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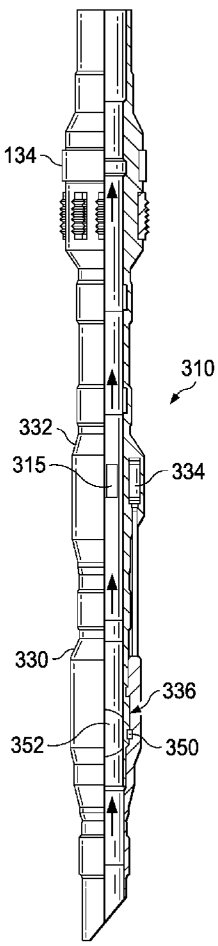

FIG. 3

(57) Abstract: A contactless valve actuation system includes a conduit, which may be a tubing segment in drill string or production string. The system includes a valve including a sealing member that is movable between an open position and a closed position. The system also includes a valve actuator coupled to the valve. The valve actuator is operable to move the sealing member between the open position and the closed position to open and close the valve. The valve actuator includes a sensor and a controller configured to generate a control signal in response to the sensor detecting an actuation signal generator. The system also includes a pump that is fluidly-coupled to the conduit. The pump is operable to convey fluid containing the actuation signal generator through the conduit.

WO 2016/003457 A1

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2014399897 19 Apr 2017

VALVES FOR REGULATING DOWNHOLE FLUIDS USING CONTACTLESS ACTUATION

TECHNICAL FIELD

[0001] The present disclosure relates generally to the recovery of subterranean deposits, and more specifically to an actuator used to open or close valves in a production string.

BACKGROUND

[0002] Crude oil and natural gas occur naturally in subterranean deposits and their extraction includes drilling a well. The well provides access to a production fluid that often contains crude oil and natural gas. Drilling of the well generally involves deploying a drill string into a formation. The drill string includes a drill bit that removes material from the formation as the drill string is lowered to form a wellbore. After drilling and prior to production, a casing may be deployed in the wellbore to isolate portions of the wellbore wall and prevent the ingress of fluids from parts of the formation that are not likely to produce desirable fluids. After completion, a production string may be deployed into the well to facilitate the flow of desirable fluids from producing areas of the formation to the surface for collection and processing.

[0003] A variety of packers and other tools may operate in the wellbore to fix the production string relative to a casing or wellbore wall, and may also function to isolate production zones (also referred to as "intervals") of the well so that hydrocarbon-rich fluids are collected from the wellbore instead of undesirable fluids (such as water). These packers and tools may operate in a wide variety of downhole environments, including extreme downhole environments having very high pressures and very high temperatures.

[0004] Valves may be incorporated into the production string at intervals between packers to allow or cease flow into the production string from the production zone that

2014399897 19 Apr 2017

abuts the wellbore between the packers, and for other purposes. Downhole valves may also be included in drilling tool strings to divert drilling fluid to, for example, facilitate a logging while drilling or measurement while drilling measurement or sampling. Downhole valves may be valves may be actuated by using pressure pulses or by transmitting a control signal directly to a valve actuator using a hydraulic or electronic control line.

[0005] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each claim of this application.

SUMMARY

[0006] According to one aspect of the present disclosure there is provided a valve assembly comprising a fluid conduit a sealing member configured to be movable between an open position and a closed position to open and close the fluid conduit, and an actuator coupled to the sealing member to move the sealing member between the open position and the closed position, the actuator comprising a detector, wherein the detector is a passive detector that senses an actuation signal generator, and wherein the actuator manipulates the sealing member in response to the detector sensing the actuation signal generator.

[0007] According to another aspect of the disclosure, there is provided a contactless valve actuation system, the system comprising a conduit, a valve fluidly coupled to the conduit, the valve having a sealing member that is movable between an open position and a closed position, a valve actuator coupled to the valve, wherein the valve actuator moves the sealing member between the open position and the closed position, the valve actuator comprising a sensor and a controller to generate a control signal in response to the sensor detecting an actuation signal generator, and a pump fluidly-coupled to the housing, wherein the pump conveys fluid containing the actuation signal generator through the conduit of the housing.

2014399897 19 Apr 2017

[0008] According to a further aspect of the disclosure, there is provided a method of actuating a valve, the method comprising conveying an actuation signal generator into a conduit of a downhole tool using a fluid, monitoring the conduit for entry of the actuation signal generator, and actuating the valve if the actuation signal generator is detected in the conduit, wherein the valve controls a sealing member arranged within the conduit and configured to move between an open position and a close position thereby regulating fluid flow therethrough.

[0009] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

BRIEF DESCRIPTION OF THE DRAWINGS

[00010] Illustrative embodiments of the present disclosure are described in detail below with reference to the attached drawing figures, which are incorporated by reference herein and wherein:

[00011] FIG. 1 is a schematic, elevation view with a portion shown in cross-section of a production system that includes a downhole valve including a contactless actuator;

[00012] FIG. 2A is a schematic, elevation view with a portion shown in cross-section of a drilling system that includes a valve including a contactless actuator, wherein the system is deployed in a subterranean well;

[00013] FIG. 2B is a schematic, elevation view with a portion shown in cross-section of a drilling system that includes a valve including a contactless actuator, wherein the system is deployed in a subsea well;

[00014] FIG. 3 is a detail, cross-sectional view of the downhole valve of FIG. 1; FIG. 4 is a schematic diagram of the downhole valve of FIG. 3; and

[00015] FIG. 5 is a schematic flowchart of an illustrative method for contactless actuation of a downhole valve, according to an embodiment.

2014399897 19 Apr 2017

[00016] The illustrated figures are only exemplary and are not intended to assert or imply any limitation with regard to the environment, architecture, design, or process in which different embodiments may be implemented.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[00017] In the following detailed description of the illustrative embodiments, reference is made to the accompanying drawings that form a part hereof. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosed principles, and it is understood that other embodiments may be utilized and that logical structural, mechanical, electrical, and chemical changes may be made without departing from the scope of the disclosure. To avoid detail not necessary to enable those skilled in the art to practice the embodiments described herein, the description may omit certain information known to those skilled in the art. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the illustrative embodiments is defined only by the appended claims.

[00018] In the drawings and description that follow, like parts are typically marked throughout the specification and drawings with the same reference numerals or coordinated numerals. The drawing figures are not necessarily to scale. Certain features of the disclosed 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.

[00019] As noted above, downhole valves are typically actuated using electronic or hydraulic control lines that utilize a line connection to a surface controller. The illustrative embodiments described herein relate to a downhole valve system having a contactless actuator, which may incorporate a number of signal generators and receivers to open and close a downhole valve without utilizing a dedicated control line.

[00020] Unless otherwise specified, any use of any form of the terms "connect," "engage," "couple," "attach," or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the

2014399897 19 Apr 2017

elements and may also include indirect interaction between the elements described. In the following 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”. Unless otherwise indicated, as used throughout this document, “or” does not require mutual exclusivity.

[00021] The various characteristics mentioned above, as well as other features and characteristics described in more detail below, will be readily apparent to those skilled in the art with the aid of this disclosure upon reading the following detailed description of the embodiments, and by referring to the accompanying drawings. Other means may be used as well.

