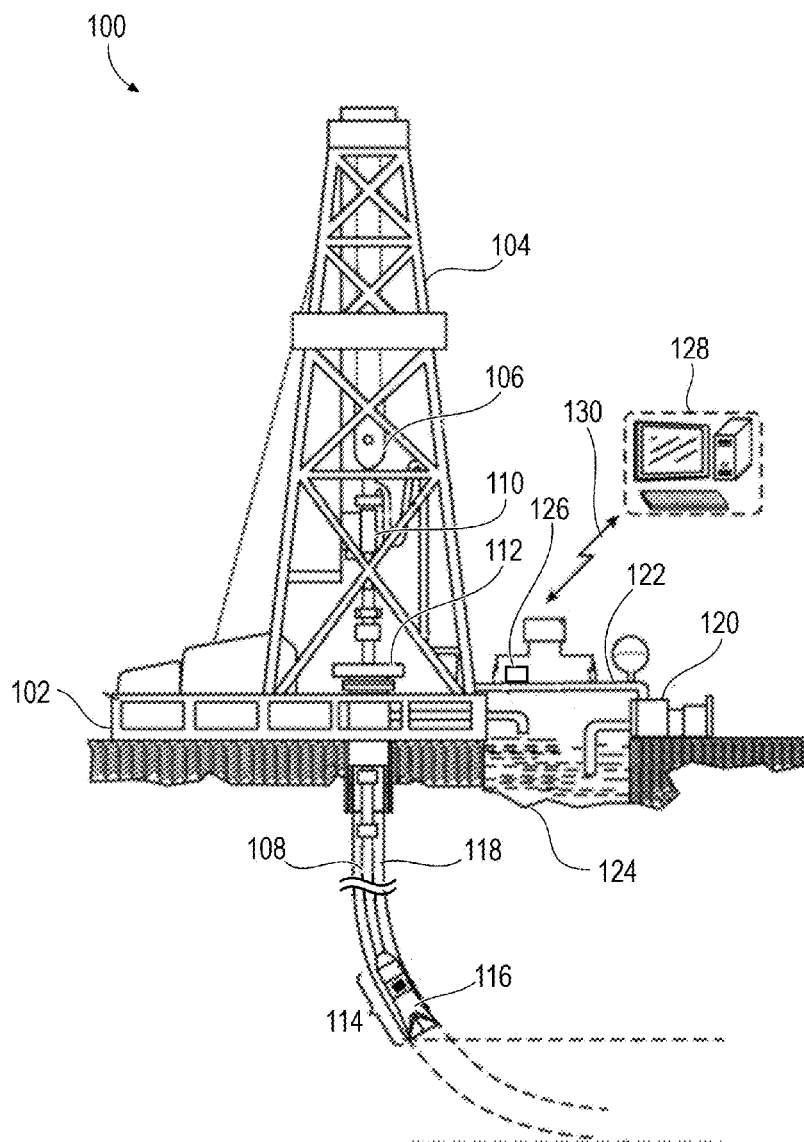




US 20210363847A1

(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2021/0363847 A1**
(43) **Pub. Date:** **Nov. 25, 2021**(54) **TORSIONAL OSCILLATION CONTROL
TOOL GENERATING HIGH-AMPLITUDE AT
VARIABLE FREQUENCIES****Publication Classification**(51) **Int. Cl.**
E21B 31/00 (2006.01)
(52) **U.S. Cl.**
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(US)(21) Appl. No.: **17/325,128**(22) Filed: **May 19, 2021****Related U.S. Application Data**(60) Provisional application No. 63/027,409, filed on May
20, 2020.(57) **ABSTRACT**

A lateral oscillation tool for using in a drill string performing a drilling operation includes a fluid driven, positive displacement motor and a rotating mandrel coupled to the positive displacement motor. At least one unbalanced mass is coupled to the rotating mandrel to generate lateral oscillation of the lateral oscillation tool. The unbalanced mass may include a plurality of tuning channels into which a high-density material may be selectively introduced to alter the positional mass of the unbalanced mass. When paired with the or variable electric drive motor turbine powered, lateral impact forces may be adjusted real-time and through the downhole adaptive learning software.



