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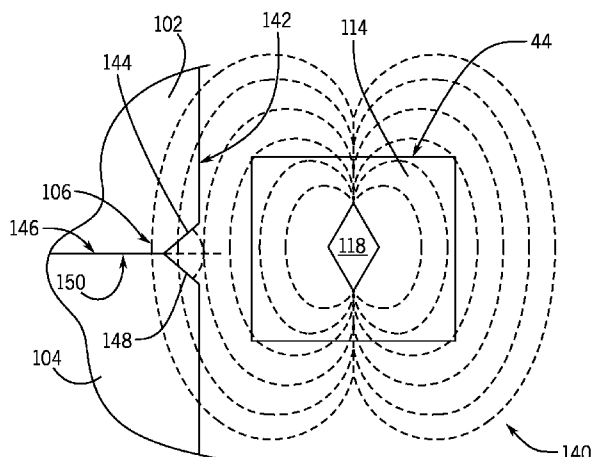


FIG. 3

(57) Abstract: A pipe joint location detection system (44) includes a main body (114), at least one magnet (118), and a plurality of magnetic sensors (120). The main body (114) has an annular shape defining a central passage (116), the at least one magnet (118) is coupled to the main body (114), the magnet (118) is configured to output a magnetic field, and the plurality of magnetic sensors (120) is coupled to the main body (114) and disposed about a circumference of the main body (114), wherein each magnetic sensor (120) of the plurality of magnetic sensors (120) is configured to detect a magnetization of a tubular string disposed within the central passage (116). The pipe joint location detection system (44) also includes a memory (222) comprising data stored thereon, wherein the data includes a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour.



## MAGNETIC PIPE JOINT LOCATION DETECTION SYSTEM AND METHOD

### CROSS REFERENCE TO RELATED APPLICATION

**[0001]** This application claims priority to and benefit of U.S. Provisional Application No. 62/222,637, entitled "PIPE JOINT LOCATION DETECTION SYSTEM AND METHOD," filed September 23, 2015, which is hereby incorporated by reference in its entirety.

### BACKGROUND

**[0002]** Embodiments of the present disclosure relate generally to the field of drilling and processing of wells. More particularly, present embodiments relate to a system and method for detecting a pipe joint and/or connection between two tubulars.

**[0003]** In conventional oil and gas operations, a well is typically drilled to a desired depth with a drill string, which includes drill pipe and a drilling bottom hole assembly (BHA). Once the desired depth is reached, the drill string is removed from the hole and casing is run into the vacant hole. In some conventional operations, the casing may be installed as part of the drilling process. A technique that involves running casing at the same time the well is being drilled may be referred to as "casing-while-drilling."

**[0004]** Casing may be defined as pipe or tubular that is placed in a well to prevent the well from caving in, to contain fluids, and to assist with efficient extraction of product. When the casing is properly positioned within a hole or well, the casing is typically cemented in place by pumping cement through the casing and into an annulus formed between the casing and the hole (e.g., a wellbore or parent casing). Once a casing string has been positioned and cemented in place or installed, the process may be repeated via the now installed casing string. For example, the well may be drilled further by passing a drilling BHA through the installed casing string and drilling. Further, additional casing strings may be subsequently passed through the installed casing string (during or after

drilling) for installation. Indeed, numerous levels of casing may be employed in a well. For example, once a first string of casing is in place, the well may be drilled further and another string of casing (an inner string of casing) with an outside diameter that is accommodated by the inside diameter of the previously installed casing may be run through the existing casing. Additional strings of casing may be added in this manner such that numerous concentric strings of casing are positioned in the well, and such that each inner string of casing extends deeper than the previously installed casing or parent casing string. In many circumstances, it may be desirable to locate or identify a split or joint between two pieces of tubular (e.g., two pieces of casing or drill pipe) that are coupled to one another. Unfortunately, it may be difficult to identify a split or joint between two pieces of tubular if an operator is not able to readily view the split or joint between the two pieces of tubular.

#### BRIEF DESCRIPTION

**[0005]** In a first embodiment, a pipe joint location detection system includes a main body, at least one magnet, and a plurality of magnetic sensors. The main body includes an annular shape defining a central passage, the at least one magnetic is coupled to the main body, the magnet is configured to output a magnetic field, and the plurality of magnetic sensors is coupled to the main body and disposed about a circumference of the main body, wherein each magnetic sensor of the plurality of magnetic sensors is configured to detect a magnetization of a tubular string disposed within the central passage. The pipe joint location detection system also includes a memory having data stored thereon, wherein the data includes a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour.

**[0006]** In another embodiment, a method includes magnetizing the tubular string with a magnetic field generated by a magnet of a joint location detection system disposed

adjacent to the tubular string, detecting a first magnetization value of the tubular string with a first magnetic sensor of the joint location detection system disposed adjacent to the tubular string, wherein the first magnetization value corresponds to a first geometry of the tubular string, and detecting a second magnetization value of the tubular string with the first magnetic sensor, wherein the second magnetization value corresponds to a second geometry of the tubular string, wherein the second geometry is different from the first geometry.

**[0007]** In a further embodiment, a system includes a joint location detection system and a tubular string having a first tubular and a second tubular, wherein the first tubular and the second tubular are coupled to one another via a joint. The joint location detection system includes a magnet configured to output a magnetic field, a plurality of magnetic sensors, wherein each magnetic sensor of the plurality of magnetic sensors is configured to detect a magnetization of the tubular string, and a memory comprising data stored thereon, wherein the data comprises a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour, and the joint comprises the second contour.