[00022] Referring now to the figures, FIG. 1 shows an illustrative embodiment of a system 100 including a valve assembly 102 that is actuated using a contactless actuator. The system 100 is depicted in a schematic, elevation view with a portion shown in cross- section. The system 100 includes a rig 108 atop a surface 110 of a well 112. Beneath the rig 108, a wellbore 106 is formed within a geological formation 114, which is expected to produce hydrocarbons in the form of production fluid 104. The wellbore 106 may be formed in the geological formation 114 using a drill string that includes a drill bit to remove material from the geological formation 114. The wellbore 106 of FIG. 1 is shown as being near-vertical, but may be formed at any suitable angle to reach a hydrocarbon-rich portion of the geological formation 114. In some embodiments, the wellbore 106 may follow a vertical, partially-vertical, angled, or even a partially-horizontal path through the geological formation 114.

[00023] A production tool string 116 is deployed from the rig 108, which may be a drilling rig, a completion rig, a workover rig, or another type of rig. The rig 108 includes a derrick 118 and a rig floor 120. The production tool string 116 extends downward through the rig floor 120, through a fluid diverter 122 and blowout preventer 124 that provide a fluidly sealed interface between the wellbore 106 and external environment, and into the wellbore 106 and geological formation 114. Coupled to the fluid diverter 122 is a pump 128 coupled to a control system 126. The pump 128 is operational to deliver or receive fluid through an internal bore of the production tool string 116 by applying a positive or negative pressure to the internal bore. The pump 128 may also deliver or receive fluid through an annulus 130 by applying a positive or negative pressure to the annulus 130. The annulus 130 is formed between an exterior of the production tool string 116 and a wellbore casing 132 or between the wall of the wellbore 106 and the exterior of the production tool string 116 when production tool string 116 is disposed within the wellbore 106.

[00024] Following formation of the wellbore 106, the production tool string 116 may be equipped with tools and deployed within the wellbore 106 to prepare, operate, or maintain the well 112. Specifically, the production tool string 116 may incorporate tools that are actuated after deployment in the wellbore 106, including without limitation bridge plugs, composite plugs, cement retainers, high expansion gauge hangers, straddles, and packers. Actuation of such tools may result in centering the production tool string 116 within the wellbore 106, anchoring the production tool string 116, isolating a segment of the wellbore 106, or other functions related to positioning and operating the production tool string 116. In the illustrative embodiment shown in FIG. 1, the production tool string 116 is depicted with a packer 134 within a production zone of the geological formation 114. The packer 134 is configured to provide a fluid seal between the production tool string 116 and the wellbore 106, thereby defining an interval or production zone adjacent the production tool string 116. Packers 134 are typically used to prepare the wellbore 106 for hydrocarbon production during operations such as fracturing of the formation or for service during formation of the well during operations such as acidizing or cement squeezing.

[00025] Below the packer 134 is the valve assembly 102 that controls the flow of production fluid 104 into the production string 116. The illustrative valve assembly 102 is coupled to, or includes, an actuator that may be triggered using a contactless signal generator, as described in more detail below. The signal generator may be a device that emits a light source, a magnetic field, a radio signal, an acoustic signal, a radioactive signal, or a combination thereof.

[00026] In other embodiments, the actuator may be used to actuate tools or assemblies within the production tool string 116, such as the packer 134 or other tools. In an embodiment, prior to actuation of the valve assembly 102 or other tool, fluid

2014399897 19 Apr 2017

may be provided to the wellbore from the pump 128. The pump 128 is coupled to the surface controller 126, which may include a signal generator dispenser or “hopper” that dispenses one or more signal generators into a fluid that is being provided downhole in response to a user generated or computer generated instruction to actuate the valve assembly 102 or other tool. Fluid may be circulated downhole for various purposes. In an embodiment, the signal generators may be a clear ball or another suitable type of particle that includes a signal generator to generate any one of the types of signals described above.

[00027] In operation, the valve assembly 102 or other tool may be actuated by the control system 126 dispensing a signal generator into the wellbore 126, which may be detected by a downhole detector that is communicatively coupled to the actuator. Detection of the signal generator by the detector may result in actuation of the valve or other downhole device. The detector may be selected based on the type of signal generated by the signal generator. For example, a photocell may be used to detect a light source, a magnetic or electromagnetic field sensor may be used to detect a magnetic field, an antenna may be used to detect a radio signal, a hydrophone or similar device may be used to detect an acoustic signal, and a radioactive isotope identification device may be used to detect a radioactive signal.

[00028] It is noted that while the operating environment shown in FIG. 1 relates to a stationary, land-based rig for raising, lowering, and setting the production tool string 116, in alternative embodiments, mobile rigs, wellbore servicing units (e.g., coiled tubing units, slickline units, or wireline units), and the like may be used to lower the production tool string 116. Furthermore, while the operating environment is generally discussed as relating to a land-based well, the systems and methods described herein may instead be operated in subsea well configurations accessed by a fixed or floating platform.

[00029] FIG. 2A shows an alternative deployment of a valve assembly 270 including, or coupled to, a contactless actuator and deployed in a drilling system 200. The drilling system 200 is deployed in a well 202 including a wellbore 206 that extends from a surface 210 of the well 202 to or through a subterranean formation 214. The well 202 is illustrated onshore in FIG. 2A with a drill string 216 deployed to

2014399897 19 Apr 2017

operate a drill bit 222 to form the wellbore 206. In another embodiment, the drilling system 200 and associated valve assembly 270 and contactless actuator may be deployed in a sub-sea well 201 accessed by a fixed or floating platform 221, as shown in FIG. 2B. FIGS. 2A and 2B each illustrate possible implementations of such systems, and while the following description of the valve assembly 270 and contactless actuator focusses primarily on the use of the valve assembly 270 and a related control system 226 with the onshore well 202 of FIG. 2A, the valve assembly 270 and contactless actuator may be used instead in the well configuration illustrated in FIG. 2B, as well as in other well configurations where it is desirable to actuate a downhole valve or other tool using a contactless actuator. Similar components in FIGS. 2A and 2B are identified with similar reference numerals.

[00030] The well 202 is formed by a drilling process in which a drill bit 222 is turned by the drill string 216 to remove material from the formation and form the wellbore 206. The drill string 216 extends from the drill bit 222 at the bottom of the wellbore 206 to the surface 210 of the well 202, where it is joined with a kelly 228. The drill string 216 may be made up of one or more connected tubes or pipes of varying or similar cross- section. The drill string 216 may refer to the collection of pipes or tubes as a single component, or alternatively to the individual pipes or tubes that comprise the string. The term drill string is not meant to be limiting in nature and may refer to any component or components that are capable of transferring rotational energy from the surface of the well to the drill bit 222. In several embodiments, the drill string 216 may include a central passage disposed longitudinally in the drill string 216 and capable of allowing fluid communication between the surface 210 of the well and downhole locations.

[00031] At or near the surface 210 of the well 202, the drill string 216 may include or be coupled to the kelly 228. The kelly 228 may have a square, hexagonal or octagonal cross-section. The kelly 228 is connected at one end to the remainder of the drill string 216 and at an opposite end to a rotary swivel 232. The kelly 228 passes through a rotary table 236 that is capable of rotating the kelly 228 and thus the remainder of the drill string 216 and drill bit 222. The rotary swivel 232 allows the kelly 228 to rotate without rotational motion being imparted to the rotary cable 242.

