Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 3042011 C 2021/02/23

(11)(21) 3 042 011

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2017/10/02
(87) Date publication PCT/PCT Publication Date: 2018/05/03
(45) Date de délivrance/Issue Date: 2021/02/23
(85) Entrée phase nationale/National Entry: 2019/04/26
(86) N° demande PCT/PCT Application No.: US 2017/054692
(87) N° publication PCT/PCT Publication No.: 2018/080733
(30) Priorité/Priority: 2016/10/31 (US15/338,809)

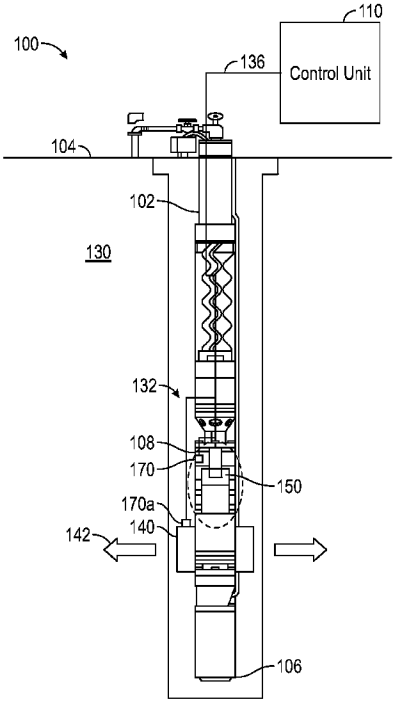
(51) Cl.Int./Int.Cl. *E21B 41/00* (2006.01), *E21B 23/04* (2006.01), *E21B 47/06* (2012.01)

(72) Inventeurs/Inventors:
OBERG, LEVI, US;
DUAN, PING, US

(73) Propriétaire/Owner:
BAKER HUGHES, A GE COMPANY, LLC, US

(74) Agent: MARKS & CLERK

(54) Titre : SYSTEME ET PROCEDE POUR LA DETECTION D'UNE MISE A FEU AU NIVEAU D'UN FOND DE TROU
(54) Title: SYSTEM AND METHOD FOR DOWNHOLE IGNITION DETECTION



(57) Abrégé/Abstract:
A system and method for confirming ignition of a fuel source in a wellbore is disclosed. The system includes a tool, a fuel source associated with the tool, a control unit to ignite the fuel source, and a sensor to receive an ignition parameter.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
03 May 2018 (03.05.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/080733 A1

(51) International Patent Classification:
E21B 41/00 (2006.01) *E21B 47/06* (2006.01)
E21B 23/04 (2006.01)

(21) International Application Number:
PCT/US2017/054692

(22) International Filing Date:
02 October 2017 (02.10.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
15/338,809 31 October 2016 (31.10.2016) US

(71) Applicant: **BAKER HUGHES, A GE COMPANY, LLC** [US/US]; 17021 Aldine Westfield, Houston, TX 77073 (US).

(72) Inventors: **OBERG, Levi**; 17021 Aldine Westfield, Houston, Texas 77073 (US). **DUAN, Ping**; 17021 Aldine Westfield, Houston, Texas 77073 (US).

(74) Agent: **PORTER, Andre** et al.; Baker Hughes, a GE company, LLC, 14990 Yorktown Plaza Drive, Houston, Texas 77040 (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, 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).

(54) Title: SYSTEM AND METHOD FOR DOWNHOLE IGNITION DETECTION

(57) Abstract: A system and method for confirming ignition of a fuel source in a wellbore is disclosed. The system includes a tool, a fuel source associated with the tool, a control unit to ignite the fuel source, and a sensor to receive an ignition parameter.

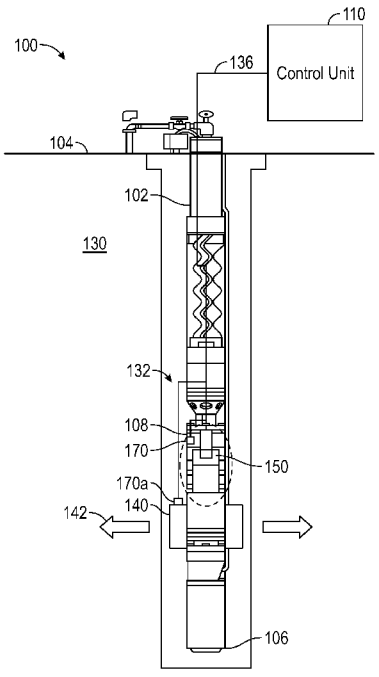


FIG. 1

WO 2018/080733 A1

[Continued on next page]

WO 2018/080733 A1

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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

SYSTEM AND METHOD FOR DOWNHOLE IGNITION DETECTION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 15/338809, filed on October 31, 2016.

