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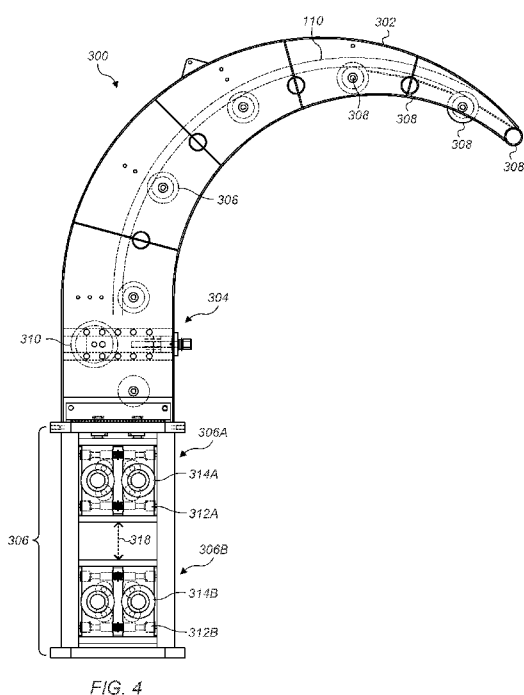
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(54) Title: ROLLER INJECTOR FOR DEPLOYING INSULATED CONDUCTOR HEATERS



(57) Abstract: An apparatus for installing an insulated conductor heater in a wellbore in a subsurface formation is disclosed. The apparatus may include a first injector drive section and a second injector drive section. The first injector drive section may include at least two first rollers coupled to a first motor. The first rollers may engage and disengage the insulated conductor heater. The second injector drive section may include at least two second rollers coupled to a second motor. The second rollers may be positioned substantially vertically below the first rollers. The second rollers may engage and disengage the insulated conductor heater independently of the first rollers. The first rollers and/or second rollers may, when engaged, move the insulated conductor heater through the apparatus.

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ROLLER INJECTOR FOR DEPLOYING INSULATED CONDUCTOR HEATERS

BACKGROUND

Field of the Invention

[0001] The present invention relates to systems and methods used for installing tubing in
5 subsurface formations. More particularly, the invention relates to systems and methods for
straightening and installing tubing used for heaters in subsurface formations.

Description of Related Art

[0002] Heaters such as mineral insulated (MI) cables (for example, insulated conductor
10 heaters) may be placed in subsurface wellbores for a variety of uses. For example, heaters
may be used to heat a formation during an in situ process. There are many different types
of heaters which may be used to heat the formation. Examples of in situ processes utilizing
downhole heaters are illustrated in U.S. Patent Nos. 2,634,961 to Ljungstrom; 2,732,195 to
Ljungstrom; 2,780,450 to Ljungstrom; 2,789,805 to Ljungstrom; 2,923,535 to Ljungstrom;
15 4,886,118 to Van Meurs et al.; 6,688,387 to Wellington et al.; 8,353,347 to Mason; and
8,851,170 to Ayodele et al.; each of which is incorporated by reference as if fully set forth
herein.

[0003] MI cables for use in subsurface applications may be longer, may have larger
outside diameters, and may operate at higher voltages and temperatures than what is
20 typical in the MI cable industry. For example, long heaters may require higher voltages to
provide enough power to the farthest ends of the heaters. There are many potential
problems during manufacture, assembly, installation, and/or operation of long length MI
cables in subsurface formations. For example, the joining of multiple MI cable sections
may be needed to make MI cables with sufficient length to reach the depths and distances
25 needed to heat the subsurface efficiently and to join segments with different functions,
such as lead-in cables joined to heater sections.

[0004] Splices and/or tubing connectors may be used to join the MI cable sections to form
long MI cables for subsurface applications. Such splices and/or tubing connectors may,
however, present problems during installation of the MI cable. For example, sections of
30 the MI cable with splices and/or tubing connectors may have a larger outside diameter than
other sections of the MI cable (for example, splices and/or tubing connectors may cause an
upset or disruption in the outside diameter of the MI cable). These upsets may present

problems with installation of the long length MI cable using standard installation apparatus used for constant diameter, short length MI cables and/or coiled tubing (for example, coiled tubing rigs and/or tubing injectors). For example, tension may have to be removed from the MI cable by removing blocks from the injector drive section (the injector head).

5 The MI cable, while without tension, may be moved manually or otherwise through the injector drive section and then tension is reapplied to the cable after the upset passes through the injector drive section. This process may be tedious and time consuming as well as increase the risk of injury for operators of the tubing injector apparatus. Thus, there is a need for more reliable systems and methods for installation of MI cables with the

10 long lengths needed for subsurface heating applications.

SUMMARY

[0005] Embodiments described herein generally relate to systems, methods, and heaters for treating a subsurface formation. Embodiments described herein also generally relate to

15 heaters that have novel components therein. Such heaters can be obtained by using the systems and methods described herein.

[0006] In certain embodiments, the invention provides one or more systems, methods, and/or heaters. In some embodiments, the systems, methods, and/or heaters are used for treating a subsurface formation.

20 [0007] In certain embodiments, an apparatus for installing an insulated conductor heater in a wellbore in a subsurface formation includes: a first injector drive section, wherein the first injector drive section includes at least two first rollers coupled to a first motor, the first rollers being configured to engage and disengage the insulated conductor heater, wherein the first rollers, when engaged, move the insulated conductor heater through the apparatus;

25 a second injector drive section positioned a selected distance from the first injector drive section, wherein the second injector drive section includes at least two second rollers coupled to a second motor, wherein the second rollers are positioned substantially vertically below the first rollers, the second rollers being configured to engage and disengage the insulated conductor heater, wherein the second rollers, when engaged, move

30 the insulated conductor heater through the apparatus, and wherein the second rollers are configured to engage and disengage the insulated conductor heater independently of the first rollers; a straightener section coupled to the first injector drive section, wherein the insulated conductor heater is configured to move into the first injector drive section

through the straightener section, and wherein the insulated conductor heater is straightened as it moves through the straightener section; and a feeding guide coupled to the straightener section, wherein the insulated conductor heater is configured to move into the straightener section through the feeding guide.

