



(51) International Patent Classification:

E21B 23/06 (2006.01)

E21B 47/12 (2006.01)

E21B 33/12 (2006.01)

(21) International Application Number:

PCT/US2018/030256

(22) International Filing Date:

30 April 2018 (30.04.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **HALLIBURTON ENERGY SERVICES, INC.** [US/US]; 3000 N. Sam Houston Parkway E., Houston, Texas 77032-3219 (US).

(72) Inventors: **GRECCI, Stephen Michael**; 3113 Luminara Dr., Little Elm, Texas 75068 (US). **FROSELL, Thomas Jules**; 7409 Bradford Pear Dr., Irving, Texas 75063 (US). **FRIPP, Michael Linley**; 3826 Cemetery Hill Rd., Carroll-

ton, Texas 75007 (US). **GEOFFROY, Gary John**; 4136 Eldorado Dr., Plano, Texas 75093 (US).

(74) Agent: **TUMEY, Corey S.**; C. Tumey Law Group PLLC, P.O. Box 890226, Houston, Texas 77062-9998 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: PACKER SETTING AND REAL-TIME VERIFICATION METHOD

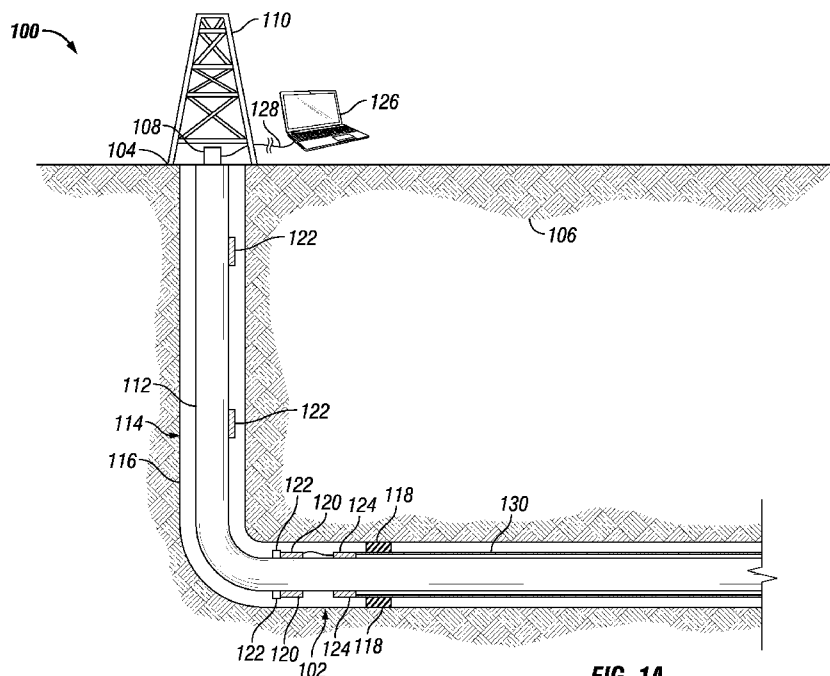


FIG. 1A

(57) Abstract: This disclosure may generally relate to subterranean operations and, more particularly, to systems and methods for setting a packer. Specifically, embodiments of the present disclosure may provide real-time verification of setting a packer in order to form a seal within a wellbore. A system for packer setting may comprise a packer, a telemetry module operable to wirelessly receive one or more control signals from a surface location, and a control module coupled to the telemetry module and the packer, wherein the control module is operable to actuate the packer in response to the one or more control signals from the surface location.



TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, 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).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

PACKER SETTING AND REAL-TIME VERIFICATION METHOD

BACKGROUND

[0001] Wells may be drilled into subterranean formations to recover valuable hydrocarbons. Various operations may be performed before, during, and after the well has been drilled to produce and continue the flow of the hydrocarbon fluids to the surface.

[0002] A typical operation concerning oil and gas operations may be to set a packer within a well. Packers may provide seals between the outside of a production tubing and the inside of a casing string, liner, or the wall of a wellbore. Packers may isolate and contain produced fluids and pressures within the wellbore. Other various uses may include preventing downhole movement of a tubing string, supporting a portion of the tubing string weight, and separating multiple production zones. The process of setting a packer may be inefficient. There are various ways to set a packer based on its design. Operation is typically done on the surface with limited knowledge of equipment placement and equipment actuation while downhole. It may be suitable to provide feedback on the setting procedure to verify that a packer has been properly set.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] These drawings illustrate certain aspects of the present disclosure, and should not be used to limit or define the disclosure.

[0004] Figures 1A and 1B illustrate a downhole system with a packer setting assembly;

[0005] Figure 2 illustrates a packer setting assembly in a wellbore;

[0006] Figure 3 illustrates a schematic diagram of a control module;

[0007] Figure 4 illustrates a control module coupled to a packer setting device;

[0008] Figures 5A-5C illustrate graphs depicting pressure and flow rate relationships;

[0009] Figures 6A-6C illustrate a packer; and

[0010] Figures 7A-7C illustrate a packer.

DETAILED DESCRIPTION

[0011] This disclosure may generally relate to subterranean operations and, more particularly, to systems and methods for setting a packer. Specifically, embodiments of the present disclosure may provide real-time verification of setting a packer in order to form a seal within a wellbore. A packer setting assembly may be used to provide feedback to the surface on packer setting conditions. Additional tools and equipment may be used to relay information from downhole to the surface.

[0012] Figure 1A illustrates a downhole system 100 that includes a packer setting assembly 102. Surface equipment 104 may be disposed above a formation 106. As illustrated, surface equipment 104 may include a hoisting apparatus 108 and a derrick 110. Hoisting apparatus 108 may be used for raising and lowering pipe strings, such as a conveyance line 112. Conveyance line 112 may include any suitable means for providing mechanical conveyance for packer setting assembly 102, including, but not limited to, wireline, slickline, coiled tubing, tubing string, pipe, drill pipe, drill string or the like. In some examples, conveyance line 112 may provide mechanical suspension, as well as electrical connectivity, for packer setting assembly 102. As illustrated, packer setting assembly 102 may be disposed on and/or around conveyance line 112. This may allow an operator to remove packer setting assembly 102 and use packer setting assembly 102 for another wellbore.

[0013] As illustrated, packer setting assembly 102 may be run into wellbore 114 on conveyance line 112. Wellbore 114 may extend through the various earth strata including formation 106. A casing 116 may be secured within wellbore 114 by cement (not shown). Casing 116 may be made from any material such as metals, plastics, composites, or the like, may be expanded or unexpanded as part of an installation procedure. Additionally, it is not necessary for casing 116 to be cemented into wellbore 114. In examples, production tubing 130 may be secured within casing 116. Production tubing 130 may be any suitable tubing string utilized in the production of hydrocarbons. In examples, production tubing may be permanently disposed within casing 116 by cement (not shown). Components of packer setting assembly 102 may be disposed on or near production tubing 130.

[0014] Packer setting assembly 102 may include a packer 118, a control module 120, and a telemetry module 122. As illustrated, control module 120 and telemetry module 122 may be disposed

on conveyance line 112 and packer 118 may be disposed on production tubing 130. However, it should be understood that these components of packer setting assembly 102 may be otherwise disposed in wellbore 114.

[0015] Without limitation, any suitable type of packer 118 may be used. Suitable types of packers may include whether they are permanently set or retrievable, mechanically set, hydraulically set, and/or combinations thereof. Packer 118 may be set downhole to seal off a portion of wellbore 114. When set, packer setting assembly 102 may isolate zones of the annulus between wellbore 114 and a tubing string by providing a seal between production tubing 130 and casing 116. In examples, packer 118 may be disposed on production tubing 130. The remaining components within packer setting assembly 102 may be disposed around conveyance line 112 and run into wellbore 114 when desired for use. Packer setting assembly 102 may temporarily couple to packer 118 to initiate a sealing operation within wellbore 114.

[0016] Control module 120 may include equipment to actuate packer 118 for operation (as described further below). Control module 120 may monitor the operation of packer 118 and send that information uphole via telemetry module 122. Telemetry module 122 may be a component of control module 120 or a separate component that communicates with control module 120. Control module 120 may also receive information from the surface via telemetry module 122. Telemetry module 122 may be configured to transmit information, and receive information from, the surface. For example, telemetry module 122 may transmit information, such as pressure, pump revolutions, and stroke, among others, regarding operation of packer setting assembly 102 in setting packer 118. Information may be transmitted from telemetry module 122 to surface using any suitable unidirectional or bidirectional wired or wireless telemetry system, including, but not limited to, an electrical conductor, a fiber optic cable, acoustic telemetry, electromagnetic telemetry, pressure pulse telemetry, combinations thereof or the like. By way of example, telemetry module 122 may include acoustic and/or vibratory devices that send and receive acoustic signals along the conveyance line 112. Where acoustic telemetry may be used, the acoustic signals may be transmitted to/from telemetry module 122 through the conveyance line 112 and or fluid (not shown) in wellbore 114. As illustrated, one or more telemetry modules 122 may be positioned in wellbore 114. As illustrated, one or more telemetry modules 122 are spaced on conveyance line 112. One or more telemetry modules 122 may form a real-time, two-way data transmission from packer

setting assembly 102 to surface. This may allow an operator at the surface to send and/or receive information from packer setting assembly 102.

[0017] Packer setting assembly 102 may also include packer setting device 124. When run into the wellbore 114, for example, packer setting assembly 102 may releasably secure to packer 118. Packer setting device 124 may then be actuated, for example, by control module 120, to actuator packer 118. Packer setting device 124 may be run into the wellbore 114 after the production tubing is run. Once in location, the packer setting device 124 may create a hydraulic circuit with the packer 118 that has been previously installed. A wireless and/or wired signal may be sent to the packer setting device 124 and the packer setting device 124 may begin to set the packer 118 by activating a downhole hydraulic pump to pump fluid into the packer 118, which causes a piston to move, thereby compressing the seal element and/or moving the slips out to the casing/open hole. After the packer 118 is set and confirmed, the packer setting device 124 may be hydraulically disconnected from the packer 118 and pulled back to the surface. A packer setting device 124 may also be run into location after the packer 118 was previously run, and mechanically latch into the packer 118. Then, the wireless and/or wired signal may turn the hydraulic pump on and move a piston, which mechanically pushes on the packer 118 to set it.

