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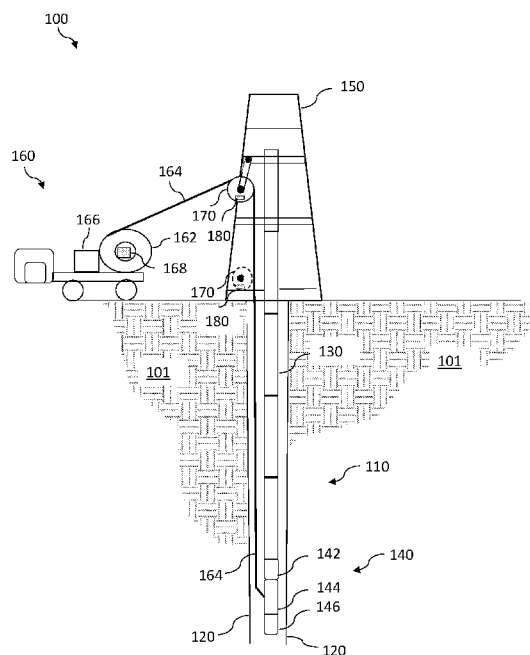


FIG. 1

(57) Abstract: The disclosure provides a movement monitor for detecting movement of downhole equipment in a wellbore during, for example, installation of the equipment. A method of installing downhole equipment in a wellbore and a system for the installation is also disclosed. In one example, the movement monitor includes: (1) a communications interface configured to provide movement information corresponding to downhole equipment in a wellbore, wherein the downhole equipment is attached to a cable, and (2) a rotation detector configured to generate rotational data associated with movement of the downhole equipment within the wellbore, wherein the movement information corresponds to the rotational data and the rotational data is based on a rotating device in contact with a tensioned-portion of the cable.



A MOVEMENT MONITOR FOR SELECTIVE POWERING OF DOWNHOLE EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Application Serial No. 17/100,262, filed on November 20, 2020, and entitled “A MOVEMENT MONITOR FOR SELECTIVE POWERING OF DOWNHOLE EQUIPMENT,” and is commonly assigned with this application, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This disclosure relates to installing downhole equipment in a wellbore and, more specifically, to safely installing downhole equipment based on movement of the downhole equipment within the wellbore

BACKGROUND

[0003] Electrically powered downhole equipment is installed in wellbores to perform various functions. For example, downhole pumps are often used in wellbores to deliver liquids, such as oil, from subterranean formations to the surface. An example of a downhole pump is an Electrical Submersible Pump (ESP), which is a multi-stage centrifugal pump having a few to hundreds of stages that runs at variable speeds, *e. g.*, from 1500 Revolutions per minute (RPM) to 8000 RPM, and can pump out from few hundreds to few hundreds of thousands of barrels per day (BPD). Typically, an electrical cable is attached to a downhole pump to provide power for operating in the wellbore. To be placed in a wellbore, a downhole pump is secured to a string of production tubing and the downhole pump is lowered from the surface to a desired location in the wellbore as the tubing string is extended. The electrical cable is connected to the downhole pump while being lowered.

[0004] The electrical cable can be damaged during the installation process of the downhole pump. The electrical cable, therefore, is typically tested during the installation process to ensure the integrity of the cable. Testing of the electrical cable involves energizing the cable. For example, the testing can involve communications from a downhole gauge coupled to the electrical cable to a gauge at the surface.

BRIEF DESCRIPTION

[0005] Reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0006] FIG. 1 illustrates a diagram of an example of a well site and the installation of downhole equipment at the wellsite according to the principle of the disclosure;

[0007] FIG. 2 illustrates a block diagram of an example of a system for installation of downhole equipment that is attached to an electrical cable according to the principles of the disclosure;

[0008] FIG. 3 illustrates a block diagram of an example of an embodiment of a movement monitor constructed according to the principles of the disclosure; and

[0009] FIG. 4 illustrates a flow diagram of an example of a method of installing downhole equipment in a wellbore carried out according to the principles of the disclosure.

DETAILED DESCRIPTION

[0010] Downhole equipment can often build-up an electrical charge in the components when being lowered downhole. If there is damage to the downhole equipment and the downhole equipment is powered on while moving downhole, a spark could develop and ignite dangerous well gases. Thus, to prevent inductive build-up downhole equipment is not typically energized via the electrical cable while being lowered into the wellbore. When testing of the electrical cable is needed, the electrical cable is energized when the downhole equipment is stationary. The downhole equipment and electrical cable are then de-energized when lowering resumes.

[0011] Syncing the testing with when the downhole equipment is stationary can delay the installation process since there can be a difference between when the downhole equipment is actually stationary and when the downhole equipment is perceived to be stationary. This difference between the perceived and actual lack of movement can be due to indirectly inferring the movement of the downhole equipment. For example, a spooler truck is typically used to let out the electrical cable during the installation of a downhole pump and movement of the downhole pump being lowered in the wellbore is typically determined at the spooler truck. There can be a delay, however, between when lowering of the downhole pump stops and when the stoppage is perceived at the spooler truck. There can also be a delay between when the spooler starts spooling the electrical cable and when the downhole pump actually begins moving. Compensating for the delays between the different movements is difficult since the delay times can be inconsistent and can also result in energizing the cable when the downhole pump is

actually moving. As such, a more direct determination of movement of downhole equipment during installation would be beneficial and allow a more accurate synching between stationary downhole equipment and cable energization.

[0012] The disclosure provides a movement monitor that directly determines movement of downhole equipment, such as a downhole pump, when being lowered in a wellbore. The disclosure also provides a system for installing downhole equipment that includes the movement monitor and a method of installing downhole equipment using the movement monitor. The movement monitor determines downward movement of the downhole equipment based on rotational data from a rotating device associated with a tensioned-portion of the electrical cable. A tensioned-portion of the electrical cable is that portion of the cable that is under tension due to the weight of the downhole equipment being lowered in the wellbore. The tensioned-portion of the cable differs, for example, from the portion of the cable that is between a sheave and a spooler truck or other slack portions of the cable. The movement monitor can be attached, for example, to the sheave. The movement monitor can also be attached to a measurement wheel that determines a distance based on rotations or another rotating device in contact with a tensioned-portion of the cable.