5 [0008] In certain embodiments, a method for installing an insulated conductor heater in a wellbore in a subsurface formation includes: moving the insulated conductor heater through a feeding guide; moving the insulated conductor heater through a straightener section coupled to the feeding guide, wherein the insulated conductor heater is straightened as it moves through the straightener section; moving the insulated conductor heater into a
10 first injector drive section coupled to the straightener section, wherein the insulated conductor heater is engaged by at least two first rollers coupled to a first motor in the first injector drive section, the first motor causing the first rollers to move the insulated conductor heater through the first injector drive section when the first rollers are engaged with the insulated conductor heater; moving the insulated conductor heater into a second
15 injector drive section coupled to the first injector drive section, the second injector drive section being positioned a selected distance from the first injector drive section, wherein the insulated conductor heater is engaged by at least two second rollers coupled to a second motor in the second injector drive section, the second motor causing the second rollers to move the insulated conductor heater through the second injector drive section and towards
20 the wellbore when the second rollers are engaged with the insulated conductor heater; disengaging the first rollers from the insulated conductor heater as an upset in an outside diameter of the insulated conductor heater nears the first injector drive section; moving the upset through the first injector drive section; reengaging the first rollers with the insulated conductor heater while the upset is positioned between the first rollers and the second
25 rollers; disengaging the second rollers from the insulated conductor heater while the upset is positioned between the first rollers and the second rollers; moving the upset through the second injector drive section; and reengaging the second rollers with the insulated conductor heater after the upset pass through the second injector drive section.

[0009] In certain embodiments, a system for installing an insulated conductor heater in a
30 wellbore in a subsurface formation includes: a coiled tubing rig comprising the insulated conductor heater coiled on the coiled tubing rig; a feeding guide coupled to the coiled tubing rig, wherein the insulated conductor heater is configured to move from the coiled tubing rig into the feeding guide; a straightener section coupled to the feeding guide,

wherein the insulated conductor heater is configured to move into the straightener section from the feeding guide, and wherein the insulated conductor heater is straightened as it moves through the straightener section; a first injector drive section coupled to the straightener section, wherein the first injector drive section comprises a first set of rollers, the first set of rollers being configured to engage the insulated conductor heater and move the insulated conductor heater; a second injector drive section positioned a selected distance below the first injector drive section, wherein the second injector drive section comprises a second set of rollers, the second set of rollers being configured to engage the insulated conductor heater and move the insulated conductor heater, and wherein the second set of rollers is configured to move the insulated conductor heater independently of the first set of rollers; and a wellhead coupled to the second injector drive section and the wellbore in the subsurface formation, wherein the insulated conductor heater is configured to move through the wellhead into the wellbore.

[0010] In further embodiments, features from specific embodiments may be combined with features from other embodiments. For example, features from one embodiment may be combined with features from any of the other embodiments.

[0011] In further embodiments, treating a subsurface formation is performed using any of the methods, systems, power supplies, or heaters described herein.

[0012] In further embodiments, additional features may be added to the specific embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Features and advantages of the methods and apparatus described herein will be more fully appreciated by reference to the following detailed description of presently preferred but nonetheless illustrative embodiments when taken in conjunction with the accompanying drawings in which:

[0014] FIG. 1 depicts a perspective view representation of an end portion of an embodiment of insulated conductor.

[0015] FIG. 2 depicts a side-view representation of an embodiment of two insulated conductors joined by a coupling to form an insulated conductor heater.

[0016] FIG. 3 depicts a side-view representation of an embodiment of an insulated conductor heater being installed in a subsurface formation.

[0017] FIG. 4 depicts a side-view representation of an embodiment of a tubing injector apparatus.

[0018] FIG. 5 depicts an end-view representation of an embodiment of an injector drive section.

5 [0019] While the disclosure is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the disclosure to the particular form illustrated, but on the contrary, the intention is to cover all modifications, equivalents and
10 alternatives falling within the spirit and scope of the present disclosure as defined by the appended claims. The headings used herein are for organizational purposes only and are not meant to be used to limit the scope of the description. As used throughout this application, the word "may" is used in a permissive sense (*i.e.*, meaning having the potential to), rather than the mandatory sense (*i.e.*, meaning must). Similarly, the words
15 "include," "including," and "includes" mean including, but not limited to. Additionally, as used in this specification and the appended claims, the singular forms "a", "an", and "the" include singular and plural referents unless the content clearly dictates otherwise. Furthermore, the word "may" is used throughout this application in a permissive sense (*i.e.*, having the potential to, being able to), not in a mandatory sense (*i.e.*, must). The term
20 "include," and derivations thereof, mean "including, but not limited to." The term "coupled" means directly or indirectly connected.

DETAILED DESCRIPTION

[0020] The following examples are included to demonstrate preferred embodiments. It
25 should be appreciated by those of skill in the art that the techniques disclosed in the examples which follow represent techniques discovered by the inventor to function well in the practice of the disclosed embodiments, and thus can be considered to constitute preferred modes for its practice. However, those of skill in the art should, in light of the present disclosure, appreciate that many changes can be made in the specific embodiments
30 which are disclosed and still obtain a like or similar result without departing from the spirit and scope of the disclosed embodiments.

[0021] This specification includes references to "one embodiment" or "an embodiment." The appearances of the phrases "in one embodiment" or "in an embodiment" do not

necessarily refer to the same embodiment, although embodiments that include any combination of the features are generally contemplated, unless expressly disclaimed herein. Particular features, structures, or characteristics may be combined in any suitable manner consistent with this disclosure.

5 [0022] The following description generally relates to systems and methods for treating hydrocarbons in the formations. Such formations may be treated to yield hydrocarbon products, hydrogen, and other products.

[0023] “Alternating current (AC)” refers to a time-varying current that reverses direction substantially sinusoidally. AC produces skin effect electricity flow in a ferromagnetic
10 conductor.

[0024] “Coupled” means either a direct connection or an indirect connection (for example, one or more intervening connections) between one or more objects or components. The phrase “directly connected” means a direct connection between objects or components such that the objects or components are connected directly to each other so that the objects
15 or components operate in a “point of use” manner.

[0025] A “heater” is any system or heat source for generating heat in a well or a near wellbore region. Heaters may be, but are not limited to, electric heaters, burners, combustors that react with material in or produced from a formation, and/or combinations thereof.

20 [0026] “Insulated conductor” refers to any elongated material that is able to conduct electricity and that is covered, in whole or in part, by an electrically insulating material.

[0027] “Rollers” refer to rollers or any other type of motion device suitable for moving coiled tubing through an injector drive apparatus. Rollers, as described herein, may include other components utilized for moving coiled tubing. For example, rollers may
25 include chain links, gripper blocks, and/or other gripping devices suitable for use with coiled tubing.

[0028] The term “wellbore” refers to a hole in a formation made by drilling or insertion of a conduit into the formation. A wellbore may have a substantially circular cross section, or another cross-sectional shape. As used herein, the terms “well” and “opening,” when
30 referring to an opening in the formation may be used interchangeably with the term “wellbore.”

