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(54) **Title**: EXPANDABLE DOWNHOLE CASING COUPLING LOCATOR TOOL

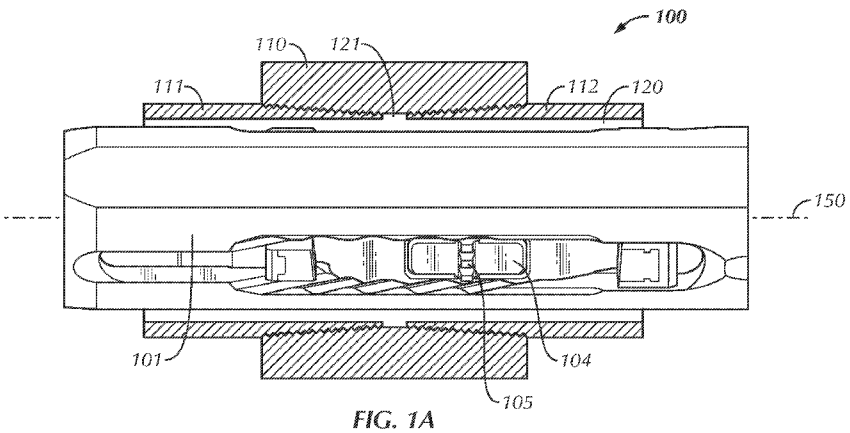

FIG. 1A

(57) **Abstract**: A downhole locator apparatus, including a tool body having a central axis defined therethrough, and at least one locator lug radially expandable from the tool body, in which the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string, in which the at least one locator lug is configured to move radially between a retracted position and an expanded position.

WO 2012/154471 A1

EXPANDABLE DOWNHOLE CASING COUPLING LOCATOR TOOL

BACKGROUND OF INVENTION

Field of the Invention

[0001] Embodiments disclosed herein relate generally to downhole tools. Specifically, embodiments disclosed herein relate to an expandable locator apparatus for locating a casing coupling in a borehole.

Background

[0002] Casing couplings, also referred to as casing joints or casing collars, are used to connect lengths of casing pipe in a borehole. Multiple lengths of casing pipe connected together with casing couplings are referred to as a casing string. Coupling locators are used to identify the location of couplings in borehole casing strings. This is typically done during borehole departure operations for various reasons. For example, the location of couplings are determined prior to a window milling operation in a sidetracking job to avoid having to mill through a coupling, which has a larger metal wall cross-section as compared to a casing. The integrity of the casing string above and below the casing coupling may be lost, to some degree, by milling through the casing coupling.

[0003] Traditionally, the locations of couplings are identified via wireline logging tools, which are lowered into the borehole. The cross-sectional area changes in the metal near the couplings are typically identified using magnetic field sensors in the wireline tools. The wireline techniques involve the use of dedicated operators and equipment and considerable amount of time for a dedicated wireline run. During such dedicated wireline runs, no drilling activity can be conducted, thereby increasing the cost of the drilling operation.

[0004] Casing coupling locators for use with wireline logging tools include an electro-magnetic device capable of measuring changes in a magnetic field. The electro-magnetic device is disposed within a downhole tool and is typically lowered

into the borehole while being tethered to the surface by means of a wire or cable. This is typically referred to as a wireline tool. The electro-magnetic device measures the magnetic field at various positions within the borehole, and the depth of the tool is determined using the length of cable that has been lowered into the borehole. Casing couplings usually have larger, metallic cross-sections as compared to the rest of the casing string. This results in a change in the magnetic field, which is recorded by the electro-magnetic device along with the corresponding depth of the casing coupling.

[0005] Once a casing coupling is located, a setting tool and a whipstock may be used to orient a drilling assembly above or below the casing coupling. As such, the drilling assembly may avoid drilling through the casing coupling, which usually has larger, metallic cross-sections as compared to the rest of the casing string, as discussed above. In operation, the whipstock is located at a desired depth in the borehole by one of several techniques (combined with an anchor or packer that can be set to a desired location in a borehole, set on bottom, or set on plug, etc.), the whipstock is then surveyed when at the desired depth so that the whipstock face can be oriented azimuthally. Then the drilling assembly is lowered into the borehole, *e.g.*, the casing string, and the whipstock serves to deflect or urge the drill bit into the side wall of the bore hole at the angle of the ramp on the whipstock. A window mill may be disposed on the drilling assembly within the casing string and may follow the curve of the whipstock through the casing wall, along a large radius path established by the whipstock. Once the window mill has penetrated the casing wall and created a window, the window mill is typically removed from the borehole and replaced by a drill bit. As the drilling assembly progresses, a secondary borehole is drilled that deviates or branches from the existing borehole. This process of drilling a deviated secondary borehole from an existing borehole is also called "sidetracking." Another aspect of sidetracking includes milling a section of casing, typically 15-25 ft., using Section Mills, setting a cement plug, and using a directional drilling assembly to drill a deviated hole from the existing borehole. The Section Mills are expandable cutting tools commonly used to remove a section of the casing. This process is known as "Section Milling."

[0006] Wireline tools, as described above, require a dedicated operation because they cannot be installed within a drill string. This requires a significant portion of time dedicated to this operation and also requires that all tools and drillstring components are removed from the borehole. The operation also requires dedicated, skilled operators trained to use the equipment. This results in significant added cost to the drilling operation.

[0007] Accordingly, there exists a need for a downhole coupling locator tool that will efficiently locate casing couplings downhole and reduce the downtime required to implement wireline locator tools.

SUMMARY OF INVENTION

[0008] According to one aspect of the present invention, there is provided a downhole locator apparatus, including a tool body having a central axis defined therethrough, and at least one locator lug radially expandable from the tool body, in which the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string, in which the at least one locator lug is configured to move radially between a retracted position and an expanded position.

[0009] According to another aspect of the present invention, there is provided a method of locating a casing coupling in a borehole, the method including disposing a locator apparatus into a borehole, the locator apparatus including a tool body having a central axis defined therethrough, and at least one locator lug radially expandable from the tool body, in which the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string, in which the at least one locator lug is configured to move radially between a retracted position and an expanded position, and moving the at least one locator lug between the retracted position and the expanded position to indicate a casing coupling location.

[0010] According to another aspect of the present invention, there is provided a method of window-milling and sidetracking, the method including locating a position of a casing coupling in a borehole using a locator apparatus, running a

sidetracking assembly into the borehole, in which the sidetracking assembly includes a setting tool, a whipstock comprising a ramp face along an axial length thereof, and a drilling assembly having a drill bit disposed on an end thereof, actuating the setting tool and securing the sidetracking assembly in the borehole, applying weight on the drilling assembly, rotating and translating the drill bit downward along an axial length of the ramp face of the whipstock, milling a window through the casing wall; and drilling into the formation in a radially outward direction.

[0011] According to another aspect of the present invention, there is provided a method of section milling, the method including locating a position of a casing coupling in a borehole using a locator apparatus, running a section milling tool in to the borehole, cutting at least a 25 ft. section of the casing, setting a cement plug in a sectioned portion of the casing, and drilling a deviated hole using a directional drilling assembly.

[0012] Other aspects and advantages of the present invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Figure 1A is a side view of an expandable locator apparatus in a retracted position in accordance with embodiments disclosed herein.

[0014] Figure 1B is a side view of an expandable locator apparatus in a first expanded position in accordance with embodiments disclosed herein.

[0015] Figure 1C is a side view of an expandable locator apparatus in a second expanded position in accordance with embodiments disclosed herein.

[0016] Figures 2A-2C are side views of various locator lug profiles in accordance with embodiments disclosed herein.