[0013] FIG. 1 illustrates a diagram of an example of a well site 100 and the installation of downhole equipment at the wellsite 100 according to the principle of the disclosure. The well site 100 includes a wellbore 110 that extends into the earth 101 and is defined by casing 120. The well site 100 is shown on land as an example of an onshore operation but the disclosed features can also be used for offshore operations. For example, an offshore oil and gas platform can employ the movement monitor and methods disclosed herein. In FIG. 1, the wellbore 110 is straight but the disclosure also applied to other types of wellbores, such as those having an angle. Within the wellbore 110 are multiple sections of production tubing that are connected together to form a tubing string 130. Attached to the end of the tubing string 130 is downhole equipment 140. In this example, the downhole equipment 140 is a pump assembly that includes a downhole pump 142 coupled to a pump motor 144 and a gauge 146 that is configured to obtain downhole measurements. The gauge 146 can be coupled to the bottom of the motor 144 and includes electronics that can build-up an electrical charge during installation. The gauge 146 can be one of multiple types of gauges that are used downhole to measure temperature, pressure, vibration,

etc. The downhole pump 142 can be an ESP. The well site 100 represents the last stages of a completion well in which the tubing string 130 and downhole pump 142 are being installed.

[0014] The tubing string 130 is suspended from a support structure 150 wherein additional sections of tubing are added to push the downhole equipment 140 to the desired location within the wellbore 110. In FIG. 1 the support structure is a derrick but another support structure can be used. For example, a crane can be used as the support structure 150. Additionally, as noted above an offshore support structure can be used for an offshore operation.

[0015] Also at the well site 100 is a spooler truck 160 that includes a cable reel 162 having an electrical cable 164. The electrical cable 164 is attached to the downhole equipment 140 and is unspooled from the cable reel 162 as the downhole equipment 140 is lowered into the wellbore 110 by the tubing string 130. At the well site 100, the electrical cable 164 is attached to the pump motor 144. The spooler truck 160 also includes a power source 166 and a power controller 168. The power source 166 is electrically connected to and provides power to the electrical cable 164. The power controller 168 controls energization of the electrical cable 164. The power controller 168 can be a selective power controller that can automatically control energization of the electrical cable 164 based on movement information. The cable reel 162, the electrical cable 164, and the power source 166, can be conventional components and/or devices typically used in the industry. As illustrated, the power controller 168 can be located in the center opening of the cable reel 162 and can spin with the cable reel 162. The power controller 168 can also be located on the spooler truck 160 or proximate thereto.

[0016] Between the cable reel 162 and the attached downhole equipment 140, the electrical cable 164 is supported by a rotating device 170 that allows the electrical cable 164 to be pulled into the wellbore 110 as the downhole equipment 140 descends. The rotating device 170 is a sheave that is connected to the support structure 150. The sheave 170 can be suspended from the support structure 150 via a mechanical connection. An alternative location of the rotating device 170 is also shown in FIG. 1 with dashed lines. The rotating device 170 can also be used to measure the amount of electrical cable that has been released into the wellbore 110. Regardless the location, the rotating device 170 is in contact with a portion of the cable 164 at the wellbore 110 that is under tension. More than one rotating device can be used. For example, a sheave and a measurement device can be used together and each can include a movement monitor with one

designated to provide back-up measurements. A single movement monitor can be used with just one of the rotating devices, also.

[0017] Attached to the rotating device 170 is a movement monitor 180 that is configured to determine movement of the downhole equipment 140 within the wellbore 110. Accordingly, the movement monitor 180 is configured to determine when the downhole equipment 140 is being lowered into the wellbore 110 and when the downhole equipment 140 is not being lowered into the wellbore 110, *i.e.*, when the downhole equipment 140 is stationary during the installation. The movement monitor 180 is configured to provide movement information that indicates whether downhole equipment 140 is stationary or moving. The movement information corresponds to rotational data based on the rotating device 170. The power controller 168 can control energization of the electrical cable 164 based on the movement information. When the movement information indicates the downhole equipment 140 is moving, *i.e.*, being lowered or raised with respect to the wellbore 110, the power controller 168 can ensure the electrical cable 164 is de-energized by disconnecting the power source 166 from the electrical cable 164. A switch (not shown) can be controlled by the power controller 168 to provide power or not provide power to the electrical cable 164. When the movement information indicates the downhole equipment 140 is not moving, then the power controller 168 can energize the electrical cable and allow testing to ensure the integrity of the electrical cable 164. The testing can be performed according to industry standards or practices. The movement monitor 180 can transmit the movement information directly to the power controller 168 via a wireless connection and the power controller 168 can automatically control the power source 166. The movement monitor 180 can also provide the movement information to a user via, for example, a computing device or a visual means of communication (*e.g.*, an indication light), wherein the user can then control energization of the electrical cable 164. The user can send the movement information to the power controller 168 for operation via a wireless or wired connection. For manual operation, the user can connect surface equipment to power the downhole gauge 146 and connect the surface equipment to the power source 166. In some examples when the power controller 168 is not spinning in the center of the cable reel 162, a user can operate a control button or switch associated with the power controller 168 for manual operation. FIG. 2 provides additional details of an example of a system for installing downhole equipment in a wellbore. The power controller 168 can be a selective power controller 230 such as disclosed in FIG. 2.

[0018] FIG. 2 illustrates a block diagram of an example of a system 200 for installation of downhole equipment that is attached to an electrical cable. The system 200 can be employed at a well site, such as well site 100 illustrated in FIG. 1. The system 200 can also be employed with an offshore well site. The system 200 includes a movement monitor 210, a computing device 220, a selective power controller 230, and a power source 240.