2014399897 19 Apr 2017

A hook 238, the cable 242, a traveling block (not shown), and a hoist (not shown) are provided to lift or lower the drill bit 222, drill string 216, kelly 228 and rotary swivel 232. The drill string 216 may be raised or lowered as needed to add additional sections of tubing to the drill string 216 as the drill bit 222 advances, or to remove sections of tubing from the drill string 216 if removal of the drill string 216 and drill bit 222 from the well 202 are not desired.

[00032] In normal operation, drilling fluid 204 is stored in a drilling fluid reservoir 244 and pumped into an inlet conduit 252 using a pump 229, or plurality of pumps disposed along the inlet conduit 252. The drilling fluid 204 passes through the inlet conduit 252 and into the drill string 216 via a fluid coupling at the rotary swivel 232. The drilling fluid 204 is circulated into the drill string 216 to maintain pressure in the drill string 216 and wellbore 206 and to lubricate the drill bit 222 as it cuts material from the formation 214 to deepen or enlarge the wellbore 206. After exiting the drill string 216, the drilling fluid 204 carries cuttings from the drill bit 222 back to the surface 210 through an annulus 230 formed by the space between the inner wall of the wellbore 206 and outer wall of the drill string 216. At the surface 210, the drilling fluid 204 exits the annulus 230 and is carried to a repository. Where the drilling fluid 204 is recirculated through the drill string 216, the drilling fluid 204 may return to the drilling fluid reservoir 244 via an outlet conduit 264 that couples the annulus 230 to the drilling fluid reservoir 244. The path that the drilling fluid 204 follows from the reservoir 244, into and out of the drill string 216, through the annulus 230, and to the repository may be referred to as the fluid flow path.

[00033] At various times during the formation of the well 202, it may be desirable to halt the flow of fluid to the drill bit 222 while maintaining fluid flow throughout the remainder of the system. For example, it may be desirable to halt fluid flow adjacent a logging-while-drilling (LWD) or measurement-while-drilling (MWD) sensor, such as a sampling chamber, thermometer, camera, or other device. To represent a LWD or MWD tool, a measurement module 272 is depicted as being downhole from the valve assembly 270. The valve assembly 270 may be oriented in the drill string 216 such that when the valve assembly 270 is in a first orientation, the drilling fluid 204 is directed downward through the downhole measurement module

2014399897 19 Apr 2017

272 to the drill bit 222, and when the valve is in a second orientation, the drilling fluid bypasses the downhole measurement module 272 and is directed into the annulus 230 and back toward the surface. This configuration may also facilitate the continuous circulation of drilling fluid 204 through the wellbore 206 even when operation of the drill bit 222 is suspended.

[00034] As described in more detail below with regard to FIGS. 3 and 4, the valve assembly 270 includes a contactless actuator that may be used to operate the valve assembly 270 without an established electronic or hydraulic control line. Further, the valve assembly 270 is discussed merely as an illustrative system and it is noted that the contactless actuator may be instead used to actuate other types of downhole tools, including, for example, a measurement module 272.

[00035] FIG. 3 shows a detail view, in partial cross-section, of a valve and contactless actuator assembly 310, as indicated in FIG. 3. In several embodiments, the valve assembly 310 is the valve assembly 102 of FIG. 1. In other embodiments, the valve assembly 310 is the valve assembly 270 of FIGS. 2A and 2B. The valve assembly 310 includes an actuator 332, which, as described in more detail below, may be a contactless actuator that actuates a downhole tool, such as a valve 330. The valve 330 may be a ball valve as shown or any other suitable type of valve, such as a sleeve valve. The actuator 332 is coupled to a hydraulic pump 334, which is also coupled to a movable member 336 of the valve 330. When using a ball valve, the valve 330 includes a sealing member, such as a valve ball 350 having an aperture 352 that allows fluid to flow through the valve 330 when the valve 330 is open and ceases fluid flow when the valve 330 is closed. In another embodiment the valve 330 may include a t-valve that allows fluid to flow through the tubing segment that includes the valve 330 when open and diverts fluid flow outside of the tubing segment when closed.

[00036] In an illustrative embodiment, the actuator 332 includes a passive detector or sensor 315 that detects one or more signals generated by a signal generator. As described above, the signal generator may be a device that emits a light source, such as a clear ball with an embedded or enclosed LED, a permanent magnet, a radio-frequency identification (RFID) tag, a mud-pulse telemetry broadcasting device or

2014399897 19 Apr 2017

speaker, or an acoustic signal, a radioactive isotope, or a combination thereof. The detector or sensor 315 may be selected based on the type of signal generated by the signal generator. For example, the sensor 315 may include a photocell, a magnetic or electromagnetic field sensor, an antenna, a hydrophone, a radioactive isotope identification device or radiation detector, or any other suitable sensor.

[00037] Upon detection of the signal generator by the sensor 315, the actuator 332 causes the hydraulic pump 334 to actuate the movable member 336 of the valve 330, which turns the valve ball 350 to close the valve 330 and prevent flow therethrough. Closing of the valve 330 may facilitate the closing of a zone of the well or enable the buildup of pressure in the tool string that includes the valve 330 so that, for example, a packer may be set up- hole from the valve 330. Similarly, opening of the valve 330 facilitates the renewal of flow through the valve 330, either to or from a downhole location.

[00038] In one embodiment, the actuator 332 includes a power source, controller, memory, a power source, an actuating member, and a sensor. The sensor monitors the fluid within a predetermined range of the actuator 332 for the presence of one or more signal generators, and is operable to detect the presence of a signal generator and the frequency at which signal generators are detected as a function of time. The controller of the actuator 332 is operable to execute instructions stored in the memory for actuating the valve 330 based on conditions detected by the sensor. The power source, which may include a battery, provides a local power to the components of the actuator 332, including the sensor, controller, and actuating member. In an embodiment, the actuating member is a motor and gearbox that are coupled to and configured to operate the hydraulic pump. In another embodiment, the actuating member may be a solenoid. In either case, the actuator 332 and its constituent components are arranged about the periphery of the assembly 310 to avoid interference with fluid flowing along a fluid flow path through the valve 330 and assembly 310.

[00039] In response to the detection of a signal generator by the sensor 315, the controller of the actuator 332 will operate the actuating member of the actuator 332 to open or close the valve 330 in accordance with the operating instructions of the

2014399897 19 Apr 2017

actuator 332. The actuator 332 thereby operates the hydraulic pump 334, which provides at least one hydraulic control line to the movable member 336. In an embodiment, at least one hydraulic control lines extends from the pump 334 to the movable member 336 of the valve 330.

[00040] In an embodiment, the valve 330 comprises a substantially cylindrical body having an axial bore running therethrough to facilitate the flow of fluids therethrough. The body may include ports or an access sleeve that connects the actuator to the movable member 336. In an embodiment, the movable member 336 includes a valve ball 350 arranged on a pivot so that the valve ball 350 can rotate within the bore to open and close the valve 330. To facilitate flow through the valve 330 when open, the valve ball 350 includes an aperture running therethrough, which is sized to match the diameter of the bore. The movable member 336 may also include a ball arm that is operated with a piston that is translated back and forth with the hydraulic pump to open and close the valve 330. A sealing arrangement may be used between the valve ball 350 and its housing to prevent fluid leakage through the valve 330. In a similar embodiment, the valve 330 may instead be formed from concentric sleeves having overlapping flow ports that are moved in and out of alignment by translation of one of the sleeves caused by movement of the piston.