BACKGROUND

1. Field of the Disclosure

[0002] The present invention is related to a system and method of detecting ignition in a wellbore, and in particular, a system and method of detecting ignition of a fuel source for equipment used in a wellbore.

2. Background of the Art

[0003] Various downhole operations, such as production, fracturing operations, etc., require downhole fuel sources. In such applications, packers and other setting tools, may be actuated and expanded by combustion of fuel sources. Fuel sources are ignited by remote ignition devices. However, certain ignition devices may not provide confirmation of ignition within the wellbore.

SUMMARY OF THE DISCLOSURE

[0004] In one aspect, there is provided a system for use in a wellbore, comprising: a tool; a fuel source associated with the tool; a control unit to ignite the fuel source; and a displacement sensor affixed to an expanding element of the tool, the displacement sensor configured to receive an ignition parameter and send an open circuit signal to the control unit when the ignition parameter indicates that ignition of the fuel source has occurred, wherein the displacement sensor sends the open circuit signal from the displacement sensor to the control unit when a movement of the expanding element meets a displacement threshold.

[0005] In another aspect, there is provided a method to confirm ignition within a wellbore, comprising: providing a tool at a downhole location within the wellbore; igniting a fuel source associated with the tool via a control unit; receiving, at a displacement sensor affixed to an expanding element of the tool, an ignition parameter; and sending an open circuit signal from the sensor to the control unit when the ignition parameter indicates that ignition of the fuel source has occurred, wherein the open circuit signal is sent from the sensor to the control unit when a movement of the expanding element meets a displacement threshold.

Date Reçue/Date Received 2020-05-22

[0006] Examples of certain features of the apparatus and method disclosed herein are summarized rather broadly in order that the detailed description thereof that follows may be better understood. There are, of course, additional features of the apparatus and method disclosed hereinafter that will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The disclosure herein is best understood with reference to the accompanying figures in which like numerals have generally been assigned to like elements and in which:

Date Reçue/Date Received 2020-05-22

FIG. 1 shows a downhole system that includes a tool utilizing an ignition parameter sensor in an exemplary embodiment of the disclosure.

DESCRIPTION OF THE EMBODIMENTS

[0008] **FIG. 1** shows a downhole system **100** that includes an expanding tool for setting, packing, or other operations of the downhole system **100** in an exemplary embodiment of the disclosure. The downhole system **100** includes a work string **102** disposed in a wellbore **132** formed in a formation **130**. The work string **102** extends in the wellbore **132** from a surface location **104** to a downhole location **106**. The work string **102** may include a drill string, a production string, a fracturing system including a multi-stage fracturing system, a perforation string, etc. A tool **108** for performing a downhole operation is conveyed to a selected depth of the wellbore by the work string **102**. The tool **108** may be a setting tool, a packing tool, a knife or other tool that relies on a downhole fuel source for expansion or general operation, for example.

[0009] The tool **108** is schematically illustrated in **FIG. 1**. The tool **108** may be any tool that expands, sets, separates, or is otherwise actuated by the expansion of combustible gases, such as those provided by the ignition of the fuel source **150**. In an exemplary embodiment, the tool **108** is a tool wherein expanding elements **140** move outwardly in an expansion direction **142** when energized by high pressure gasses created by fuel source **150**. Tool **108** may be used to prevent flow beyond the position of tool **108**, secure another element of string **102** at a certain position at the wellbore **132,** chemically cut an element of string **102**, etc. In an exemplary embodiment, the fuel source **150** may be ignited to create high temperature and high pressure combustion gasses. In response to these gases, expanding elements **140** of tool **108** may move outwardly in an expansion direction **142** to secure expanding elements **140** towards the outer extents of wellbore **132**. In certain embodiments, expanding elements **140** may be compliant elements, while in other embodiments, expanding elements **140** may be rigid elements. Further, expanding elements **140** may be slips or other elements that may expand to create contact with wellbore **132**.

[0010] The tool **108** may be coupled to a control unit **110** via cable **136**. Control unit **110** controls the tool **108** to actuate the tool via igniting the fuel source **150**, controlling combustion of a fuel source within the tool, and other functions of the tool. In various embodiments, the control unit **110** may be at a surface location **104** or at a suitable location in the work string **102**.