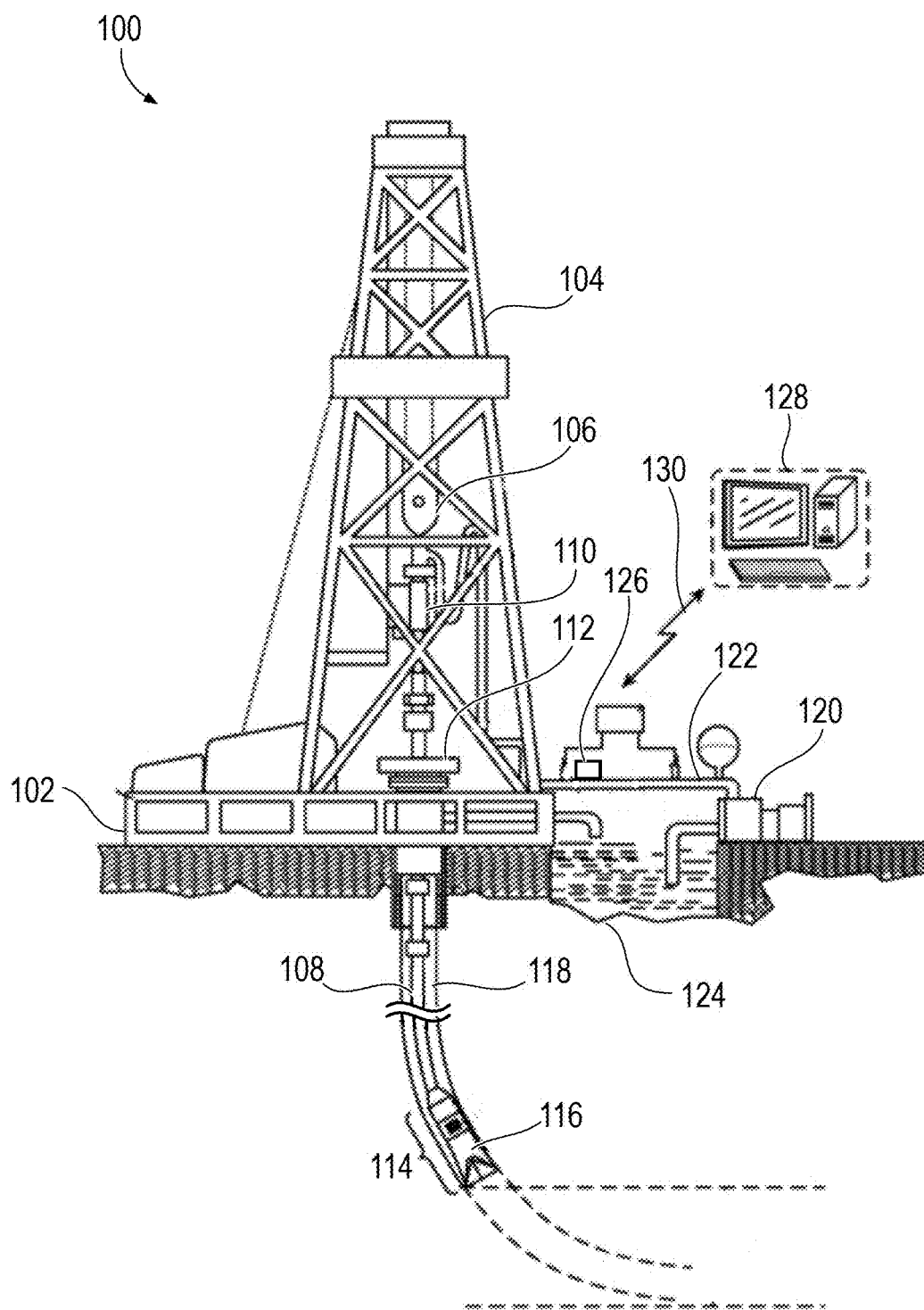


FIG. 1

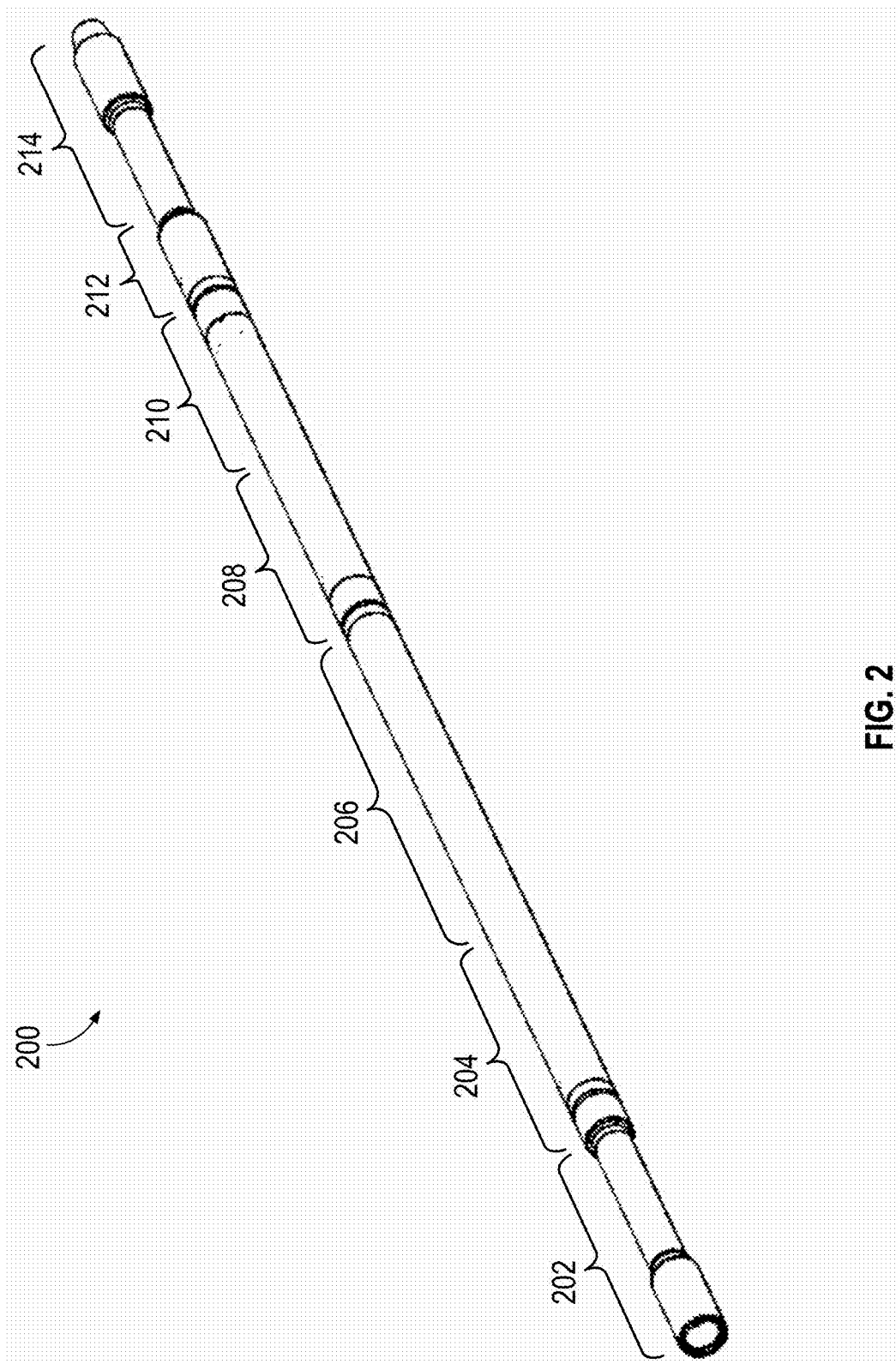