## DRAWINGS

**[0008]** These and other features, aspects, and advantages of present embodiments will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

**[0009]** FIG. 1 is a schematic of a well being drilled, in accordance with an embodiment of present techniques;

**[0010]** FIG. 2 is a cross-sectional side view of a tubular string with a pipe joint location detection system, in accordance with an embodiment of present techniques;

**[0011]** FIG. 3 is a partial cross-sectional side view of the tubular string and pipe joint location detection system of FIG. 2, taken within line 3-3 of FIG. 2, in accordance with an embodiment of present techniques;

**[0012]** FIG. 4 is cross-sectional axial view of the tubular string and pipe joint detection location system of FIG. 2, taken along line 4-4 of FIG. 2, in accordance with an embodiment of present techniques;

**[0013]** FIG. 5 is a perspective view of a pipe joint location detection system, in accordance with an embodiment of present techniques; and

**[0014]** FIG. 6 is a schematic of a pipe joint location detection system in accordance with an embodiment of present techniques.

#### DETAILED DESCRIPTION

**[0015]** Present embodiments provide a system and method for detecting a joint, split, and/or connection between two sections of tubular (e.g., sections of casing or drill pipe) that are coupled to one another. As described in detail below, a pipe joint location detection system includes at least one magnet and at least one magnetic sensor. The system may be generally circular, cylindrical, and/or annular such that sections of tubular (e.g., a tubular string) may pass through a central opening of the system. When sections of tubular pass through the system, the at least one magnet of the system may be positioned on one side of the tubular string, and the at least one magnetic sensor may be positioned on another side (e.g., an opposite side) of the tubular string. In operation, the magnet outputs a magnetic field that energizes or magnetizes the tubular string. As the tubular string passes through the system, the magnetic sensor may detect any variation or variance in the magnetization of the tubular string. For example, a change in the contour or geometry (e.g., surface geometry) of the tubular string may be reflected in the magnetization of the tubular string that is detected by the sensor. As described in detail below, the joint, split, and/or connection between two sections of tubular may have such

a change in geometry relative to a base line. Thus, when a joint or connection between two sections of tubular passes through the pipe joint location detection system, the change in magnetization of the tubular string caused by the contour variation at the joint or connection may be detected by the sensor of the system, thereby detecting the joint or connection between the sections of tubular. The pipe joint location detection system may also have other functions and features, as described below.

**[0016]** Turning now to the drawings, FIG. 1 is a schematic of a drilling rig 10 in the process of drilling a well in accordance with present techniques. The drilling rig 10 features an elevated rig floor 12 and a derrick 14 extending above the rig floor 12. A supply reel 16 supplies drilling line 18 to a crown block 20 and traveling block 22 configured to hoist various types of drilling equipment above the rig floor 12. The drilling line 18 is secured to a deadline tiedown anchor 24, and a drawworks 26 regulates the amount of drilling line 18 in use and, consequently, the height of the traveling block 22 at a given moment. Below the rig floor 12, a casing string 28 (e.g., tubular string) extends downward into a wellbore 30 and is held stationary with respect to the rig floor 12 by a rotary table 32 and slips 34. A portion of the casing string 28 extends above the rig floor 12, forming a stump 36 to which another length of tubular 38 (e.g., casing) may be added. In certain embodiments, the tubular 38 may include 30 foot segments of oilfield pipe having a suitable diameter (e.g., 13 3/8 inches) that are joined as the casing string 28 is lowered into the wellbore 30. As will be appreciated, in other embodiments, the length and/or diameter of segments of the casing 16 (e.g., tubular 38) may be other lengths and/or diameters. The casing string 28 is configured to isolate and/or protect the wellbore 30 from the surrounding subterranean environment. For example, the casing string 28 may isolate the interior of the wellbore 30 from fresh water, salt water, or other minerals surrounding the wellbore 30.

**[0017]** When a new length of tubular 38 is added to the casing string 28, a top drive 40, hoisted by the traveling block 22, positions the tubular 38 above the wellbore 30 before coupling with the casing string 28. The top drive 40 includes a grappling system

42 that couples the tubular 38 to the top drive 40. In operation, the grappling system 42 is inserted into the tubular 38 and then exerts a force on an internal diameter of the tubular 38 to block the tubular 38 from sliding off the grappling system 42 when the top drive 40 hoists and supports the tubular 38.

**[0018]** The drilling rig 10 also includes a pipe joint location detection system 44, which is configured to detect a joint, split, or connection between two sections of tubular 38. For example, the pipe joint location detection system 44 may be used to detect a joint, split, or connection between two sections of tubular 38 as the casing string 28 is run into the wellbore 30. In other embodiments, the pipe joint location detection system 44 may be used to detect a joint, split, or connection between two sections of a drill string being run into the wellbore 30 during a drilling operation or as a drill string is being removed from the wellbore 30. In other words, the tubular 38 shown in FIG. 1 may represent a section of drill pipe that may be added to a drill string (not shown) being lowered into the wellbore 30 to complete a drilling process. In the illustrated embodiment, the pipe joint location detection system 44 is a modular system positioned above the slips 34. However, in other embodiments, the pipe joint location detection system 44 may be integrated with another component of the drilling rig 10, such as the top drive 40, the grappling system 42, a casing drive system, a pipe drive system, an iron roughneck, or other component of the drilling rig 10. Further, the pipe joint location detection system 44 may be located beneath the rig floor 12 or even down hole. Additionally, the drilling rig 10 may include a monitoring system 46 configured to communicate with the pipe joint location detection system 44 (e.g., via a wired or wireless connection). As discussed below, the monitoring system 46 may be configured to monitor data gathered by the system 44, such as a number of pipe joints detected, a rate of pipe joint detection, and so forth.

**[0019]** It should be noted that the illustration of FIG. 1 is intentionally simplified to focus on the pipe joint location detection system 44 described in detail below. Many other components and tools may be employed during the various periods of formation

and preparation of the well. Similarly, as will be appreciated by those skilled in the art, the orientation and environment of the well may vary widely depending upon the location and situation of the formations of interest. For example, rather than a generally vertical bore, the well, in practice, may include one or more deviations, including angled and horizontal runs. Similarly, while shown as a surface (land-based) operation, the well may be formed in water of various depths, in which case the topside equipment may include an anchored or floating platform.