[0029] An insulated conductor (MI cable) may be used as an electric heater element of a heater or a heat source used in a subsurface formation. The insulated conductor may

include an inner electrical conductor (core) surrounded by an electrical insulator and an outer electrical conductor (jacket). The electrical insulator may include mineral insulation (for example, magnesium oxide) or other electrical insulation.

[0030] FIG. 1 depicts a perspective view representation of an end portion of an

5 embodiment of insulated conductor 100 (for example, an MI cable). In certain embodiments, insulated conductor 100 includes core 102, electrical insulator 104, and jacket 106. Core 102 may resistively heat when an electrical current passes through the core. Alternating or time-varying current and/or direct current may be used to provide power to core 102 such that the core resistively heats.

10 **[0031]** In some embodiments, electrical insulator 104 inhibits current leakage and arcing to jacket 106. Electrical insulator 104 may thermally conduct heat generated in core 102 to jacket 106. Jacket 106 may radiate or conduct heat to the subsurface formation. The dimensions of core 102, electrical insulator 104, and jacket 106 of insulated conductor 100 may be selected such that the insulated conductor has enough strength to be self-supporting
15 even at upper working temperature limits. Such insulated conductors may be suspended from wellheads or supports positioned near an interface between an overburden and a hydrocarbon containing formation without the need for support members extending into the hydrocarbon containing formation along with the insulated conductors.

[0032] Insulated conductor 100 may be designed to operate at voltages above 1000 volts,
20 above 1500 volts, or above 2000 volts and may operate for extended periods without failure at elevated temperatures, such as over 650 °C (about 1200 °F), over 700 °C (about 1290 °F), or over 800 °C (about 1470 °F). Insulated conductor 100 may be designed so that a maximum voltage level at a typical operating temperature does not cause substantial thermal and/or electrical breakdown of electrical insulator 104. Insulated conductor 100
25 may be designed such that jacket 106 does not exceed a temperature that will result in a significant reduction in corrosion resistance properties of the jacket material. In certain embodiments, insulated conductor 100 may be designed to reach temperatures within a range between about 650 °C and about 900 °C. Insulated conductors having other operating ranges may be formed to meet specific operational requirements.

30 **[0033]** FIG. 1 depicts insulated conductor 100 having a single core 102. In some embodiments, insulated conductor 100 has two or more cores 102. For example, a single insulated conductor may have three cores. Core 102 may be made of metal or another electrically conductive material. The material used to form core 102 may include, but not

be limited to, nichrome, copper, nickel, carbon steel, stainless steel, and combinations thereof. In certain embodiments, core 102 is chosen to have a diameter and a resistivity at operating temperatures such that its resistance, as derived from Ohm's law, makes it electrically and structurally stable for the chosen power dissipation per meter, the length of the heater, and/or the maximum voltage allowed for the core material.

[0034] In some embodiments, core 102 is made of different materials along a length of insulated conductor 100. For example, a first section of core 102 may be made of a material that has a significantly lower resistance than a second section of the core. The first section may be placed adjacent to a formation layer that does not need to be heated to as high a temperature as a second formation layer that is adjacent to the second section. The resistivity of various sections of core 102 may be adjusted by having a variable diameter and/or by having core sections made of different materials.

[0035] Electrical insulator 104 may be made of a variety of materials. Commonly used powders may include, but are not limited to, MgO, Al₂O₃, Zirconia, BeO, different chemical variations of Spinel, and combinations thereof. MgO may provide good thermal conductivity and electrical insulation properties. The desired electrical insulation properties include low leakage current and high dielectric strength. A low leakage current decreases the possibility of thermal breakdown and the high dielectric strength decreases the possibility of arcing across the insulator. Thermal breakdown can occur if the leakage current causes a progressive rise in the temperature of the insulator leading also to arcing across the insulator.

[0036] Jacket 106 may be an outer metallic layer or electrically conductive layer. Jacket 106 may be in contact with hot formation fluids. Jacket 106 may be made of material having a high resistance to corrosion at elevated temperatures. Alloys that may be used in a desired operating temperature range of jacket 106 include, but are not limited to, 304 stainless steel, 310 stainless steel, Incoloy® 800, and Inconel® 600 (Inco Alloys International, Huntington, West Virginia, U.S.A.). A thickness of jacket 106 may generally vary between about 1 mm and about 2.5 mm. Larger or smaller jacket thicknesses may be used to meet specific application requirements.

[0037] One or more insulated conductors may be placed within an opening (for example, wellbore) in a formation to form a heater or heaters. Electrical current may be passed through each insulated conductor in the opening to heat the formation. Alternatively, electrical current may be passed through selected insulated conductors in an opening. The

unused conductors may be used as backup heaters. Insulated conductors may be electrically coupled to a power source in any convenient manner. Each end of an insulated conductor may be coupled to lead-in cables that pass through a wellhead. Such a configuration typically has a 180° bend (a “hairpin” bend) or turn located near a bottom of the heater. An insulated conductor that includes a 180° bend or turn may not require a bottom termination, but the 180° bend or turn may be an electrical and/or structural weakness in the heater. Insulated conductors may be electrically coupled together in series, in parallel, or in series and parallel combinations. In some embodiments of heaters, electrical current may pass into the conductor of an insulated conductor and may be returned through the jacket of the insulated conductor by connecting core 102 to jacket 106 (shown in FIG. 1) at the bottom of the heater (the end of the heater distal from the surface of the formation).

[0038] In certain embodiments, two or more insulated conductors are joined (for example, spliced) together to form a longer insulated conductor. For example, two or more insulated conductors may be joined to form a long insulated conductor heater. In certain embodiments, an insulated conductor heater formed from two or more insulated conductors is at least about 100 m in length. In some embodiments, the insulated conductor heater is at least about 1000 m or more in length. Longer or shorter insulated conductor heaters may also be used to meet specific application needs.

[0039] FIG. 2 depicts a side-view representation of an embodiment of two insulated conductors 100A, 100B joined by coupling 108 to form insulated conductor heater 110. Coupling 108 may be a splice or other coupling suitable for joining two lengths of an insulated conductor together. Examples of splices that may be used to join insulated conductor 100A and insulated conductor 100B are found in U.S. Patent Nos. 8,257,112 to Tilley et al.; 8,502,120 to Bass et al.; 8,586,866 to D’Angelo III et al.; 8,586,867 to Coles et al.; 8,732,946 to Harmason et al.; 8,816,203 to Coles et al.; 8,857,051 to Burns et al.; 8,943,686 to Hartford et al.; 9,048,653 to D’Angelo, III et al.; and 9,080,409 to Craney et al. and U.S. Pat. Appl. Pub. Nos. 2011/0132661 to Harmason et al.; and 2015/0285033 to Noel et al., each of which is incorporated by reference as if fully set forth herein.