FIG. 2

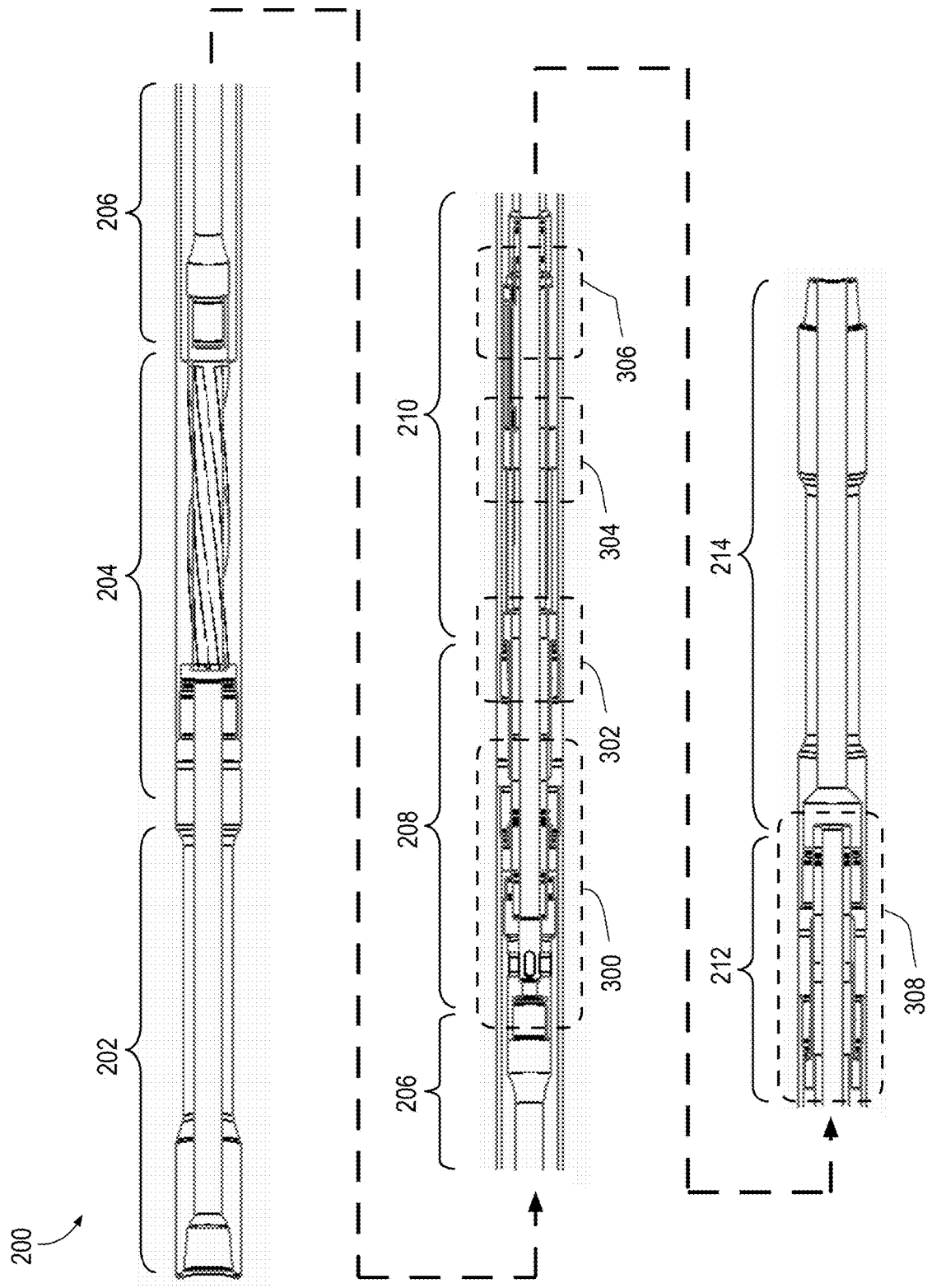


FIG. 3

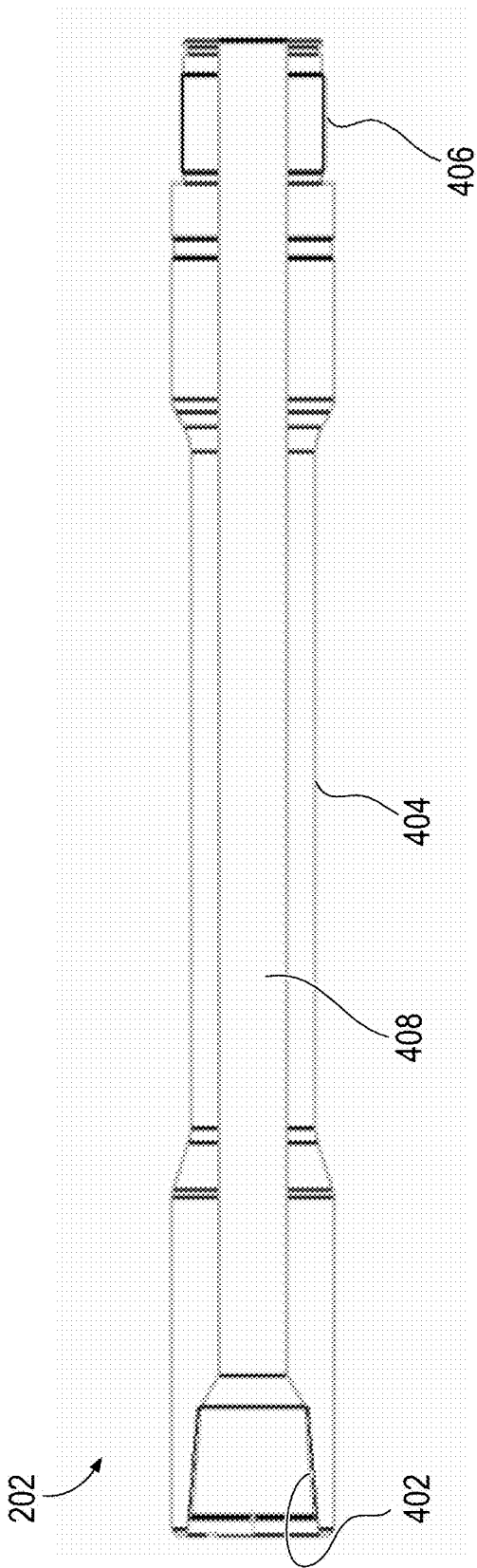