[0017] Figure 3 is a flow chart of a method of window-milling and sidetracking in accordance with embodiments disclosed herein.

[0018] Figure 4 is a schematic view a sidetracking assembly in accordance with embodiments disclosed herein.

DETAILED DESCRIPTION

[0019] The present disclosure relates to a locator apparatus for locating a casing coupling in a borehole. More specifically, embodiments disclosed herein relate to an expandable locator apparatus for engaging with an annular groove formed in an inner surface of a casing string to locate a casing coupling in a borehole. Further, embodiments disclosed herein relate to a method of window-milling and sidetracking.

[0020] Embodiments of an expandable locator apparatus disclosed herein may be disposed on a bottom hole assembly (BHA) and may allow casing couplings to be located while the BHA is still disposed in the borehole. An expandable locator apparatus, according to embodiments disclosed herein, may be able to ascertain depth and mechanically locate the location or position of casing couplings through the use of at least one locator lug, *e.g.* at least one locator device such as a locator lug, pin, or protrusion. While a locator lug is referred to herein, one having ordinary skill in the art will appreciate that a pin, bolt, or other protrusion member may be used without departing from the scope of embodiments disclosed herein. Further, the at least one locator lug of the expandable locator apparatus, according to embodiments disclosed herein, may be coupled to at least one movable arm and the at least one movable arm may be radially expandable from the tool body. Furthermore, in one or more embodiments, the at least one locator lug may be integrally formed with the at least one movable arm or with a pad on the arm. In other embodiments, two or more locator lugs and/or movable arms may be circumferentially spaced around the tool body.

[0021] The expandable locator apparatus may be disposed within a BHA containing additional tools and may be selectively actuated and deactuated, as required. This may allow multiple operations to be completed in a single run, thereby producing significant time and cost savings. Additionally, the operation of the tool may not require any additional equipment or resources, as the expandable locator apparatus may use sensors and gauges found on a typical drilling rig to produce the same information as a wireline tool, which may have dedicated sensors and equipment. Finally, the expandable locator apparatus may be operated by a skilled rig operator, thereby eliminating the need for dedicated, wireline personnel.

[0022] Referring generally to Figures 1A-1C, side views of an expandable locator apparatus 100 according to embodiments disclosed herein are shown. The expandable locator apparatus 100 includes a tool body 101 having a central axis 150 formed therethrough. The expandable locator apparatus 100 may include at least one locator lug 105 that is radially expandable from the tool body 101. In one or more embodiments, the at least one locator lug 105 may be coupled to at least one movable arm 104. The at least one movable arm 104 may be coupled to the tool body 101 and may be radially expandable from the tool body 101. As used herein, "coupled" refers to having two or more elements or components directly attached to each other or indirectly attached to each other. For example, although the at least one movable arm 104 is coupled to the tool body 101, the at least one movable arm 104 may not necessarily need to be in direct contact and directly attached to the tool body 101.

[0023] Further, as used herein, "radially expandable" refers to having one or more elements or components being able to move in a direction that is divergent from the central axis 150. For example, the at least one locator lug 105 that is radially expandable from the tool body 101 may move away from the tool body 101 in a direction that is perpendicular or angled downward/upward to the central axis 150. In one or more embodiments, the tool body 101 may include at least one groove (not shown) configured to be received by at least spline (not shown) that may be disposed on the at least one movable arm 104. The engagement between the at least one groove of the tool body 101 and the at least one spline of the at least one movable arm may provide a track or path that may assist with the radial expansion of the at least one movable arm 104.

[0024] In one or more embodiments, the expandable locator apparatus 100 may be disposed within a borehole (not shown). The borehole may be lined with a casing string (not shown), which may include a first length of casing 111 and a second length of casing 112. The first length of casing 111 may be connected with the second length of casing 112 by a casing coupling 110. As shown, the casing coupling 110 is threadably connected to the first length of casing 111 and the second length of casing 112. However, those having ordinary skill in the art will appreciate that other connecting means may be used to connect a first length of casing to a

second length of casing. For example, the casing coupling may be connected to a first length of casing and a second length of casing using bolts, screws, or any other connection means known in the art. An annular groove 121 may be formed in an inner surface of the casing string, between the first length of casing 111 and the second length of casing 112. The annular groove 121 may be a gap that is formed near a center of the casing coupling 110, where the casing coupling 110 connects the first length of casing 111 and the second length of casing 112. In one or more embodiments, the at least one locator lug 105 may be configured to move radially between a retracted position and an expanded position, which will be explained in further detail below. In one or more embodiments, the at least one locator lug 105 may be configured to be received in the annular groove 121.

[0025] In one or more embodiments, the expandable locator apparatus 100 may include an actuation mechanism (not shown) that may be configured to move the at least one locator lug 105 and/or the at least one movable arm 104 in a radial direction, between the retracted position and the expanded position. Those having ordinary skill in the art will appreciate that the at least one movable arm 104 may not be required to move the at least one locator lug in the radial direction, between the retracted position and the expanded position. For example, in one or more embodiments, the at least one locator lug 105 may be coupled to the tool body 101 and be configured to move in the radial direction between the retracted position and the expanded position without the use of an at least one movable arm.

[0026] In one or more embodiments, the actuation mechanism may be a mechanical actuation mechanism, such as a spring or springs. The springs may force the at least one locator lug 105 and/or the at least one movable arm 104 in a radial direction away from the tool body 101 and toward the inner surface of the casing string. Alternatively, the actuation mechanism may be a hydraulic actuation mechanism. For example, in one or more embodiments, the expandable locator apparatus 100 may be actuated by a hydraulic pressure differential between the expandable locator apparatus 100 and an annulus 120 that is formed between an interior surface of the casing string and the expandable locator apparatus 100. In other words, a hydraulic force may cause the at least one locator lug 105 and/or the at least one movable arm 104 to move or extend outwardly, in a radial direction that is away from the tool

body 101, due to a differential pressure of the drilling fluid between the expandable locator apparatus and the annulus 120. However, those having ordinary skill in the art will appreciate that the actuation mechanism may include other means known in the art to move or force an element or component in the radial direction. For example, the actuation mechanism may be an electrical-mechanical actuation mechanism or an electro-hydraulic actuation mechansim.

[0027] Referring to Figure 1A, a side view of the expandable locator apparatus 100 in the retracted position according to embodiments disclosed herein is shown. In the retracted position, the at least one locator lug 105 is not in contact with an inner surface of the casing string, *e.g.* the first length of casing 111 or the second length of casing 112. Further, in the retracted position, the at least one locator lug 105 is not engaged with the annular groove 121 that may be formed about the casing coupling 110, between the first length of casing 111 and the second length of casing 112. As used herein, "retracted" may refer to any position in which the at least one locator lug 105 and/or the at least one movable arm 104 is not in contact with the inner surface of the casing string and is not engaged with the annular groove 121. For example, although the at least one locator lug 105 and/or the at least one movable arm 104 may not be completely retracted within the tool body 101, the at least one locator lug 105 and/or the at least one movable arm 104 may be considered to be in the retracted position as long as the at least one locator lug 105 is not in contact with the inner surface of the casing string and is not engaged with the annular groove 121.