[0011] In the illustrated embodiment, the control unit **110** can directly provide an ignition signal to the fuel source **150** to ignite the fuel source **150**. In other embodiments, the control until **110** can remotely ignite the fuel source **150** via an intermediate ignition device. In certain embodiments utilizing certain ignition devices, the control unit **110** and/or an operator may not receive confirmation of ignition of the fuel source **150** or proper activation of the tool **108**. In the illustrated embodiment, the downhole system **100** includes an ignition parameter sensor **170** to provide relevant ignition parameters to the control unit **110**. Advantageously, the ignition parameter sensor **170** can provide confirmation that the fuel source **150** was ignited and/or that the tool **108** was properly activated.

[0012] In the illustrated embodiment, the ignition parameter sensor **170** is disposed near the fuel source **150**. Further, the ignition parameter sensor **170** is operatively connected to the control unit **110**. In certain embodiments, the ignition parameter sensor **170** is connected to the control unit **110** via the control line **136**.

[0013] In the illustrated embodiment, the ignition parameter sensor **170** can be any suitable sensor to receive ignition parameters. Ignition parameters can be any suitable parameter that can be utilized to indicate that ignition of the fuel source **150** has occurred. In certain embodiments, the ignition parameter sensor **170** is a pressure sensor. In the illustrated embodiment, the ignition parameter sensor **170** is disposed near the fuel source **150** to receive changes in pressure that may indicate successful ignition of the fuel source **150**.

[0014] In certain embodiments, the ignition parameter sensor **170** is a mechanical pressure switch. In certain embodiments, the mechanical switch can move from a closed position to an open position in response to pressure provided by the ignited fuel source **150**.

[0015] In certain embodiments, the ignition parameter sensor **170** is a solid state pressure sensor that can utilize a logic circuit or an otherwise embedded system to provide an open circuit or any other suitable signal to the control unit **110** when a pressure threshold is met. In certain embodiments, the ignition parameter sensor **170** can be energized by the control unit **110** in response to attempted ignition of the fuel source **150**.

[0016] In certain embodiments, the ignition parameter sensor **170** can monitor temperatures within the wellbore or in an area near the fuel source **150**. In certain embodiments, the ignition parameter sensor **170** can provide an open circuit or any other suitable signal to the control unit **110** when a temperature threshold is met. In certain embodiments, the temperature threshold can be selected to reflect successful ignition of the fuel source **150**.

[0017] In certain embodiments, the ignition parameter sensor **170** can monitor current received by the fuel source **150** during ignition. In certain embodiments, the ignition parameter sensor **170** can provide an open circuit or any other suitable signal to the control unit **110** when a current threshold is met. In certain embodiments, the current threshold can be selected to reflect successful ignition of the fuel source **150**.

[0018] In certain embodiments, the ignition parameter sensor **170** can monitor gases present within the wellbore or near the fuel source **150**. In certain embodiments, the ignition parameter sensor **170** can provide an open circuit or any other suitable signal to the control unit **110** when a type of gas, a quantity of gas, or an explosive gas byproduct threshold is met. In certain embodiments, the gas threshold can be selected to reflect successful ignition of the fuel source **150**.

[0019] In certain embodiments, the ignition parameter sensor **170**a can be associated or otherwise affixed to the expanding or moveable elements **140** of the tool **108**. In the illustrated embodiment, the ignition parameter sensor **170**a can monitor displacement of the expanding elements **140** or any other suitable portion of the tool **108**. In certain embodiments, the ignition parameter sensor **170**a can provide an open circuit or any other suitable signal to the control unit **110** when a desired movement or displacement threshold is met. In certain embodiments, the position or displacement threshold can be selected to reflect successful ignition of the fuel source **150** and/or successful activation of the tool **108**.

[0020] Advantageously, the use of the ignition parameter sensor **170**,**170**a allows for the control unit **110** and/or an operator to confirm ignition of the fuel source **150** or actuation of the tool **108**. Further, by providing an open circuit signal to the control unit **110**, the ignition parameter sensor **170**,**170**a can simulate a "cap break" signal that is provided by certain ignition methods. Use of the ignition parameter sensor **170**,**170**a allows for robust ignition devices that can withstand handling, run-in, and excessive current, while still providing ignition confirmation via a simulated "cap break" signal. Robust ignition methods can allow for reliable ignition of the fuel source **150** and actuation of the tool **108**. Further, the ignition parameter sensor **170**,**170**a can further provide ignition confirmation even if multiple ignition attempts are required to ignite the fuel source **150**.