[0019] The movement monitor 210 is configured to determine movement of a downhole device during installation in a wellbore based on rotational data. The movement monitor 210 is coupled to a rotating device at the wellbore, such as the rotating device 170 of FIG. 1. The movement monitor 210 includes a rotation detector 212, a communications interface 214, and a power supply 216. The power supply 216 can be one or more batteries, such as ion lithium batteries.

[0020] The rotation detector 212 is configured to generate rotational data associated with movement of downhole equipment within a wellbore. The rotational data is based on a rotating device in contact with a tensioned-portion of cable that is attached to the downhole equipment. The rotation detector 212 generates the rotational data when the rotating device, such as 170 in FIG. 1, is rotating, which corresponds to movement of the downhole equipment in-line with the wellbore (*i.e.*, along a length of the wellbore). The rotational data is raw data generated from one or more measurement devices. The one or more measurement devices include a gyroscope, an accelerometer, a magnetometer, or a combination thereof. Multiple of each of the measurement devices can be used and multiple of the different measurement devices can be combined with one or more of other types of measurement devices. The rotation detector 212 can include at least one of an accelerometer, a gyroscope, or a magnetometer. One or more of the axes can have a gyroscope and/or accelerometer. In one example, the rotation detector 212 can include a gyroscope on three axes. An accelerometer can be used with the gyroscopes for calibration of the gyroscopes.

[0021] The rotational data can be sent to a processor and compared to a movement threshold. Based on the comparison, the processor can generate movement information indicating stationary or moving downhole equipment. The processor can be configured to process the rotational data based on the type and number of measurement devices that are used by the rotation detector 212. A memory associated with the processor can store a series of operating instructions on a non-transitory computer readable medium that directs the operations of the processor. The operating instructions can correspond to an algorithm or algorithms that process

the rotational data from the rotation detector 212. The processor can be located with the rotation detector and receive the rotational data directly therefrom. In FIG. 2, the processor is located external to an enclosure 218 that includes the rotation detector 212 and the communications interface 214. As such, the movement monitor 210 is a distributed device wherein the processor is located in the computing device 220. Accordingly, the communication interface 214 transmits the rotational data as the movement information to the computing device 220. The processor 222 processes the rotational data and provides the processed rotational data as movement information.

[0022] The computing device 220 can be a mobile computing device of a user at the wellbore. For example, the computing device 220 can be a computing pad, a smartphone, a laptop, or another type of mobile computing device. Based on the movement information, the user can operate the selective power controller 230 to control energization of the cable. The user can send a power control signal to the selective power controller 230 to operate the selective power controller 230 based on the movement information. In some examples, the computing device 220 can be desktop computer located at the well site. The computing device 220 can also be located remote from the well site and connected to the movement monitor 210 and the selective power controller 230 via a communications network.

[0023] The communications interface 214 can be a wireless communication device that is configured to transmit the movement information. The communications interface 214 can be a soft access point that is configured to transmit information but not receive information. The communications interface 214 can be WiFi transmitter, a Bluetooth compliant transmitter, or another type of wireless transmitting device. The communications interface 214 can also be a transceiver that is configured to receive secure communications from a known device. Secure protocols used in the industry can be used to establish communications with the communications interface 214 and other communication interfaces disclosed herein. The communications interface 214 can employ a communications network to connect with the computing device 220 depending on the location thereof. The communications network can be a conventional network including wireless, wired or a combination of both types of communications structures. In some examples the enclosure 218 is a metal explosion proof container and an antenna of the communications interface 214 is located external to the enclosure 218.

[0024] In some examples, the communications interface 214 can transmit the movement information directly to the selective power controller 230. For example, when the rotational data is processed before being transmitted, the selective power controller 230 can receive the movement information and automatically control energization of the electrical cable. An example of this configuration is provided in FIG. 3. As such, the selective power controller 230 can also include a communications interface 232 that is configured to communicate with the communications interface 214. The communications interface 232 can also be configured to communicate with the computing device 220 and receive processed movement information therefrom. As such, the communications interface 232 can be a wireless transceiver configured to communicate with the communications interface 214.

[0025] The selective power controller 230 also includes a selective power processor 234 that controls the power source 240 based on the movement information. The selective power processor 234 is configured to direct the power source 240 to provide power to the electrical cable based on the movement information. The selective power controller 230 can send an energization control signal to the power source 240 to control powering of the electrical cable. The energization control signal can be based on the power control signal from the computing device 220. The selective power processor 234 can be configured to process the movement information as the processor 222. For example, the selective power processor 234 can include the necessary logic to process rotational data from the rotation detector 212 and compare the rotational data to a movement threshold to determine movement or not of the downhole equipment. As such, in different examples the selective power processor 234 can use the movement information that has been processed or can use the raw rotational data and process it. The selective power processor 234, thus, can be configured to perform the functionality of the processor for the movement monitor 210.

[0026] FIG. 3 illustrates a block diagram of an example of an embodiment of a movement monitor 300 constructed according to the principles of the disclosure. The movement monitor 300 can be connected to a rotating device, such as a sheave, that is in contact with a tensioned-portion of cable connected to downhole equipment. The downhole equipment can be an ESP. The movement monitor 300 includes a power supply 310, a rotation detector 320, a processor 330, and a communications interface 340. The movement monitor 300 can operate as the movement monitors 180 and 210 of FIGS. 1 and 2. In contrast to the distributed movement

monitor 210, the movement monitor 300 is an integrated device. As such, each of the components are positioned in an enclosure 350 and communicatively connected via, for example, conventional connections. Each of the components can be positioned on a printed circuit board within the enclosure 350. The enclosure 350 can be constructed of metal or another material that protects the components from the environment of a well site. The enclosure 350 can be an explosion proof enclosure.

[0027] The power supply 310 is configured to provide power to the various components of the movement monitor 300. The power supply 310 can be one or more batteries. The battery or batteries can be conventional ion lithium batteries.