[0028] As shown in Figures 1B and 1C, respectively, the expanded position may include a first expanded position and a second expanded position. Referring to Figure 1B, a side view of the expandable locator apparatus 100 in a first expanded position according to embodiments disclosed herein is shown. In the first expanded position, the at least one locator lug 105 may be engaged with an inner surface of the casing string, *e.g.*, the first length of casing 111 or the second length of casing 112. As discussed above, the expandable locator apparatus 100 may be actuated, *i.e.*, the at least one locator lug 105 may move or extend in a radial direction that is away from the tool body 101, by an actuation mechanism (not shown). In one or more embodiments, the at least one locator lug 105 and/or the at least one movable arm

may move or extend outward, away from the tool body 101, until the movement of the at least one locator lug 105 is restricted by an internal diameter of the casing string, *i.e.*, an internal surface of the casing string. The expandable locator apparatus 100 may move within the casing string, *i.e.*, along the central axis 150, and the at least one locator lug 105 may maintain contact with an internal surface of the casing string due to hydraulic pressure acting on the tool. As discussed above, the at least one locator lug 105 and/or the at least one movable arm 104 may be actuated, alternatively, by a mechanical actuator, such as springs, which may also cause the at least one locator lug 105 to maintain contact with an internal surface of the casing string.

[0029] Referring to Figure 1C, a side view of the expandable locator apparatus 100 in a second expanded position according to embodiments disclosed herein is shown. In the second expanded position, the at least one locator lug 105 may be engaged with the annular groove 121. As discussed above, the movement of the at least one locator lug 105 is initially restricted by an internal diameter of the casing string. As the expandable locator apparatus 100 moves within the casing string, the at least one locator lug 105 may maintain contact with an internal surface of the casing string due to, for example, hydraulic pressure acting on the tool. As the internal diameter of the casing string changes at the location of the casing coupling 110, the hydraulic pressure may force the at least one locator lug 105 and/or the at least one movable arm 104 to move or extend further outward, away from the tool body 101, until the at least one locator lug 105 is engaged in the annular groove 121. As an operator may attempt to move the expandable locator apparatus 100 past the annular groove 121, the engagement of the at least one locator lug 105 and the annular groove 121 may be observed by the operator as an increase in the force required to move, *e.g.* pull or push, the expandable locator apparatus 100 within the casing string.

[0030] Further, the expandable locator apparatus 100 may be deactuated such that the at least one locator lug 105 moves from the expanded position, either the first expanded position or the second expanded position, to the retracted position. Deactuation of the expandable locator apparatus 100 may allow the at least one locator lug to disengage from the annular groove 121 and allow the expandable locator apparatus 100 to move along the central axis 150 within the casing string.

For example, deactuation may be achieved by changing or relieving the hydraulic force between the expandable locator apparatus 100 and the annulus 120 to allow the at least one locator lug 105 to move from the expanded position to the retracted position. Those having ordinary skill in the art will appreciate that other methods of deactuation may be used with other types of actuators and that deactuation is not limited to relieving the hydraulic force acting on the at least one locator lug 105 and/or the at least one movable arm 104, between the expandable locator apparatus 100 and the annulus 120. Alternatively, in one or more embodiments, the expandable locator apparatus 100 may not need to deactuated in order for the at least one locator lug 105 to disengage from the annular groove 121 and allow the expandable locator apparatus 100 to move along the central axis 150 within the casing string. For example, in one or more embodiments, springs (not shown) may be used to move or extend the at least one locator lug 105 in the radial direction, away from the tool body 101. Once the at least locator lug 105 is engaged with the annular groove 121, a force with enough magnitude in a direction parallel with the central axis 150 may cause the at least one locator lug 105 to disengage from the annular groove 121 without full deactuation. The force, described above, may cause the springs to compress as the at least one locator lug 105 is forced out of engagement with the annular groove 121. Once the expandable locator apparatus 100 is deactuated, or when the at least one locator lug 105 is disengaged from the annular groove 121, the operator may move, *e.g.*, pull or push, the expandable locator apparatus 100 along with a BHA and a drillstring within the borehole, *e.g.* within a casing string, and away from the casing coupling 110. This process may be repeated, as required, at various points in the borehole to identify the location of multiple casing couplings.

[0031] As shown in Figures 1A-1C, the at least one locator lug 105 may have a square or a rectangular profile. However, those having ordinary skill in the art will appreciate that the profile of the at least one locator lug may be one of a variety of shapes or forms. For example, referring to Figures 2A-2C, in one or more embodiments, at least one locator lug 205 may have at least a square/rectangular profile, an angled/wedged profile, or a round/semi-circular profile. As shown in Figure 2A-2C, an annular groove 221 may be formed in an inner surface of a casing string (not shown) between a first length of casing 211 and a second length of casing

212. In one or more embodiments, a casing coupling 210 may be used to connect the first length of casing 211 and the second length of casing 212, as described above. Further, as described above, the at least one locator lug 205 may be configured to engage with the annular groove 221. As shown in Figure 2A, in one or more embodiments, the at least one locator lug 205 may have a square or rectangular profile. As shown in Figure 2B, in one or more embodiments, the at least one locator lug 205 may have an angled, or wedged, profile. This may allow the at least one locator lug 205 to be able to engage the annular groove 221 and also clear out any debris that may have built up within the casing string and the annular groove 221. Alternatively, as shown in Figure 2C, in one or more embodiments, the at least one locator lug may have a round or semi-circular profile, which may allow the at least one locator lug 205 to disengage from the annular groove 221 without deactuation, as discussed above. The at least one locator lug 205 may be round, angled, triangular, hexagonal, or any other shape known in the art.

[0032] A method of locating a casing coupling in a borehole, in accordance with embodiments disclosed herein, may include disposing a locator apparatus into a borehole, and moving at least one locator lug between a retracted position and an expanded position to indicate a casing coupling location. The locator apparatus may include a tool body having a central axis defined therethrough, and the at least one locator lug radially expandable from the tool body, in which the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string, in which the at least one locator lug is configured to move radially between the retracted position and the expanded position. Once the at least one locator lug is engaged in the annular groove, the operator receives an indication of the casing coupling location, as an increase in the force required to move the drill string, including the locator apparatus, within the casing string.

[0033] The method may also include actuating the locator apparatus at a predetermined location within the borehole. For example, as discussed above, the locator apparatus may be a part of the BHA. The BHA, *i.e.*, the locator apparatus, may be moved within the borehole to a location of interest, where the locator apparatus may be actuated to locate a casing coupling at this location of interest. This location of interest may be an area, *e.g.*, a depth, in a formation in which there is an

interest in performing a sidetracking operation. As such, the locator apparatus may be moved to this location of interest, *i.e.*, the predetermined location, in order to locate a casing coupling at the predetermined location. As discussed above, the borehole may be lined with multiple lengths of casing, *i.e.*, a casing string. Actuating the locator apparatus may include moving the at least one locator lug from the retracted position to the expanded position. As discussed above, the expanded position may include a first expanded position and a second expanded position. In the first expanded position, the at least one locator lug may be engaged with the inner surface of the casing string. In the second expanded position, the at least one locator lug may be engaged with the annular groove formed in the inner surface of the casing string. The method may also include determining a length of the casing string within the borehole and positioning the locator apparatus at a predetermined distance from a drill bit based on the determined length of the casing string within the borehole. For example, the length of the casing string may be known by an operator operating the equipment by the number of lengths of casing used in the casing string. The depth of the drill bit, which is a known distance away from the locator apparatus on the BHA, may be ascertained by actuating the locator apparatus to locate a casing coupling to determine how many lengths of casing are between the locator apparatus and the surface. The method may also include deactuating the locator apparatus at a predetermined location within the borehole. Deactuating the locator apparatus may include moving the at least one locator lug from the expanded position to the retracted position, as discussed above.

