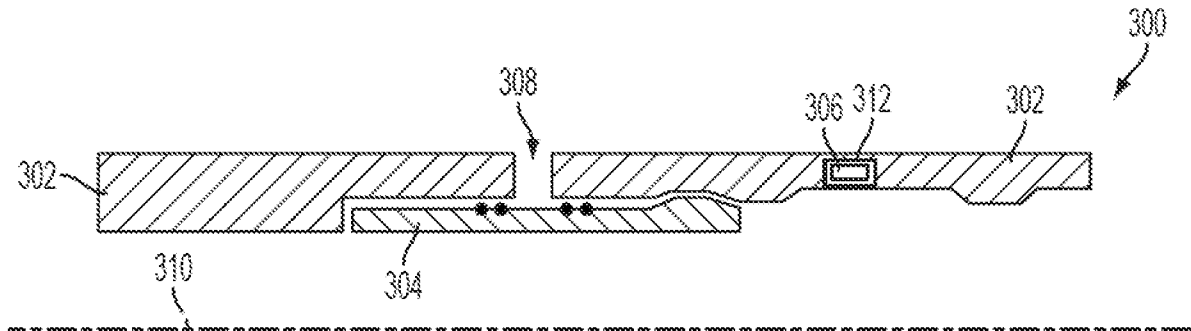


FIG. 3A

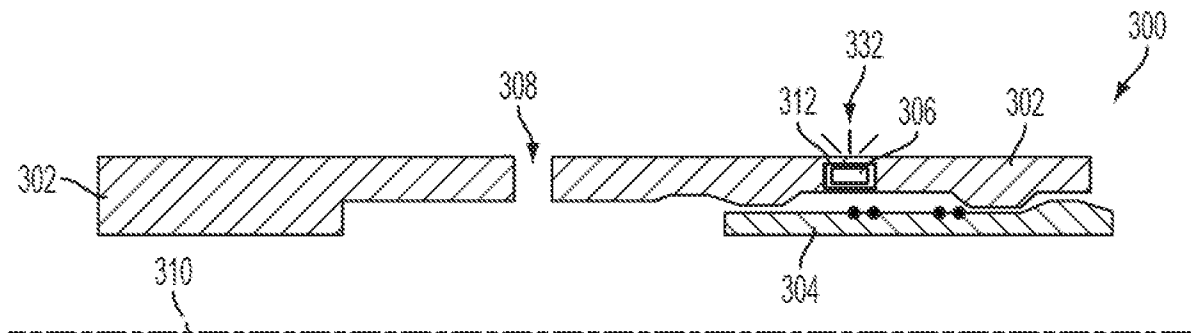
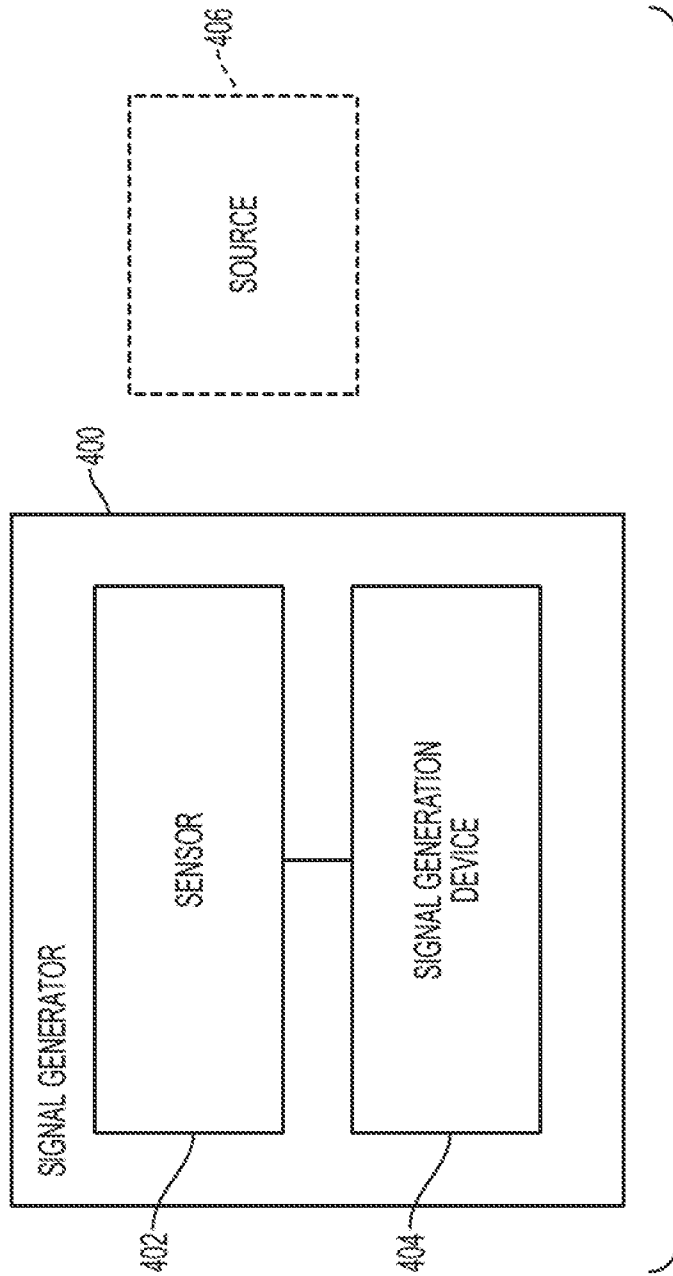