FIG. 4

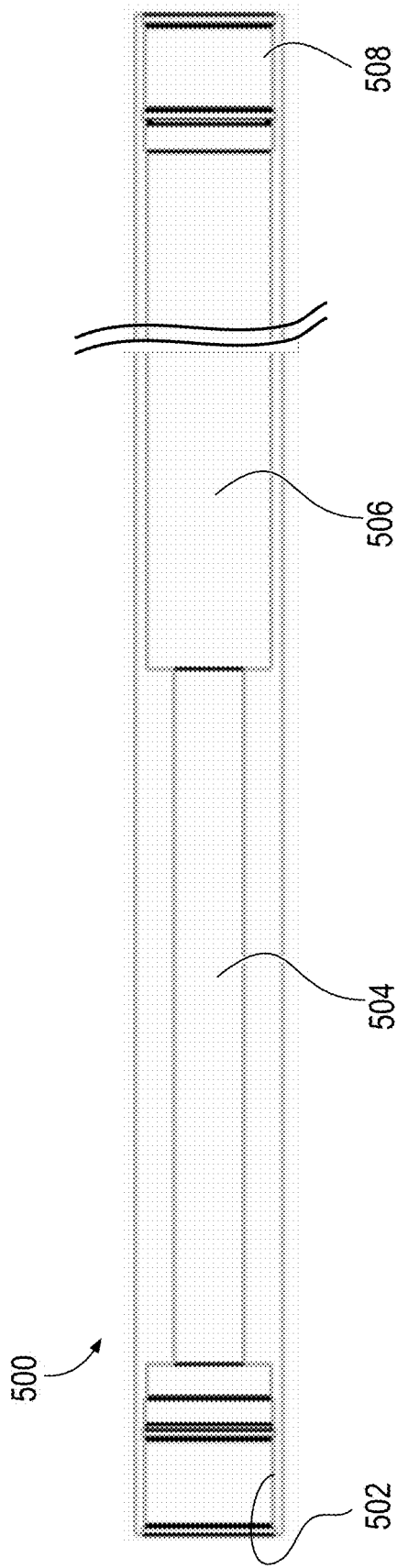


FIG. 5