[00041] In another embodiment, when the sensor 315 detects a signal generator and the actuator 332 determines to open the valve 330, the actuator 332 operates the hydraulic pump 334 to evacuate the control line to retract the piston or to provide pressure to a second control line that causes the piston to retract and open.

[00042] FIG. 4 shows a schematic diagram of a contactless actuator system 400 including a valve 402 within a downhole tool string, such as a production string or a drilling string. A conduit 404 forms a fluid flow path 406 through the tool string, and includes a sensor 410 operable to detect a signal generator 416 in the conduit 404. The conduit 404 is fluidly coupled to the valve 402. The sensor 410 is coupled to a control module that includes a processor 414, a memory 415, and a power supply 412. The power supply 412 may include a battery and/or a downhole power generation device, such as a turbine, to generate power to be stored in the battery. The power supply 412 supplies electrical energy to the sensor 410 and an actuating member 408,

2014399897 19 Apr 2017

which may be a solenoid or a motor coupled to a hydraulic pump, as noted previously. The actuating member 408 is coupled to the valve 402, or a movable member thereof, and is thereby operable to open and close the valve 402.

[00043] In an embodiment, the actuator system 400 functions as a contactless tool that replaces a mechanical interface that is typically used to open and close a valve, e.g., in the form of a dropped ball or mechanical manipulation of an entire tool string, such as pulling up (close) or pushing down (open) using a collet or shifting tool that is attached to the end of the tool string. The signal generator may be a magnet, a radioactive source (such as strontium-90, tritium, carbon-14, phosphorus-32, nickel-63, or a combination thereof), and electronic signal generator such as an RFID tag, or an acoustic sound generator (such as a speaker or projector operable to generate a periodic SONAR ping). Depending on the selected signal generator, the sensor 410 may be a magnetic field sensor, such as a MEMS magnetic field sensor, a radiation detector or Gieger counter, an antenna or RFID tag reader, or a hydrophone that is configured to detect the signal generator.

[00044] The actuator system 400 may be configured to actuate and close the valve 402 in response to the sensor 410 detecting a signal generator 416, the sensor 410 detecting a threshold quantity of signal generators 416, or the passage of a time delay following detection of a signal generator 416. Similarly, the actuator system 400 may be configured to actuate and open the valve 402 in response to the sensor 410 detecting a signal generator 416, the sensor 410 detecting a threshold quantity of signal generators 416, the passage of a time delay following detection of a signal generator 416, or the passage of time delay following the closing of the valve 402. It is noted that the signal generator 416 may be a discrete object, such as a ball or small particle deployed in the fluid flow path 406, or a signal generator 416 that is remotely deployed from the surface by, for example, a slickline or wireline cable deployed within the tool string or wellbore annulus in an area that will be detected by the sensor 410. Such a signal generator may thereby be a contactless tool that is deployed without a dedicated electrical connection or power supply to open or close a downhole valve.

2014399897 19 Apr 2017

[00045] In an embodiment, the sensor 410 may also include a pressure sensor and thereby be configured to detect pressure pulses, or brief surges or variations in the fluid pressure at the sensor location. In such an embodiment, the memory may be provided with instructions for opening or closing the valve 402 in response to detecting a pressure pulse or a sequence of pressure pulses. For example, a timed sequence of pressure pulses may be associated with a command to open the valve 402 and a second timed sequence of pressure pulses may be associated with a command to close the valve 402. In such an embodiment, the actuator system 400 will transition to an open state in response to the sensor 410 detecting the first timed sequence of pressure pulses and transition to a closed state in response to the sensor 410 detecting the second timed sequence of pressure pulses.

[00046] In an embodiment, the sensor 410 may also include a contact sensor or wet connect that is configured to receive an electrical current, and a wire delivering the electrical current may be the signal generator. The wire may be a low voltage wire that is easily provided downhole by a slickline or wireline application. In such an embodiment, the sensor 410 may also be configured to receive and transmit the electrical current to the power supply 412 to charge the battery of the actuator. In an embodiment, the electrical current may thereby facilitate charging of a power supply 412, thereby extending the life of such valves.

[00047] In another embodiment, the actuator system 400 or a plurality of actuators may be coupled to one or more valves or other tools, such as packers or measuring devices that may also be actuated by such an actuator system 400, three way valves, etc. In such an embodiment, the sensor 410 may include a photo-sensor, or photo-electric cell that is selected to detect a signal generator 416 that is a LED or similar light source included in a clear glass or plastic ball that is deployed downhole. A plurality of such signal generators may be deployed downhole, each producing a selected different wavelength of light.

[00048] Correspondingly, a plurality of actuator systems 400 may be configured to detect different wavelengths of light so that each tool may be actuated by deploying a signal generator 416 that corresponds to the tool. For example, a first valve may be actuated by deploying a signal generator 416 that generates a blue light to a sensor

410 of an actuator that is configured actuate the valve in response to the detection of blue light. Similarly, a second tool may be actuated by deploying a signal generator 416 that emits a red light to a sensor 410 of an actuator system 400 that is configured to actuate the tool in response to detecting red light. Thus, deployment of signal generators 416 that emit different wavelengths of light or otherwise discernible signals of the types described above (such as magnetic, radioactive, and acoustic signals) may be deployed in succession to actuated a plurality of tools within a tool string.

[00049] In another embodiment, the actuator 332 of FIG. 1 includes the sensor 410, the power supply 412, the processor 414, the memory 415, and the actuating member 408 of FIG. 4, and operates in accordance with one or more of the foregoing embodiments of the contactless actuation system 400 of FIG. 4.

[00050] Now referring primarily to FIG. 5, a schematic flow chart shown therein depicts an illustrative method 500 for contactless actuation of a downhole valve, according to an embodiment. The method 500 may be used with any of the previous illustrative embodiments. The method 500 includes a step 502 of conveying an actuation signal generator into a conduit of a downhole tool using a fluid. In some embodiments, the actuation signal generator is selected from the group consisting of a light source, a magnetic field source, a radioactive source, and an acoustic source. The method 500 also includes a step 504 of monitoring the conduit for entry of the actuation signal generator. In certain embodiments, the step 504 of monitoring the conduit includes detecting electromagnetic radiation from a light emitting diode using a photo-detector. The method 500 involves a decision, represented by interrogatory 506, to determine if the actuation signal generator has been detected. Such a determination may include detecting a threshold quantity of actuation signal generators. If the no actuation signal generator has been detected, the method 500 returns to the step 504 of monitoring the conduit.

[00051] However, if the actuation signal generator is detected at the interrogatory 506, the method 500 proceeds to a step 508 of actuating the downhole valve. After the step 508 of actuating the downhole valve, the system may end 510, or return to a point between the step 502 and the step 504 to wait for further signals to actuate the valve again. In some embodiments, the method 500 further includes the step (not

2014399897 19 Apr 2017

shown) of releasing the actuation signal generator in the fluid. This step is typically performed before the step 502 of conveying the actuation signal generator.