**[0020]** FIG. 2 is a cross-sectional side view of a tubular string 100 having a first tubular 102 and a second tubular 104 connected to one another at a joint, split, or connection 106. Specifically, the first tubular 102 has a pin end 108 and the second tubular 104 has a box end 110. The pin end 108 and the box end 110 are coupled to one another by a threaded connection 112. As mentioned above, the first and second tubulars 102 and 104 may be lengths of casing (e.g., tubular 38 shown in FIG. 1) or lengths of drill pipe. The pipe joint location detection system 44 is also shown in FIG. 2. The pipe joint location detection system 44 has a main body 114 with a generally annular or ring-shaped configuration, such that the tubular string 100 may pass through a central passage 116 of the pipe joint location detection system 44. In certain embodiments, the main body 114 of the pipe joint location detection system 44 may be made from metal, plastic, a polymer, or other suitable material.

**[0021]** As shown, the pipe joint location detection system 44 includes a magnet 118 and a sensor 120. More specifically, the magnet 118 and the sensor 120 are disposed within or on the main body 114 of the pipe joint location detection system 44. For example, the magnet 118 and/or the sensor 120 may be secured to an outer surface 122 of the main body 114 via an adhesive or other securement. In other embodiments, the magnet 118 and/or the sensor 120 may be molded within the main body 114, disposed within internal cavities of the main body 114, or otherwise secured to the main body 114 of the pipe joint location detection system 44.



**[0022]** The magnet 118 may be a rare earth magnet, and the sensor 120 may be a magnetic sensor, a Hall-effect sensor, an azimuth sensor, or other suitable sensor. In certain embodiments, the pipe joint location detection system 44 may include multiple magnets 118 and/or multiple sensors 120. For example, multiple magnets 118 and/or multiple sensors 120 may be disposed and/or spaced about a circumference of the annular main body 114, as discussed in further detail below.

**[0023]** In operation, the magnet 118 of the pipe joint location detection system 44 emits a magnetic field 140, as shown in FIG. 3. The magnetic field 140 emitted by the magnet 118 energizes or magnetizes the tubular string 100. The one or more sensors 120 of the pipe joint location detection system 44 may then detect the magnetization of the tubular string 100 (e.g., the first tubular 102 and the second tubular 104).

**[0024]** As will be appreciated, the detected magnetization may be affected by the shape or geometry of the surface of the tubular string 100. For example, as the tubular string 100 passes through the central passage 116 of the pipe joint location detection system 44, the magnetization of the tubular string 100 detected by the sensor 120 may be relatively constant due to the generally smooth cylindrical contour of an outer diameter 142 of the tubular string 100. However, as shown in FIG. 3, the contour of the outer diameter 142 of the tubular string 100 may include variations at the joint, split, or connection 106 between adjacent sections of the tubular string 100 (e.g., between the first tubular 100 and the second tubular 102). For example, the first tubular 102 may include a first chamfer 144 at a first axial end 146 of the first tubular 102, and the second tubular 104 may also include a second chamfer 148 at a second axial end 150 of the second tubular 104. Together, the first and second chamfers 144 and 148 for the first and second tubulars 102 and 104, respectively, create a variation in the contour of the outer diameter 142 of the tubular string 100 at the joint or connection 106 between the first and second tubulars 102 and 104. This variation in contour alters the magnetization of the tubular string 100 at the joint or connection 106. Thus, when the sensor 120 of the pipe joint location detection system 44 detects the altered magnetization, the pipe joint location

detection system 44 thereby detects the presence of the joint or connection 106 between the first and second tubulars 102 and 104 as the tubular string 100 is passing through the central passage 116 of the pipe joint location detection system 44.

**[0025]** To avoid false joint or connection 106 detection by the pipe joint location detection system 44 (e.g., due to other detected variations in the contour of the tubular string 100), the pipe joint location detection system 44 may first be calibrated. For example, the tubular string 100 may be passed through the central passage 116 of the pipe joint location detection system 44, and variations in detected magnetization due to joints or connections 106 between adjacent tubulars (e.g., first and second tubulars 102 and 104) may be recorded (e.g., in memory 222 shown in FIG. 6) and associated with the presence of the joints or connections 106 within the central passage 116 of the pipe joint location detection system 44. In other words, a variation in contour of the tubular string 100 (e.g., the first and second chamfers 144 and 148 shown in FIG. 2) that is a reflection of the joint or split 106 between adjacent tubulars (e.g., first and second tubulars 102 and 104) of the tubular string 100 may be associated (e.g., via recordation, registration, storing, etc.) with a particular (e.g., quantifiable and/or identifiable) change in detected magnetization in a calibration process.

**[0026]** The pipe joint location detection system 44 may also be used to detect lateral movement of the tubular string 100 (e.g., with respect to a center of the wellbore 30). For example, FIG. 4 is a schematic axial view of the pipe joint location detection system 44 and tubular string 100, taken along line 4-4 of FIG. 2, illustrating positioning of three sensors 120 of the pipe joint location detection system 44 about the tubular string 100. That is, the three sensors 120 are spaced about a circumference 160 of the main body 114 of the pipe joint location detection system 44. As shown in FIG. 4, the tubular string 100 passes through the central passage 116 defined by the annular configuration of the main body 114 of the pipe joint location detection system 44. Thus, the sensors 120 and the magnet 118 of the pipe joint location detection system 44 are disposed about the tubular string 100 when the tubular string 100 passes through the central passage 116. As

discussed above, the magnet 120 of the pipe joint location detection system 44 emits a magnetic field (e.g., magnetic field 140 shown in FIG. 2) that magnetizes the tubular string 100 (e.g., the outer diameter 142 of the tubular string 100), which is then detected by the sensors 120. While three sensors 120 are shown in the illustrated embodiment, different embodiments may include other numbers of sensors (e.g., 1, 2, 4, 5, 6, 7, 8, 9, 10, etc.). Additionally, the sensors 120 may be spaced equidistantly about the circumference 140 of the main body 114 or may having varying spacing about the circumference 140 of the main body 114.