[0028] The rotation detector 320 is configured to generate rotational data associated with movement of downhole equipment within a wellbore. The rotation detector 320 can include at least one of an accelerometer, a gyroscope, or a magnetometer to determine the rotational data. The rotation detector 320 also generates ambient data that indicates ambient conditions after the electrical cable is attached to the downhole equipment and before lowering of the downhole equipment. The processor 330 is configured to use the ambient data to establish a movement threshold. The ambient data can also be provided by the rotation detector 320 after an installation process begins for recalibration of the movement monitor 300. The recalibration can be triggered by the processor 330 based on a determined number of comparisons of the rotational data to the movement threshold that result in an indication of no movement. In examples where the communications interface 340 can receive incoming communications, a known device, can send secure signals that initiate calibration, recalibration, or diagnostics.

[0029] The processor 330 can be a microprocessor. As indicated above, the processor 330 is configured to determine the movement threshold based on the ambient data at the wellbore after the downhole equipment is attached to the cable and before lowering of downhole equipment in the wellbore. Additionally, the processor 330 is configured to determine the movement information based on the comparison of the rotational data to the movement threshold. When the rotational data indicates movement above the movement threshold, then the processor 330 provides movement information that indicates the downhole equipment is moving. When the rotational data indicates movement below the movement threshold, then the processor 330 provides movement information that indicates the downhole equipment is stationary and the

electrical cable can be energized. The movement information can be provided to the communications interface 340 for transmission.

[0030] The communications interface 340 is configured to transmit the movement information to one or more connected devices. The movement information can be sent, for example, to a selective power controller. The communications interface 340 can be a conventional transmitter that transmits the movement information to approved devices via a secure connection. The communications interface 340 can be configured to prevent receiving of communications to prevent or at least reduce improper use of the movement monitor 300. The communications interface 340 can also be configured to receive secure communications.

[0031] FIG. 4 illustrates a flow diagram of an example of a method 400 of installing downhole equipment in a wellbore carried out according to the principles of the disclosure. The wellbore can be the wellbore 110 of FIG. 1. At least a portion of the method 400 can be performed by a movement monitor such as disclosed herein. The method 400 begins in a step 405.

[0032] In step 410, the movement monitor is energized. The movement monitor can be energized by connecting the power supply. For example, batteries can be positioned in the movement monitor to turn it on. Alternatively, a switch can be used. In some example, the switch can be controlled by a wireless signal from a known device.

[0033] In step 420, the movement monitor is connected to a rotating device. The rotating device can be a sheave. The movement monitor can be connected via a mechanical connection. Alternatively, the movement monitor can be connected to the rotating device using magnets.

[0034] A movement threshold is determined in step 430 based on ambient data measured and/or determined by the rotation detector of the movement monitor. The movement threshold is determined once the downhole equipment is attached to the electrical cable and the electrical cable is suspended from the rotating device. As such, a portion of the electrical cable is under tension.

[0035] Installation of the downhole equipment is started by lowering the downhole equipment into the wellbore in step 440. Movement of the downhole equipment is monitored as the downhole equipment is being installed in step 450. The movement monitor is used for the monitoring based on rotations of the rotating device. A rotation detector of the movement monitor provides rotational data corresponding to the movement. In parallel to the step 440, steps 450 to 470 can occur.

[0036] In step 460, movement information is provided based on the monitoring. A processor of the movement monitor provides the movement information based on a comparison of the rotational data to the movement threshold. The processor can be located with the rotation detector or can be located distal from the rotation detector. The movement information can be provided by a communications interface of the movement monitor to one or more dedicated devices. The movement information can be provided to a selective power controller. In some examples, the movement information can be provided to a computing device of a user.

[0037] In step 470, the cable is energized based on the movement information. The cable can be automatically energized based on reception of the movement information when indicating that the downhole equipment is stationary. When the movement information indicates the downhole equipment is not stationary, the electrical cable is not energized. A selective power controller can be used to energize the electrical cable based on the movement information.

[0038] The movement monitor is de-energized in step 480 when the downhole device is positioned in the desired location within the wellbore. Conventional measures can be used to indicate that the downhole device is located at the desired location in the wellbore. The movement monitor can be de-energized by simply removing the batteries. Alternatively, a switch can be used to turn-off the movement monitor. The method ends in step 490.

[0039] A portion of the above-described apparatus, systems or methods may be embodied in or performed by various analog or digital data processors, wherein the processors are programmed or store executable programs of sequences of software instructions to perform one or more of the steps of the methods. A processor may be, for example, a programmable logic device such as a programmable array logic (PAL), a generic array logic (GAL), a FPGA, or another type of computer processing device (CPD). The processor can be a microprocessor. The software instructions of such programs may represent algorithms and be encoded in machine-executable form on non-transitory digital data storage media, *e.g.*, magnetic or optical disks, random-access memory (RAM), magnetic hard disks, flash memories, and/or read-only memory (ROM), to enable various types of digital data processors or computers to perform one, multiple or all of the steps of one or more of the above-described methods, or functions, systems or apparatuses described herein.

[0040] Portions of disclosed examples or embodiments may relate to computer storage products with a non-transitory computer-readable medium that have program code thereon for performing

various computer-implemented operations that embody a part of an apparatus, device or carry out the steps of a method set forth herein. Non-transitory used herein refers to all computer-readable media except for transitory, propagating signals. Examples of non-transitory computer-readable media include, but are not limited to: magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM disks; magneto-optical media such as floppy disks; and hardware devices that are specially configured to store and execute program code, such as ROM and RAM devices. Examples of program code include both machine code, such as produced by a compiler, and files containing higher level code that may be executed by the computer using an interpreter.

[0041] In interpreting the disclosure, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

[0042] Those skilled in the art to which this application relates will appreciate that other and further additions, deletions, substitutions and modifications may be made to the described embodiments. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the present disclosure will be limited only by the claims. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present disclosure, a limited number of the exemplary methods and materials are described herein.