[00052] Although the disclosed principles and associated advantages have been disclosed in the context of certain illustrative, non-limiting embodiments, it should be understood that various changes, substitutions, permutations, and alterations can be made without departing from the scope of the disclosure as defined by the appended claims. It will be appreciated that any feature that is described in connection to any one embodiment may also be applicable to any other embodiment.

Example 1. A valve assembly comprising:

a fluid conduit;

a sealing member to open and close the fluid conduit; and

an actuator coupled to the sealing member to move the sealing member from an open position to a closed position, the actuator comprising a detector;

wherein the detector is a passive detector that senses an actuation signal generator; and

wherein the actuator manipulates the sealing member in response to the detector sensing the actuation signal generator.

Example 2. The valve assembly of Example 1, further comprising a power source coupled to the actuator.

Example 3. The valve assembly of Example 1 or Example 2, further comprising a controller coupled to the detector, the controller having at least one processor and at least one memory, the at least one processor and the at least one memory perform logical operations and calculations in relation to the actuation signal generator sensed by the detector.

Example 4. The valve assembly of Example 1 or any of Examples 2-3, wherein the sealing member comprises a ball having a throughbore and movably arranged within the fluid conduit, the ball movable between the open position, where the throughbore is axially aligned with the fluid conduit, and the closed position, where the throughbore is perpendicular to the conduit.

Example 5. The valve assembly of Example 1 or any of Examples 2-3, wherein the sealing member comprises a sleeve valve.

Example 6. The valve assembly of Example 1 or any of Examples 2-5, wherein the actuator comprises a hydraulic pump fluidly-coupled to the sealing member.

Example 7. The valve assembly of Example 1 or any of Examples 2-6, wherein the actuation signal generator is selected from the group consisting of a light source, a magnetic field generator, a radioactive source, and an acoustic signal generator.

Example 8. The valve assembly of Example 1 or any of Examples 2-6, wherein the actuation signal generator comprises a light source and wherein the detector comprises a photo sensor.

Example 9. The valve assembly of Example 8, wherein the light source comprises a transparent body containing a light emitting diode.

Example 10. A contactless valve actuation system, the system comprising: a conduit;

a valve fluidly coupled to the conduit, the valve having a sealing member that is movable between an open position and a closed position;

a valve actuator coupled to the valve, wherein the valve actuator moves the sealing member between the open position and the closed position, the valve actuator comprising a sensor and a controller to generate a control signal in response to the sensor detecting an actuation signal generator; and

a pump fluidly-coupled to the housing, wherein the pump conveys fluid containing the actuation signal generator through the conduit of the housing.

2014399897 19 Apr 2017

Example 11. The system of Example 10, wherein the valve actuator further comprises a local power source to provide power to a movable member.

Example 12. The system of Example 10 or Example 11, wherein quantities of the actuation signal generator are released into fluid.

Example 13. The system of Example 10 or any of Examples 11-12, wherein the controller determines a position of the valve based on a signal received from the sensor.

Example 14. The system of Example 10 or any of Exampled 11-13, wherein the valve actuator comprises a hydraulic pump fluidly-coupled to the valve.

Example 15. The system of Example 10 or any of Examples 11-14, wherein the valve comprises a ball having a throughbore and movably arranged with the conduit, the throughbore axially-aligned with conduit in the open position and perpendicular to the conduit in the closed position.

Example 16. The system of Example 10 or any of Examples 11-14, wherein the valve is a sleeve valve.

Example 17. The system of Example 10 or any of Examples 11-16, wherein the actuation signal generator is selected from the group consisting of a light source, a magnetic field source, a radioactive source, and an acoustic source.

Example 18. The system of Example 10 or any of Examples 11-16, wherein the actuation signal generator comprises a light emitting diode and wherein the sensor comprises a photo sensor.

Example 19. A method of actuating a valve, the method comprising:

2014399897 19 Apr 2017

conveying an actuation signal generator into a conduit of a downhole tool using a fluid;

monitoring the conduit for entry of the actuation signal generator; and actuating the valve if the actuation signal generator is detected in the conduit;

wherein the valve controls a sealing member within the conduit thereby regulating fluid flow therethrough.

Example 20. The method of Example 19, further comprising the step of releasing the actuation signal generator into the fluid.

Example 21. The method of Example 19 or Example 20, wherein the actuation signal generator is selected from the group consisting of a light source, a magnetic field source, a radioactive source, and an acoustic source.

Example 22. The method of Example 19 or Example 20, wherein the step of monitoring the conduit comprises detecting electromagnetic radiation from a light emitting diode using a photo-detector.

[00053] It will be understood that the benefits and advantages described above may relate to one embodiment or may relate to several embodiments. It will further be understood that reference to “an” item refers to one or more of those items.

[00054] The steps of the methods described herein may be carried out in any suitable order or simultaneous where appropriate. Where appropriate, aspects of any of the examples described above may be combined with aspects of any of the other examples described to form further examples having comparable or different properties and addressing the same or different problems.

[00055] It will be understood that the above description of the embodiments is given by way of example only and that various modifications may be made by those skilled in the art. The above specification, examples, and data provide a complete description of the structure and use of exemplary embodiments. Although various embodiments have been described above with a certain degree of particularity, or with reference to one or more individual embodiments, those skilled in the art could make numerous alterations to the disclosed embodiments without departing from the scope of the claims.

2014399897 07 Jun 2017

CLAIMS

1. A valve assembly comprising: a fluid conduit;

a sealing member configured to be movable between an open position and a closed position to open and close the fluid conduit; and

an actuator coupled to the sealing member to move the sealing member between the open position and the closed position, the actuator comprising a detector;

wherein the detector is a passive detector that senses an actuation signal generator; and wherein the actuator manipulates the sealing member in response to the detector sensing the actuation signal generator.

2. The valve assembly of claim 1, further comprising a power source coupled to the actuator.

3. The valve assembly of claim 1 or 2, further comprising a controller coupled to the detector, the controller having at least one processor and at least one memory, the at least one processor and the at least one memory perform logical operations and calculations in relation to the actuation signal generator sensed by the detector.

4. The valve assembly of any one of the preceding claims, wherein the sealing member comprises a ball having a throughbore and movably arranged within the fluid conduit, the ball movable between the open position, where the throughbore is axially aligned with the fluid conduit, and the closed position, where the throughbore is perpendicular to the conduit.

5. The valve assembly of any one of claims 1 to 3, wherein the sealing member comprises a sleeve valve.

6. The valve assembly of any one of the preceding claims, wherein the actuator comprises a hydraulic pump fluidly-coupled to the sealing member.

2014399897 07 Jun 2017

7. The valve assembly of any one of the preceding claims, wherein the actuation signal generator is selected from the group consisting of a light source, a magnetic field generator, a radioactive source, and an acoustic signal generator.

8. The valve assembly of any one of claims 1 to 7, wherein the actuation signal generator comprises a light source and wherein the detector comprises a photo sensor.

9. A contactless valve actuation system, the system comprising: a conduit;

a valve fluidly coupled to the conduit, the valve having a sealing member that is movable between an open position and a closed position;

a valve actuator coupled to the valve, wherein the valve actuator moves the sealing member between the open position and the closed position, the valve actuator comprising a sensor and a controller to generate a control signal in response to the sensor detecting an actuation signal generator; and

a pump fluidly-coupled to the housing, wherein the pump conveys fluid containing the actuation signal generator through the conduit of the housing.