**[0027]** If the central passage 116 of the pipe joint location detection system 44 is centered over the wellbore 30 (i.e., if the center of the central passage 116 and the center of the wellbore 30 are generally co-axial), the pipe joint location detection system 44 shown in FIG. 4 may be able to detect lateral movement of the tubular string 100. For example, if the tubular string 100 moves off center with respect to the wellbore 30, at least one of the sensors 120 of the pipe joint location detection system 44 will detect a stronger magnetization of the tubular string 100 than at least one of the other sensors 120 of the pipe joint location detection system 44. In other words, when the tubular string 100 moves off center with respect to the wellbore 30, the tubular string 100 will move within the central passage 116 of the main body 114 of the pipe joint location detection system 44 and will move closer to at least one of the sensors 120, while moving farther away from another one of the sensors 120. This change in relative location between the tubular string 100 and each of the sensors 120 results in varying readings or detections of each of the sensors 120. Thus, variations in the detected magnetization by multiple sensors 120 of the pipe joint location detection system 44 may be used to detect lateral movement of the tubular string 100 (e.g., within the wellbore 30).

**[0028]** As will be appreciated, in an embodiment of the pipe joint location detection system 44 where all sensors 120 of the pipe joint location detection system 44 are spaced equidistantly about the circumference 160 of the main body 114, each sensor 120 may detect the same magnetization (e.g., generally or approximately the same magnetization)

of the tubular string 100 when the tubular string 100 is centered with the wellbore 30. Thus, when the sensors 120 detect different magnetizations from one another, lateral movement of the tubular string 100 may be detected. However, it will be appreciated that other embodiments of the pipe joint location detection system 44 may include numerous sensors 120 that are not equidistantly spaced from one another. Even so, such embodiments may still be configured to detect lateral movement of the tubular string 100 by calibrating the various sensors 120 appropriately.

**[0029]** The embodiment shown in FIG. 4 may also be configured to detect changes in a diameter 162 of the tubular string. For example, one tubular string 100 of a larger diameter will be closer to the sensors 120 of the pipe joint location detection system 44 than another tubular string 100 of a smaller diameter. That is, the outer diameter 142 of one tubular string 100 having a larger diameter will be closer to the sensors 120 of the system 44 than the outer diameter 142 of another tubular string 100 of a smaller diameter when the different tubular strings 100 are positioned within the central passage 116 of the pipe joint location detection system 44. Thus, the detected magnetization of the tubular string 100 may vary with the diameter 162 of the tubular string 100. Therefore, the pipe joint location detection system 44 may be used to verify the size of the diameter 162 of the tubular string 100 that is passing through the pipe joint location detection system 44. To this end, the pipe joint location detection system 44 may be calibrated in a manner similar to that described above. For example, tubular strings 100 of varying diameter 162 may be passed through the central passage 116 of the pipe joint location detection system 44, and variations in detected magnetization due to the varying diameters 162 may be recorded (e.g., in memory 222 shown in FIG. 6) and associated with the respective diameter 162 of the tubular string 100 passing through the central passage 116 of the pipe joint location detection system 44 at a given time.

**[0030]** FIG. 4 also illustrates a hinge 180 and a clasp/fastener 182 of the pipe joint location detection system 44. In operation, the clasp or fastener 182 may be released to enable two or more sections 184 (e.g., first section 186 and second section 188) of the

main body 114 of the pipe joint location detection system 44 to pivot about the hinge 180 and enable placement of the pipe joint location detection system 44 about the tubular string 100. With the pipe joint location detection system 44 positioned about the tubular string 100 (i.e., with the tubular string 100 positioned within the central passage 116 of the main body 114), the sections 184 of the pipe joint location detection system 44 may be closed together and the clasp 182 may be fastened to secure the sections 184 of the pipe joint location detection system 44 to one another.

**[0031]** FIG. 5 is a perspective view of an embodiment of the pipe joint location detection system 44, illustrating two arrays 200 of sensors 120 supported by the main body 114. In the illustrated embodiment, the main body 114 has a single piece configuration. That is, the main body 114 has one section 184. Specifically, the pipe joint location detection system 44 includes a first array 202 of sensors 120 at a first axial position 206 of the main body 114 and a second array 204 of sensors 120 at a second axial position 208 of the main body 114. In certain embodiments, each array 200 of sensors 120 may include its own magnet 118, however other embodiments of the pipe joint location detection system 44 having two arrays 200 of sensors 120 may include only one magnet 118 (e.g., positioned at the first axial position 206, the second axial position 208, at a third axial position 210 between the first and second axial positions 206 and 208, etc.).

**[0032]** The first and second arrays 202 and 204 of sensors 120 shown in FIG. 5 enable the pipe joint location detection system 44 to also detect a change in the angle of the tubular string 100 relative to a central axis of the wellbore 30. For example, in an embodiment of the pipe joint location detection system 44 having the first and second arrays 202 and 204 of sensors 120 where the sensors 120 of the first array 202 are equidistantly spaced about the circumference 160 of the main body 114 and the sensors 120 of the second array 204 are likewise equidistantly spaced, the sensors 120 may all detect similar magnetizations of the tubular string 100 (assuming no joint or connection 106 of the tubular string 100 is present within the central passage 116) when the tubular

string 100 is substantially or generally completely vertical. However, if the tubular string 100 is tilted (e.g., relative to a vertical axis), one or more the sensors 120 in each of the first and second arrays 202 and 204 may detect a variation in the magnetization of the tubular string 100. In this way, the inclusion of multiple arrays 200 of sensors 120 at multiple axial positions (e.g., first, second, or third axial positions 206, 208, or 210) of the main body 114 enable three-dimensional detection of the position (e.g., angle) of tubular string 100.

**[0033]** In certain embodiments, the magnets 118 and the sensors 120 may have other configurations in the pipe joint location detection system 44. In some embodiments, different magnets 118 of the pipe joint location detection system 44 may have different polarities (e.g., positive or negative). For example, in one embodiment, the first array 202 at the first axial position 206 may have at least one magnet 118 having a positive (or negative) polarity, and the second array 204 at the second axial position 208 may have at least one magnet 118 having a negative (or positive) polarity. In such an embodiment, the at least one magnet 118 of the first array 202 at the first axial position 206 and the at least one magnet 118 of the second array 204 at the second axial position 208 have opposite polarities.