[0018] Downhole system 100 may also include an information handling system 126. Information handling system 126 may be used to communicate with control module 120 during operation. The information handling system 126 may be in signal communication with control module 120, for example, by way of one or more telemetry modules 122. Without limitation, signals from control module 120 may be transmitted through one or more telemetry modules 122, which may be disposed throughout wellbore 114. Telemetry modules 122 may operate to pass information and/or measurements between information handling system 126 and control module 120. Information handling system 126 may be disposed at a surface location. In alternate embodiments, information handling system 126 may be disposed downhole. Without limitation, information handling system 126 may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, the information handling system 126 may be a personal computer, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. Information handling system may

include random access memory (RAM), one or more processing resources (e.g. a microprocessor) such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. In examples, information handling system 126 may include a processing unit (e.g., a central processor), a monitor, an input device (e.g., keyboard, mouse, etc.) as well as computer media (e.g., optical disks, magnetic disks) that can store code for processing receiving information. Information handling system 126 may be operable to receive information from telemetry module 122 via communication link 128, which may be any suitable wired or wireless communication technique. Information handling system 126 may be adapted to receive signals from telemetry module 122 that may be representative of measurements from control module 120 disposed on conveyance line 112. Information handling system 126 may be adapted to transmit signals to telemetry module 122 and/or control module 120. Information handling system 126 may act as a data acquisition system and possibly a data processing system that analyzes measurements, for example, measurements and/or information from control module 120.

[0019] It should be understood by those skilled in the art that present examples are equally well suited for use in wellbores having other directional configurations including vertical wellbore, horizontal wellbores, deviated wellbores, multilateral wells and the like. Accordingly, it should be understood by those skilled in the art that the use of directional terms such as above, below, upper, lower, upward, downward, uphole, downhole and the like are used in relation to the illustrative embodiments as they are depicted in the figures, the upward direction being toward the top of the corresponding figure and the downward direction being toward the bottom of the corresponding figure, the uphole direction being toward the surface of the well and the downhole direction being toward the toe of the well. Also, even though Figure 1 depicts an onshore operation, it should be understood by those skilled in the art that the packer assemblies of the present invention are equally well suited for use in offshore operations. In addition, while Figure 1 depicts use of packer 118 in a cased portion of wellbore 114, it should be understood that packer 118 may also be used in uncased portions of wellbore 114.

[0020] Figure 1B illustrates another example of a downhole system 100 that includes a packer setting assembly 102. As illustrated, casing 116 and production tubing 130 may be disposed in wellbore 114. Conveyance line 112 may also be run into wellbore 114 and secured, for example, to production tubing 130. In contrast to Figure 1A in which control module 120 and packer setting device 124 are disposed on conveyance line 112, the example shown on Figure 1B provides

control module 120 and packer setting device 124 on production tubing 130. As illustrated, at least one of telemetry modules 122 may also be disposed on production tubing 130. In some embodiments, placement of these components of packer setting assembly 102 may allow for a permanent installation in wellbore 114. Packer setting assembly 102 may be secured at any suitable location on production tubing 130. For example, packer setting assembly 102 may be disposed at an end of production tubing 130 as shown on Figure 1B. In examples, conveyance line 112 may travel downhole through wellbore 114. An end 132 of conveyance line 112 may couple to an end 134 of production tubing 130. After conveyance line 112 is coupled to production tubing 130, an operator may actuate packer setting assembly 102 to packer 118 to form a seal between casing 116 and production tubing 130.

[0021] Referring now to Figure 2, packer setting assembly 102 is shown disposed on a conveyance line 112 that is coupled to a production tubing 130. Packer setting assembly 102 may a control module 120 and a telemetry module 122, both of which are disposed on conveyance line 112. Packer setting assembly 102 may also include packer setting device 200. As illustrated, packer setting device 200 may be disposed on production tubing 130. Typically, the packer setting device 200 may be attached to the packer 118 and run on the production tubing 130 with the packer 118. Once in location, a wireless and/or wired signal may be sent to the packer setting device 200 and the packer setting device 200 may begin to set the packer 118 by activating a downhole hydraulic pump to hydraulically move a piston, and thereby compressing the element and/or moving the slips out to the casing and/or inner surface of the wellbore. During the process, the packer setting device 200 may be unlatched from the packer 118 to allow for retrieval of the hydraulic pump and associated electronics. Conveyance line 112 may be extend into production tubing 130 and couple to an end 134 of production tubing 130, which may be secured within casing 116 of wellbore 114 by cement (e.g., referring to Figures 1A and 1B). Control module 120 may monitor the operation of and/or instruct packer setting device 200 to actuate packer 118. For example, control module 120 may receive a command (by way of telemetry module 122) from surface to set packer 118. Telemetry module 122 may be configured to transmit information, and receive information from, the surface. As illustrated, there may be channels 202 within packer setting assembly 102. Channels 202 may direct the flow of a hydraulic fluid in order to pressurize packer 118. In examples, a hydraulic fluid may travel through channels 202 and into packer setting

device 200. Packer setting device 200 may be forced to push against packer 118. As packer 118 is acted upon, packer 118 may radially expand to set against an inner surface of wellbore 114.

[0022] Figure 3 is a schematic diagram illustrating an embodiment of control module 120 in more detail. Control module 120 may serve to monitor and/or influence the operation of packer 118 (e.g., referring to Figure 1). Control module 120 may include a motor 302, a pump 304, a controller 306, and/or combinations thereof. Motor 302 may be used, for example, to produce mechanical energy. Without limitation, any suitable electric motor may be used, including, magnetic, electrostatic, piezoelectric, and/or combinations thereof. Motor 302 may require energy to produce the mechanical energy. While not shown, a power source may be included within control module 120 to provide the motor with electrical energy (e.g., a battery). In alternate embodiments, conveyance line 112 (e.g., referring to Figure 1) may be able to provide the required electrical energy to power motor 302. Pump 304 may use the produced mechanical energy to move a fluid into packer setting device 200 (e.g., referring to Figure 2). Without limitation, any suitable pump may be used, including, rotary hydraulic, piezoelectric, solenoid, and/or combinations thereof. As illustrated, control module 120 may include a reservoir 308 within control module 120 containing a hydraulic fluid to be used by pump 304. In alternate embodiments, a fluid may be pumped from the surface, through conveyance line 112, through control module 120, and to packer setting device 200. In embodiments, controller 306 may control any and/or all equipment within control module 120. Controller 306 may be any suitable device able to energize the actuation of a tool. Controller 306 may energize motor 302 to start producing mechanical energy, energize pump 304 to start pumping a fluid, stop a process, and/or combinations thereof. In embodiments, controller 306 may be able to send and/or receive signals.

[0023] Control module 120 may include one or more sensors 300 to take measurements of packer 118 and/or wellbore 114 (e.g., referring to Figure 1). Without limitation, the one or more sensors 300 may include pressure gauges, thermocouples, flow meters, magnetometers, voltmeters, current sensors, accelerometers, force gauges, strain gauges, load cells, piezoelectric sensors, and/or combinations thereof. Controller 306 may energize a sensor 300 to start taking measurements. Measurements from sensor 300 may provide an operator with real-time feedback and verification that packer 118 has been set within wellbore 114. Measurements from sensor

300 may include, but are not limited to, pressure, temperature, strain, distance, force, vibration, flow rate, flow volume.

[0024] Referring now to Figure 4, tool string 400 is provided. As illustrated, tool string 400 includes control module 120 and packer setting device 200. For simplicity, packer 118 and telemetry module 122 are not shown. As illustrated, control module 120 may be disposed at an end of a packer setting device 310. With additional reference to Figure 2, packer setting device 310 may mechanically latch to packer 118. Packer setting device 310 may be any suitable size, height, and/or shape which may accommodate an end of packer 118. Without limitation, a suitable shape may include, but is not limited to, cross-sectional shapes that are circular, elliptical, triangular, rectangular, square, hexagonal, and/or combinations thereof. Packer setting device 310 may be made from any suitable material. Suitable materials may include, but are not limited to, metals, nonmetals, polymers, ceramics, and/or combinations thereof. In embodiments, packer setting device 310 may indirectly couple control module 120 to packer 118. Packer setting device 310 may be actuated to separate control module 120 from packer 118 once packer 118 has been set within wellbore 114 (e.g., referring to Figure 1). In other embodiments, packer setting device 310 may be actuated to connect packer 118 to control module 120 for a retrieval process.

[0025] Referring to Figures 1, 2, and 4, control module 120 may be threadably coupled to conveyance line 112 (e.g., referring to Figure 1). Control module 120 may be disposed above or below packer 118 while in line with conveyance line 112. Control module 120 may be any suitable size, height, and/or shape. Without limitation, a suitable shape may include, but is not limited to, cross-sectional shapes that are circular, elliptical, triangular, rectangular, square, hexagonal, and/or combinations thereof. Control module 120 may be made from any suitable material. Suitable materials may include, but are not limited to, metals, nonmetals, polymers, ceramics, and/or combinations thereof.

[0026] With continued reference to Figures 1, 2, and 4, an operator may dispose packer setting assembly 102 downhole in wellbore 114. Packer setting assembly 102 may stop descending once it reaches a designated depth. The information handling system 126 may send signals to packer setting assembly 102. In embodiments, these signals may be received by control module 120 by way of telemetry module 122. Control module 120 may actuate packer 118 to set against the inner wall of wellbore 114. With additional reference to Figure 3, packer

118 may be hydraulically actuated with pump 304 disposed within control module 120. Without limitation, sensors 300 within control module 120 may be able to take measurements concerning the pressure build-up within packer 118 and the revolutions per minute of pump 304. Control module 120 may send signals back to the information handling system 126 for data processing. An operator may be able to obtain the setting force with pressure data and knowledge of the piston area within packer 118. The information handling system 126 may be able to determine displacement of the fluid with the revolutions per minute of the pump data. Without limitation, the information handling system 126 may also be able to determine the setting stroke of packer 118, pump output flow, pump efficiency, and/or combinations thereof. Analysis of the described properties may provide feedback to an operator on the condition of packer 118.

[0027] As previously described, one property that may be monitored to determine condition of packer 118 may include pressure. Pressure may be monitored, for example, with sensors 300. The pressure may be monitored at any suitable location, including, but not limited to, proximate to a pump, proximate to the packer 118, in the flow path between the pump and the packer 118, in gauges within the packer setting assembly 102 that communicate back to the surface, and/or combinations thereof. By way of example, steady increases in pressure over time may indicate proper setting of packer 118 as increased resistance may be observed as packer 118 may be placed into its proper position. However, rapid pressure spikes in pressure may indicate a problem with packer 118 deployment. Similarly, minor to no increase in observed pressure may also indicate a problem with packer 118 deployment. Another property that may be monitored to determine condition of packer 118 may include flow rate. Flow rate may be monitored, for example, with sensors 300. The flow rate being monitored may be the flow rate of hydraulic fluid being delivered to packer 118 by way of pump 304. By way of example, steady decreases in flow rate over time may indicate proper setting of packer 118 as increased resistance to fluid flow may be observed as packer 118 may be placed into its proper position. However, rapid pressure decreases in flow rate may indicate a problem with packer 118 deployment. Similarly, minor to no decreases in observed flow rate may also indicate a problem with packer 118 deployment. Additionally, the setting stroke of operating packer 118 may be calculated by knowing the volume of the fluid displaced, which may also be observed through sensors 300.