[0040] In some embodiments, coupling 108 includes reinforcement sleeves 112. Reinforcement sleeves 112 may provide strain relief to strengthen coupling 108 between insulated conductors 100A, 100B. Reinforcement sleeves 112 may allow the joined insulated conductors to be spooled, unspooled, and pulled in tension for

installation/removal in wellbores and/or in an installation conduit (for example, coiled tubing installation).

[0041] In certain embodiments, insulated conductor heater 110 is placed in an opening (for example, a wellbore) in a subsurface formation. FIG. 3 depicts a side-view representation of an embodiment of insulated conductor heater 110 being installed in subsurface formation 200. In certain embodiments, insulated conductor heater 110 is installed in wellbore 202 in subsurface formation 200. Insulated conductor heater 110 may be wound up on coiled tubing rig 204 to store and/or transport the insulated conductor heater. Coiled tubing rig 204 may be a spool or other apparatus used for winding tubing or coil. In certain embodiments, insulated conductor heater 110, while on coiled tubing rig 204, is moved to and positioned at the site of wellbore 202.

[0042] As shown in FIG. 3, apparatus 300 may be used to install insulated conductor heater 110 from coiled tubing rig 204 into wellbore 202. Apparatus 300 may be coupled to wellhead 206 at the surface of wellbore 202. Insulated conductor heater 110 may be coupled to and/or supported by wellhead 206 after installation of the heater in wellbore 202. In some embodiments, wellbore 202 is an uncased opening in subsurface formation 200. Placing insulated conductor heater 110 in an uncased opening in subsurface formation 200 may allow heat transfer from the heater to the formation by radiation as well as conduction. Using an uncased opening may facilitate retrieval of insulated conductor heater 110 from wellbore 202, if necessary.

[0043] In certain embodiments, apparatus 300 is a tubing injector apparatus. As shown in FIG. 2, insulated conductor heater 110 may have one or more couplings 108 with a larger outside diameter than insulated conductor 100A and insulated conductor 100B. Thus, coupling 108 may cause an upset (or disruption) in the outside diameter of insulated conductor heater 110. If apparatus 300, shown in FIG. 3, is a conventional tubing injector, the upset in the outer diameter of insulated conductor heater 110 may present problems in installation and/or removal of the heater from wellbore 202 in subsurface formation 200.

[0044] FIG. 4 depicts a side-view representation of an embodiment of tubing injector apparatus 300 capable of handling insulated conductor heaters 110 with upsets in the outside diameter of the heater. In certain embodiments, apparatus 300 includes feeding guide 302, straightener section 304, and injector drive section 306. Feeding guide 302 may be a gooseneck or similar curved feeding guide that allows insulated conductor heater 110 to transition from a coiled tubing rig (e.g., coiled tubing rig 204, shown in FIG. 3) into

apparatus 300. In some embodiments, feeding guide 302 has a radius of curvature that corresponds to a curvature formed in insulated conductor heater 110 by the coiled tubing rig. In certain embodiments, feeding guide 302 includes rollers 308 that guide insulated conductor heater 110 as it passes through the feeding guide.

- 5 [0045] Feeding guide 302 may pass insulated conductor heater 110 into straightener section 304. Straightener section 304 may include rollers 310 that work to straighten any residual curvature out of insulated conductor heater 110 as the heater passes through the straightener section. After passing through straightener section 304, insulated conductor heater 110 may move into injector drive section 306.
- 10 [0046] FIG. 5 depicts an end-view representation of an embodiment of injector drive section 306. In certain embodiments, as shown in FIGS. 4 and 5, injector drive section 306 includes first injector drive section 306A and second injector drive section 306B. First injector drive section 306A may include first motor 312A and first rollers 314A. Second injector drive section 306B may include second motor 312B and second rollers 314B.
- 15 Rollers 314A, 314B may include sets of rollers (for example, sets of 2 or more rollers). [0047] Motors 312A, 312B may be hydraulic motors or any other motor suitable for a tubing injector apparatus. Motors 312A, 312B may operate independently of each other and thus independently operate (rotate) rollers 314A, 314B, respectively. For example, motor 312A may operate rollers 314A to move insulated conductor heater 110 through
- 20 apparatus 300 when rollers 314A are engaged with the heater and rollers 314B are disengaged with the heater. Similarly, motor 312B may operate rollers 314B to move insulated conductor heater 110 through apparatus 300 when rollers 314B are engaged with the heater and rollers 314A are disengaged with the heater. When rollers 314A and rollers 314B are both engaged with insulated conductor heater 110, the rollers may work in
- 25 combination to move the heater through apparatus 300.
- [0048] In certain embodiments, one or more hydraulic units 316A are coupled to rollers 314A and one or more hydraulic units 316B are coupled to rollers 314B. Hydraulic units 316A, 316B may be hydraulic cylinders or other hydraulic power units. Hydraulic units 316A, 316B may operate to cause rollers 314A, 314B, respectively, to engage and
- 30 disengage insulated conductor heater 110 as the heater passes through injector drive section 306. For example, hydraulic units 316A, 316B may provide pressure to rollers 314A, 314B causing the rollers to press inwards towards insulated conductor heater 110 and provide tension on the heater. When tension is provided on insulated conductor heater

110, the heater is engaged by rollers 314A and/or 314B and the rollers move the heater through apparatus 300 as the rollers rotate. To disengage rollers 314A and/or 314B from insulated conductor heater 110, pressure is released from the rollers by hydraulic units 316A and/or 316B. Releasing the pressure on rollers 314A and/or 314B releases the tension on insulated conductor heater 110 and disengages the heater from the rollers. When disengaged, rollers 314A and/or 314B.

[0049] In certain embodiments, hydraulic units 316A, 316B operate independently of each other (for example, the hydraulic units are controlled independently). Thus, rollers 314A and rollers 314B may be engaged with insulated conductor heater 110 and disengaged from the heater independently. Engaging and disengaging rollers 314A and rollers 314B independently of each other allows insulated conductor 110 to be continually moved through apparatus 300 and into wellbore 202 (shown in FIG. 3) even when one of the rollers is disengaged (for example, rollers 314A continue to move the heater into the wellbore while rollers 314B are disengaged).