[0034] A method of window-milling and sidetracking, according to embodiments disclosed herein, may include locating a position of a casing coupling in a borehole using a locator apparatus, running a sidetracking assembly into the borehole, actuating the setting tool and securing the sidetracking assembly in the borehole, applying weight on a drilling assembly, rotating and translating a drill bit downward along an axial length of a ramp face of a whipstock, and deviating the drill bit in a radially outward direction, and contacting an inner surface of a casing string to drill a deviated hole. The sidetracking assembly may include a setting tool, a whipstock including a ramp face along an axial length thereof, and a drilling assembly having a drill bit disposed on an end thereof. As discussed above, locating a position of a casing coupling in a borehole, in accordance with embodiments disclosed herein, may

include disposing a locator apparatus into a borehole, and moving the at least locator lug between a retracted position and an expanded position to indicate a casing coupling location. The locator apparatus may include a tool body having a central axis defined therethrough, and at least one locator lug radially expandable from the tool body, in which the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string, in which the at least one locator lug is configured to move radially between the retracted position and the expanded position. As discussed above, the length of the casing string may be known by an operator operating the equipment by the number of lengths of casing used in the casing string. The depth of the drill bit, which is a known distance away from the locator apparatus on the BHA, may be ascertained by actuating the locator apparatus, *i.e.*, moving the at least one locator lug radially between the retracted position and the expanded position, to locate a casing coupling and determining how many lengths of casing are between the locator apparatus and the surface.

[0035] The method of window-milling and sidetracking may also include actuating the locator apparatus at a predetermined location within the borehole. The method of window-milling and sidetracking may also include setting an orientation for the whipstock. For example, a whipstock may be oriented in the borehole to a specific orientation as measured by a measurement-while-drilling (MWD) tool. As discussed above, the expanded position may include a first expanded position and a second expanded position. In the first expanded position, the at least one locator lug may be engaged with the inner surface of the casing string. In the second expanded position, the at least one locator lug may be engaged with the annular groove formed in the inner surface of the casing string. The method may also include determining a length of the casing string within the borehole and positioning the locator apparatus at a predetermined distance from a drill bit based on the determined length of the casing string within the borehole. As discussed above, once the at least one locator lug is engaged in the annular groove, the operator receives an indication of the casing coupling location, as an increase in the force required to move the drill string, including the locator apparatus, within the casing string. The operator may then determine the length of the casing string within the borehole based on how many lengths of casing are between the locator apparatus and the surface. Once the operator knows the location of a casing coupling in an area of interest, the operator

may begin window-milling and/or sidetracking through a length of casing or the borehole, and avoid window-milling or sidetracking through a casing coupling. The method may also include deactuating the locator apparatus at a predetermined location within the borehole. Deactuating the locator apparatus may include moving the at least one locator lug from the expanded position to the retracted position, as discussed above.

[0036] A method of section milling, according to embodiments disclosed herein, may include locating a position of a casing coupling in a borehole using a locator apparatus, running a section milling tool in to the borehole, cutting at least a 25 ft. section of the casing, setting a cement plug in a sectioned portion of the casing, and drilling a deviated hole using a directional drilling assembly. The section milling tool may be expandable cutting tools that may be used to remove a section of the casing. Those having ordinary skill in the art will appreciate that the section milling tool may be any cutting tool that may be used to remove a section of a casing. Those having ordinary skill in the art will appreciate that, in one or more embodiments, the section milling tool may be used to cut a section that is more or less than 25 ft. in the casing. A cement plug may be placed as a slurry in a specific location within the borehole and may provide a means of pressure isolation or a mechanical platform. Those having ordinary skill in the art will appreciate that the cement plug may be any feature, mechanism, or element known in the art that may provide a means of isolation or provide a mechanical platform within a borehole.

[0037] The method of section milling, may also include disposing a locator apparatus into a borehole, and moving the at least locator lug between a retracted position and an expanded position to indicate a casing coupling location. The locator apparatus may include a tool body having a central axis defined therethrough, and at least one locator lug radially expandable from the tool body, in which the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string, in which the at least one locator lug is configured to move radially between the retracted position and the expanded position.

[0038] Referring to Figure 3, a flow chart of a method of window-milling and sidetracking according to embodiments disclosed herein is shown. A locator apparatus may be used to locate a position of a casing coupling in a borehole, 361.

Further, a sidetracking assembly may be run into the borehole, 362. A setting tool may be actuated to secure the sidetracking assembly within the borehole, step 363. Further, weight may be applied to the drilling assembly, 364. A drill bit may be rotated and translated downward along an axial length of a ramp face of a whipstock, 365. A drill bit may be deviated in a radially outward direction by contacting the ramped face of the whipstock and may contact an inner surface of a casing string to drill a deviated hole, 366.

[0039] Referring to Figure 4, a schematic view a sidetracking assembly 440, also known as a sidetracking BHA, according to embodiments disclosed herein is shown. As shown in Figure 4, the sidetracking assembly 440 may include one or more of a setting tool, *e.g.*, an anchor 441, a whipstock 442, a drilling assembly 443 having a drill bit 453 or, alternatively, a mill (not shown) disposed on an end thereof, a running tool 444, a segment of heavyweight drill pipe 445, a circulation valve 446, an MWD tool 447 in addition to, or alternatively, a logging-while drilling (LWD) tool (not shown), and an expandable locator apparatus 400. Additionally, the sidetracking assembly 440 may include various other elements or components. For example, the sidetracking assembly 440 may include an expandable reamer assembly (not shown). For example, and without limitation, exemplary expandable reamer assemblies are shown in U.S. Patent No. 6,732,817 and U.S. Patent No. 7,048,078, which are incorporated herein by reference in their entirety. Both U.S. Patent No. 6,732,817 and U.S. Patent No. 7,048,078 are assigned to the assignee of the present application. Further, the sidetracking assembly 440 may include a scraper apparatus (not shown). The scraper apparatus may be used to scrape or remove debris that may build up within the casing string. Those having ordinary skill in the art will appreciate that the sidetracking assembly 440 may not necessarily be used exclusively for sidetracking purposes, and that the sidetracking assembly 440, or components of the sidetracking assembly 440, may be used to drill the borehole. For example, the whipstock 442 may be excluded from the sidetracking assembly 440, and the remaining components of the sidetracking assembly 440 may be used to drill the borehole.

[0040] Still referring to Figure 4, the sidetracking assembly 440 may be run into a borehole (not shown), which may be lined with a casing string (not shown), and the expandable locator apparatus 400 may locate a position or location of a casing

coupling (not shown), as described above. The anchor 441 may be set and may secure the sidetracking assembly 440 within the borehole. The anchor 441 may be an expandable anchor, or packer, that may inflate or expand in order to secure the sidetracking assembly 440 within the borehole. However, those having ordinary skill in the art will appreciate that various other types of anchors or packers known in the art may be used to secure the sidetracking assembly 440 within the borehole. Weight may be applied to the drilling assembly 443 by, for example, the segment of heavyweight drill pipe 445, as well as by additional components, such as the running tool 444, the circulation valve 446, and the MWD tool 447. The drill bit 453 of the drilling assembly 443 may rotate and translate along an axial length of a ramp face of the whipstock 442 and allow the drill bit 453 to deviate radially outward and contact an inner surface of a casing string to drill a deviated hole. Those having ordinary skill in the art will appreciate that the drill bit 453 may be a window mill (not shown) that may be used to mill a window in the casing string and may be removed, once the window is milled, and replaced with a drill bit to complete a sidetracking process. The window mill may be substantially similar to a drill bit, and may translate along an axial length of a ramp face of the whipstock 442 to mill a window in the casing string. Although the expandable locator apparatus 400 is shown to be above the anchor 441 in the exemplary sidetracking assembly 440 shown in Figure 4, those having ordinary skill in the art will appreciate that, in one or more embodiments, the expandable locator apparatus 400 may be located below the anchor 441. Further, those having ordinary skill in the art will appreciate that the expandable locator apparatus 400 may be used before or after the scraper apparatus, discussed above, is used. As discussed above, one or more embodiments of the expandable locator apparatus may include angled or wedged locator lugs that may assist in clearing any debris build-up that may occur within an interior surface of a casing string.