10. The system of claim 9, wherein the valve actuator further comprises a local power source to provide power to a movable member.

11. The system of claim 9 or 10, wherein quantities of the actuation signal generator are released into fluid.

12. The system of any one of claims 9 to 11, wherein the valve actuator comprises a hydraulic pump fluidly-coupled to the valve.

13. The system of any one of claims 9 to 12 wherein the valve comprises a ball having a throughbore and movably arranged with the conduit, the throughbore axially-aligned with conduit in the open position and perpendicular to the conduit in the closed position.

14. The system of any one of claims 9 to 12, wherein the valve is a sleeve valve.

15. The system of any one of claims 9 to 14, wherein the actuation signal generator is selected from the group consisting of a light source, a magnetic field source, a radioactive source, and an acoustic source.

16. The system of any one of claims 9 to 15, wherein the actuation signal generator comprises a light emitting diode and wherein the sensor comprises a photo sensor.

17. A method of actuating a valve, the method comprising:

conveying an actuation signal generator into a conduit of a downhole tool using a fluid; monitoring the conduit for entry of the actuation signal generator; and

actuating the valve if the actuation signal generator is detected in the conduit;

wherein the valve controls a sealing member arranged within the conduit and configured to move between an open position and a close position thereby regulating fluid flow therethrough.

18. The method of claim 17, further comprising the step of releasing the actuation signal generator into the fluid.

19. The method of claim 17 or 18, wherein the actuation signal generator is selected from the group consisting of a light source, a magnetic field source, a radioactive source, and an acoustic source.

2014399897 07 Jun 2017

20. The method of any one of claims 17 to 19, wherein the step of monitoring the conduit comprises detecting electromagnetic radiation from a light emitting diode using a photo-detector.

FIG. 1

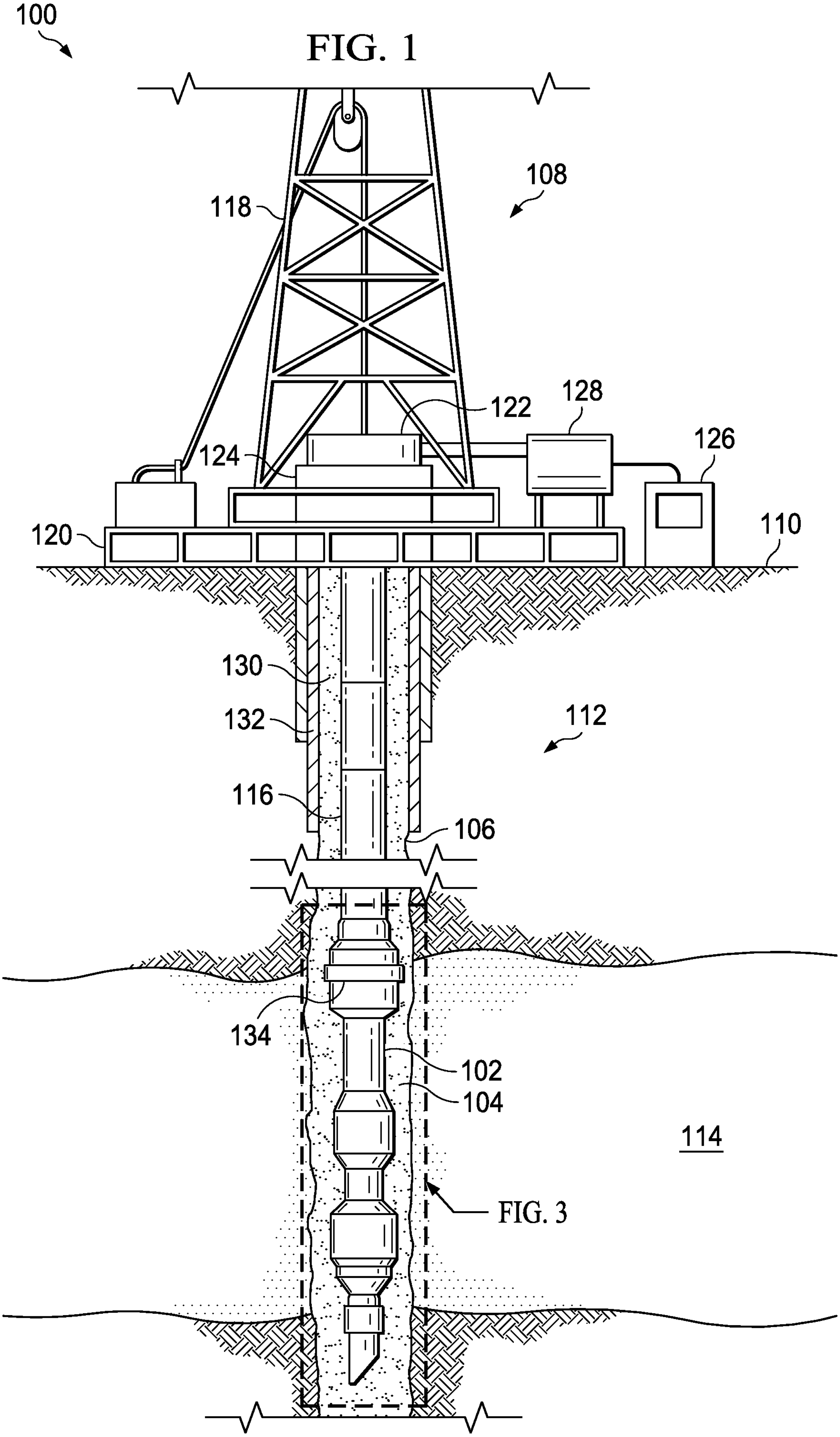
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FIG. 3