[0050] Additionally, having rollers 314A and rollers 314B engaged/disengage independently allows insulated conductor heater 110 with coupling 108, as shown in FIG. 2, or any other upset in the outside diameter of the heater to run through apparatus 300 while maintaining tension on the heater throughout the installation process. For example, in certain embodiments, rollers 314A are disengaged as an upset in the outside diameter of insulated conductor heater 110 approaches first injector drive section 306A. Rollers 314B remain engaged with insulated conductor heater 110 and thus keep the heater moving through apparatus 300 and into wellbore 202. Disengaging rollers 314A allows the rollers to open up and provide space for the upset in the outside diameter of insulated conductor heater 110 to pass through first injector drive section 306A (for example, there is clearance for the upset to pass between the rollers).

[0051] Once the upset has passed through rollers 314A, rollers 314A may be reengaged with insulated conductor heater 110. In certain embodiments, first injector drive section 306A is positioned (selected) distance 318 from second injector drive section 306B. Distance 318 may be selected to allow the upset in insulated conductor heater 110 to be positioned between rollers 314A and rollers 314B while both rollers are engaged with the heater. Thus, selected distance 318 between first injector drive section 306A and second injector drive section 306B may be at least a length of the upset in the outside diameter of insulated conductor heater 110.

[0052] For an insulated conductor heater with multiple upsets of different lengths, selected distance 318 may be set at a distance of at least a length of the longest upset on the heater. In some embodiments, selected distance 318 between first injector drive section 306A and second injector drive section 306B on apparatus 300 is adjustable. In certain embodiments, selected distance 318 is adjusted when apparatus 300 is idle (for example, when motors 312A, 312B are turned off). In some embodiments, apparatus 300 may allow adjustment of selected distance 318 between first injector drive section 306A and second injector drive section 306B while motors 312A, 312B are running. For example, second injector drive section 306B may be movable up or down when rollers 314B are disengaged from insulated conductor heater 110.

[0053] After the upset has passed through rollers 314A and rollers 314A have been reengaged, rollers 314B may be disengaged to allow the upset to pass through second injector drive section 306B. Rollers 314A remain engaged with insulated conductor heater 110 and thus keep the heater moving through apparatus 300 and into wellbore 202. Disengaging rollers 314B allows the rollers to open up and provide space for the upset to pass through second injector drive section 306B and into wellbore 202.

[0054] The process of engaging/disengaging rollers 314A and rollers 314B as described above may be repeated for any number of upsets along insulated conductor heater 110 as the heater is installed into wellbore 202. In addition, process of engaging/disengaging rollers 314A and rollers 314B may be used to continuously move insulated conductor heater 110 through apparatus 300 when the outside diameter of the heater changes along the length of the heater. For example, insulated conductor heater 110 may have different outside diameters along its length to provide different heating, electrical, and/or mechanical properties along its length. Transitions in outside diameter along insulated conductor heater 110 may be handled similarly to upsets in the outside diameter with rollers 314A and rollers 314B being set for reengagement to the new outside diameter after the transition passes through the rollers. For example, hydraulic units 316A, 316B may apply a different pressure depending on the outside diameter of a section of insulated conductor heater 110.

[0055] Operating first injector drive section 306A independently of second injector drive section 306B with selected distance 318 between the sections allows insulated conductor heater 110 to be continuously moved through apparatus 300 while maintaining tension on the heater through the installation process. Maintaining tension on insulated conductor

heater 110 with rollers 314A and/or rollers 314B throughout the installation process may decrease the overall time needed for installation of the heater, improve reliability of the installation process, and reduce risks to operators involved with handling of apparatus 300, the heater, and associated devices. In addition, independently operating first injector drive
5 section 306A and second injector drive section 306B allows many different heaters or tubing to be installed and/or straightened using apparatus 300. For example, apparatus 300 may be used to install and/or straighten any heater or tubing with up to about 4.5" outside diameter.

[0056] In some embodiments, apparatus 300 is used for other coiled tubing applications in
10 addition to installing insulated conductor heater 110 in wellbore 202. Apparatus 300 may be used for applications that straighten out insulated conductor heater 110 or any other tubing without installing the heater or tubing in a wellbore. For example, apparatus 300 may be used for paying out coil (tubing) from a spool (for example, coiled tubing rig 204) and laying out the coil horizontally.

[0057] It is to be understood the invention is not limited to particular systems described
15 which may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. As used in this specification, the singular forms "a", "an" and "the" include plural referents unless the content clearly indicates otherwise. Thus, for example,
20 reference to "a core" includes a combination of two or more cores and reference to "a material" includes mixtures of materials.

[0058] In this patent, certain U.S. patents and U.S. patent applications have been incorporated by reference. The text of such U.S. patents and U.S. patent applications is, however, only incorporated by reference to the extent that no conflict exists between such
25 text and the other statements and drawings set forth herein. In the event of such conflict, then any such conflicting text in such incorporated by reference U.S. patents and U.S. patent applications is specifically not incorporated by reference in this patent.

[0059] Although specific embodiments have been described above, these embodiments are not intended to limit the scope of the present disclosure, even where only a single
30 embodiment is described with respect to a particular feature. Examples of features provided in the disclosure are intended to be illustrative rather than restrictive unless stated otherwise. The above description is intended to cover such alternatives, modifications, and

equivalents as would be apparent to a person skilled in the art having the benefit of this disclosure.

[0060] The scope of the present disclosure includes any feature or combination of features disclosed herein (either explicitly or implicitly), or any generalization thereof, whether or
5 not it mitigates any or all of the problems addressed herein. Accordingly, new claims may be formulated during prosecution of this application (or an application claiming priority thereto) to any such combination of features. In particular, with reference to the appended claims, features from dependent claims may be combined with those of the independent
10 claims and features from respective independent claims may be combined in any appropriate manner and not merely in the specific combinations enumerated in the appended claims.

[0061] Further modifications and alternative embodiments of various aspects of the embodiments described in this disclosure will be apparent to those skilled in the art in view of this description. Accordingly, this description is to be construed as illustrative only and
15 is for the purpose of teaching those skilled in the art the general manner of carrying out the embodiments. It is to be understood that the forms of the embodiments shown and described herein are to be taken as the presently preferred embodiments. Elements and materials may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the embodiments may be utilized independently,
20 all as would be apparent to one skilled in the art after having the benefit of this description. Changes may be made in the elements described herein without departing from the spirit and scope of the following claims.