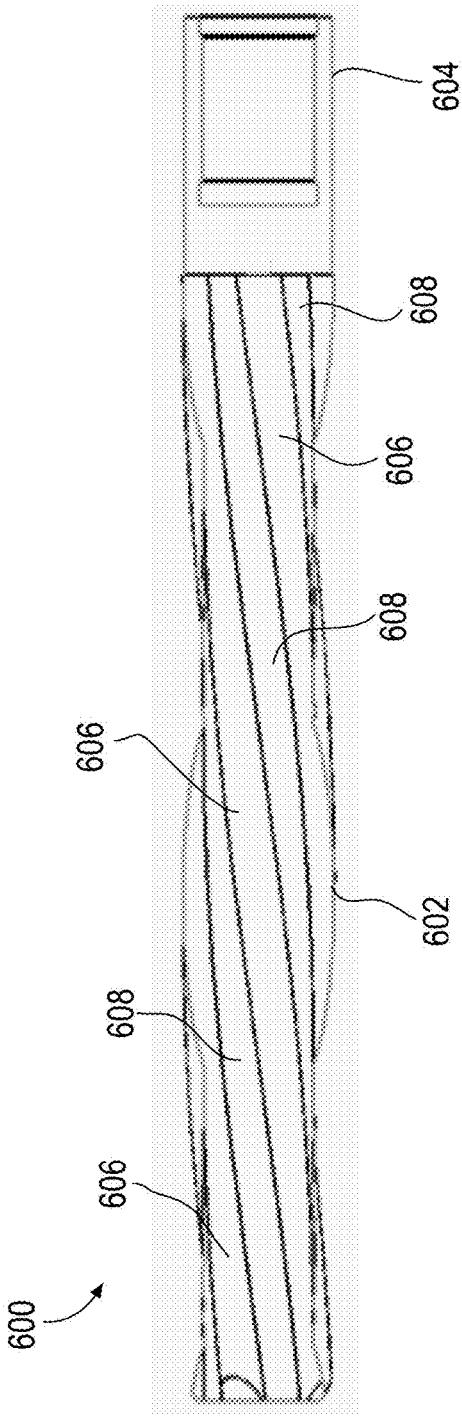


FIG. 6

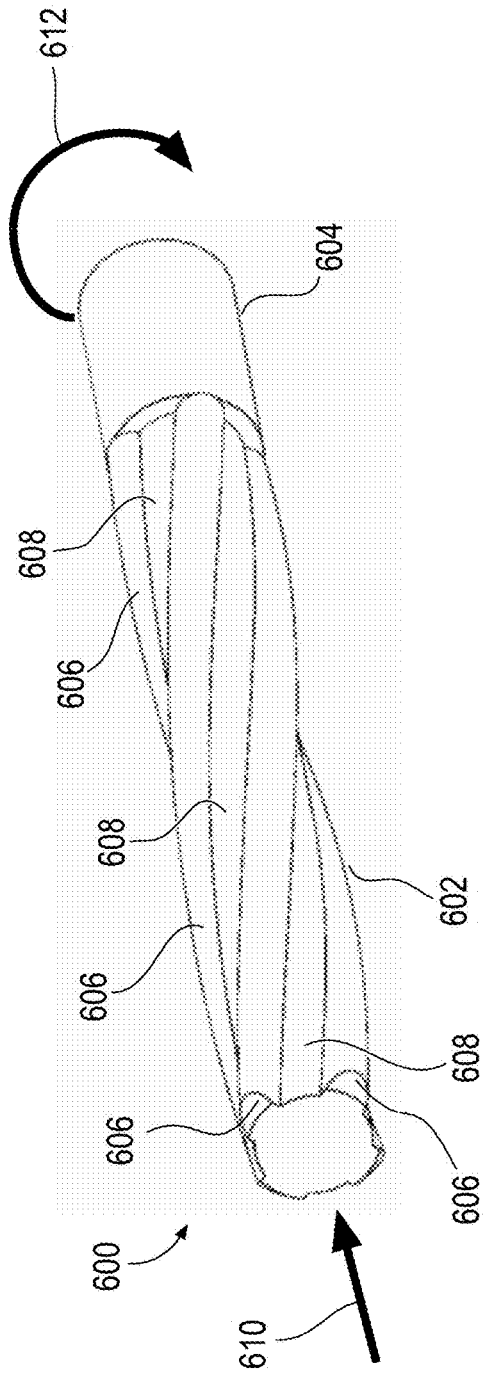