[0043] Various aspects of the disclosure can be claimed including the apparatuses, systems and methods as disclosed herein. Aspects disclosed herein include:

[0044] A. A movement monitor for downhole equipment including: (1) a communications interface configured to provide movement information corresponding to downhole equipment in a wellbore, wherein the downhole equipment is attached to a cable, and (2) a rotation detector configured to generate rotational data associated with movement of the downhole equipment within the wellbore, wherein the movement information corresponds to the rotational data and the rotational data is based on a rotating device in contact with a tensioned-portion of the cable.

[0045] B. A method of installing downhole equipment in a wellbore including: (1) determining a movement threshold after the downhole equipment is attached to a tubing string and an electrical cable is attached to the downhole equipment, (2) monitoring movement of the downhole equipment during installation in the wellbore, (3) determining when the downhole equipment is stationary based on movement information corresponding to rotational data, and (4) energizing the electrical cable coupled to the downhole equipment when the movement information indicates the downhole equipment is stationary.

[0046] C. A system for installation of downhole equipment in a wellbore that is attached to a cable, the system including: (1) a selective power controller configured to control energizing of the cable during the installation based on movement information that corresponds to lowering of the downhole equipment in the wellbore, and (2) a movement monitor configured to provide the movement information, wherein the movement information corresponds to rotational data based on a rotating device associated with a portion of the cable at the wellbore that is under tension.

[0047] Each of the aspects A, B, and C may have one or more of the following additional elements in combination:

[0048] Element 1: wherein the rotating device is a sheave. Element 2: wherein the rotation detector includes at least one of an accelerometer, a gyroscope, or a magnetometer. Element 3: further comprising a processor configured to determine a movement threshold based on ambient conditions at the wellbore after the downhole equipment is attached to the cable and before lowering of downhole equipment in the wellbore. Element 4: wherein the processor is configured to determine the movement information based on the rotational data and the movement threshold. Element 5: wherein the communications interface, the rotation detector, and the processor are integrated with a single enclosure. Element 6: wherein the movement information is the rotational data from the movement detector. Element 7: wherein the communications interface is a wireless transceiver. Element 8: wherein the tensioned-portion of the cable is between a sheave and the wellbore. Element 9: further comprising determining the movement information based on a comparison between rotational data and the movement threshold, wherein the movement threshold is determined based on ambient data. Element 10: wherein a movement monitor coupled to a rotation device associated with a tensioned-portion of the electrical cable provides the movement information. Element 11: wherein the energizing is performed automatically. Element 12: further comprising de-energizing the electrical cable

when the movement information indicates the downhole equipment is moving. Element 13: further comprising a power source configured to energize the cable during the installation, wherein the selective power controller controls the power source based on the movement information. Element 14: wherein the selective power controller is configured to automatically energize the cable when the movement information indicates the downhole equipment is stationary within the wellbore and de-energizes the cable when the movement information indicates the downhole equipment is being lowered in the wellbore. Element 15: wherein the movement monitor is configured to wirelessly transmit the movement information to the selective power controller. Element 16: wherein the downhole equipment is an electric submersible pump. Element 17: wherein the movement monitor is mounted to the rotating device.

WHAT IS CLAIMED IS:

1. A movement monitor for downhole equipment, comprising
a communications interface configured to provide movement information corresponding to downhole equipment in a wellbore, wherein the downhole equipment is attached to a cable; and
a rotation detector configured to generate rotational data associated with movement of the downhole equipment within the wellbore, wherein the movement information corresponds to the rotational data and the rotational data is based on a rotating device in contact with a tensioned-portion of the cable.
2. The movement monitor as recited in Claim 1, wherein the rotating device is a sheave.
3. The movement monitor as recited in Claim 1, wherein the rotation detector includes at least one of an accelerometer, a gyroscope, or a magnetometer.
4. The movement monitor as recited in Claim 1, further comprising a processor configured to determine a movement threshold based on ambient conditions at the wellbore after the downhole equipment is attached to the cable and before lowering of downhole equipment in the wellbore.
5. The movement monitor as recited in Claim 4, wherein the processor is configured to determine the movement information based on the rotational data and the movement threshold.
6. The movement monitor as recited in Claim 4, wherein the communications interface, the rotation detector, and the processor are integrated with a single enclosure.
7. The movement monitor as recited in Claim 1, wherein the movement information is the rotational data from the rotation detector.
8. The movement monitor as recited in Claim 1, wherein the communications interface is a wireless transceiver.
9. The movement monitor as recited in Claim 1, wherein the tensioned-portion of the cable is between a sheave and the wellbore.
10. A method of installing downhole equipment in a wellbore, comprising:
determining a movement threshold after the downhole equipment is attached to a tubing string and an electrical cable is attached to the downhole equipment;

monitoring movement of the downhole equipment during installation in the wellbore;

determining when the downhole equipment is stationary based on movement information corresponding to rotational data; and

energizing the electrical cable coupled to the downhole equipment when the movement information indicates the downhole equipment is stationary.

11. The method as recited in Claim 10, further comprising determining the movement information based on a comparison between rotational data and the movement threshold, wherein the movement threshold is determined based on ambient data.

12. The method as recited in Claim 11, wherein a movement monitor coupled to a rotation device associated with a tensioned-portion of the electrical cable provides the movement information.

13. The method as recited in Claim 11, wherein the energizing is performed automatically.

14. The method as recited in Claim 11, further comprising de-energizing the electrical cable when the movement information indicates the downhole equipment is moving.

15. A system for installation of downhole equipment in a wellbore that is attached to a cable, comprising:

a selective power controller configured to control energizing of the cable during the installation based on movement information that corresponds to lowering of the downhole equipment in the wellbore; and

a movement monitor configured to provide the movement information, wherein the movement information corresponds to rotational data based on a rotating device associated with a portion of the cable at the wellbore that is under tension.

16. The system as recited in Claim 15, further comprising a power source configured to energize the cable during the installation, wherein the selective power controller controls the power source based on the movement information.

17. The system as recited in Claim 15, wherein the selective power controller is configured to automatically energize the cable when the movement information indicates the downhole equipment is stationary within the wellbore and de-energizes the cable when the movement information indicates the downhole equipment is being lowered in the wellbore.