CLAIMS

1. An apparatus for installing an insulated conductor heater in a wellbore in a subsurface formation, comprising:
 - 5 a first injector drive section, wherein the first injector drive section comprises at least two first rollers coupled to a first motor, the first rollers being configured to engage and disengage the insulated conductor heater, wherein the first rollers, when engaged, move the insulated conductor heater through the apparatus;
 - a second injector drive section positioned a selected distance from the first injector drive section, wherein the second injector drive section comprises at least two second
10 rollers coupled to a second motor, wherein the second rollers are positioned substantially vertically below the first rollers, the second rollers being configured to engage and disengage the insulated conductor heater, wherein the second rollers, when engaged, move the insulated conductor heater through the apparatus, and wherein the second rollers are
15 configured to engage and disengage the insulated conductor heater independently of the first rollers;
 - a straightener section coupled to the first injector drive section, wherein the insulated conductor heater is configured to move into the first injector drive section through the straightener section, and wherein the insulated conductor heater is straightened
20 as it moves through the straightener section; and
 - a feeding guide coupled to the straightener section, wherein the insulated conductor heater is configured to move into the straightener section through the feeding guide.
2. The apparatus of claim 1, wherein the first motor is configured to rotate the first rollers.
3. The apparatus of claim 1, further comprising a hydraulic unit coupled to the first
25 rollers, wherein the hydraulic unit is operable to cause the first rollers to engage and disengage the insulated conductor heater.
4. The apparatus of claim 1, wherein the first rollers and the second rollers are configured such that when the first rollers are disengaged from the insulated conductor heater, the second rollers are engaged with the insulated conductor heater.
- 30 5. The apparatus of claim 1, wherein the first rollers, when disengaged, are configured to allow an upset in an outer diameter of the insulated conductor heater to pass through the first injector drive section while the second rollers are engaged with the insulated conductor heater and move the insulated conductor heater through the apparatus.

6. The apparatus of claim 5, wherein the upset in the outer diameter comprises a splice or tubing connector.
7. The apparatus of claim 5, wherein the selected distance between the first injector drive section and the second injector drive section is at least a length of the upset in the outer diameter of the insulated conductor heater.
8. The apparatus of claim 1, wherein the insulated conductor heater comprises a length of at least about 100 m.
9. A method for installing an insulated conductor heater in a wellbore in a subsurface formation, comprising:
- 10 moving the insulated conductor heater through a feeding guide;
- moving the insulated conductor heater through a straightener section coupled to the feeding guide, wherein the insulated conductor heater is straightened as it moves through the straightener section;
- moving the insulated conductor heater into a first injector drive section coupled to the straightener section, wherein the insulated conductor heater is engaged by at least two first rollers coupled to a first motor in the first injector drive section, the first motor causing the first rollers to move the insulated conductor heater through the first injector drive section when the first rollers are engaged with the insulated conductor heater;
- moving the insulated conductor heater into a second injector drive section coupled to the first injector drive section, the second injector drive section being positioned a selected distance from the first injector drive section, wherein the insulated conductor heater is engaged by at least two second rollers coupled to a second motor in the second injector drive section, the second motor causing the second rollers to move the insulated conductor heater through the second injector drive section and towards the wellbore when the second rollers are engaged with the insulated conductor heater;
- 25 disengaging the first rollers from the insulated conductor heater as an upset in an outside diameter of the insulated conductor heater nears the first injector drive section;
- moving the upset through the first injector drive section;
- reengaging the first rollers with the insulated conductor heater while the upset is positioned between the first rollers and the second rollers;
- 30 disengaging the second rollers from the insulated conductor heater while the upset is positioned between the first rollers and the second rollers;
- moving the upset through the second injector drive section; and

reengaging the second rollers with the insulated conductor heater after the upset pass through the second injector drive section.

10. The method of claim 9, further comprising moving the insulated conductor heater into the wellbore in the subsurface formation using the first rollers and the second rollers.

5 11. The method of claim 9, further comprising engaging the first rollers with the insulated conductor heater by applying pressure on the insulated conductor heater with the first rollers, the pressure being applied using a hydraulic unit coupled to the first rollers.

12. The method of claim 11, wherein disengaging the first rollers from the insulated conductor heater comprises releasing pressure at the hydraulic unit.

10 13. The method of claim 9, wherein upset is moved through the first injector drive section by moving the insulated conductor heater with the second rollers that are engaged with the insulated conductor heater.

14. The method of claim 9, wherein upset is moved through the second injector drive section by moving the insulated conductor heater with the first rollers that are engaged

15 with the insulated conductor heater.

15. A system for installing an insulated conductor heater in a wellbore in a subsurface formation, comprising:

a coiled tubing rig comprising the insulated conductor heater coiled on the coiled tubing rig;

20 a feeding guide coupled to the coiled tubing rig, wherein the insulated conductor heater is configured to move from the coiled tubing rig into the feeding guide;

a straightener section coupled to the feeding guide, wherein the insulated conductor heater is configured to move into the straightener section from the feeding guide, and wherein the insulated conductor heater is straightened as it moves through the straightener

25 section;

a first injector drive section coupled to the straightener section, wherein the first injector drive section comprises a first set of rollers, the first set of rollers being configured to engage the insulated conductor heater and move the insulated conductor heater;

a second injector drive section positioned a selected distance below the first injector drive section, wherein the second injector drive section comprises a second set of rollers, the second set of rollers being configured to engage the insulated conductor heater and move the insulated conductor heater, and wherein the second set of rollers is configured to move the insulated conductor heater independently of the first set of rollers; and

30

a wellhead coupled to the second injector drive section and the wellbore in the subsurface formation, wherein the insulated conductor heater is configured to move through the wellhead into the wellbore.

16. The system of claim 15, further comprising a first motor coupled to the first set of
5 rollers and a second motor coupled to the second set of rollers, wherein the first motor and the second motor operated independently to move the insulated conductor heater independently through the sets of rollers.

17. The system of claim 15, further comprising a first hydraulic unit coupled to the first set
of rollers and a second hydraulic unit coupled to the second set of rollers, wherein the first
10 hydraulic unit and the second hydraulic unit are configured to independently control a pressure applied to the insulated conductor heater by the first set of rollers and the second set of rollers, respectively.

18. The system of claim 17, wherein the first hydraulic unit and the second hydraulic unit
are configured to apply pressure to first set of rollers and the second set of rollers,
15 respectively, to engage the rollers with the insulated conductor heater, and wherein the first hydraulic unit and the second hydraulic unit are configured to release pressure from the first set of rollers and the second set of rollers, respectively, to disengage the rollers from the insulated conductor heater.