[0028] Figures 5A-5C illustrate varying graphs depicting pressure and flow rate as a function of time. Pressure is indicated on Figures 5A-5C by line 500 while flow rate is indicated

on Figures 5A-5C by line 505. As previously described, the pressure and flow rate are properties that may be monitored to determine proper setting of packer 118. Pressure and flow rate of hydraulic fluid being delivered from pump 304 (e.g., shown on Figure 3) to actuate packer 118 may be monitored. Figure 5A illustrates an example graph for a properly set packer. As shown, the pressure gradually increases as components within packer 118 (e.g., referring to Figure 1) operate. The flow rate of hydraulic fluid decreases with the rise in pressure as components within packer 118 actuate. Figure 5B illustrates an example graph for an improperly set packer. As shown, the pressure gradually increases and spikes before the proper volume of fluid was pumped. By way of example, this may indicate that a component within packer 118 is locked up or jammed, and packer 118 is not fully set. Figure 5C illustrates another graph for an improperly set packer. As shown, the pressure does not increase. The fluid flow rate remains high because the pressure does not actuate. By way of example, this may indicate that the setting mechanism is detached from packer 118 and stroking freely without putting a load on other components within packer 118. Control module 120 (e.g., referring to Figure 1) may provide real-time data to the information handling system. The information handling system 126 may display various graphs, similar to those illustrated in Figures 5A-5C, depicting conditions of packer 118 operation.

[0029] Referring now to Figures 6A-6C, therein are depicted successive axial sections of packer 118. It should be understood that Figures 6A-6C illustrate an example of packer 118 that may be used with the present technique and the present disclosure is intended to encompass other configurations of packer 118. Packer 118 may be threadably coupled to other downhole tools as part of conveyance line 112 (e.g., referring to Figure 1). Packer 118 may include a packer mandrel 602. Packer mandrel 602 may include a pin groove 604, as best seen in Figure 6A and a pin groove 606, as best seen in Figure 6B. Positioned around an upper portion of packer mandrel 602 may be an upper housing section 608 that may be threadably coupled to packer mandrel 602. One or more threaded pins 610 may be used to secure upper housing section 608 against rotation. At its lower end, upper housing section 608 may be securely coupled by one or more pins 612 to a first wedge 614 that may be disposed about packer mandrel 602. First wedge 614 may include a pair of ramps 616, 618 that may be operable to engage an inner surface of an upper slip element 620 that may be disposed about packer mandrel 602. Upper slip element 620 may include a substantially cylindrical, non-directional contact surface 622 for diverting force to the wall of wellbore 114 (referring to Figure 1) when set and a substantially cylindrical, directional

gripping surface 624 depicted as including a plurality of teeth 626 for providing a gripping arrangement with the interior of the wall of wellbore 114 when set. As illustrated, upper slip element 620 is located between first wedge 614 and a second wedge 630 that may include a pair of ramps 632, 634. In the running configuration of packer 118 depicted in Figures 6A-6C, second wedge 630 may be securely coupled to packer mandrel 602 by one or more pins 636. In addition, upper slip element 620 may be prevented from moving up ramp 632 of second wedge 630 by one or more pins 638. As explained in greater detail below, when a compressive force is generated between first wedge 614 and second wedge 630, upper slip element 620 may be radially expanded into contact with the wall of wellbore 114.

[0030] An upper element backup shoe 640 that may be slidably positioned around packer mandrel 602 may be adjacent to second wedge 630. Additionally, a seal assembly 642, depicted as expandable seal elements 644, 646, 648, may be slidably positioned around packer mandrel 602 between upper element backup shoe 640 and a lower element backup shoe 650. Even though three expandable seal elements 644, 646, 648 are depicted and described, those skilled in the art will recognize that a seal assembly of the packer of the present invention may include any number of seal elements.

[0031] Upper element backup shoe 640 and lower element backup shoe 650 may be made from a deformable or malleable material, such as mild steel, soft steel, brass and the like and may be thin cut at their distal ends. The ends of upper element backup shoe 640 and lower element backup shoe 650 may deform and flare outwardly toward the inner surface of the wall of wellbore 114 during setting. In an embodiment, upper element backup shoe 640 and lower element backup shoe 650 may form metal-to-metal barriers between packer 118 and the inner surface the wall of wellbore 114.

[0032] A third wedge 652 may be disposed about packer mandrel 602 and include a pair of ramps 654, 656. In the running configuration of packer 118 depicted in Figures 6A-6C, third wedge 652 may be securely coupled to packer mandrel 602 by one or more pins 658. A lower slip element 660 that may be disposed about packer mandrel 602 may be below third wedge 652. Lower slip element 660 may include a substantially cylindrical, directional gripping surface 662 depicted as including a plurality of teeth 664 for providing a gripping arrangement with the interior of the wall of wellbore 114 when set and a substantially cylindrical, non-directional contact surface 666 for diverting force to the wall of wellbore 114 when set. A force ring 668

may be disposed between lower slip element 660 and packer mandrel 602. Lower slip element 660 may be located between third wedge 652 and a fourth wedge 670 that may include a pair of ramps 672, 674 that may be operable to engage an inner surface of lower slip element 660. Initially, fourth wedge 670 may be coupled to force ring 668 by one or more pins 669. As explained in greater detail below, when a compressive force is generated between third wedge 652 and fourth wedge 670, lower slip element 660 may be radially expanded into contact with the wall of wellbore 114.

[0033] A piston assembly 676 may be slidably disposed about packer mandrel 602 and coupled to fourth wedge 670 through a threaded connection. Piston assembly 676 may include an upper piston section 678, an intermediate piston section 680 that may be threadably and sealingly coupled to upper piston section 678, a lower piston section 682 that may be threadably coupled to intermediate piston section 680, and a retainer ring 684 that may be threadably coupled to lower piston section 682. Even though piston assembly 676 is depicted and described as having a particular number of sections, those skilled in the art will recognize that other arrangements of piston sections including a greater number or lesser number of piston sections including a single piston section could alternatively be used in the present invention. Upper piston section 678 may include a sealing profile 686 having multiple sealing elements that provide a seal with packer mandrel 602.

[0034] A lower cylinder 688 may be disposed between packer mandrel 602 and the lower sections of piston assembly 676. Lower cylinder 688 may include a sealing profile 690 having multiple sealing elements that may provide a seal with packer mandrel 602. Lower cylinder 688 may also include a second sealing profile 692 having multiple sealing elements that provide a seal with intermediate piston section 680. Packer mandrel 602 and intermediate piston section 680, as well as the seals of upper piston section 678 and lower cylinder 688, may define a setting chamber 694 that may be in fluid communication with one or more fluid ports 696 that extend through packer mandrel 602. Retainer ring 684 may be initially coupled to lower cylinder 688 by one or more frangible members depicted as shear screws 698. Lower cylinder 688 may include a serrated outer surface 700 that may be operable to interact with a body lock ring 702 disposed between lower cylinder 688 and lower piston section 682. At its lower end, lower cylinder 688 may be threadably coupled to a lower housing section 704. A lock ring 706 may be disposed

between lower housing section 704 and packer mandrel 602 that may secure lower housing section 704 onto packer mandrel 602.

[0035] Figures 6A-6C and 7A-7C collectively illustrate an operating mode of packer 118. Packer 118 may be depicted before and after activation and expansion of expandable seal elements 644, 646, 648 and slip elements 620, 660, respectively, in Figures 6A-6C and 7A-7C. Packer 118 may be run into wellbore 114 on conveyance line 112 (referring to Figure 1) to a desired depth and then set against a casing string, a liner string or wall of wellbore 114. Setting may be accomplished by increasing the tubing pressure within packer mandrel 602. The force generated by the fluid pressure acting on a surface of a piston area within packer 118 may cause expansion of expandable seal elements 644, 646, 648 against an inner surface of casing 116 and/or of wellbore 114.

[0036] In examples, control module 120 (e.g., referring to Figure 1) may be coupled to packer 118. Pump 304 (e.g., referring to Figure 3) may displace a hydraulic fluid from control module 120 (e.g., referring to Figure 1) into packer 118. The pressure of the hydraulic fluid may be directed onto the piston area which may cause slip element 620 to be radially outwardly shifted by ramps 616, 618, 632, 634. This may set slip element 620 against the setting surface of wellbore 114. As slip element 620 sets, greater force may be applied between second wedge 630 and third wedge 652. This may apply a compressive force against seal assembly 642, which causes radial expansion of expandable seal elements 644, 646, 648 against the sealing surface of wellbore 114. In addition, the compressive forces may cause upper element backup shoe 640 and lower element backup shoe 650 to flare outward toward the sealing surface to provide a metal-to-metal seal against a casing or liner string (i.e., if wellbore 114 is cased).

[0037] In this manner, packer 118 may create a sealing relationship between expandable seal elements 644, 646, 648 and the sealing surface of wellbore 114. In addition, packer 118 may create a gripping relationship between directional gripping surface 624 of slip element 620, directional gripping surface 662 of slip element 660 and setting surfaces of wellbore 114. Further, packer 118 may create a contact relationship between non-directional contact surface 622 of slip element 620, non-directional contact surface 666 of slip element 660 and setting surfaces of wellbore 114. In this set configuration, directional gripping surface 624 of slip element 620 may oppose movement of slip element 620 in the uphole direction, and directional gripping surface 662 of slip element 660 may oppose movement of slip element 660 in the

downhole direction. In addition, non-directional contact surface 622 of slip element 620 may divert force acting on slip element 620 in the downhole direction to the wellbore, and non-directional contact surface 666 of slip element 660 may divert force acting on slip element 660 in the uphole direction of wellbore 114.

[0038] The systems and methods for setting a packer may include any of the various features of the systems and methods disclosed herein, including one or more of the following statements.

[0039] Statement 1. A system for packer setting, comprising: a packer, a telemetry module operable to wirelessly receive one or more control signals from a surface location, and a control module coupled to the telemetry module and the packer, wherein the control module is operable to actuate the packer in response to the one or more control signals from the surface location

[0040] Statement 2. The system of statement 1, wherein the control module comprises a controller, a pump, and a reservoir of hydraulic fluid.

[0041] Statement 3. The system of statement 2, wherein the pump comprises a rotary hydraulic pump.

[0042] Statement 4. The system of any of the previous statements, wherein the control module comprises at least one sensor.

[0043] Statement 5. The system of statement 4, wherein the at least one sensor comprises a pressure gauge.