FIG. 7

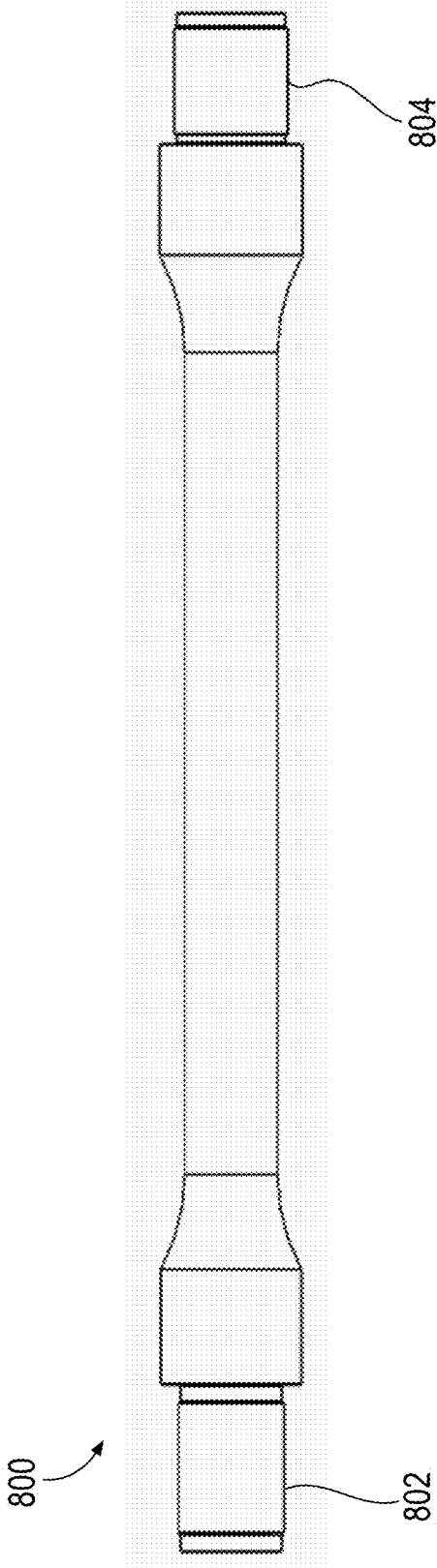


FIG. 8

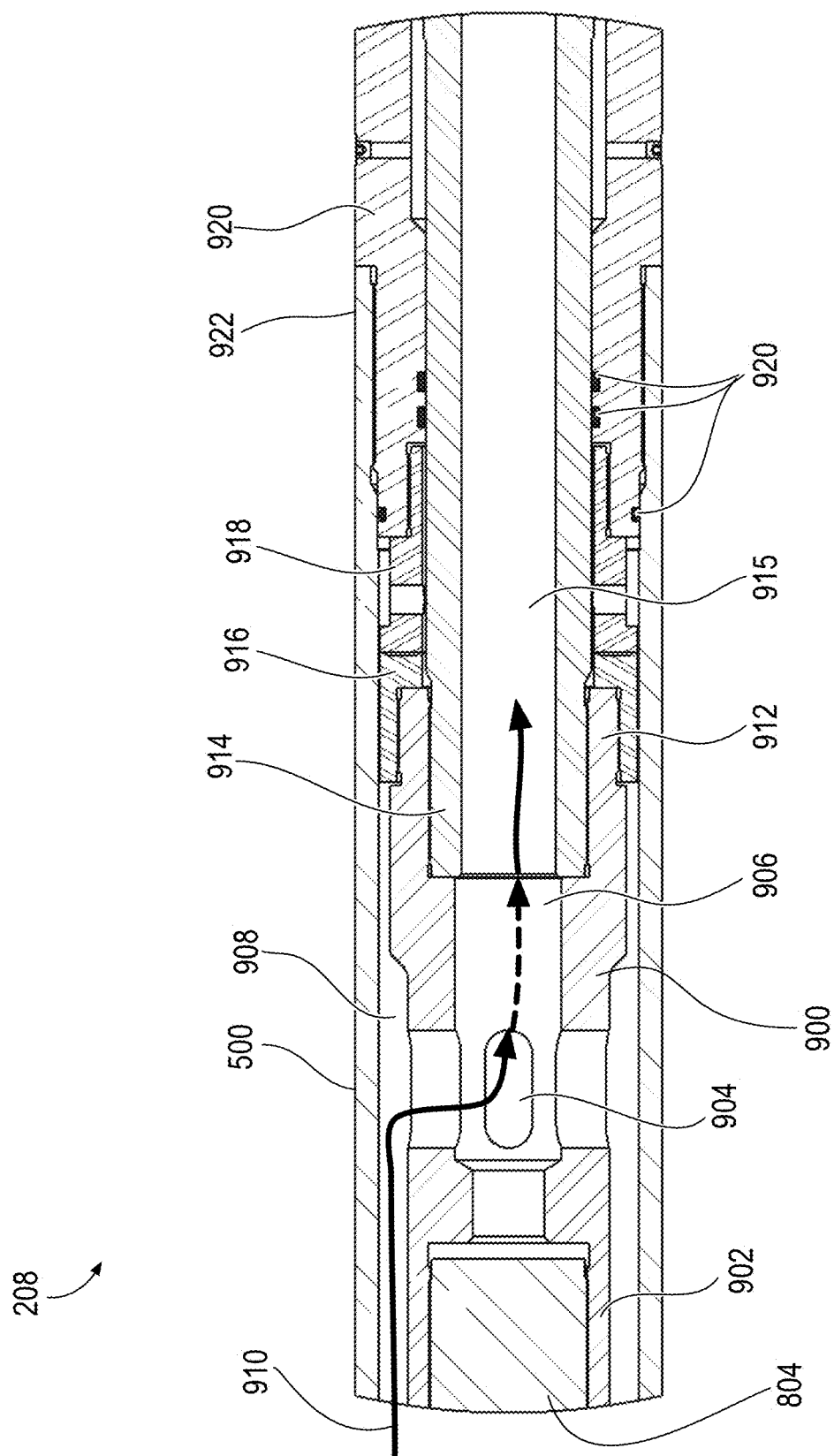