[0021] Therefore, in one aspect, the present disclosure provides a system for use in a wellbore, the system including a tool, a fuel source associated with the tool, a control unit to ignite the fuel source, and a sensor to receive an ignition parameter corresponding to the fuel source. In various embodiments, the sensor is a pressure sensor. In various embodiments, the pressure sensor is a mechanical switch. In various embodiments, the ignition parameter is

a threshold pressure value. In various embodiments, the sensor is a temperature sensor. In various embodiments, the sensor is an ammeter. In various embodiments, the sensor is a gas detector. In various embodiments, the sensor is a displacement sensor associated with the tool.

[0022] In another aspect, the present disclosure provides a method for use in a wellbore, the method including: providing a tool at a downhole location within the wellbore, igniting a fuel source associated with the tool via a control unit ,and receiving an ignition parameter corresponding to the fuel source via a sensor. In various embodiments, the method further includes providing the ignition parameter to the control unit. In various embodiments, the sensor is a pressure sensor. In various embodiments, the pressure sensor is a mechanical switch. In various embodiments, the ignition parameter is a threshold pressure value. In various embodiments, the sensor is a temperature sensor. In various embodiments, the sensor is an ammeter. In various embodiments, the sensor is a gas detector. In various embodiments, the sensor is a displacement sensor associated with the tool.

[0023] While the foregoing disclosure is directed to the certain exemplary embodiments of the disclosure, various modifications will be apparent to those skilled in the art. It is intended that all variations within the scope and spirit of the appended claims be embraced by the foregoing disclosure.

What is claimed is:

1. A system for use in a wellbore, comprising:

a tool;

a fuel source associated with the tool;

a control unit to ignite the fuel source; and

a displacement sensor affixed to an expanding element of the tool, the displacement sensor configured to receive an ignition parameter and send an open circuit signal to the control unit when the ignition parameter indicates that ignition of the fuel source has occurred, wherein the displacement sensor sends the open circuit signal from the displacement sensor to the control unit when a movement of the expanding element meets a displacement threshold.

2. The system of claim 1, further comprising a pressure sensor disposed near the fuel source, the pressure sensor being configured to receive an additional ignition parameter and send an additional signal to the control unit when the additional ignition parameter indicates that the ignition of the fuel source has occurred, the pressure sensor comprising a mechanical switch, the pressure sensor sending the additional signal to the control unit when the mechanical switch moves from a closed position to an open position in response to pressure provided by the ignition.

3. The system of claim 1, further comprising an ammeter disposed near the fuel source, the ammeter being configured to receive an additional ignition parameter and send an additional signal to the control unit when the additional ignition parameter indicates that the ignition of the fuel source has occurred, the ammeter monitoring current received by the fuel source during the ignition and sending the additional signal to the control unit when the current meets a current threshold.

4. The system of claim 1, further comprising a gas detector disposed near the fuel source, the gas detector being configured to receive an additional ignition parameter and send an additional signal to the control unit when the additional ignition parameter indicates that the ignition of the fuel source has occurred, the gas detector monitoring gases present within the wellbore and sending the additional signal when a type of gas, a quantity of gas, or an explosive gas byproduct monitored by the gas detector meets a threshold.

Date Reçue/Date Received 2020-07-13

.

5. A method to confirm ignition within a wellbore, comprising:

providing a tool at a downhole location within the wellbore;

igniting a fuel source associated with the tool via a control unit;

receiving, at a displacement sensor affixed to an expanding element of the tool, an ignition parameter; and

sending an open circuit signal from the sensor to the control unit when the ignition parameter indicates that ignition of the fuel source has occurred, wherein the open circuit signal is sent from the sensor to the control unit when a movement of the expanding element meets a displacement threshold.

6. The method of claim 5, further comprising:

receiving, at a pressure sensor disposed near the fuel source, an additional ignition parameter, the pressure sensor comprising a mechanical switch; and

sending an additional signal from the pressure sensor to the control unit when the additional ignition parameter indicates that the ignition of the fuel source has occurred, the additional signal being sent to the control unit when the mechanical switch moves from a closed position to an open position in response to pressure provided by the ignition of the fuel source.