[0044] Statement 6. The system of statement 4, wherein the at least one sensor comprises a flow meter.

[0045] Statement 7. The system of any of the previous statements, wherein the packer comprises a piston assembly, a seal element, and a slip element.

[0046] Statement 8. The system of any of the previous statements, wherein the telemetry module is operable to wirelessly transmit signals to the surface location, wherein the signals actuate the packer to set or unset.

[0047] Statement 9. The system of any of the previous statements, wherein the signals transmitted to the surface location comprise information related to one or more of pressure of hydraulic fluid, flow rate of hydraulic fluid, pump revolutions, setting stroke of the packer, volumetric flow, volumetric displacement, temperature, strain, distance, force, or vibration.

[0048] Statement 10. The system of any of the previous statements, wherein the system comprises a packer setting assembly in the form of a tool string, wherein the tool comprises the control module and a packer setting device at a distal end of the control module, wherein the packer setting device is mechanically latchable to the packer to secure the packer setting assembly to the packer.

[0049] Statement 11. The system of any of the previous statements, further comprising a plurality of transceivers spaced in a wellbore between the surface location and the telemetry module, wherein the plurality of transceivers are operable to wirelessly communicate the control signals from the surface location to the control module.

[0050] Statement 12. A method of setting a packer, comprising: transmitting one or more control signals from a surface location to a telemetry module disposed in a wellbore, pumping a hydraulic fluid to hydraulically actuate a packer in response to the one or more control signals, and setting the packer in the wellbore using the hydraulic fluid.

[0051] Statement 13. The method of statement 12, wherein the one or more control signals are transmitted to the surface location by way of wireless communication.

[0052] Statement 14. The method of statements 12 or 13, wherein the transmitting the one or more control signals from the surface location to the telemetry module comprises transmitting the one or more control signals to one or more transceivers disposed in the wellbore and then transmitting the one or more control signals from the one or more transceivers to the telemetry module.

[0053] Statement 15. The method of any of statements 12 to 14, further comprising transmitting one or more signals from the telemetry module to the surface location by way of wireless communication, wherein the one or more signals are indicative of packer operation.

[0054] Statement 16. The method of statement 15, wherein the one or more signals comprise information related to one or more of pressure of hydraulic fluid, flow rate of hydraulic fluid, pump revolutions, setting stroke of the packer, volumetric flow, volumetric displacement, temperature, strain, distance, force, or vibration.

[0055] Statement 17. The method of any of statements 12 to 16, further comprising measuring one or more properties indicating of packer setting as the packer is set in the wellbore.

[0056] Statement 18. The method of statement 17, wherein the measuring comprises measuring pressure of the hydraulic fluid.

[0057] Statement 19. The method of statement 17, wherein the measuring comprises measuring flow rate of the hydraulic fluid.

[0058] Statement 20. The method of statement 17, further comprising displaying an image of the one or more properties as a function of time.

[0059] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations may be made herein without departing from the spirit and scope of the invention as defined by the appended claims. The preceding description provides various examples of the systems and methods of use disclosed herein which may contain different method steps and alternative combinations of components. It should be understood that, although individual examples may be discussed herein, the present disclosure covers all combinations of the disclosed examples, including, without limitation, the different component combinations, method step combinations, and properties of the system. It should be understood that the compositions and methods are described in terms of “including,” “containing,” or “including” various components or steps, the compositions and methods can also “consist essentially of” or “consist of” the various components and steps. Moreover, the indefinite articles “a” or “an,” as used in the claims, are defined herein to mean one or more than one of the element that it introduces.

[0060] For the sake of brevity, only certain ranges are explicitly disclosed herein. However, ranges from any lower limit may be combined with any upper limit to recite a range not explicitly recited, as well as, ranges from any lower limit may be combined with any other lower limit to recite a range not explicitly recited, in the same way, ranges from any upper limit may be combined with any other upper limit to recite a range not explicitly recited. Additionally, whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range are specifically disclosed. In particular, every range of values (of the form, “from about a to about b,” or, equivalently, “from approximately a to b,” or, equivalently, “from approximately a-b”) disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values even if not explicitly recited. Thus, every point or individual value may serve as its own lower or upper limit combined with any other point or individual value or any other lower or upper limit, to recite a range not explicitly recited.

[0061] Therefore, the present examples are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular examples disclosed above are illustrative only, and may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Although individual examples are discussed, the disclosure covers all combinations of all of the examples. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. It is therefore evident that the particular illustrative examples disclosed above may be altered or modified and all such variations are considered within the scope and spirit of those examples. If there is any conflict in the usages of a word or term in this specification and one or more patent(s) or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

What is claimed is:

1. A system for packer setting, comprising:
 - a packer;
 - a telemetry module operable to wirelessly receive one or more control signals from a surface location; and
 - a control module coupled to the telemetry module and the packer, wherein the control module is operable to actuate the packer in response to the one or more control signals from the surface location.
2. The system of claim 1, wherein the control module comprises a controller, a pump, and a reservoir of hydraulic fluid.
3. The system of claim 2, wherein the pump comprises a rotary hydraulic pump.
4. The system of claim 1, wherein the control module comprises at least one sensor.
5. The system of claim 4, wherein the at least one sensor comprises a pressure gauge.
6. The system of claim 4, wherein the at least one sensor comprises a flow meter.
7. The system of claim 1, wherein the packer comprises a piston assembly, a seal element, and a slip element.
8. The system of claim 1, wherein the telemetry module is operable to wirelessly transmit signals to the surface location, wherein the signals actuate the packer to set or unset.
9. The system of claim 8, wherein the signals transmitted to the surface location comprise information relating to one or more of pressure of hydraulic fluid, flow rate of hydraulic fluid,

pump revolutions, setting stroke of the packer, volumetric flow, volumetric displacement, temperature, strain, distance, force, or vibration.

10. The system of claim 1, wherein the system comprises a packer setting assembly in the form of a tool string, wherein the tool comprises the control module and a packer setting device at a distal end of the control module, wherein the packer setting device is mechanically latchable to the packer to secure the packer setting assembly to the packer.

11. The system of claim 1, further comprising a plurality of transceivers spaced in a wellbore between the surface location and the telemetry module, wherein the plurality of transceivers are operable to wirelessly communicate the control signals from the surface location to the control module.

12. A method of setting a packer, comprising:

transmitting one or more control signals from a surface location to a telemetry module disposed in a wellbore;

pumping a hydraulic fluid to hydraulically actuate a packer in response to the one or more control signals; and

setting the packer in the wellbore using the hydraulic fluid.

13. The method of claim 12, wherein the one or more control signals are transmitted to the surface location by way of wireless communication.

14. The method of claim 12, wherein the transmitting the one or more control signals from the surface location to the telemetry module comprises transmitting the one or more control signals to one or more transceivers disposed in the wellbore and then transmitting the one or more control signals from the one or more transceivers to the telemetry module.

15. The method of claim 12, further comprising transmitting one or more signals from the telemetry module to the surface location by way of wireless communication, wherein the one or more signals are indicative of packer operation.

16. The method of claim 15, wherein the one or more signals comprise information related to one or more of pressure of hydraulic fluid, flow rate of hydraulic fluid, pump revolutions, setting stroke of the packer, volumetric flow, volumetric displacement, temperature, strain, distance, force, or vibration.
17. The method of claim 12, further comprising measuring one or more properties indicating of packer setting as the packer is set in the wellbore.
18. The method of claim 17, wherein the measuring comprises measuring pressure of the hydraulic fluid.
19. The method of claim 17, wherein the measuring comprises measuring flow rate of the hydraulic fluid.
20. The method of claim 17, further comprising displaying an image of the one or more properties as a function of time.