FIG. 2A

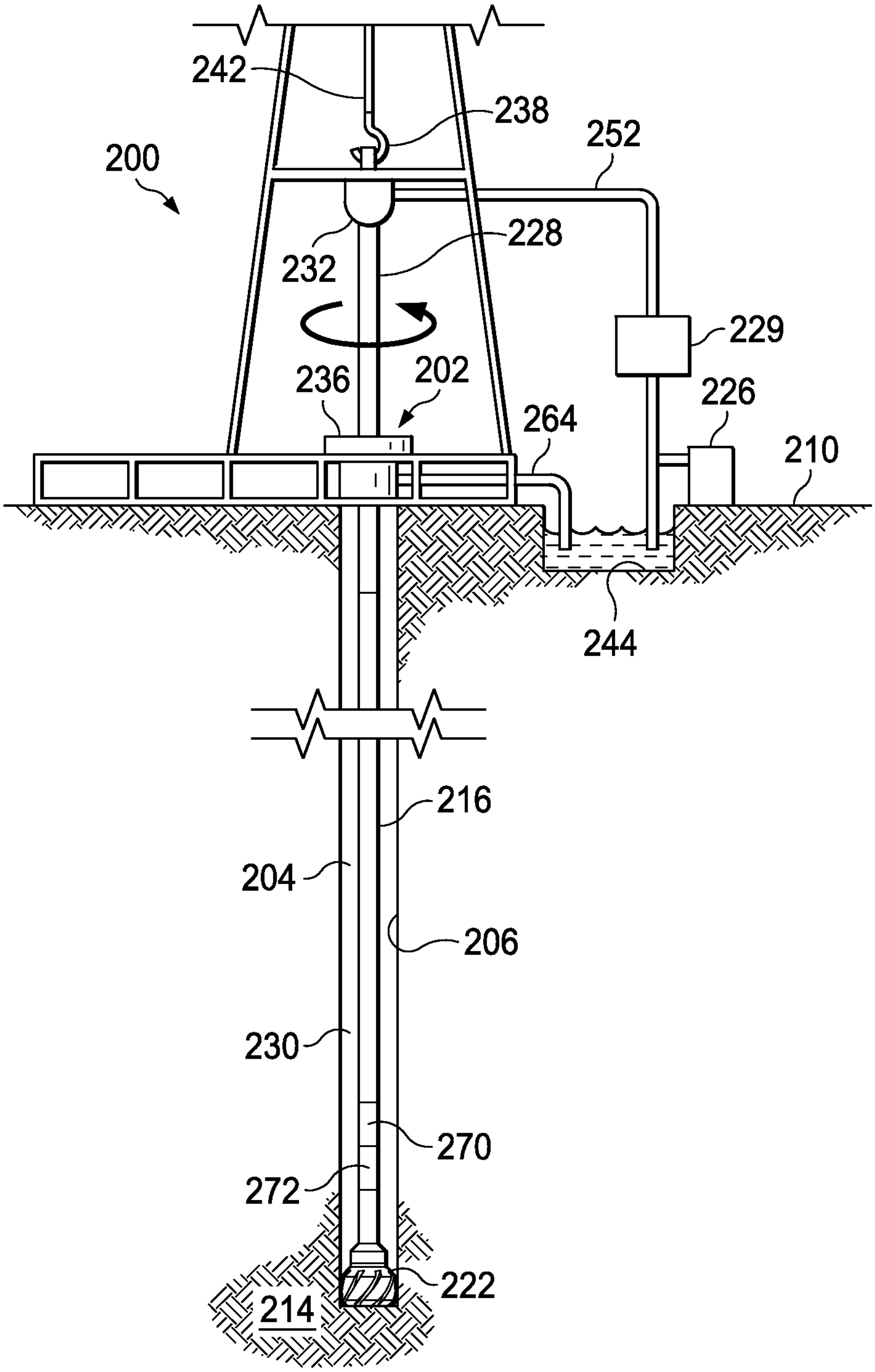
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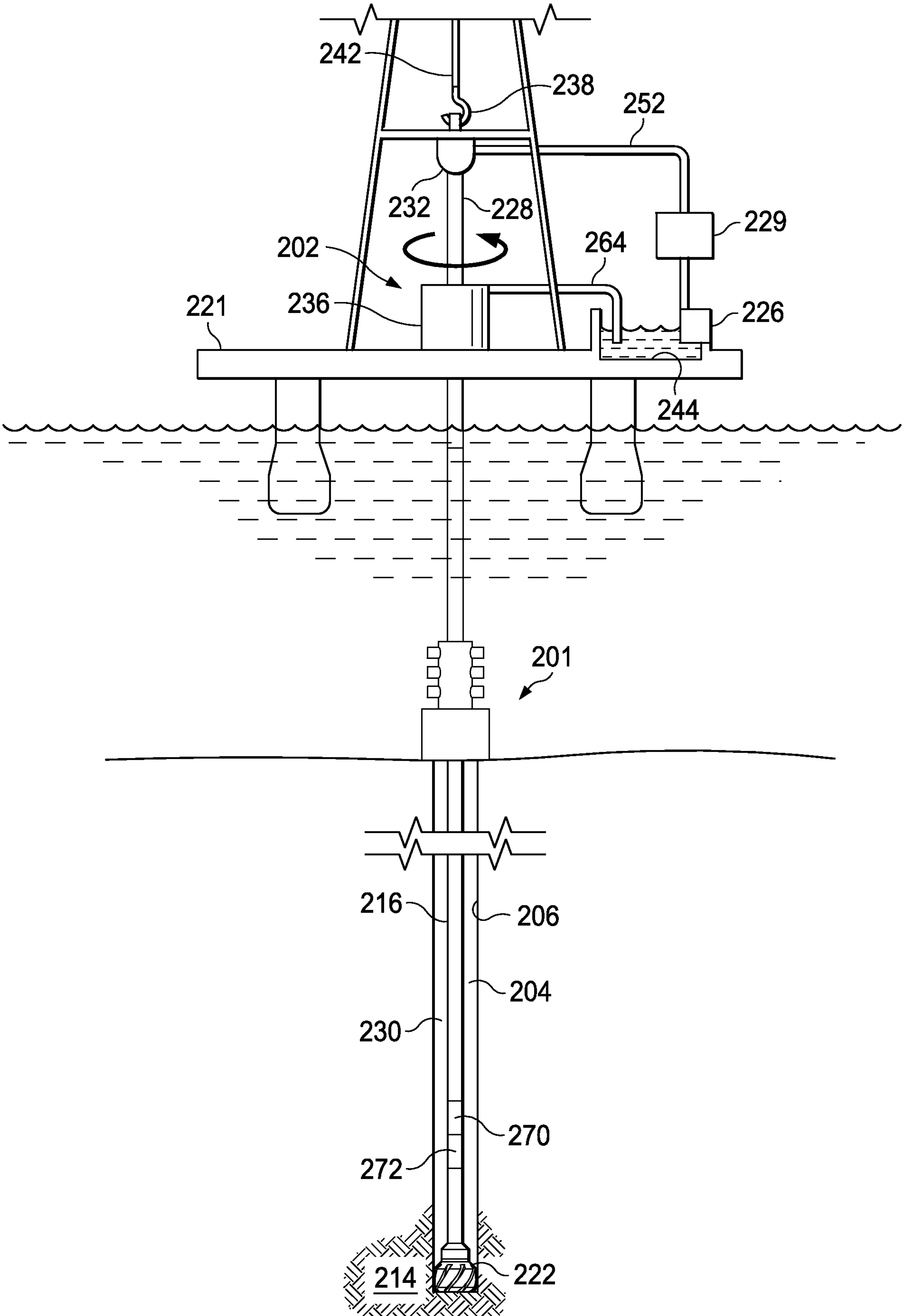
FIG. 2B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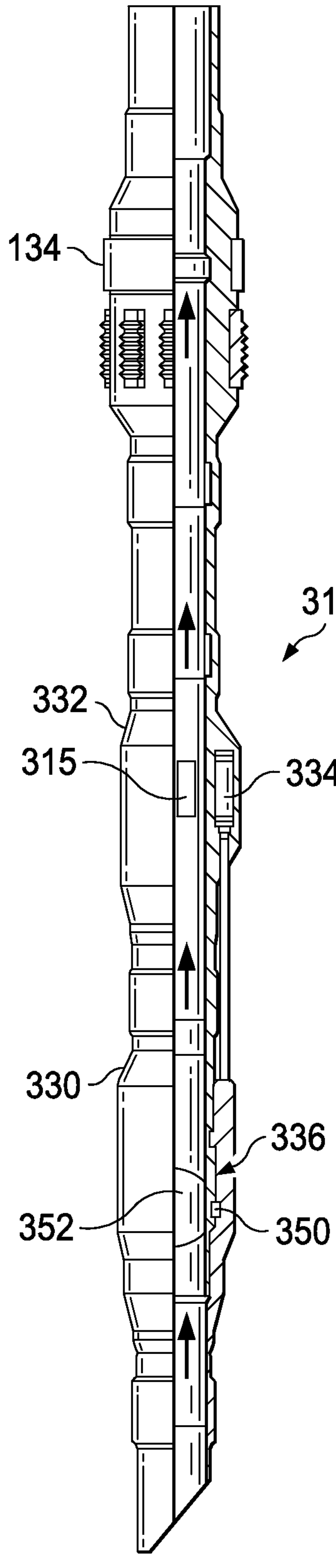