19. The system of claim 15, wherein the first set of rollers are configured to be disengaged
20 from the insulated conductor heater to allow an upset in an outer diameter of the insulated conductor heater to pass through the first injector drive section while the second set of rollers are engaged with the insulated conductor heater.

20. The system of claim 15, wherein the second set of rollers are configured to be
disengaged from the insulated conductor heater to allow an upset in an outer diameter of
25 the insulated conductor heater to pass through the second injector drive section while the first set of rollers are engaged with the insulated conductor heater.

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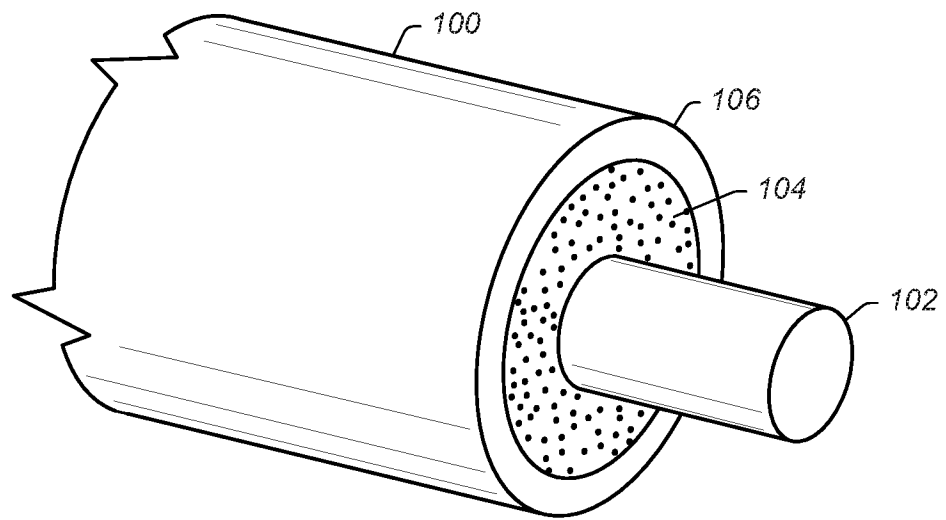