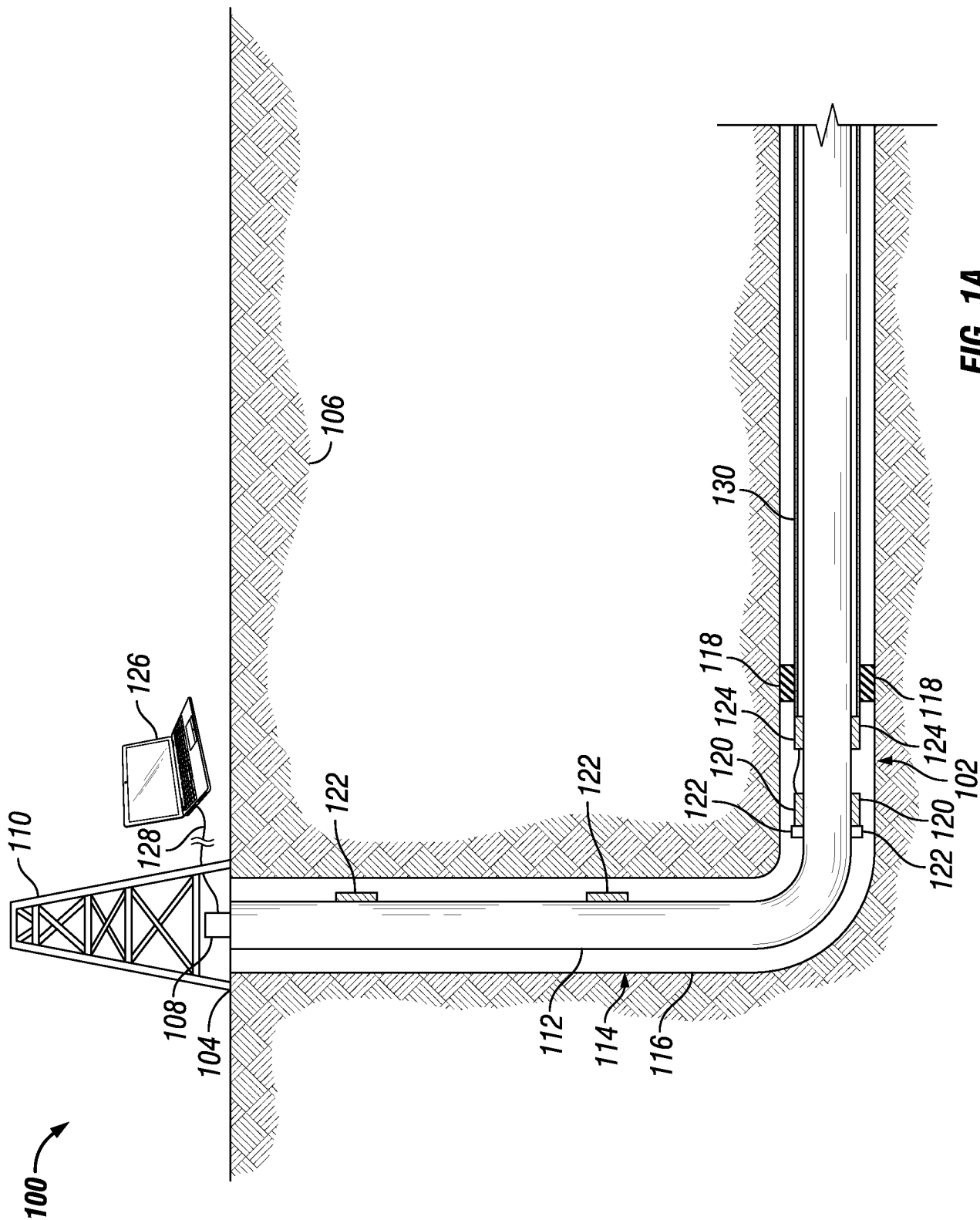
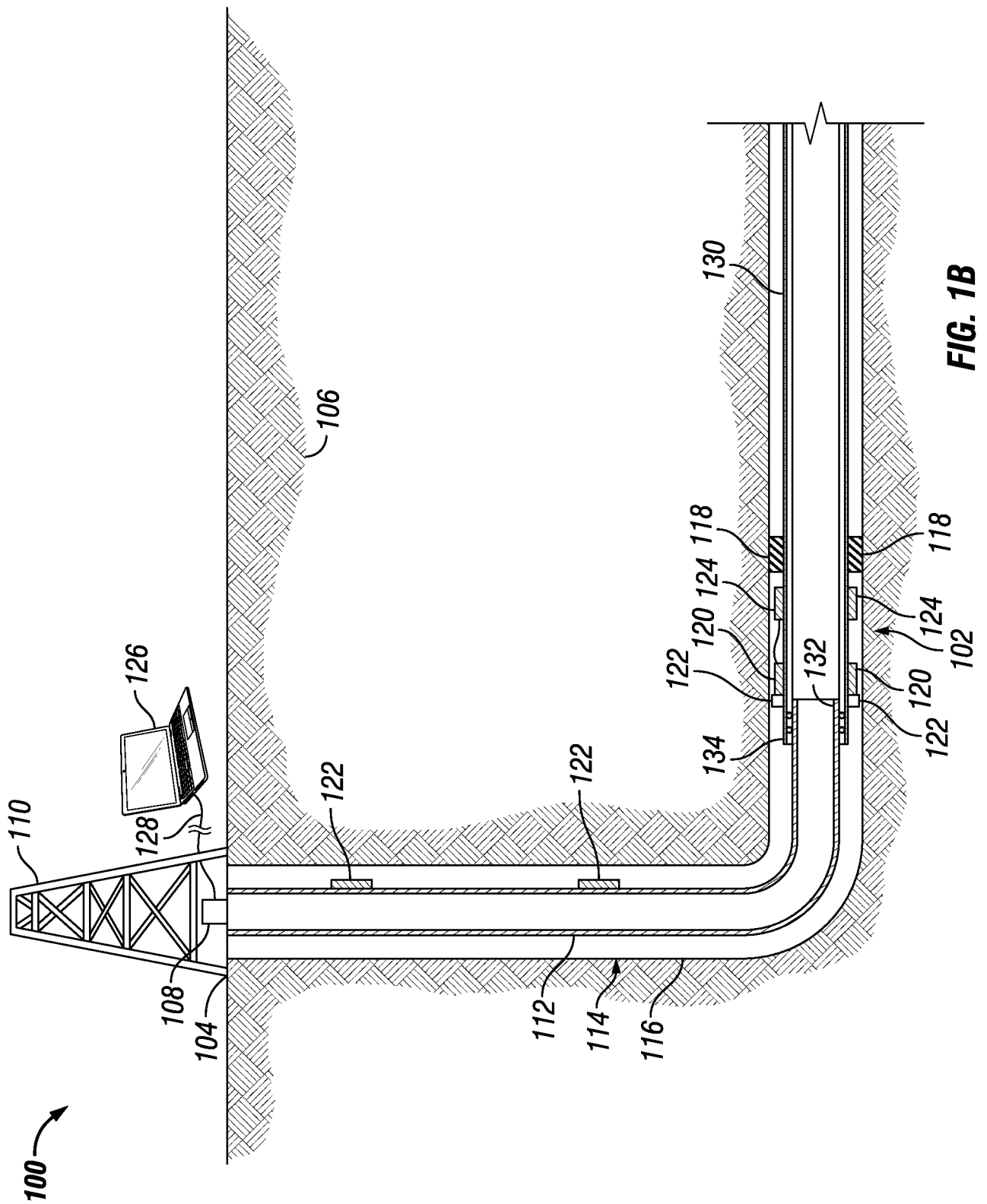


FIG. 1A



3/7

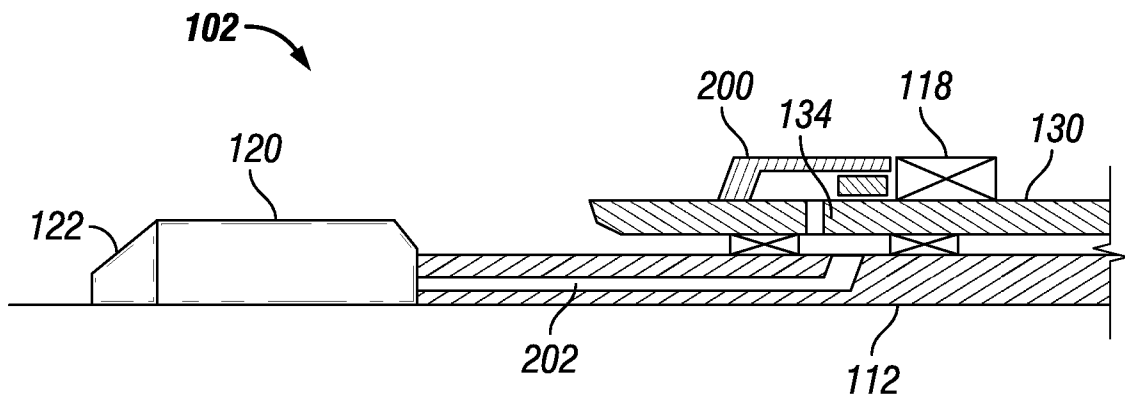


FIG. 2

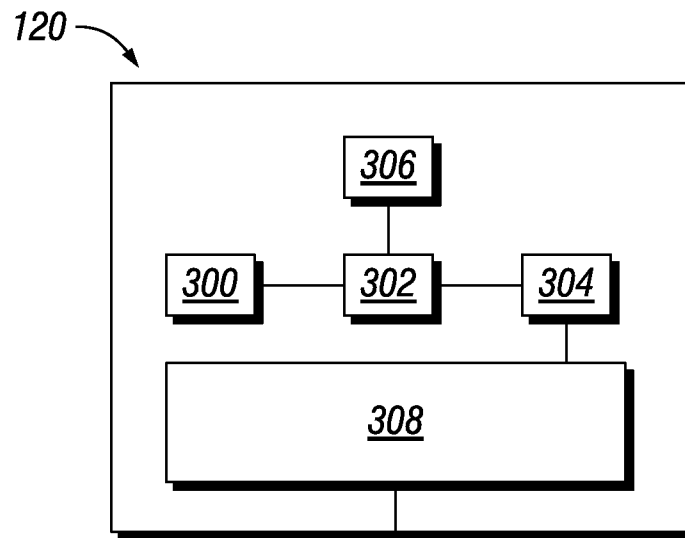


FIG. 3

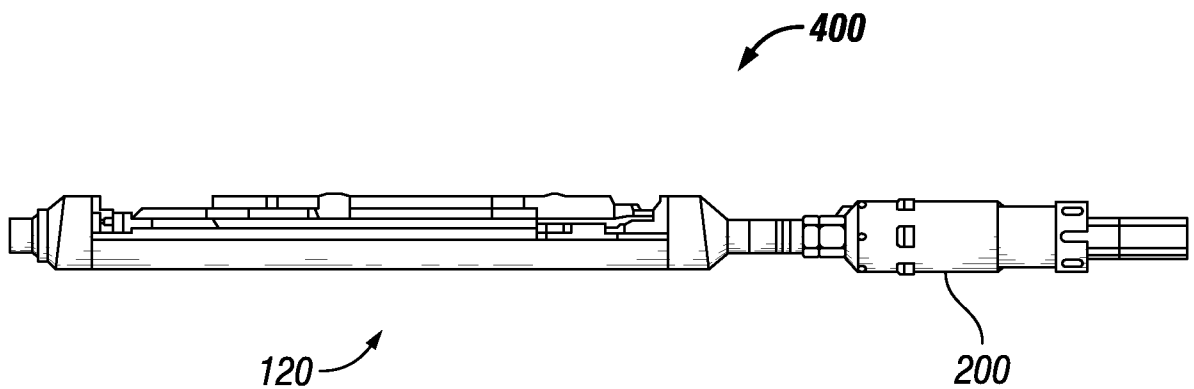
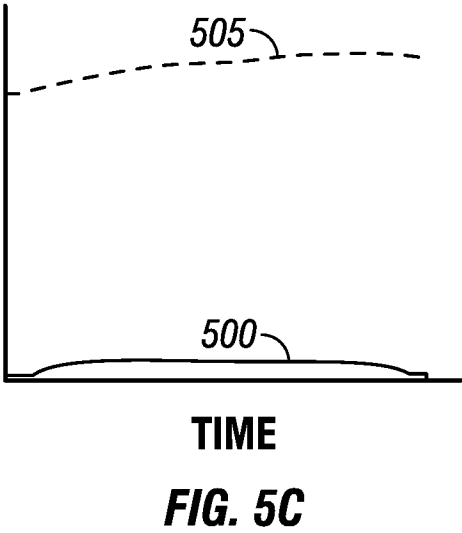
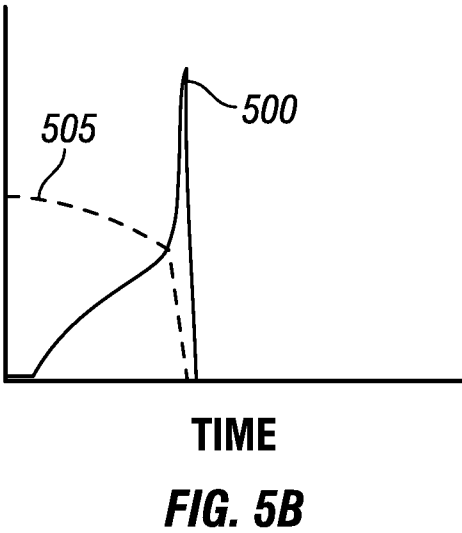
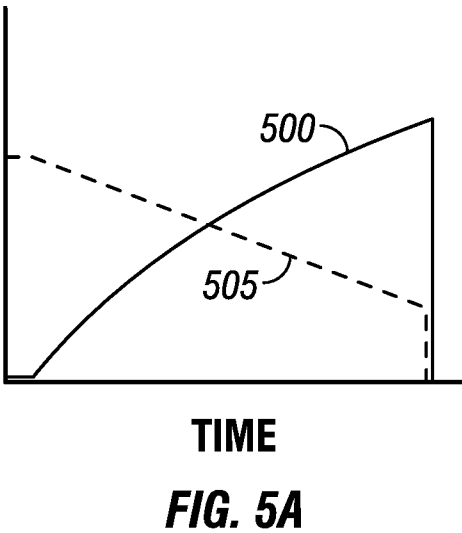