FIG. 9

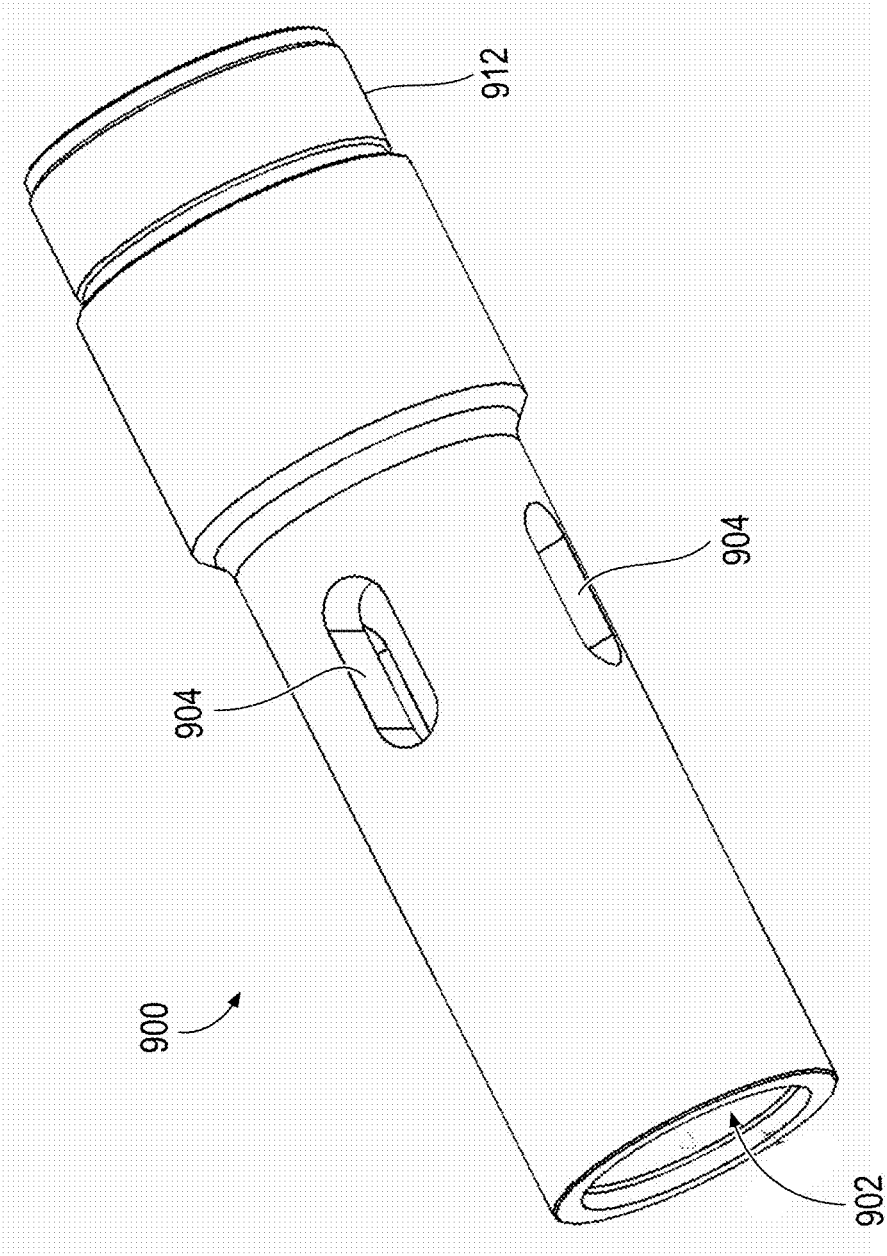


FIG. 10