**[0034]** Additionally, in such an embodiment, the pipe joint location detection system 44 may have at least one sensor 120 disposed at the third axial location 210. Thus, a portion of the tubular string 100 above the at least one sensor 120 disposed at the third axial location 210 may have a first magnetization or charge, and a portion of the tubular string 100 below the at least one sensor 120 disposed at the third axial location 210 may have a second magnetization or charge (e.g., opposite the first magnetization or charge). When one of the splits/joints/connections 106 of the tubular string 100 passes through the pipe joint location detection system 44, the splits/joints/connection 106 will initially have a first (e.g., positive) magnetization from the at least one magnet 118 of the first array 202 at the first axial position 206. Then, the splits/joints/connection 106 will cross the at least one sensor 120 disposed at the third axial location 210 and will subsequently have a

second (e.g., negative) magnetization from the at least one magnet 118 of the second array 204 at the second axial position 208. Thus, the at least one sensor 120 disposed at the third axial location 210 will detect a changing (e.g., from positive to negative or vice versa) magnetization of the splits/joints/connection 106 as the splits/joints/connection 106 passes through the pipe joint location detection system 44, which may help verify the identification and/or presence of a splits/joints/connection 106 in the tubular string 100.

**[0035]** FIG. 6 is a schematic of an embodiment of the pipe joint location detection system 44. The pipe joint location detection system 44 includes the magnet 118 and sensors 120 described above, as well as a processor 220, a memory 222, and an encoder 224. Although not shown in FIG. 6, the pipe joint location detection system 44 may also include other components. For example, the pipe joint location detection system 44 may include a power source, such as a battery, communications circuitry (e.g., wireless communications circuitry), and/or other components.

**[0036]** The processor 220 may be configured to perform a variety of functions, such as processing data (e.g., detected magnetization of the tubular) gathered by the sensors 120, storing the data in the memory 222, communicating the data to other components of the drilling rig 10 (e.g., to the monitoring system 46 via communications circuitry), and so forth. For example, the processor 220 may be configured to compare detected magnetizations of the tubular string 100 with established profiles to determine position, orientation, diameter 162 size, presence of splits/joints/connections 106, etc., of the tubular string 100. In certain embodiments, the processor 220 may be configured to detect signatures associated with other characteristics of the tubular string 100, such as unexpected surface characteristics, cracks, deformations, other tubular string 100 components, and so forth. The encoder 224 may also be configured to perform a variety of functions. For example, the encoder 224 may be programmed to measure a length of tubular 38 added to the tubular string 100. More specifically, the encoder 224 may be configured to monitor the number of joints 106 detected, and the encoder 224 may calculate a total length of tubular 38 added or subtracted to the tubular string 100 based

on the number of joints 106 detected (e.g., number of sections of tubular 38 added) and a known length of each section of tubular 38. The encoder 224 could also work with other systems of the drilling rig 10 to determine whether the total length of tubular 38 calculated should be added or subtracted to the length of the tubular string 100, which may be stored as data in the memory 222. For example, the drilling rig 10 may include a motion detection system configured to detect upward and/or downward movement of a tubular gripping system (e.g., pipe drive system, casing drive system, top drive system, etc.). The encoder 224 may communicate with the motion detection system to determine whether a calculated total length of tubular 38 should be added or subtracted to a total length of the tubular string 100 that is stored in the memory 222. For example, if the motion detection system detects upward movement of a tubular gripping system of the drilling rig 10, the tubular string 100 is likely being removed from the wellbore 30, and thus the total calculated length of tubular 38 may be subtracted from the length of the tubular string 100. Conversely, if the motion detection system detects downward movement of the gripping system, the tubular string 100 is likely being run into the wellbore 30, and the total calculated length of tubular 38 may be added to the length of the tubular string 100 stored in the memory 222.

**[0037]** As discussed above, present embodiments provide a system and method for detecting the joints, splits, and/or connections 106 between two sections of tubular 38 (e.g., sections of casing or drill pipe). The pipe joint location detection system 44 includes at least one magnet 118 and at least one magnetic sensor 120. The pipe joint location detection system 44 may have a main body 114 that is generally circular, cylindrical, and/or annular such that sections of tubular 38 (e.g., the tubular string 100) may pass through the central passage 116 of the main body 114 of the pipe joint location detection system 44. When sections of tubular 38 pass through the main body 114, the at least one magnet 118 of the pipe joint location detection system 44 may be positioned on one side of the tubular string 100, and the at least one magnetic sensor 120 may be positioned on another side of the tubular string 100. In operation, the magnet 118 outputs the magnetic field 140 that energizes or magnetizes the tubular string 100. As the tubular



string 100 passes through the main body 114, the magnetic sensor 120 may detect any variation or variance in the magnetization of the tubular string 100. For example, a change in the contour or geometry (e.g., surface geometry) of the tubular string 100 may be reflected in the magnetization of the tubular string 100 that is detected by the sensor 120. As discussed above, the joint, split, and/or connection 106 between two sections of tubular 38 may have such a change in geometry or contour. Thus, when the joint or connection 106 between two sections of tubular 38 passes through the pipe joint location detection system 44, the change in magnetization of the tubular string 100 caused by the contour variation at the joint or connection 160 may be detected by the sensor 120 of the system 44, thereby detecting the joint or connection 106 between the sections of tubular 38.

**[0038]** While only certain features of the disclosure have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the disclosure.