FIG. 4

4/7



5/7

118

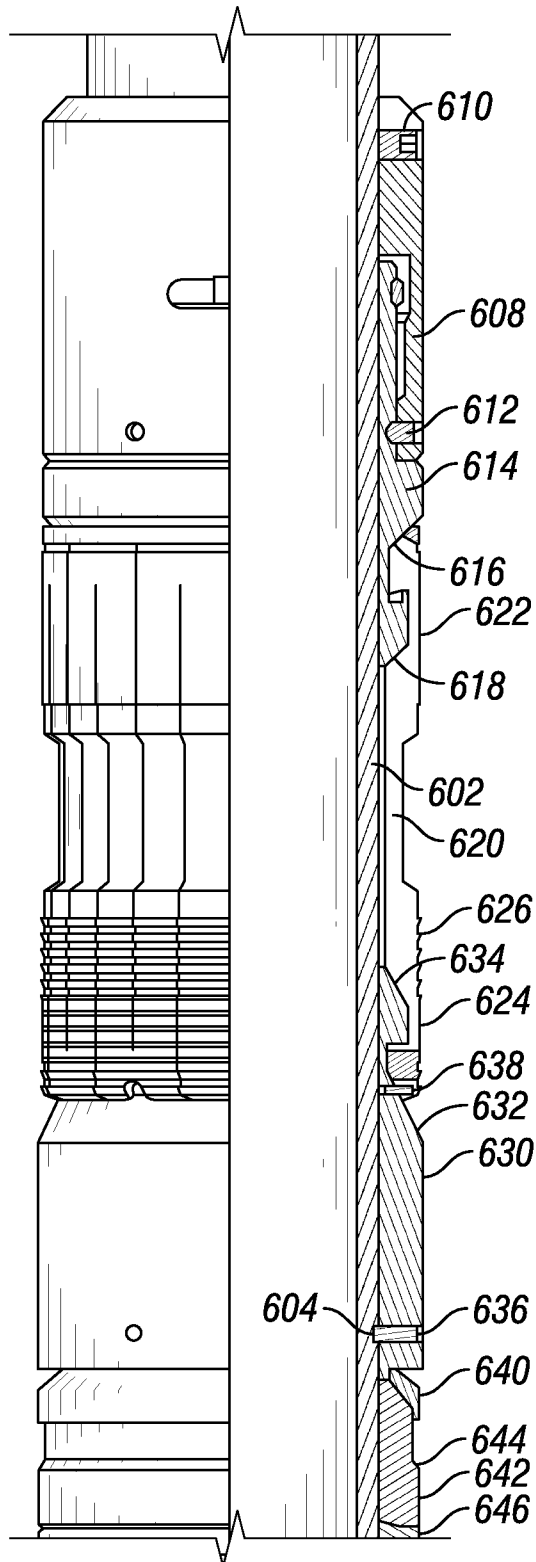


FIG. 6A

118

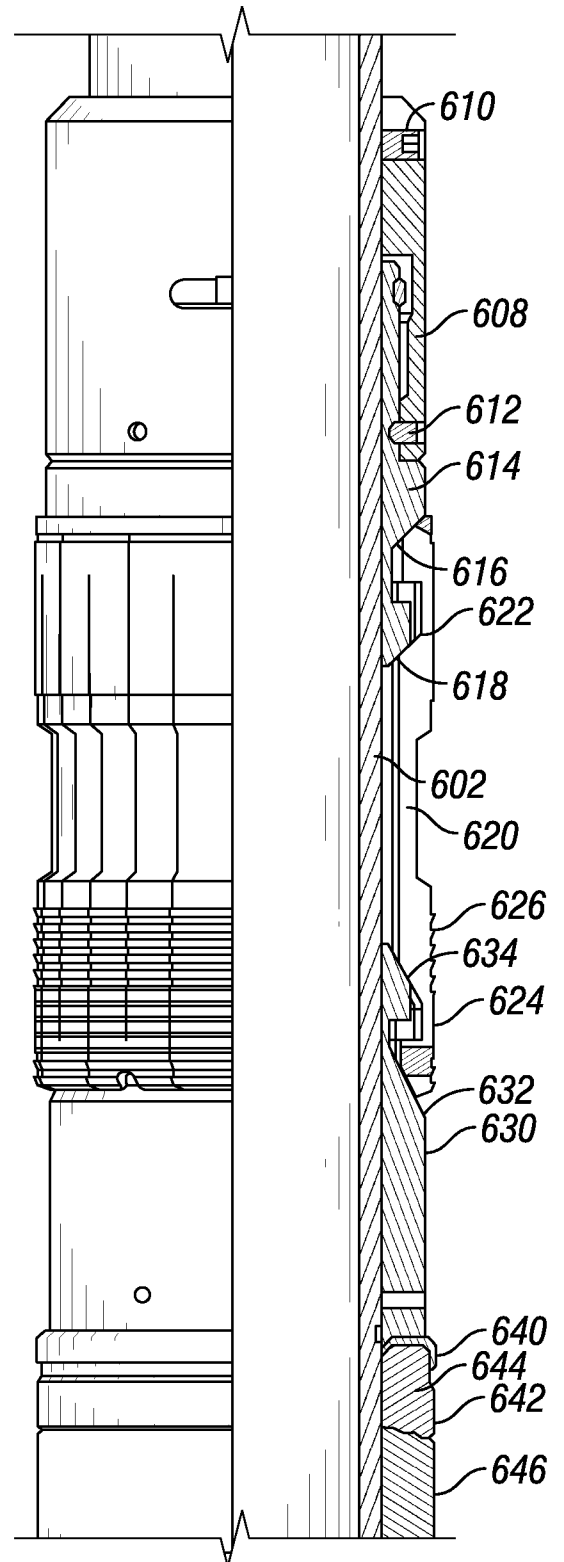


FIG. 7A

6/7

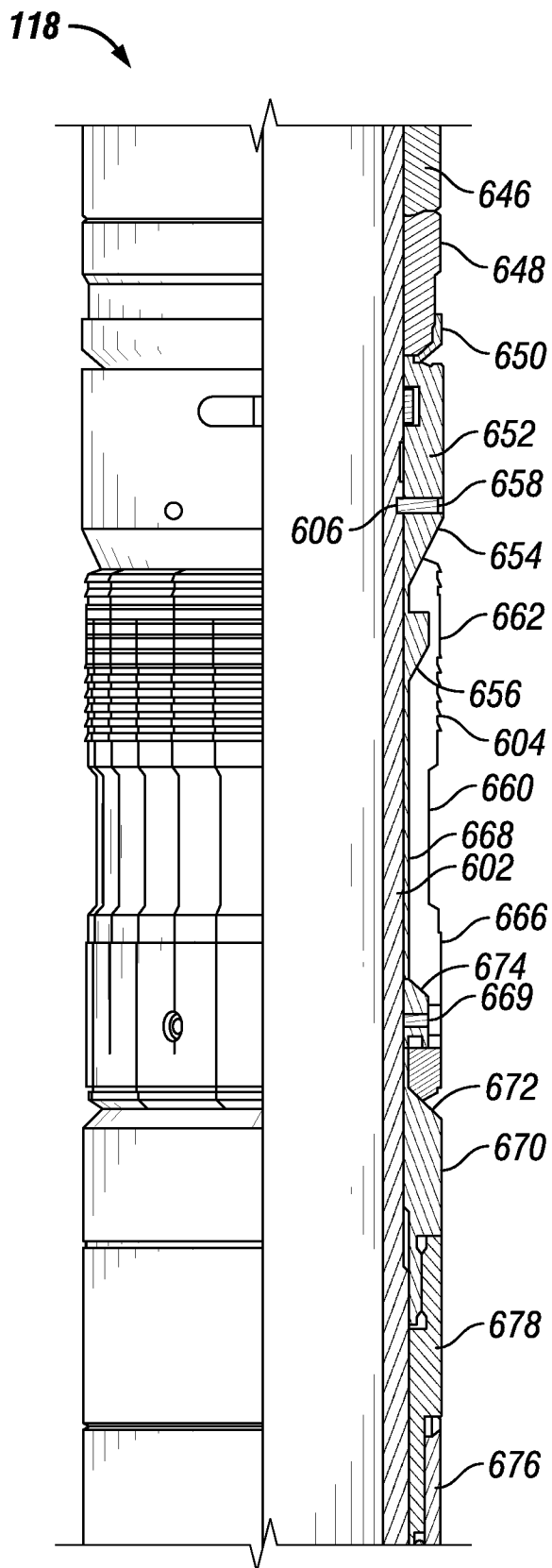


FIG. 6B

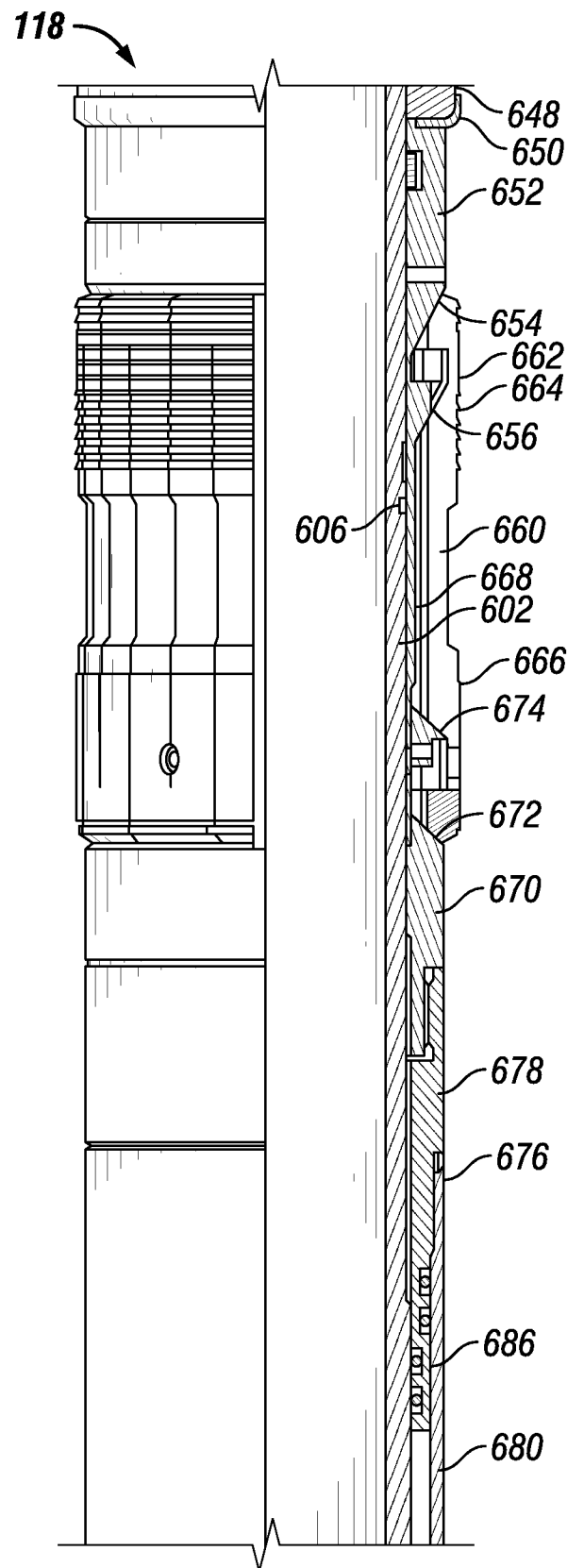


FIG. 7B

7/7

118

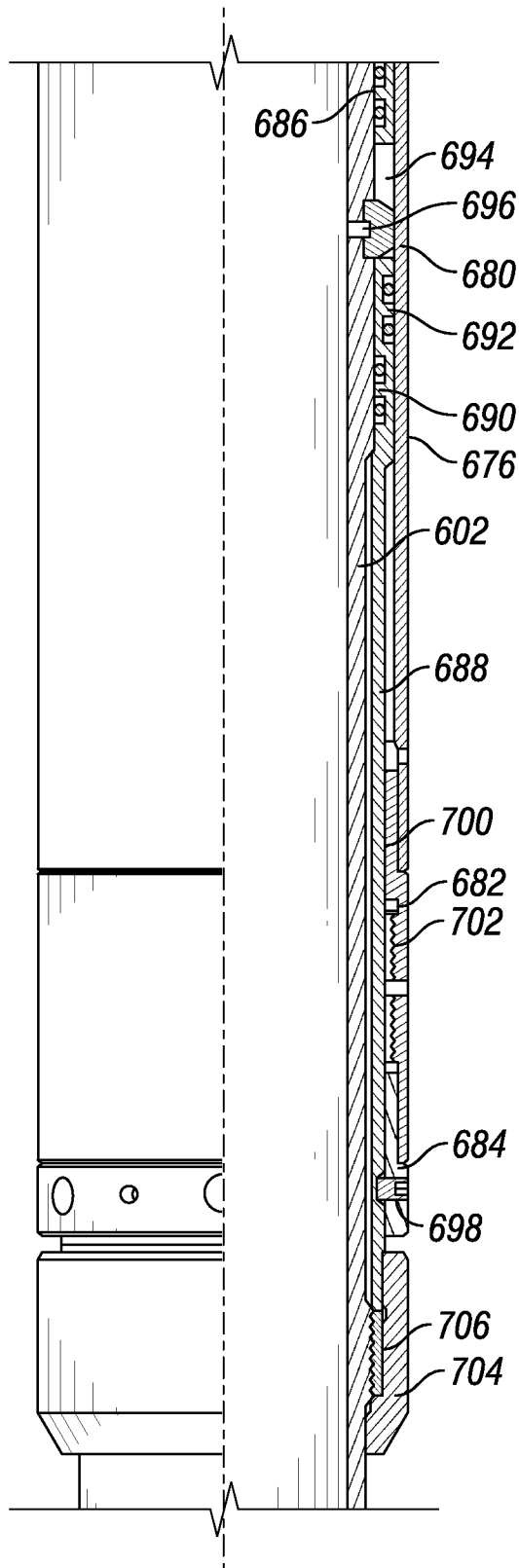


FIG. 6C

118

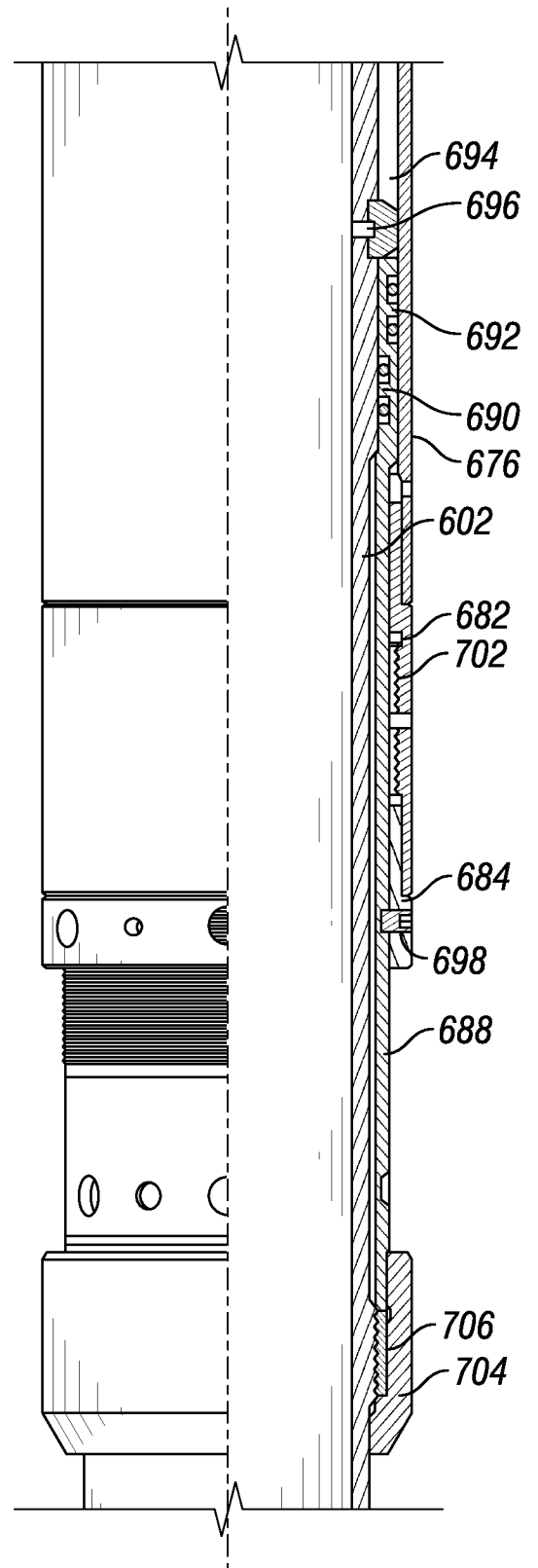


FIG. 7C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/030256**A. CLASSIFICATION OF SUBJECT MATTER****E21B 23/06(2006.01)i, E21B 33/12(2006.01)i, E21B 47/12(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 23/06; E21B 33/12; E21B 33/122; E21B 47/16; E21B 47/12

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: packer, downhole, well, control, telemetry

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003-0042026 A1 (VINEGAR et al.) 06 March 2003	1,4-6,8-9,11
Y	See abstract; paragraphs [0010]-[0051]; claim 24; and figures 2, 4.	2-3,7,10,12-20
Y	US 2009-0218107 A1 (CHAUFFE, STEPHEN J.) 03 September 2009	2-3,7,12-20
	See paragraphs [0016], [0019]; and figures 2, 4.	
Y	US 2002-0096325 A1 (SONNIER, JAMES A.) 25 July 2002	10
	See abstract; paragraph [0025]; claims 4, 9; and figure 3.	
A	US 2010-0149919 A1 (SEGAL, ARKADIY YURIEVICH) 17 June 2010	1-20
	See paragraphs [0011]-[0024]; and figure 1.	
A	WO 2014-092836 A1 (HALLIBURTON ENERGY SERVICES, INC.) 19 June 2014	1-20
	See paragraphs [0024]-[0080]; and figures 2A-2C, 3.	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

28 January 2019 (28.01.2019)

Date of mailing of the international search report