18. The system as recited in Claim 15, wherein the movement monitor is configured to wirelessly transmit the movement information to the selective power controller.

19. The system as recited in Claim 15, wherein the downhole equipment is an electric submersible pump.

20. The system as recited in Claim 15, wherein the movement monitor is mounted to the rotating device.

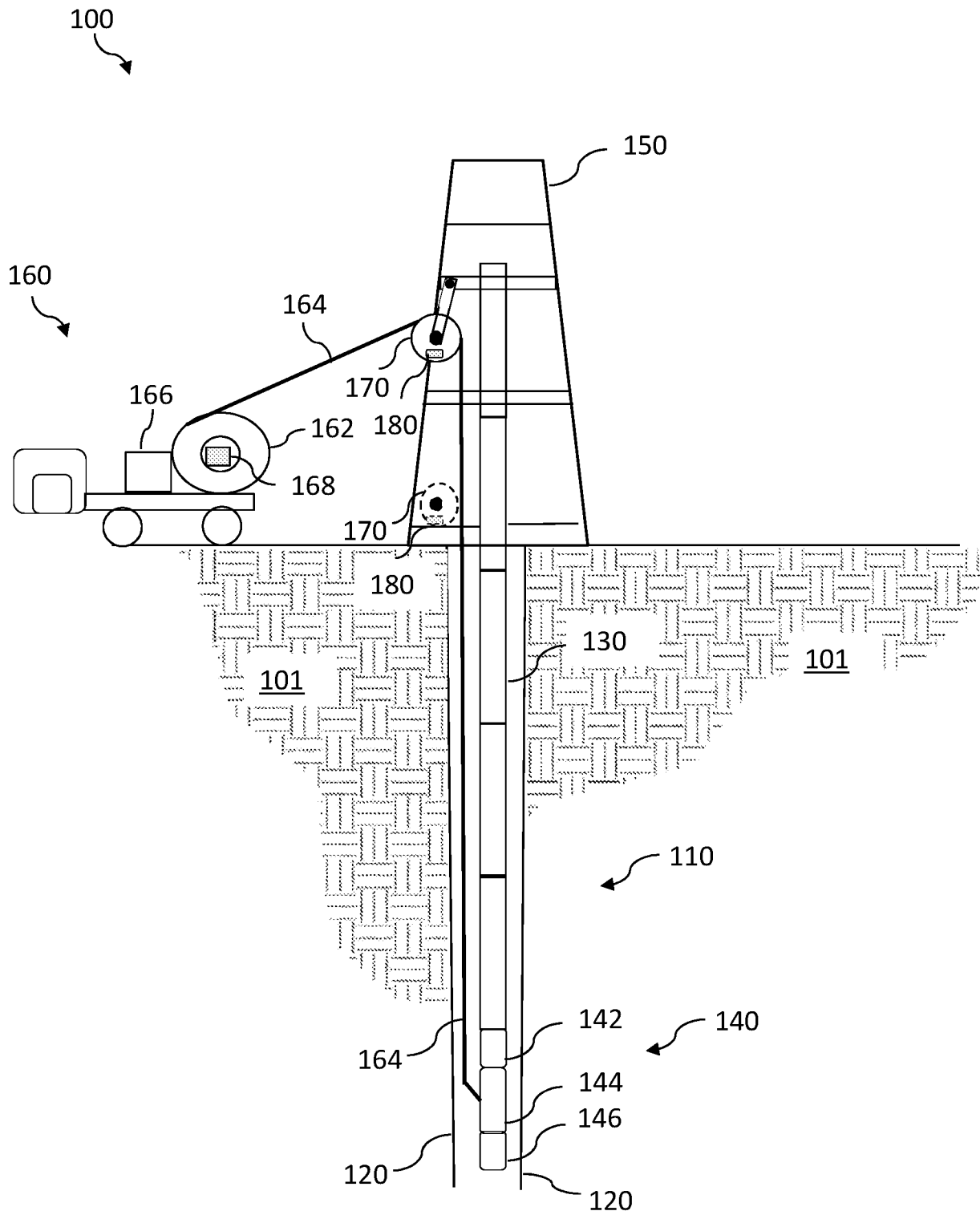


FIG. 1

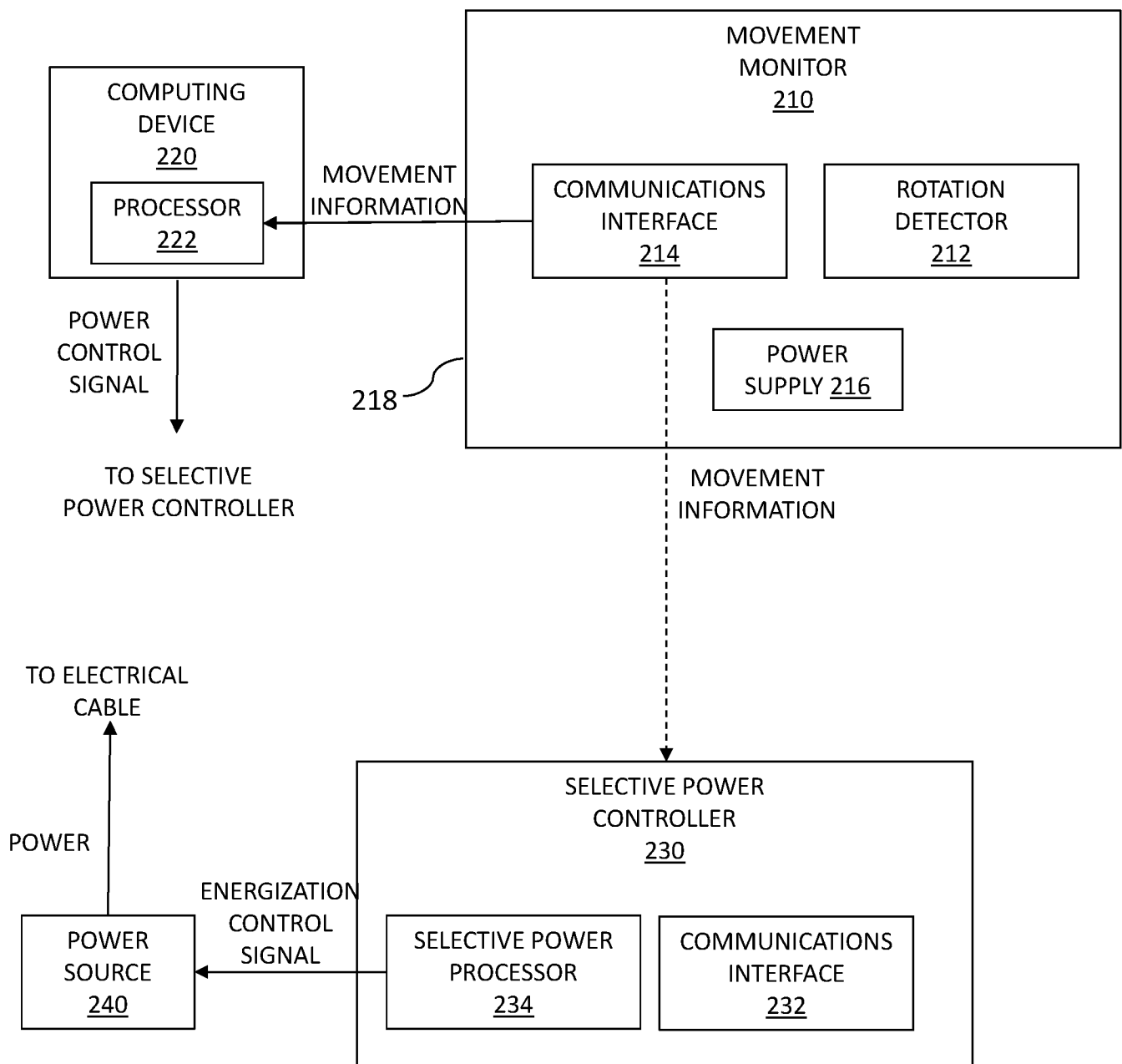


FIG. 2

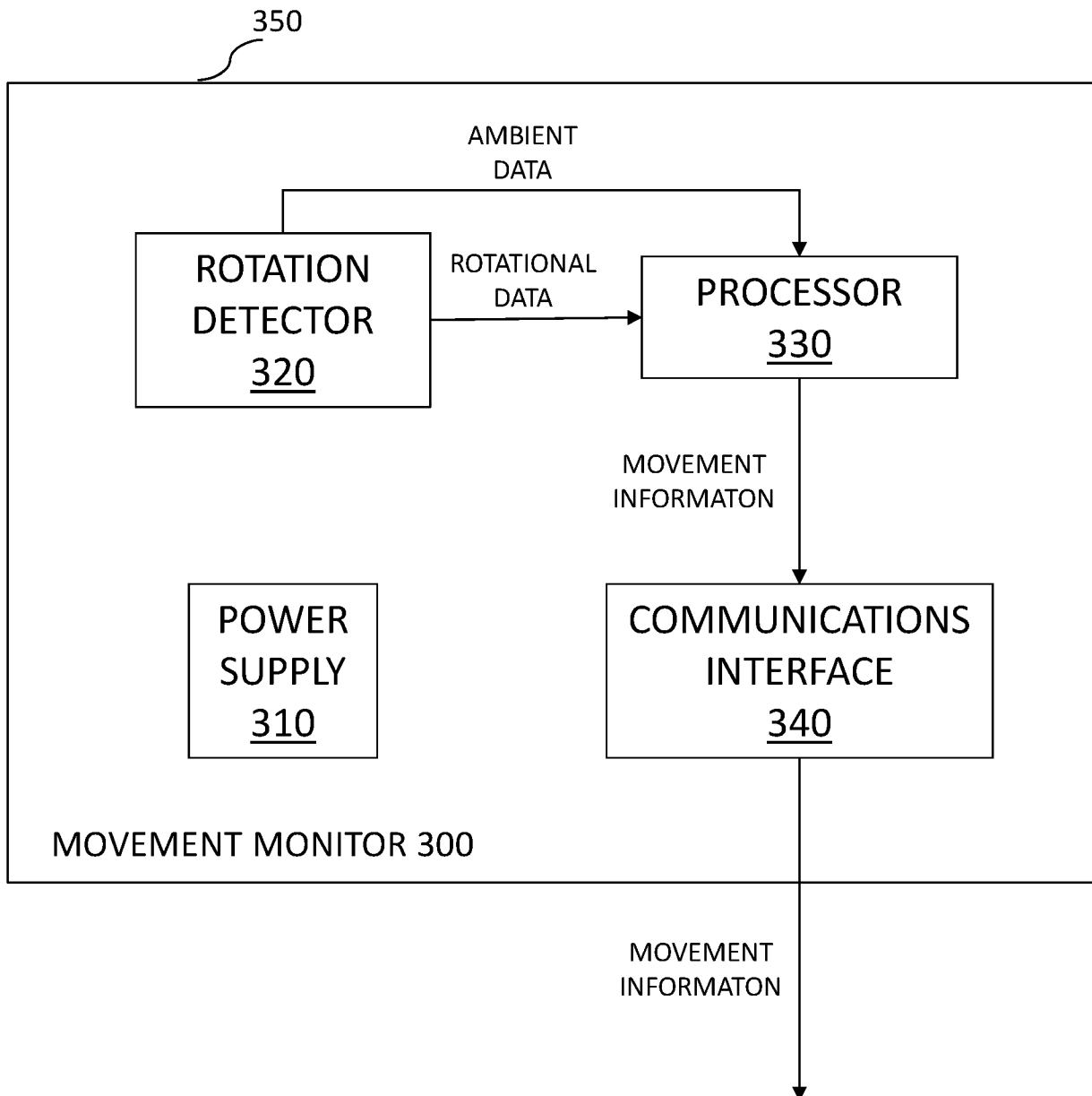


FIG. 3

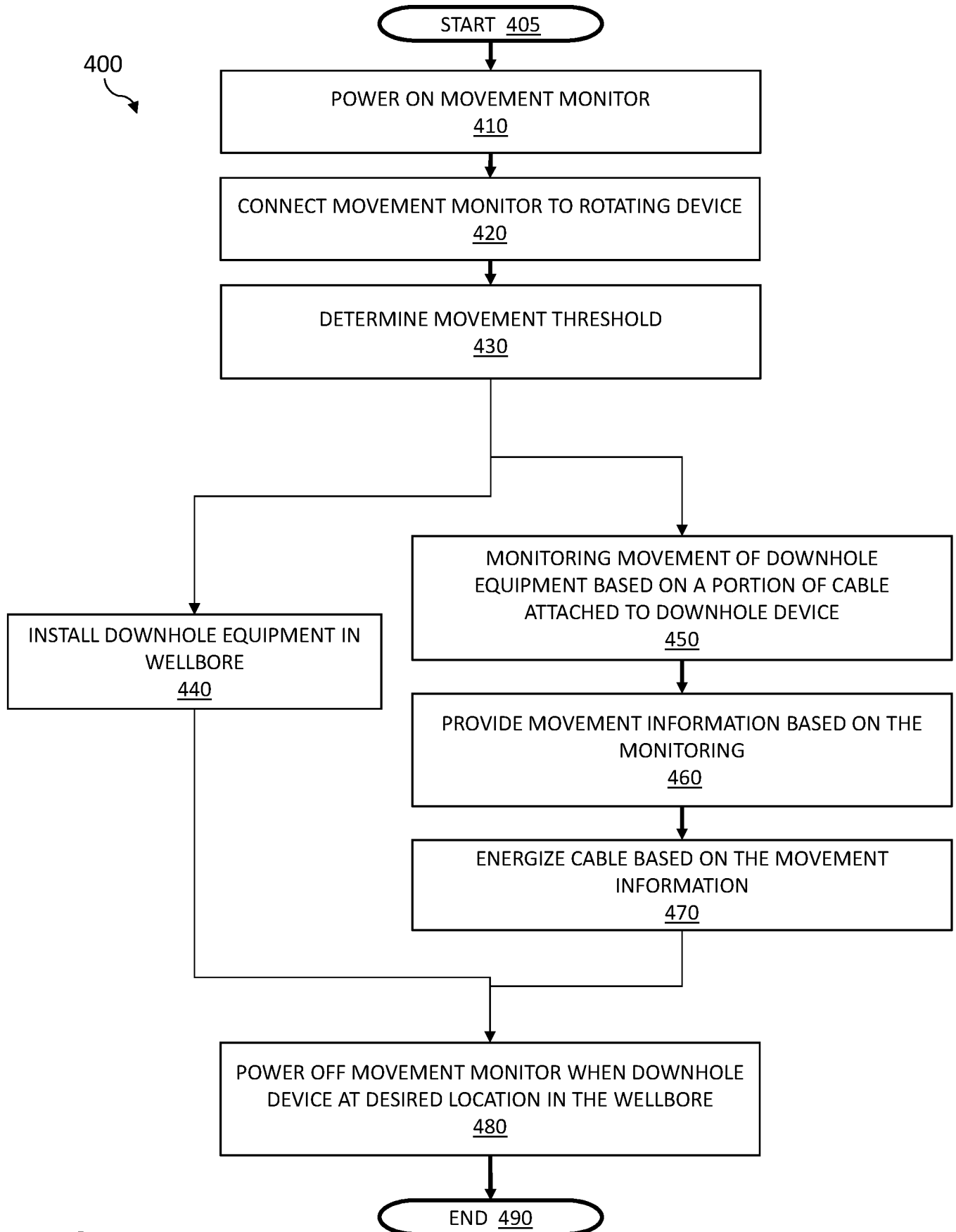


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2020/061582

A. CLASSIFICATION OF SUBJECT MATTER E21B 47/13(2012.01)i; E21B 17/00(2006.01)i; E21B 41/00(2006.01)i; E21B 43/12(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 47/13(2012.01); E21B 47/00(2006.01); E21B 47/022(2006.01); E21B 47/04(2006.01); E21B 