[0041] Advantageously, embodiments disclosed herein may provide an expandable locator apparatus that may be able to ascertain depth and mechanically locate the location or position of casing couplings through the use of at least one locator lug. The expandable locator apparatus may be disposed within a BHA containing additional tools and may be selectively actuated and deactuated, as required. This may allow multiple operations to be completed in a single run, thereby producing significant time and cost savings. Additionally, the operation of the tool may not

require any additional equipment or resources, as the expandable locator apparatus may use sensors and gauges found on a typical drilling rig, such as pressure, force, and temperature gauges, to produce the same information as a wireline tool, which may have dedicated sensors and equipment. Finally, the expandable locator apparatus may be operated by a skilled rig operator, thereby eliminating the need for dedicated, wireline personnel.

[0042] While embodiments have been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of embodiments disclosed herein. Accordingly, the scope of embodiments disclosed herein should be limited only by the attached claims.

CLAIMS

What is claimed is:

1. A downhole locator apparatus, comprising:
    a tool body having a central axis defined therethrough; and
    at least one locator lug radially expandable from the tool body,
    wherein the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string,
    wherein the at least one locator lug is configured to move radially between a retracted position and an expanded position.

2. The apparatus of claim 1, further comprising an actuation mechanism configured to move the at least one locator lug between the retracted position and the expanded position.

3. The apparatus of claim 1, wherein the expanded position comprises a first expanded position and a second expanded position.

4. The apparatus of claim 3, wherein, in the first expanded position, the at least one locator lug is engaged with the inner surface of the casing string.

5. The apparatus of claim 3, wherein, in the second expanded position, the at least one locator lug is engaged with the annular groove formed between a first length of casing and a second length of casing along the inner surface of the casing string.

6. The apparatus of claim 1, wherein the at least one locator lug is coupled to at least one movable arm.

7. The apparatus of claim 6, wherein the at least one movable arm is coupled to the tool body and is radially expandable from the tool body.

8. The apparatus of claim 2, wherein the actuation mechanism is one of a hydraulic actuation mechanism, a mechanical actuation mechanism, an electro-hydraulic actuation mechanism, and an electro-mechanical actuation mechanism.

9. A method of locating a casing coupling in a borehole, the method comprising:
    disposing a locator apparatus into a borehole, the locator apparatus comprising:

a tool body having a central axis defined therethrough; and

at least one locator lug radially expandable from the tool body,

wherein the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string,

wherein the at least one locator lug is configured to move radially between a retracted position and an expanded position; and

moving the at least one locator lug between the retracted position and the expanded position to indicate a casing coupling location.

10. The method of claim 9, further comprising actuating the locator apparatus at a predetermined location within the borehole.

11. The method of claim 10, wherein actuating the locator apparatus comprises moving the at least one locator lug from the retracted position to the expanded position.

12. The method of claim 9, wherein the expanded position comprises a first expanded position and a second expanded position.

13. The method of claim 12, wherein, in the first expanded position, the at least one locator lug is engaged with the inner surface of the casing.

14. The method of claim 12, wherein, in the second expanded position, the at least one locator lug is engaged with the annular groove formed in the inner surface of the casing string.

15. The method of claim 9, further comprising determining a length of the casing string within the borehole.

16. The method of claim 15, further comprising positioning the locator apparatus at a predetermined distance from a drill bit based on the determined length of the casing string within the borehole.

17. The method of claim 9, further comprising deactuating the locator apparatus at a predetermined location within the borehole.

18. The method of claim 17, wherein deactuating the locator apparatus comprises moving the at least one locator lug from the expanded position to the retracted position.

19. A method of window-milling and sidetracking, the method comprising:

locating a position of a casing coupling in a borehole using a locator apparatus;

running a sidetracking assembly into the borehole, wherein the sidetracking assembly comprises:

a setting tool;

a whipstock comprising a ramp face along an axial length thereof; and

a drilling assembly having a drill bit disposed on an end thereof;

actuating the setting tool and securing the sidetracking assembly in the borehole;

applying weight on the drilling assembly;

rotating and translating the drill bit downward along an axial length of the ramp face of the whipstock;

milling a window through the casing wall; and

drilling into the formation in a radially outward direction.

20. The method of claim 19, wherein locating a position of a casing coupling in a borehole using a locator apparatus comprises:

disposing a locator apparatus into a borehole, the locator apparatus comprising:

a tool body having a central axis defined therethrough; and

at least one locator lug radially expandable from the tool body,

wherein the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string,

wherein the at least one locator lug is configured to move radially between a retracted position and an expanded position; and

moving the at least one locator lug between the retracted position and the expanded position to indicate a casing coupling location.

21. The method of claim 20, further comprising actuating the locator apparatus at a predetermined location within the borehole.

22. The method of claim 21, wherein actuating the locator apparatus comprises moving the at least one locator lug from the retracted position to the expanded position.

23. The method of claim 19, further comprising orienting the whipstock in a desired azimuthal direction.

24. The method of claim 20, wherein the expanded position comprises a first expanded position and a second expanded position.

25. The method of claim 24, wherein, in the first expanded position, the at least one locator lug is engaged with the inner surface of the casing.

26. The method of claim 24, wherein, in the second expanded position, the at least one locator lug is engaged with the annular groove formed in the inner surface of the casing.

27. The method of claim 20, further comprising determining a length of the casing string within the borehole.

28. The method of claim 27, further comprising positioning the locator apparatus at a predetermined distance from the drill bit based on the determined length of the casing string within the borehole.

29. The method of claim 20, further comprising deactuating the locator apparatus at a predetermined location within the borehole.

30. The method of claim 29, wherein deactuating the locator apparatus comprises moving the at least one locator lug from the expanded position to the retracted position.

31. A method of section milling, the method comprising:

locating a position of a casing coupling in a borehole using a locator apparatus;

running a section milling tool in to the borehole;

cutting a section of the casing;

setting a cement plug in a sectioned portion of the casing; and

drilling a deviated hole using a directional drilling assembly.

32. The method of claim 31, wherein locating a position of a casing coupling in a borehole using a locator apparatus comprises:

disposing a locator apparatus into a borehole, the locator apparatus comprising:

a tool body having a central axis defined therethrough; and

at least one locator lug radially expandable from the tool body,

wherein the at least one locator lug is configured to be received in an annular groove formed in an inner surface of a casing string,

wherein the at least one locator lug is configured to move radially between a retracted position and an expanded position; and

moving the at least one locator lug between the retracted position and the expanded position to indicate a casing coupling location.