29 January 2019 (29.01.2019)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Dal Kyong

Telephone No. +82-42-481-8440



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003-0042026 A1	06/03/2003	AT 292742 T	15/04/2005
		AT 292744 T	15/04/2005
		AT 299986 T	15/08/2005
		AU 2001-243391 B2	07/10/2004
		AU 2001-243412 B2	14/10/2004
		AU 2001-243413 B2	07/10/2004
		AU 2001-245389 B2	19/08/2004
		AU 2001-245433 B2	19/08/2004
		AU 2001-245434 B2	14/10/2004
		AU 2001-247272 B2	14/10/2004
		AU 2001-247280 B2	07/10/2004
		AU 2001-250795 B2	07/10/2004
		AU 2680801 A	07/08/2001
		AU 3733701 A	07/08/2001
		AU 3737401 A	20/08/2001
		AU 4053701 A	07/08/2001
		AU 4339101 A	12/09/2001
		AU 4340501 A	12/09/2001
		AU 4341201 A	12/09/2001
		AU 4341301 A	12/09/2001
		AU 4538901 A	12/09/2001
		AU 4543301 A	12/09/2001
		AU 4543401 A	12/09/2001
		AU 4727201 A	12/09/2001
		AU 4727601 A	12/09/2001
		AU 4728001 A	12/09/2001
		AU 4908901 A	12/09/2001
		AU 5079501 A	12/09/2001
		AU 765859 B2	02/10/2003
		AU 767417 B2	06/11/2003
		AU 772610 B2	06/05/2004
		BR 0107819 A	06/07/2004
		BR 0107819 B1	22/02/2011
		BR 0107820 A	06/07/2004
		BR 0107820 B1	13/01/2009
		BR 0107821 A	06/07/2004
		BR 0107821 B1	08/09/2010
		BR 0108873 A	18/01/2005
		BR 0108873 B1	04/05/2010
		BR 0108874 A	29/06/2004
		BR 0108874 B1	27/12/2011
		BR 0108876 A	18/03/2003
		BR 0108876 B1	24/08/2010
		BR 0108877 A	18/03/2003
		BR 0108877 B1	04/05/2010
		BR 0108881 A	29/06/2004
		BR 0108881 B1	05/10/2010
		BR 0108886 A	29/06/2004
		BR 0108887 A	29/06/2004