47/12(2006.01); G01B 7/02(2006.01); G01B 7/26(2006.01) 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: communications interface, movement information, rotation detector, rotational data, rotating device, tensioned-portion		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020-0332644 A1 (HALLIBURTON ENERGY SERVICES, INC.) 22 October 2020 (2020-10-22) abstract, paragraphs [0010]-[0023], [0038], [0045], [0058], claims 5, 9, and figures 1-2, 4	10
Y		1-9,11-20
Y	US 2017-0306749 A1 (PARADIGM TECHNOLOGY SERVICES B.V.) 26 October 2017 (2017-10-26) paragraphs [0180], [0183], [0186], [0189] and figure 1	1-9,11-20
A	CN 107304672 A (GUIZHOU AEROSPACE KAISHAN PETROLEUM INSTRUMENT CO., LTD.) 31 October 2017 (2017-10-31) paragraphs [0012]-[0013] and figure 1	1-20
A	WO 2007-068877 A1 (SCHLUMBERGER TECHNOLOGY B.V. et al.) 21 June 2007 (2007-06-21) paragraphs [0017]-[0024] and figure 1	1-20
☒ 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 "D" document cited by the applicant in the international application "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 06 August 2021		Date of mailing of the international search report 06 August 2021
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer BAHNG, SEUNG HOON Telephone No. +82-42-481-5560

INTERNATIONAL SEARCH REPORT

International application No.

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5172480 A (LABUC et al.) 22 December 1992 (1992-12-22) column 3, line 18 - column 4, line 29 and figure 1	1-20

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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				EP	3201435	B1	31 March 2021
				US	10422213	B2	24 September 2019
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US	5172480	A	22 December 1992	CA	2024429	A1	01 March 1992
				GB	2247526	A	04 March 1992