FIG. 1

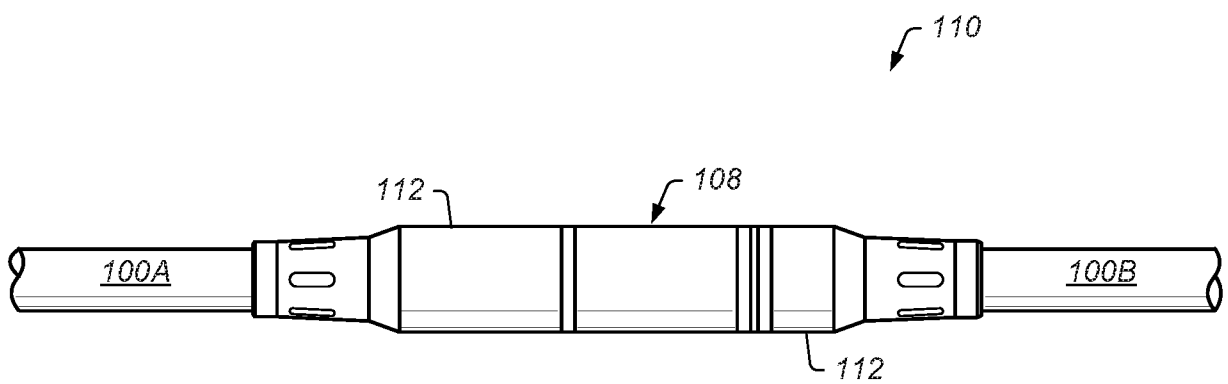


FIG. 2

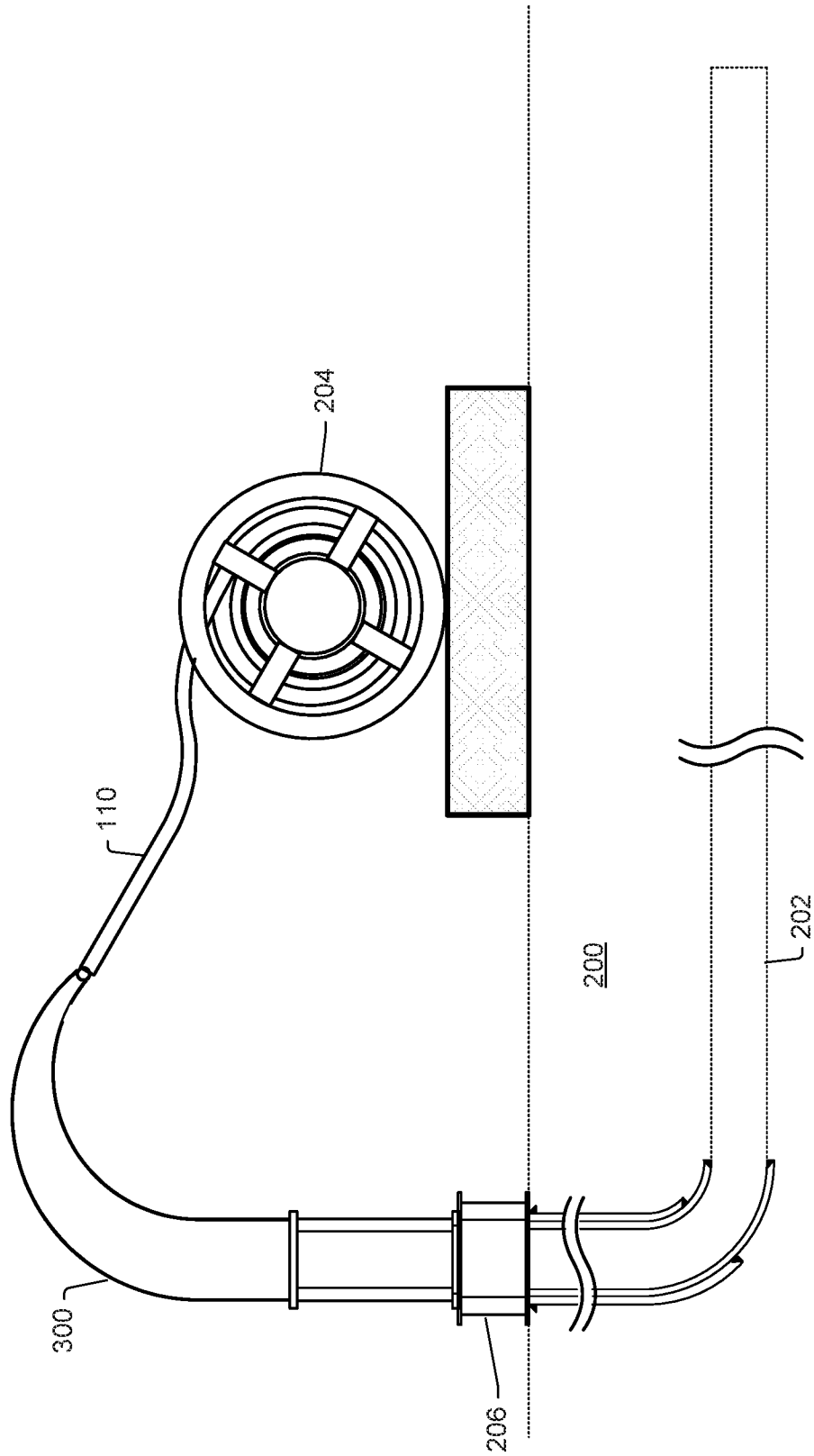
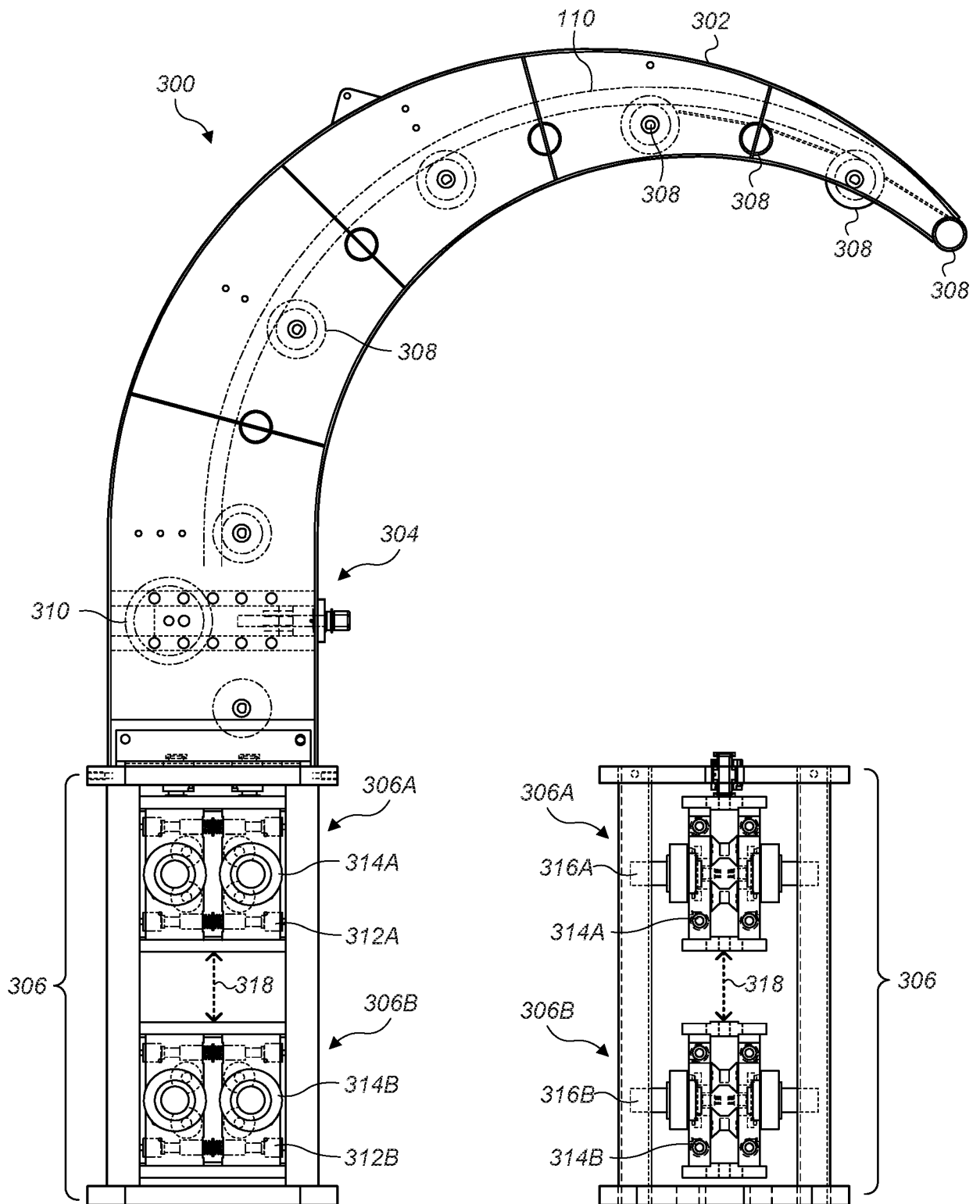


FIG. 3

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/029060

A. CLASSIFICATION OF SUBJECT MATTER INV. E21B19/22 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	US 2003/010505 A1 (GIPSON TOMMIE C [US]) 16 January 2003 (2003-01-16) paragraphs [0010] - [0017], [0069] - [0076]; figures 1-5 -----	1-3,5-20
Y	US 3 313 346 A (CROSS ROBERT V) 11 April 1967 (1967-04-11) column 4, line 68 - column 5, line 16; figure 2 column 5, line 60 - column 6, line 11 -----	1-3,5-20
A	US 6 382 322 B1 (GIPSON TOMMIE C [US]) 7 May 2002 (2002-05-07) column 10, line 29 - column 11, line 37; figures 8-10 column 13, lines 17-27 ----- -/--	1-20
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "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 9 June 2017	Date of mailing of the international search report 20/06/2017	
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/US2017/029060

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/015978 A2 (EXPRESS ENERGY SERVICES OPERATING LP [US]; PERIO DUDLEY J [US]) 31 January 2013 (2013-01-31) paragraph [0024] -----	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/029060

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003010505 A1	16-01-2003	CA 2384214 A1 US 2003010505 A1	11-01-2003 16-01-2003
US 3313346 A	11-04-1967	DE 1279577 B FR 1461032 A GB 1107493 A US 3313346 A	10-10-1968 02-12-1966 27-03-1968 11-04-1967
US 6382322 B1	07-05-2002	CA 2375733 A1 US 6382322 B1	11-01-2003 07-05-2002
WO 2013015978 A2	31-01-2013	US 2011278515 A1 WO 2013015978 A2	17-11-2011 31-01-2013