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		BR 0108888 A	22/06/2004
		BR 0108888 B1	05/05/2009
		BR 0108895 A	29/06/2004
		BR 0108895 B1	25/01/2011
		CA 2398289 A1	02/08/2001
		CA 2398289 C	24/03/2009
		CA 2399130 A1	16/08/2001
		CA 2399130 C	02/06/2009
		CA 2401668 A1	07/09/2001
		CA 2401668 C	15/12/2009
		CA 2401681 A1	07/09/2001
		CA 2401681 C	20/10/2009
		CA 2401705 A1	07/09/2001
		CA 2401705 C	24/09/2013
		CA 2401707 A1	07/09/2001
		CA 2401707 C	03/11/2009
		CA 2401709 A1	07/09/2001
		CA 2401709 C	23/06/2009
		CA 2401723 A1	07/09/2001
		CA 2401723 C	09/06/2009
		CA 2401730 A1	07/09/2001
		CA 2401730 C	04/08/2009
		CA 2401734 A1	07/09/2001
		CA 2401734 C	12/05/2009
		CA 2401744 A1	07/09/2001
		CA 2401744 C	27/04/2010
		CA 2401791 A1	07/09/2001
		CA 2401791 C	28/04/2009
		CA 2402163 A1	07/09/2001
		CA 2402163 C	20/10/2009
		CA 2402203 A1	07/09/2001
		CA 2402203 C	12/05/2009
		CN 1229567 C	30/11/2005
		CN 1406311 A	26/03/2003
		DE 60109894 T2	23/03/2006
		DE 60109895 T2	09/02/2006
		DE 60112041 T2	13/04/2006
		DE 60119898 T2	10/05/2007
		DE 60119899 T2	30/11/2006
		DE 60123584 T2	21/06/2007
		DE 60123759 T2	11/10/2007
		DE 60123760 T2	23/08/2007
		DE 60125020 T2	05/04/2007
		DE 60128446 T2	17/01/2008
		EA 004215 B1	26/02/2004
		EA 200200797 A1	27/02/2003
		EG 22206 A	31/10/2002
		EG 22420 A	29/01/2003
		EG 22608 A	31/05/2003
		EP 1250513 A1	23/10/2002

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		EP 1250513 B1	06/04/2005
		EP 1250514 A1	23/10/2002
		EP 1250514 B1	06/04/2005
		EP 1252416 A1	30/10/2002
		EP 1252416 B1	20/07/2005
		EP 1259700 A1	27/11/2002
		EP 1259700 B1	16/05/2007
		EP 1259701 A1	27/11/2002
		EP 1259701 B1	24/05/2006
		EP 1259702 A1	27/11/2002
		EP 1259702 B1	24/05/2006
		EP 1259705 A1	27/11/2002
		EP 1259706 A2	27/11/2002
		EP 1259706 B1	04/10/2006
		EP 1259707 A1	27/11/2002
		EP 1259708 A2	27/11/2002
		EP 1259708 B1	11/10/2006
		EP 1259709 A1	27/11/2002
		EP 1259709 B1	06/12/2006
		EP 1259710 A1	27/11/2002
		EP 1259710 B1	11/10/2006
		GB 2376965 A	31/12/2002
		GB 2376965 B	18/02/2004
		GB 2376967 A	31/12/2002
		GB 2376967 B	10/03/2004
		GB 2376968 A	31/12/2002
		GB 2376968 B	03/03/2004
		GB 2377466 A	15/01/2003
		GB 2377466 B	03/03/2004
		MX PA02007176 A	28/01/2003
		MX PA02007180 A	28/01/2003
		MX PA02007181 A	28/01/2003
		MX PA02008507 A	28/01/2003
		MX PA02008508 A	28/01/2003
		MX PA02008576 A	14/04/2003
		MX PA02008577 A	14/04/2003
		MX PA02008578 A	14/04/2003
		MX PA02008579 A	14/04/2003
		MX PA02008580 A	23/08/2004
		MX PA02008582 A	14/04/2003
		MX PA02008583 A	14/10/2004
		MY 128294 A	31/01/2007
		MY 129879 A	31/05/2007
		MY 134669 A	31/12/2007
		NO 20023499 A	11/09/2002
		NO 20023500 A	23/09/2002
		NO 20023501 A	13/09/2002
		NO 20024135 A	01/11/2002
		NO 20024136 A	01/11/2002
		NO 20024137 A	29/10/2002

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		NO 20024138 A	01/11/2002
		NO 20024139 A	30/10/2002
		NO 20024140 A	30/10/2002
		NO 20024142 A	25/10/2002
		NO 20024143 A	25/10/2002
		NO 20024145 A	29/10/2002
		NO 322163 B1	21/08/2006
		NO 322599 B1	30/10/2006
		NO 323531 B1	04/06/2007
		NO 324145 B1	03/09/2007
		NO 324777 B1	10/12/2007
		NO 324854 B1	17/12/2007
		NO 325380 B1	14/04/2008
		NO 326317 B1	10/11/2008
		NO 326367 B1	17/11/2008
		NO 330933 B1	22/08/2011
		NO 330961 B1	29/08/2011
		NO 330977 B1	29/08/2011
		NZ 520416 A	27/02/2004
		NZ 521120 A	25/06/2004
		NZ 521121 A	24/03/2005
		NZ 521122 A	25/02/2005
		OA 12141 A	05/05/2006
		OA 12213 A	09/05/2006
		OA 12214 A	09/05/2006
		OA 12223 A	09/05/2006
		OA 12224 A	09/05/2006
		OA 12225 A	10/05/2006
		OA 12226 A	10/05/2006
		OA 12321 A	12/05/2006
		OA 12390 A	18/04/2006
		OA 12426 A	18/04/2006
		OA 13129 A	13/12/2006
		OA 13130 A	13/12/2006
		RU 2002-122759 A	27/01/2004
		RU 2002-122762 A	27/01/2004
		RU 2002-126206 A	20/02/2004
		RU 2002-126207 A	20/02/2004
		RU 2002-126208 A	20/02/2004
		RU 2002-126209 A	20/02/2004
		RU 2002-126210 A	20/02/2004
		RU 2002-126211 A	20/02/2004
		RU 2002-126212 A	27/02/2004
		RU 2002-126213 A	27/02/2004
		RU 2002-126218 A	20/02/2004
		RU 2256067 C2	10/07/2005
		RU 2256074 C2	10/07/2005
		RU 2258799 C2	20/08/2005
		RU 2258800 C2	20/08/2005
		RU 2258805 C2	20/08/2005

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		RU 2260676 C2	20/09/2005
		RU 2262597 C2	20/10/2005
		RU 2262598 C2	20/10/2005
		RU 2263202 C2	27/10/2005
		RU 2263783 C2	10/11/2005
		RU 2273727 C2	10/04/2006
		US 2001-0033164 A1	25/10/2001
		US 2002-0000316 A1	03/01/2002
		US 2002-0029883 A1	14/03/2002
		US 2002-0036085 A1	28/03/2002
		US 2002-0043369 A1	18/04/2002
		US 2002-0121366 A1	05/09/2002
		US 2002-0126021 A1	12/09/2002
		US 2003-0024704 A1	06/02/2003
		US 2003-0038734 A1	27/02/2003
		US 2003-0042016 A1	06/03/2003
		US 2003-0047308 A1	13/03/2003
		US 2003-0048697 A1	13/03/2003
		US 2003-0051881 A1	20/03/2003
		US 2003-0056952 A1	27/03/2003
		US 2003-0066652 A1	10/04/2003
		US 2003-0066671 A1	10/04/2003
		US 2003-0164240 A1	04/09/2003
		US 2003-0227393 A1	11/12/2003
		US 2004-0060703 A1	01/04/2004
		US 2004-0079524 A1	29/04/2004
		US 2004-0144530 A1	29/07/2004
		US 2004-0263350 A1	30/12/2004
		US 6633164 B2	14/10/2003
		US 6633236 B2	14/10/2003
		US 6662875 B2	16/12/2003
		US 6679332 B2	20/01/2004
		US 6715550 B2	06/04/2004
		US 6758277 B2	06/07/2004
		US 6817412 B2	16/11/2004
		US 6840316 B2	11/01/2005
		US 6840317 B2	11/01/2005
		US 6851481 B2	08/02/2005
		US 6868040 B2	15/03/2005
		US 6958704 B2	25/10/2005
		US 6981553 B2	03/01/2006
		US 7055592 B2	06/06/2006
		US 7073594 B2	11/07/2006
		US 7075454 B2	11/07/2006
		US 7114561 B2	03/10/2006
		US 7147059 B2	12/12/2006
		US 7170424 B2	30/01/2007
		US 7259688 B2	21/08/2007
		US 7322410 B2	29/01/2008
		WO 01-55553 A1	02/08/2001

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/030256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		WO 01-55554 A1	02/08/2001
		WO 01-55555 A1	02/08/2001
		WO 01-59258 A1	16/08/2001
		WO 01-65053 A1	07/09/2001
		WO 01-65054 A1	07/09/2001
		WO 01-65055 A1	07/09/2001
		WO 01-65056 A1	07/09/2001
		WO 01-65061 A1	07/09/2001
		WO 01-65062 A2	07/09/2001
		WO 01-65062 A3	03/01/2002
		WO 01-65063 A1	07/09/2001
		WO 01-65066 A1	07/09/2001
		WO 01-65067 A1	07/09/2001
		WO 01-65068 A1	07/09/2001
		WO 01-65069 A1	07/09/2001
		WO 01-65718 A2	07/09/2001
		WO 01-65718 A3	28/03/2002
US 2009-0218107 A1	03/09/2009	None	
US 2002-0096325 A1	25/07/2002	AU 1194002 A	25/07/2002
		AU 785413 B2	03/05/2007
		CA 2368915 A1	22/07/2002
		CA 2368915 C	28/03/2006
		GB 2375556 A	20/11/2002
		GB 2375556 B	06/07/2005
		NO 20020316 A	23/07/2002
		NO 323125 B1	08/01/2007
		US 6684953 B2	03/02/2004
US 2010-0149919 A1	17/06/2010	RU 2382197 C1	20/02/2010
		US 9042200 B2	26/05/2015
WO 2014-092836 A1	19/06/2014	AU 2013-360280 A1	07/05/2015
		AU 2013-360280 B2	11/08/2016
		BR 112015008938 A2	04/07/2017
		CA 2888601 A1	19/06/2014
		CA 2888601 C	04/04/2017
		EP 2912253 A1	02/09/2015
		EP 3054080 A1	10/08/2016
		MX 2015005107 A	17/07/2015
		SG 11201502958Y A	28/05/2015
		US 2014-0116699 A1	01/05/2014
		US 2015-0376976 A1	31/12/2015
		US 9169705 B2	27/10/2015
		US 9988872 B2	05/06/2018