7. The method of claim 5, further comprising:

receiving, at an ammeter disposed near the fuel source, an additional ignition parameter, the ammeter being configured to monitor current received by the fuel source during the ignition; and

sending an additional signal from the ammeter to the control unit when the additional ignition parameter indicates that the ignition of the fuel source has occurred, the additional signal being sent to the control unit when the current measured by the ammeter meets a current threshold.

8. The method of claim 5, further comprising:

receiving, at a gas detector disposed near the fuel source, an additional ignition parameter, the gas detector being configured to monitor gases present within the wellbore;

Date Reçue/Date Received 2020-07-13

and

sending an additional signal from the gas detector to the control unit when the additional ignition parameter indicates that the ignition of the fuel source has occurred, the additional signal being sent to the control unit when a type of gas, a quantity of gas, or an explosive gas byproduct detected by the gas threshold meets a threshold.

Date Reçue/Date Received 2020-07-13

1/1

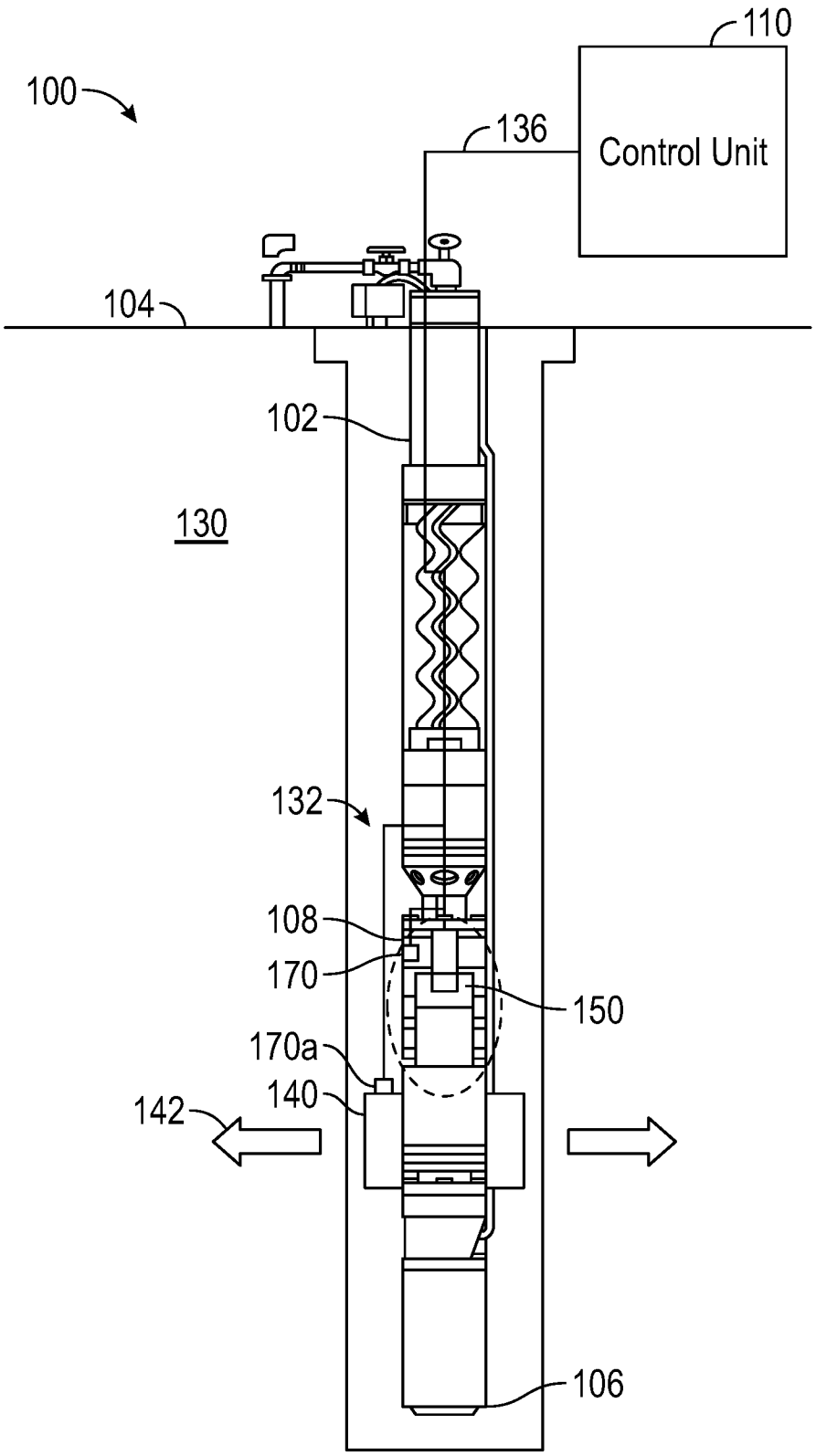
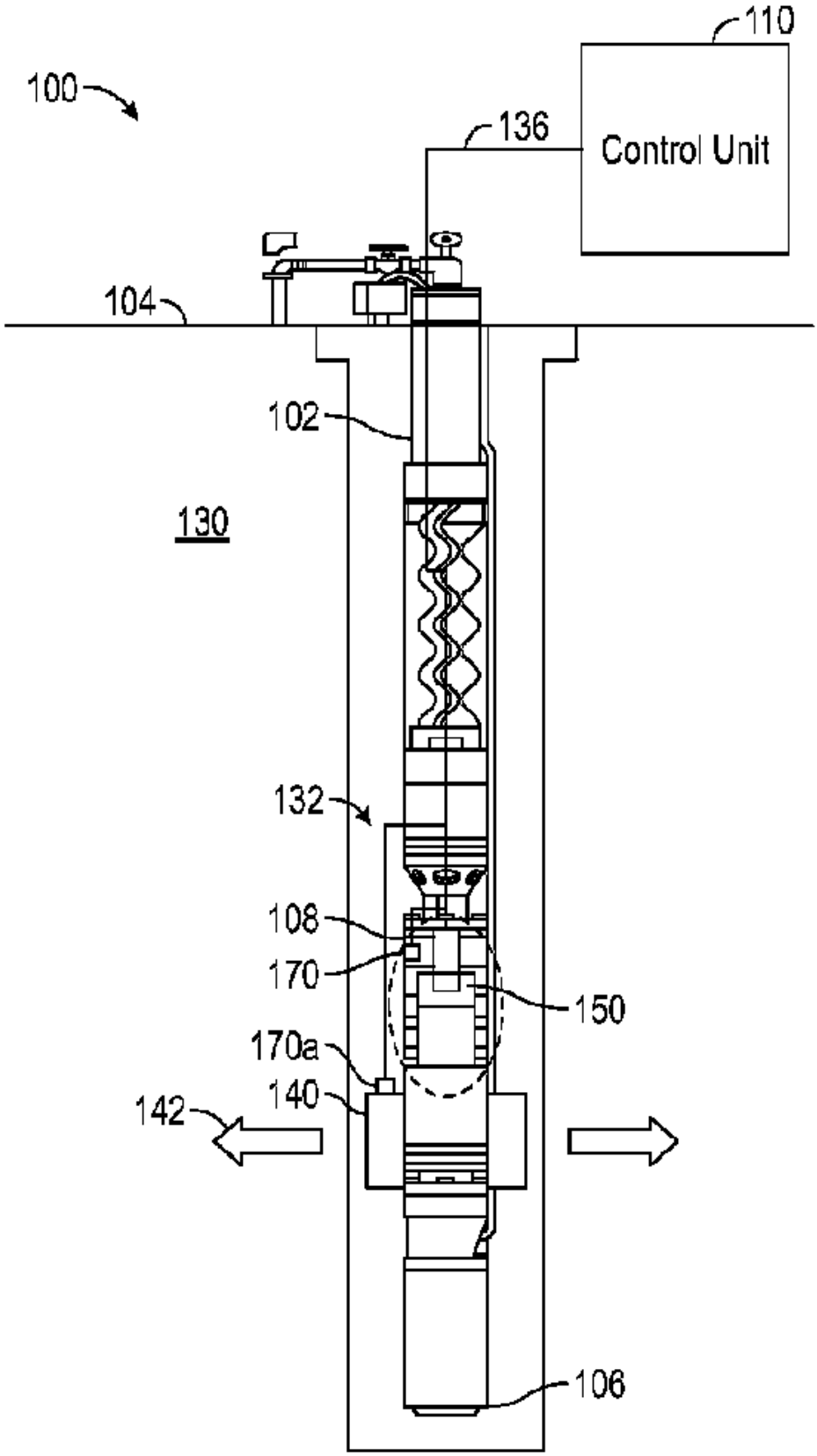

110
100
136
Control Unit
104
102
130
132
108
170
150
170a
140
142
106

FIG. 1


110
Control Unit
100
136
104
102
130
132
108
170
150
170a
140
142
106