FIG. 3

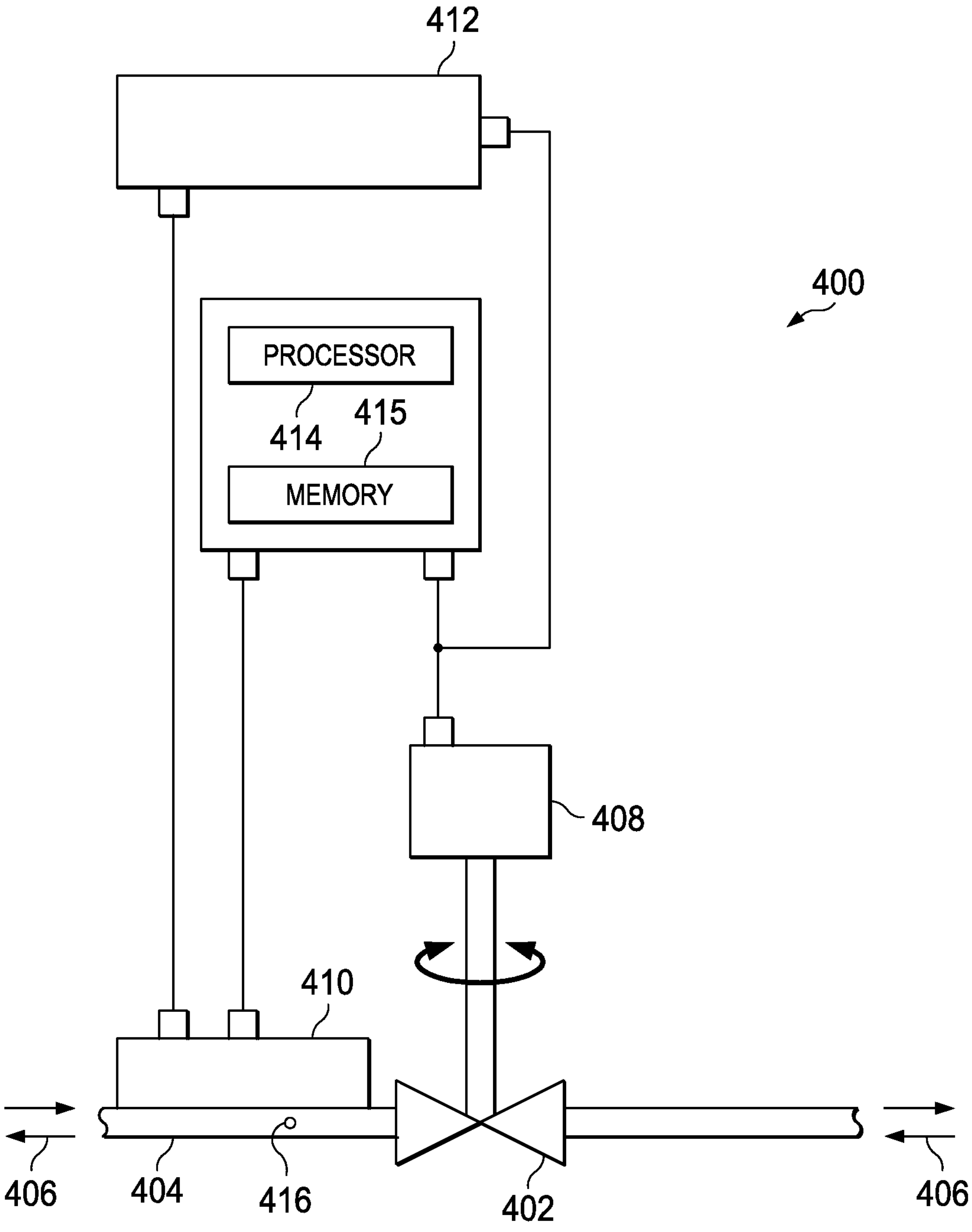

FIG. 4

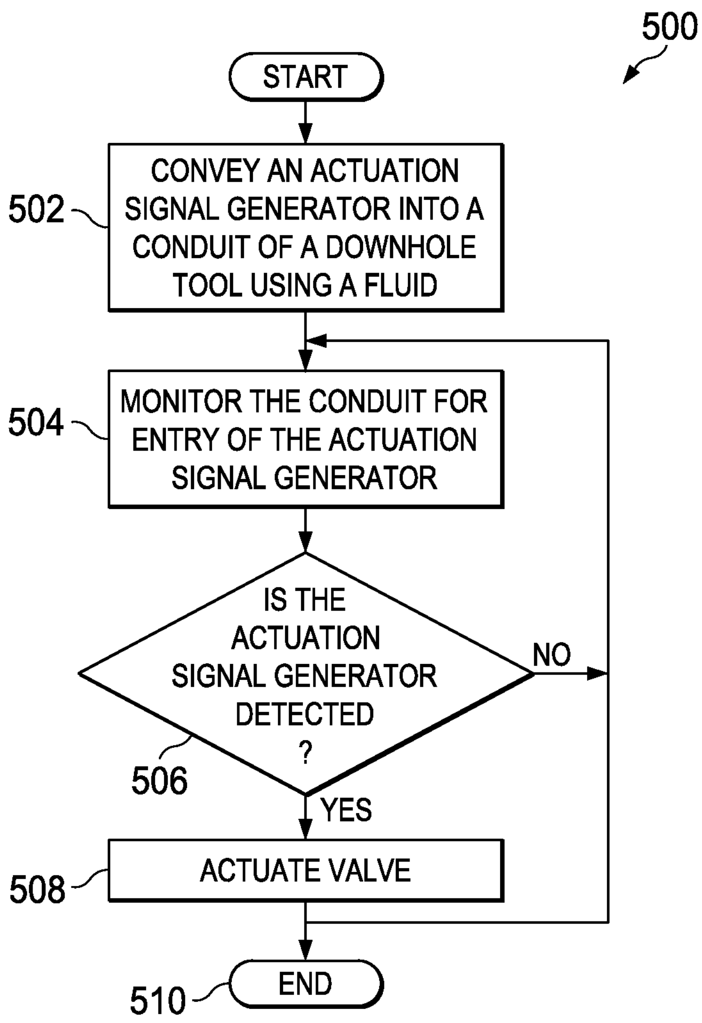
500
START
502
CONVEY AN ACTUATION SIGNAL GENERATOR INTO A CONDUIT OF A DOWNHOLE TOOL USING A FLUID
504
MONITOR THE CONDUIT FOR ENTRY OF THE ACTUATION SIGNAL GENERATOR
IS THE ACTUATION SIGNAL GENERATOR DETECTED ?
506
NO
YES
508
ACTUATE VALVE
510
END

FIG. 5