## CLAIMS:

1. A pipe joint location detection system, comprising:
  - a main body comprising an annular shape defining a central passage;
  - at least one magnet coupled to the main body, wherein the at least one magnet is configured to output a magnetic field;
  - a plurality of magnetic sensors coupled to the main body and disposed about a circumference of the main body, wherein each magnetic sensor of the plurality of magnetic sensors is configured to detect a magnetization of a tubular string disposed within the central passage; and
  - a memory comprising data stored thereon, wherein the data comprises a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour.
2. The pipe joint location detection system of claim 1, wherein the first contour comprises a radially outermost surface of the tubular string.
3. The pipe joint location detection system of claim 2, wherein the second contour comprises an indentation in the radially outermost surface of the tubular string.
4. The pipe joint location detection system of claim 3, wherein the second contour comprises a chamfer disposed an axial end of a section of tubular of the tubular string.
5. The pipe joint location detection system of claim 1, wherein the at least one magnet is disposed on a side of the main body opposite at least one magnetic sensor of the plurality of magnetic sensors.

6. The pipe joint location detection system of claim 1, wherein each magnetic sensor of the plurality of magnetic sensors is disposed generally equidistantly about the circumference of the main body relative to one another.

7. The pipe joint location detection system of claim 1, wherein the at least one magnet and the plurality of magnetic sensors are disposed internal to the main body.

8. The pipe joint location detection system of claim 1, wherein the plurality of magnetic sensors comprises a first plurality of magnetic sensors arranged in a first array and a second plurality of magnetic sensors arranged in a second array, wherein the first plurality of magnetic sensors is disposed at a first axial point of the main body relative to a central axis of the main body, and the second plurality of magnetic sensors is disposed at a second axial point of the main body relative to the central axis of the main body, wherein the first axial point and the second axial point are different from one another.

9. The pipe joint location detection system of claim 8, wherein the at least one magnet is disposed at a third axial point of the main body relative to the central axis of the main body, wherein the third axial point is axially between the first axial point and the second axial point relative to the central axis of the main body.

10. The pipe joint location detection system of claim 1, wherein the main body comprises a first second and a second section, the first second and the second section cooperatively form the annular shape, and the first second and the second section are coupled to one another by a hinge.

11. A method for detecting a joint location of a tubular string, comprising:  
magnetizing the tubular string with a magnetic field generated by a magnet of a joint location detection system disposed adjacent to the tubular string;

detecting a first magnetization value of the tubular string with a first magnetic sensor of the joint location detection system disposed adjacent to the tubular string, wherein the first magnetization value corresponds to a first geometry of the tubular string; and

detecting a second magnetization value of the tubular string with the first magnetic sensor, wherein the second magnetization value corresponds to a second geometry of the tubular string, wherein the second geometry is different from the first geometry.

12. The method of claim 11, wherein the first geometry is a radially outermost diameter of the tubular string, and wherein the second geometry an indentation of the radially outermost diameter, and the indentation is radially aligned with the joint location of the tubular string relative to a central axis of the joint location detection system.

13. The method of claim 11, comprising passing the tubular string through an annular ring of the joint location detection system, wherein the annular ring comprises the magnet and the first magnetic sensor.

14. The method of claim 11, comprising detecting a tilt in the tubular string relative to a central axis of a wellbore, wherein detecting the tilt in the tubular string relative to the central axis of the wellbore comprises detecting the first magnetization value with the first magnetic sensor and detecting a third magnetization value with a second magnetic sensor of the joint location detection system, wherein the first magnetic sensor and the second magnetic sensor are disposed at a common axial location of the joint location detection system relative to a central axis of the joint location detection system, and wherein the first magnetization value and the third magnetization value are different from one another.

15. The method of claim 11, comprising calibrating the joint location detection system, wherein calibrating the joint location detection system comprises radially aligning the first geometry of the tubular string with the first magnetic sensor relative to a central axis of the pipe joint detection system and storing the first magnetization value in a memory of the joint location detection system and radially aligning the second geometry of the tubular string with the first magnetic sensor relative to the central axis of the pipe joint detection system and storing the second magnetization value in the memory of the joint location detection system.

16. A system, comprising:  
a tubular string comprising a first tubular and a second tubular, wherein the first tubular and the second tubular are coupled to one another via a joint; and  
a joint location detection system, comprising:  
a magnet configured to output a magnetic field;  
a plurality of magnetic sensors, wherein each magnetic sensor of the plurality of magnetic sensors is configured to detect a magnetization of the tubular string; and  
a memory comprising data stored thereon, wherein the data comprises a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour, and the joint comprises the second contour.

17. The system of claim 16, wherein the first geometry comprises a radially outermost diameter of the first tubular and/or the second tubular, and the second geometry comprises a first chamfer of the first tubular and/or a second chamfer of the second tubular.

18. The system of claim 16, wherein the joint location detection system comprises a main body, the main body comprises an annular ring, and the magnet and the plurality of magnetic sensors are coupled to the main body.

19. The system of claim 18, wherein the annular ring defines a central passage and the tubular string is disposed within the central passage.

20. The system of claim 16, wherein the plurality of magnetic sensors comprises a first plurality of magnetic sensors arranged in a first array and a second plurality of magnetic sensors arranged in a second array, wherein the first plurality of magnetic sensors is disposed at a first axial point of the main body relative to a central axis of the main body, and the second plurality of magnetic sensors is disposed at a second axial point of the main body relative to the central axis of the main body, wherein the first axial point and the second axial point are different from one another.