FIG. 3B



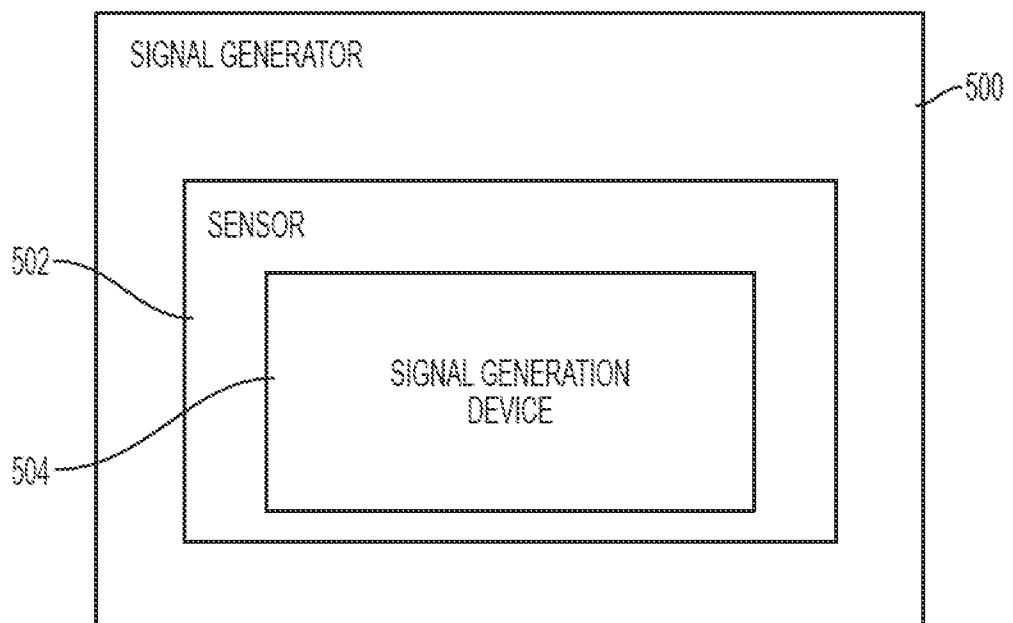


FIG. 5

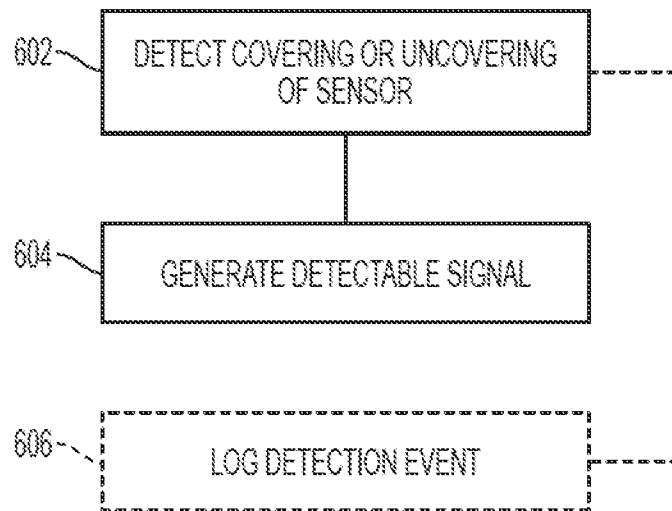


FIG. 6

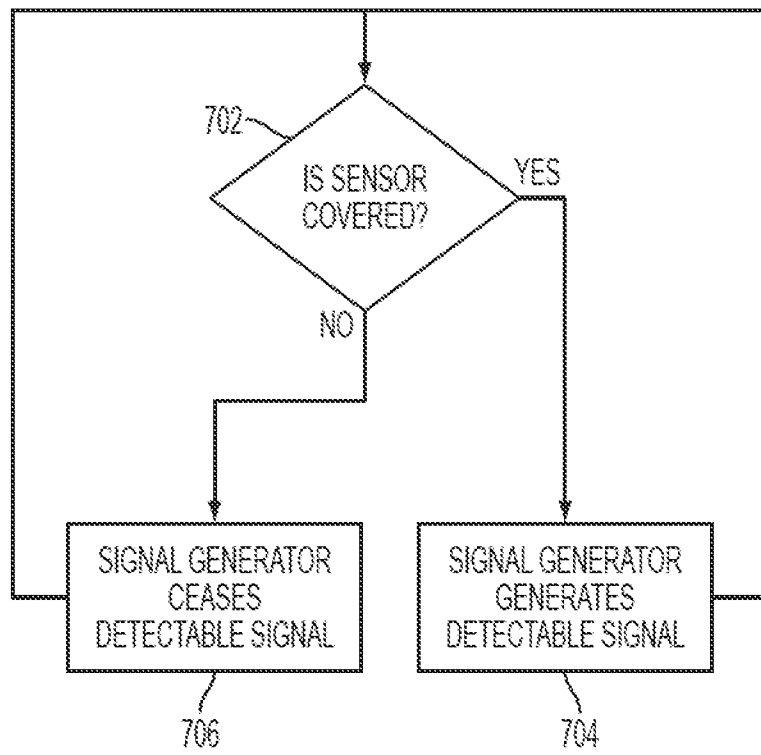


FIG. 7

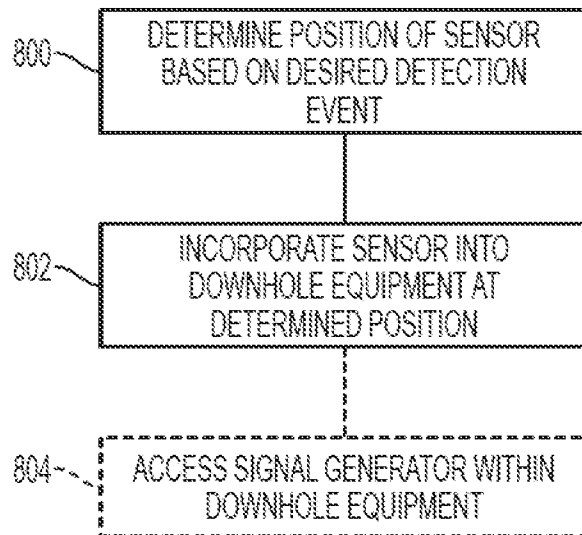


FIG. 8

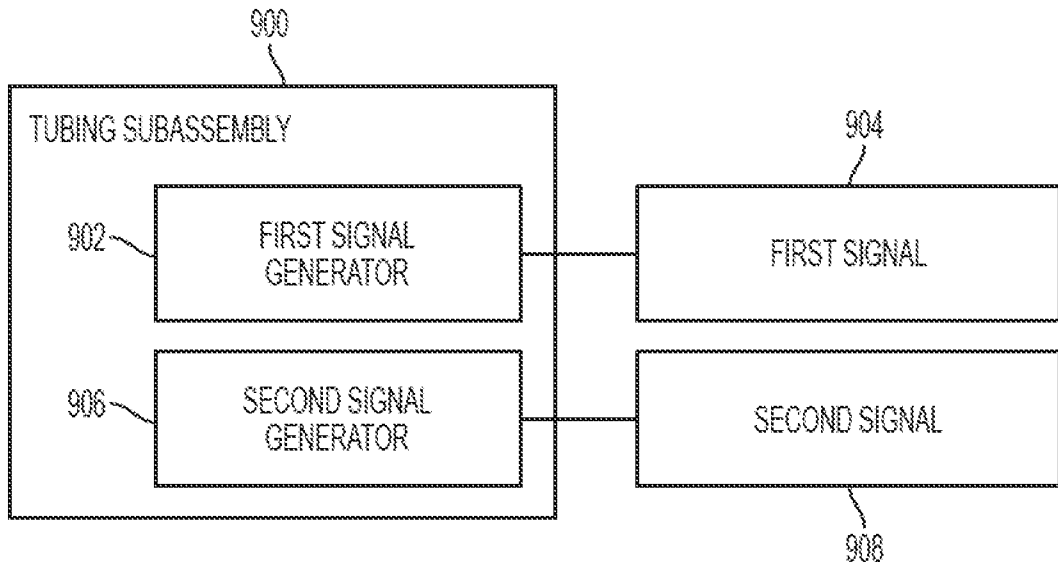


FIG. 9A

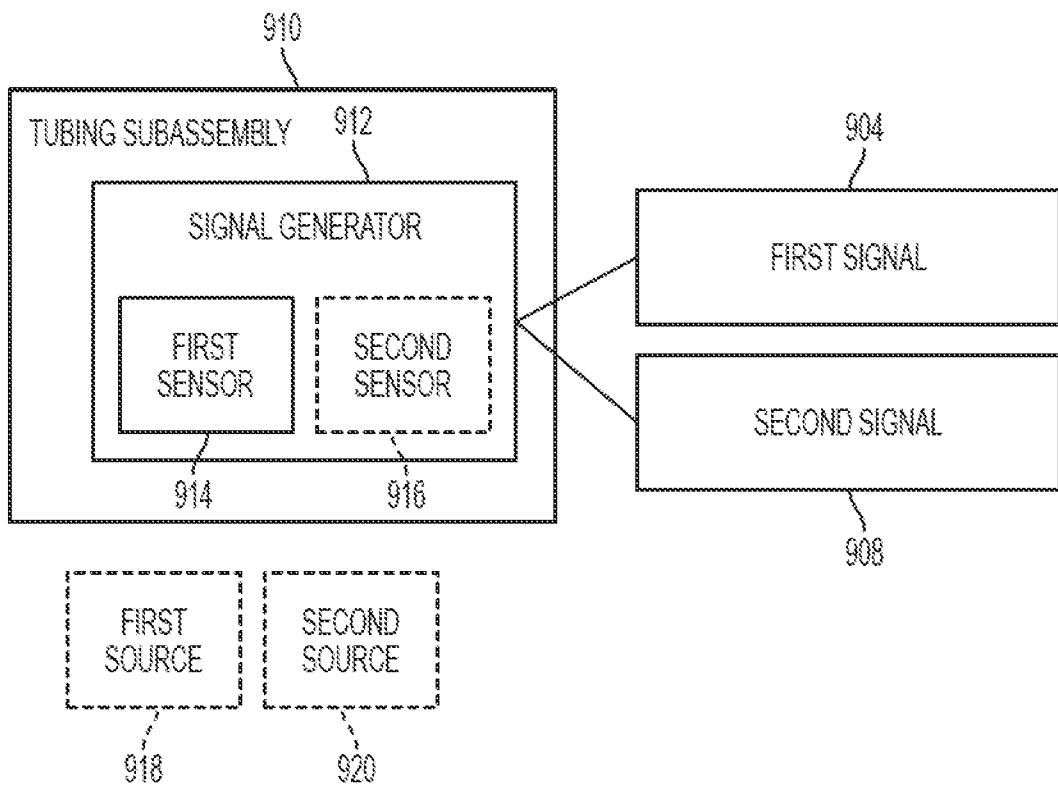


FIG. 9B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/012438**A. CLASSIFICATION OF SUBJECT MATTER****E21B 47/024(2006.01)i, E21B 47/09(2006.01)i, E21B 12/02(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 47/024; E21B 47/00; E21B 34/06; G01V 3/00; G01B 7/14; E21B 33/12; E21B 47/09; E21B 29/02; E21B 12/02

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: signal generator, sensor, repeating element, released state, downhole tool, and tubing subassembly

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004-0194958 A1 (MAYEU, CHRISTOPHER W. et al.) 07 October 2004 See abstract, paragraphs [0016]-[0021], [0029], and figures 1, 2, 5.	1-6,10-16
Y		7-9,17-20
Y	US 2003-0102980 A1 (KORO, VICTOR) 05 June 2003 See abstract, paragraph [0076], and figure 2.	7-9,17-20
A	US 2009-0128141 A1 (HOPMANN, DON A. et al.) 21 May 2009 See abstract, paragraphs [0029], [0030], and figure 1.	1-20
A	US 2005-0263279 A1 (VACHON, GUY) 01 December 2005 See abstract, paragraphs [0030], [0031], and figure 2.	1-20
A	US 2004-0163809 A1 (MAYEU, CHRISTOPHER W. et al.) 26 August 2004 See abstract, paragraphs [0025]-[0027], and figures 1, 2.	1-20

 Further documents are listed in the continuation of Box C. See patent family annex.

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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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

21 October 2014 (21.10.2014)

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/012438

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