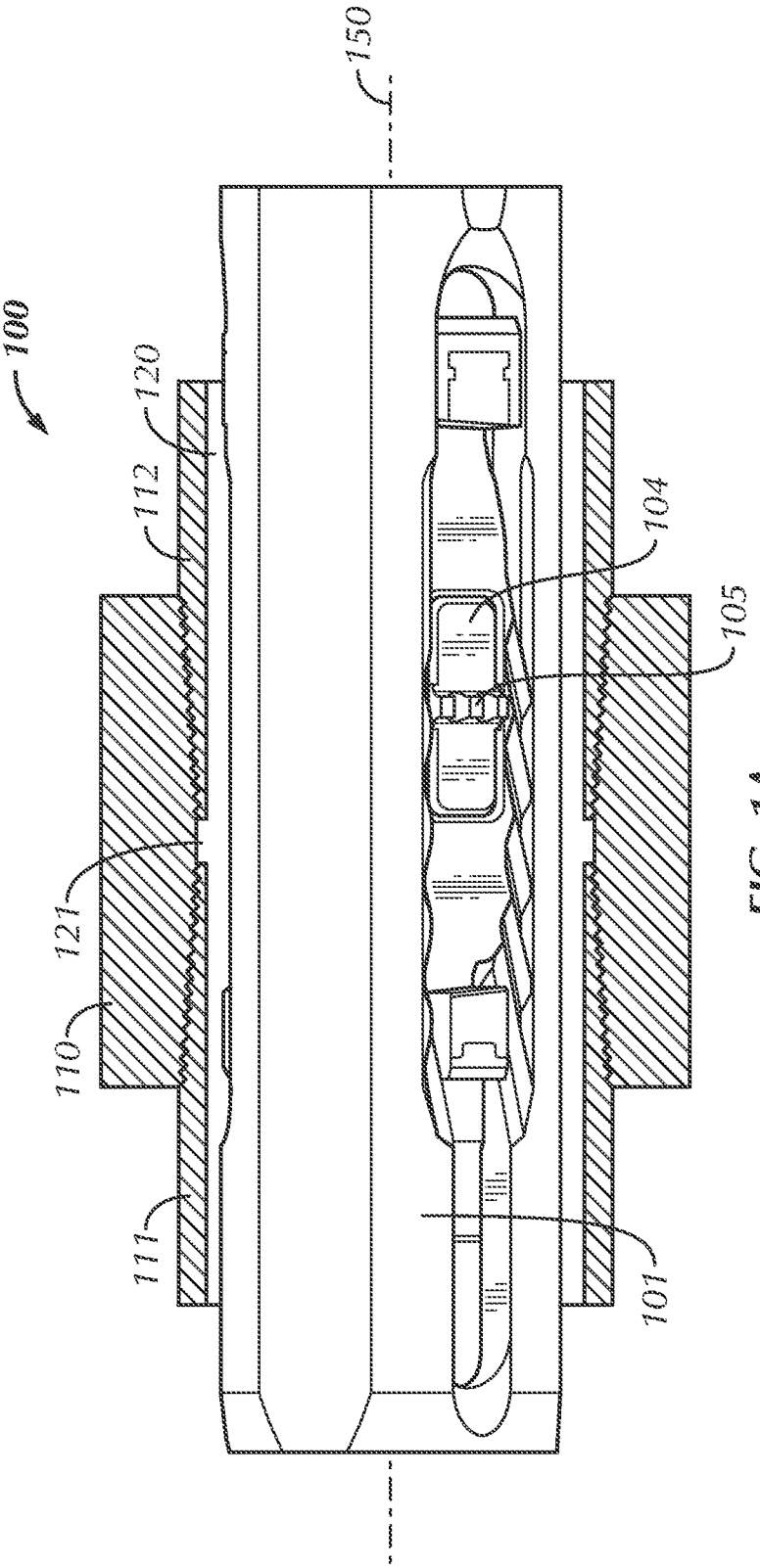

FIG. 1A

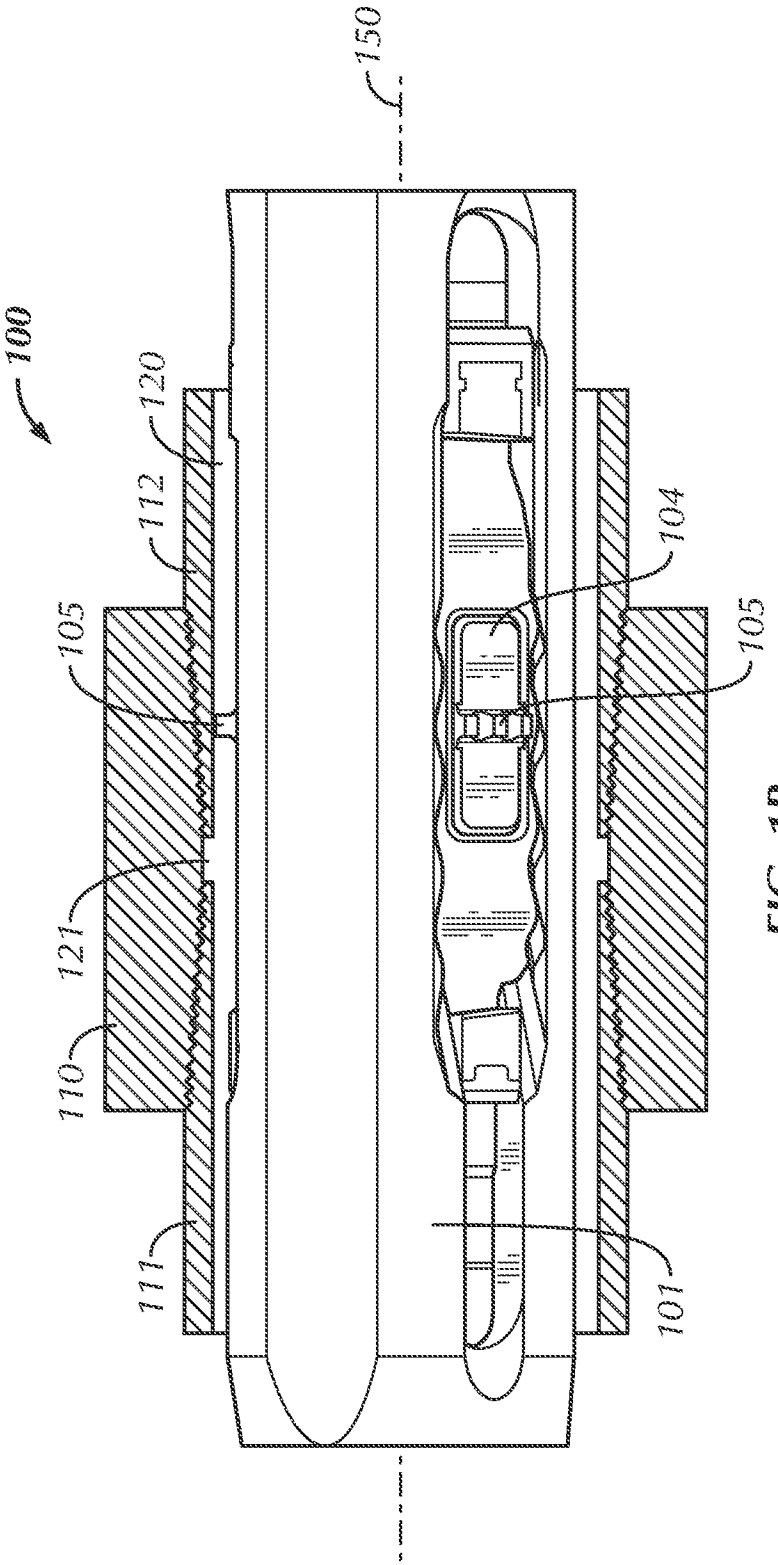

FIG. 1B

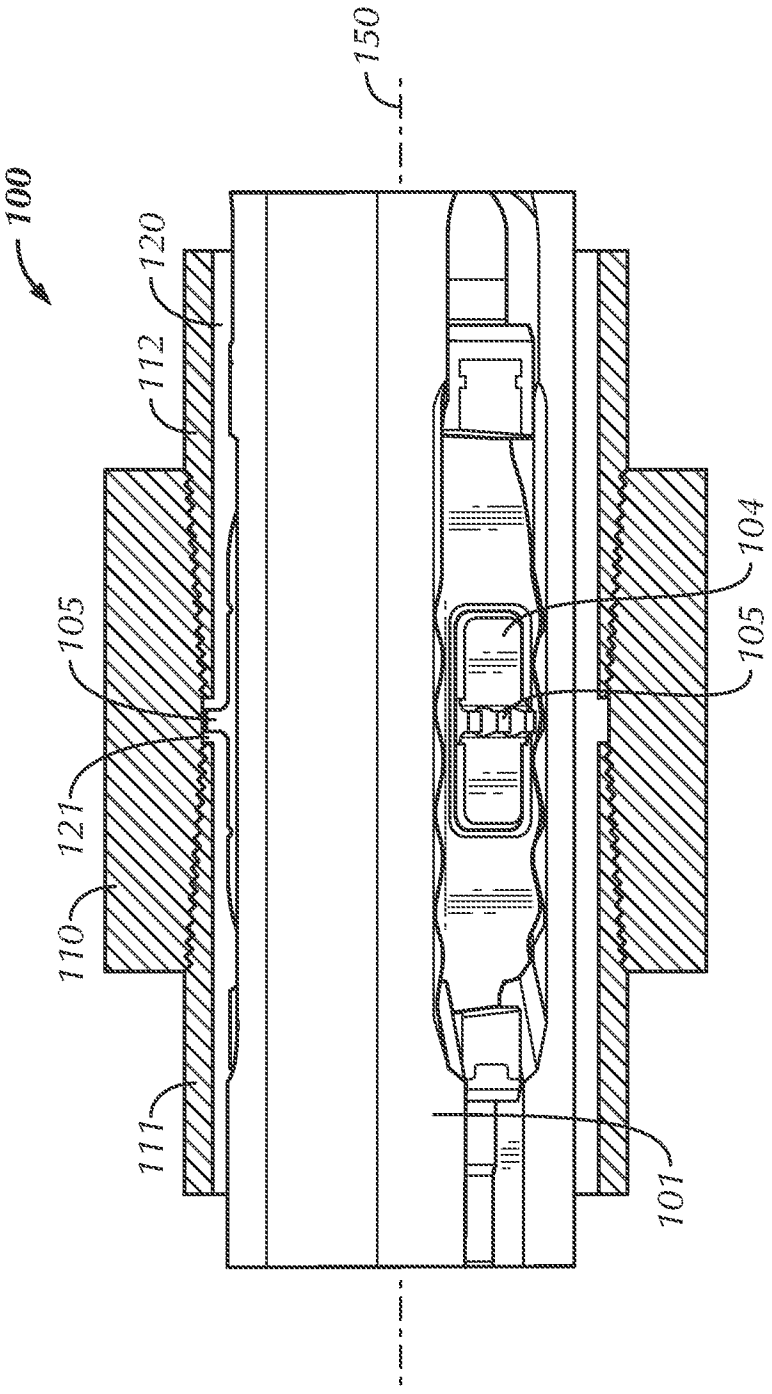

FIG. 1C

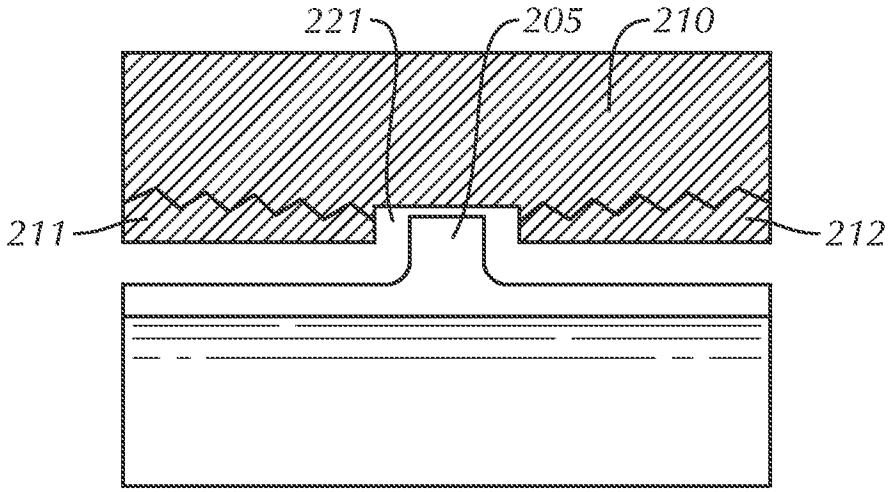

FIG. 2A

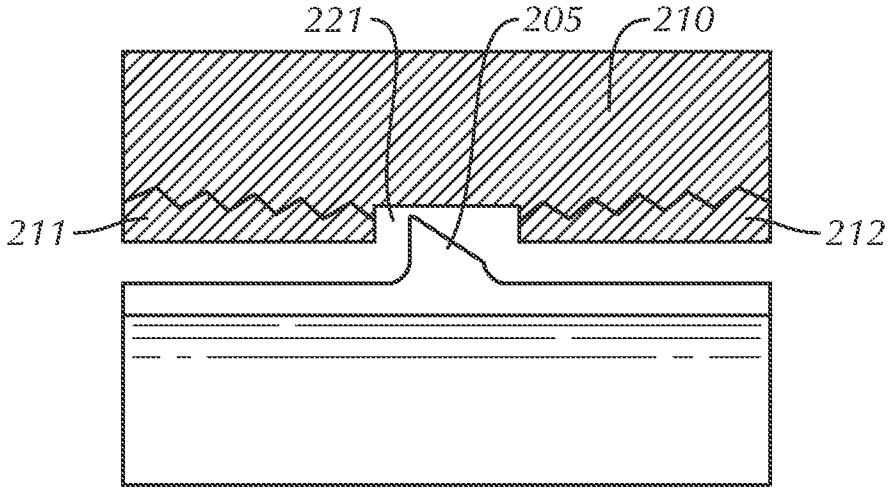

FIG. 2B

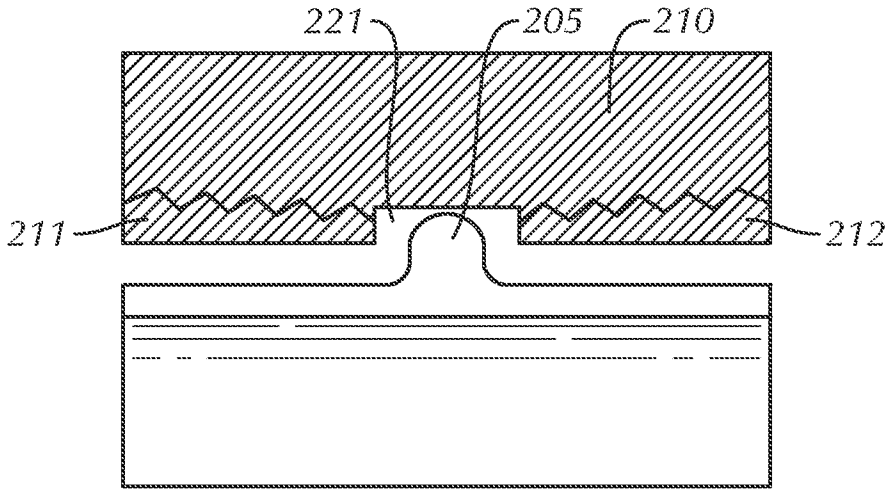

FIG. 2C

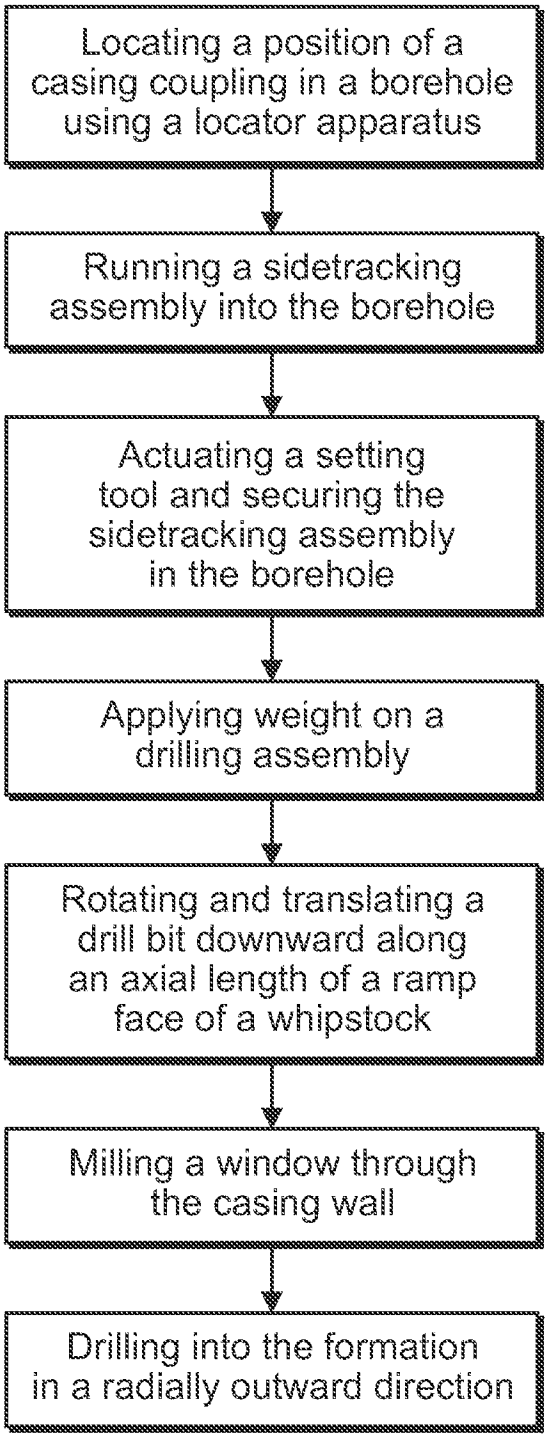
Locating a position of a casing coupling in a borehole using a locator apparatus
Running a sidetracking assembly into the borehole
Actuating a setting tool and securing the sidetracking assembly in the borehole
Applying weight on a drilling assembly
Rotating and translating a drill bit downward along an axial length of a ramp face of a whipstock