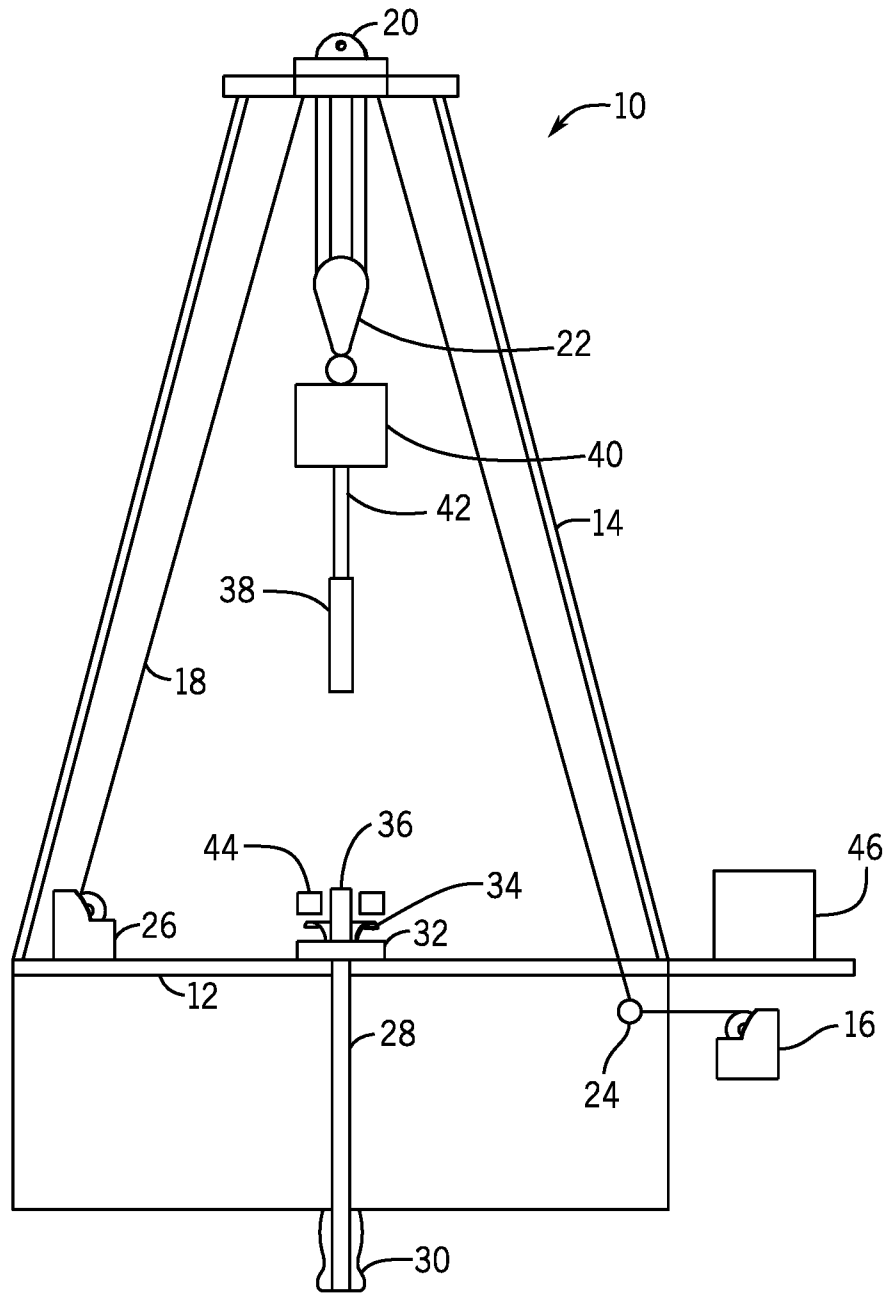


FIG. 1

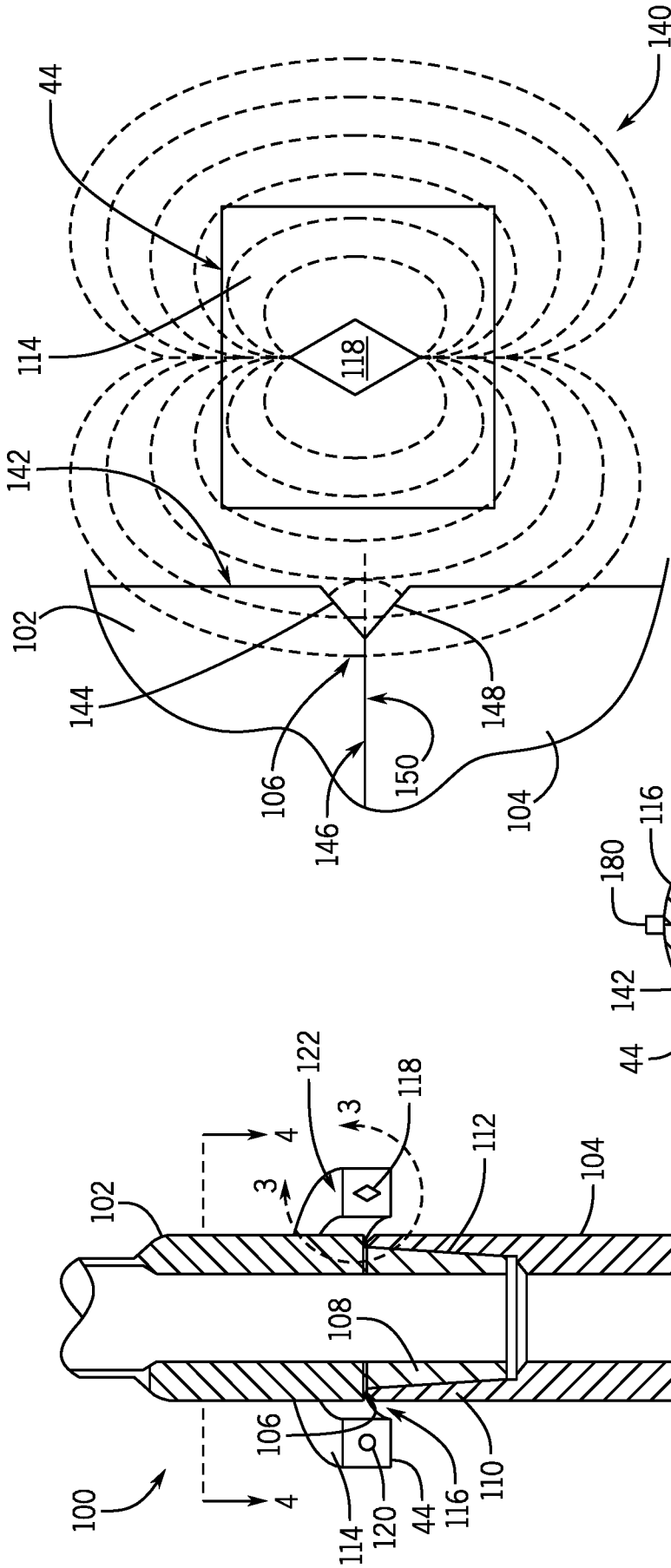


FIG. 3

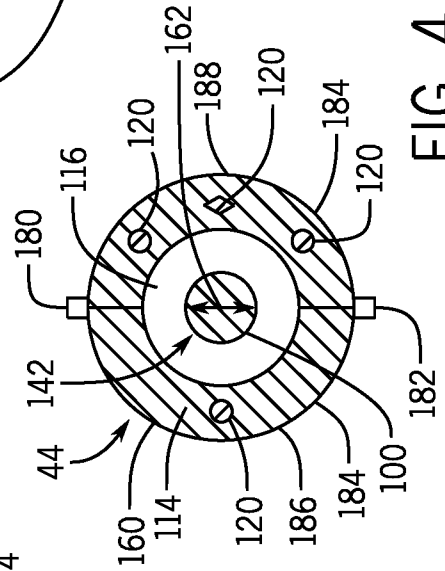


FIG. 4

FIG. 2



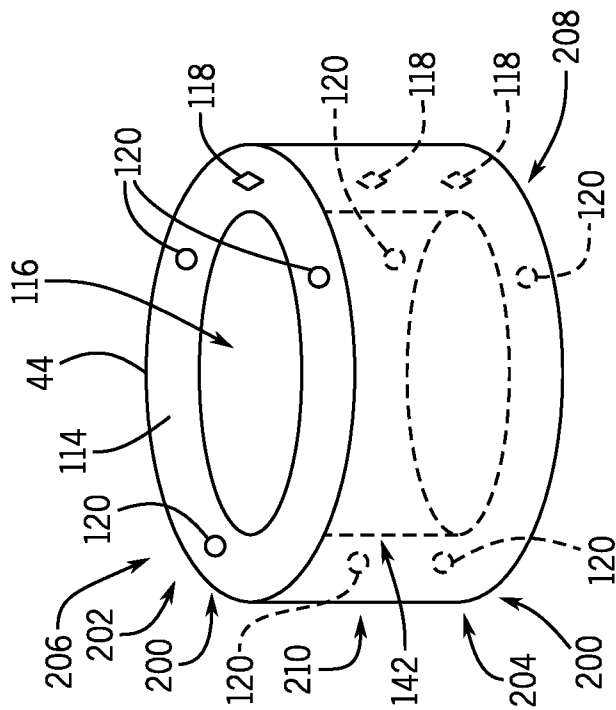


FIG. 5

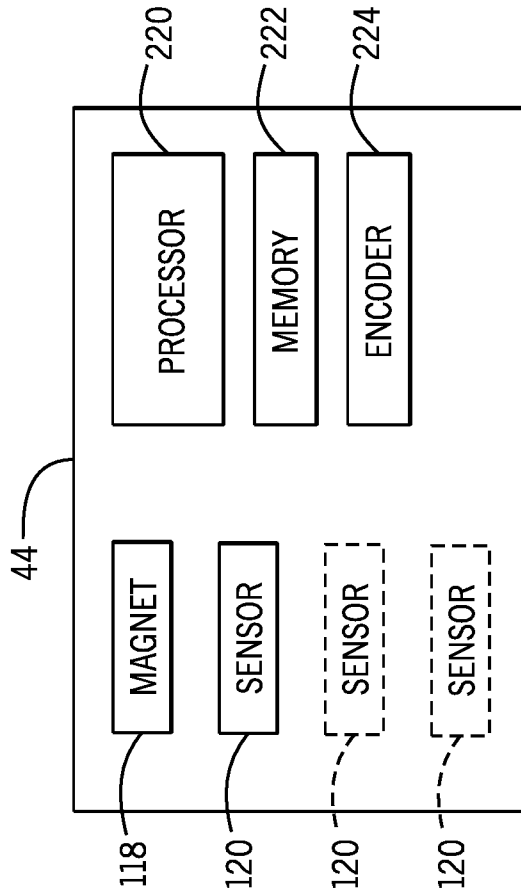


FIG. 6

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2016/053333

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2016/053333

A. CLASSIFICATION OF SUBJECT MATTER  
INV. E21B47/09  
ADD.  
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  
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 2 607 621 A1 (WELLTEC AS [DK]) 26 June 2013 (2013-06-26)  paragraphs [0027], [0046], [0055] - [0062], [0106], [0107]; figures 1,2,17 -----	1-4, 6-13, 15-20
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Y	US 2013/249705 A1 (SHARP DAVID P [US] ET AL) 26 September 2013 (2013-09-26) paragraphs [0015] - [0031]; figures 1,2 -----  -/--	16-20

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
- "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  6 December 2016	Date of mailing of the international search report  16/12/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Beran, Jiri

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2016/053333

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2015/102621 A1 (HALLIBURTON ENERGY SERVICES INC [US]) 9 July 2015 (2015-07-09) paragraphs [0027] - [0041] -----	1-20
A	EP 2 317 071 A1 (WELLTEC AS [DK]) 4 May 2011 (2011-05-04) paragraphs [0031] - [0042] -----	1-15

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Information on patent family members

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**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-20

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1.1. claims: 1-16

A pipe joint location detection system, comprising at least one magnetic field outputting magnet coupled to a main body having an annular shape with a central passage and a plurality of magnetic sensors coupled to the main body and disposed about a circumference of the main body to detect a magnetization of a tubular string disposed within the central passage; and a memory comprising data stored thereon, wherein the data comprises a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour.

1.2. claims: 16-20

A system, comprising a tubular string comprising a first tubular and a second tubular coupled to one another via a joint; and a joint location detection system, comprising a magnet and a plurality of magnetic sensors to detect a magnetization of the tubular string; and a memory comprising data stored thereon, wherein the data comprises a first magnetization value associated with a first contour of the tubular string and a second magnetization value associated with a second contour of the tubular string, wherein the first contour is different from the second contour, and the joint comprises the second contour.

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