Milling a window through the casing wall
Drilling into the formation in a radially outward direction

FIG. 3

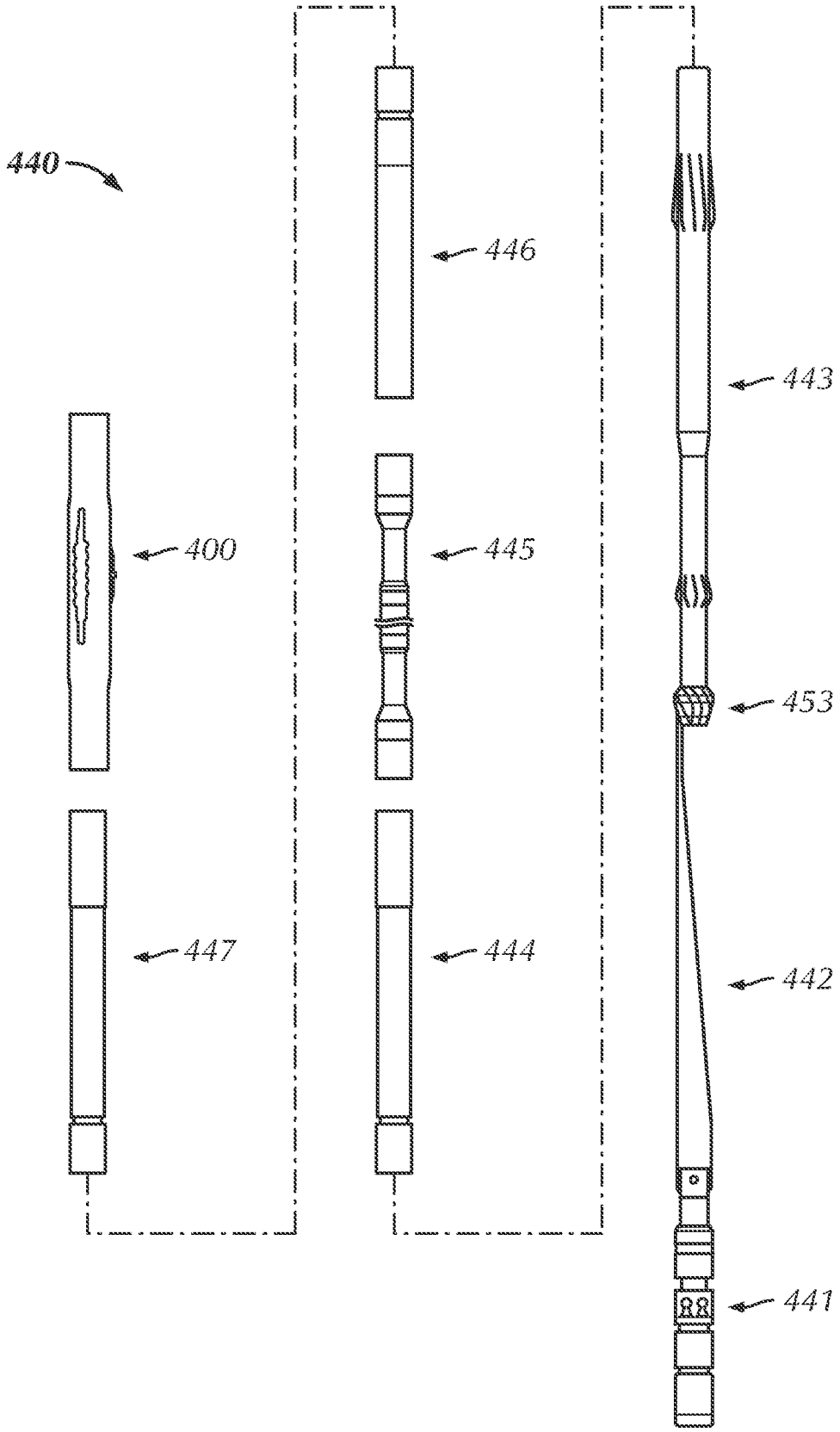

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 2012/036147

A. CLASSIFICATION OF SUBJECT MATTER ***E21B 23/00*** *(2006.01)*
E21B 23/14 *(2006.01)*

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 10/00-10/66, 23/00, 23/14, 29/00-29/12, H02G 1/00-1/16

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)

PatSearch (RUPTO internal), Esp@cenet, PAJ, USPTO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2213198 C1 (OBSCHESTVO S OGRANICHENNOI OTVETSTVENNOSTIYU "INKOS") 27.09.2003	1-32
A	US 2003/0155155 A1 (CHARLES H. DEWEY et al.) 21.08.2003	1-32
A	RU 2103472 C1 (ENSTITYU FRANSE DYU PETROL et al.) 27.01.1998	1-32
A	US 2004/0206549 A1 (SMITH INTERNATIONAL, INC.) 21.10.2004	1-32
A	EP 0834643 B1 (ANADRILL INTERNATIONAL SA et al.) 28.03.2007	1-32

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"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	Date of mailing of the international search report
23 July 2012 (23.07.2012)	16 August 2012 (16.08.2012)
Name and mailing address of the ISA/ FIPS Russia, 123995, Moscow, G-59, GSP-5, Berezhkovskaya nab., 30-1 Facsimile No. +7 (499) 243-33-37	Authorized officer E. Krylova Telephone No. 499-240-25-91

Form PCT/ISA/210 (second sheet) (July 2009)