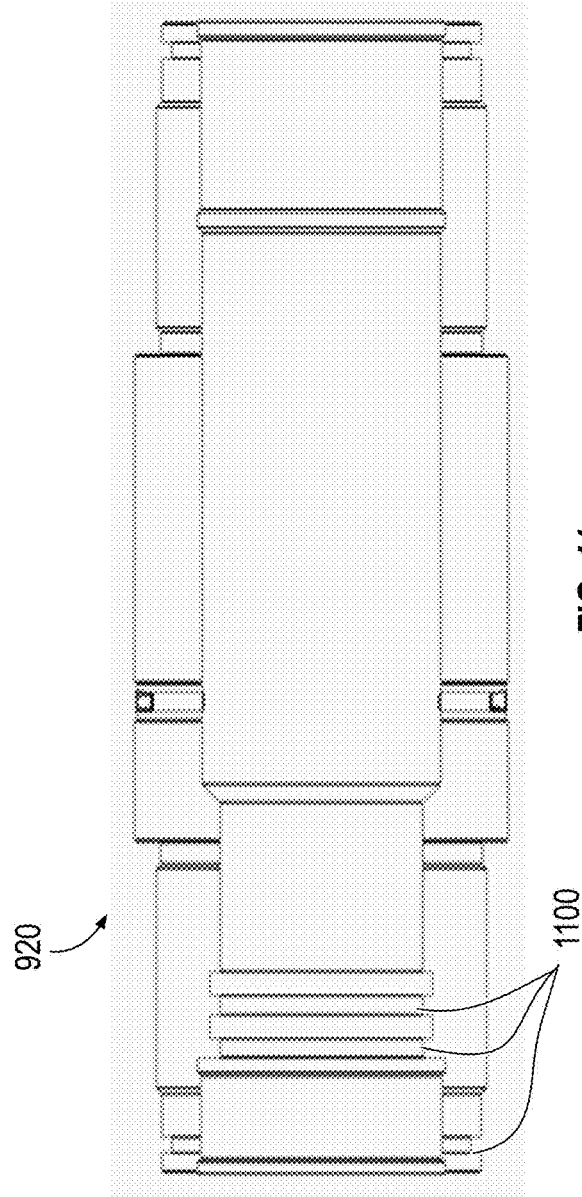


FIG. 11

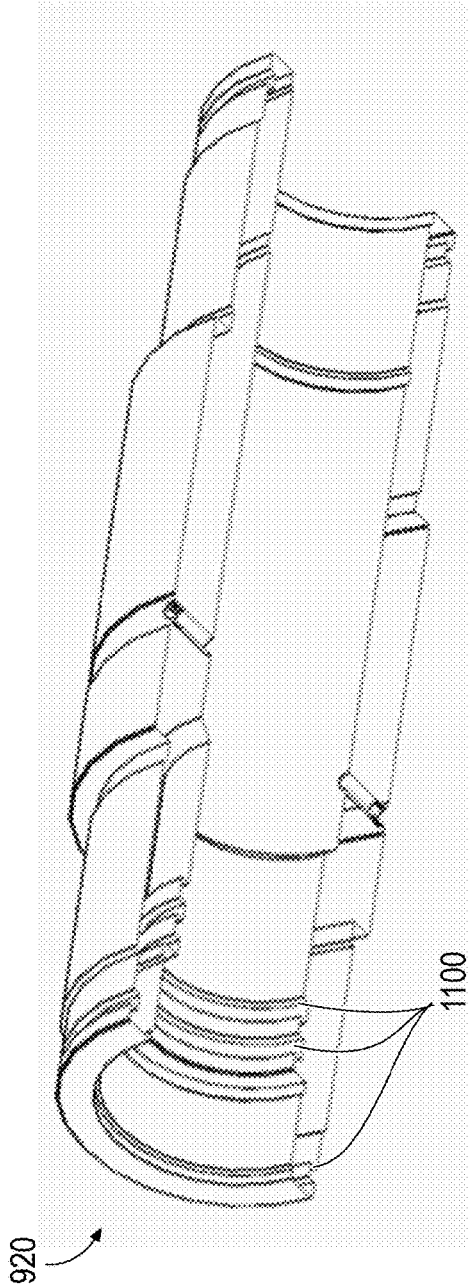


FIG. 12

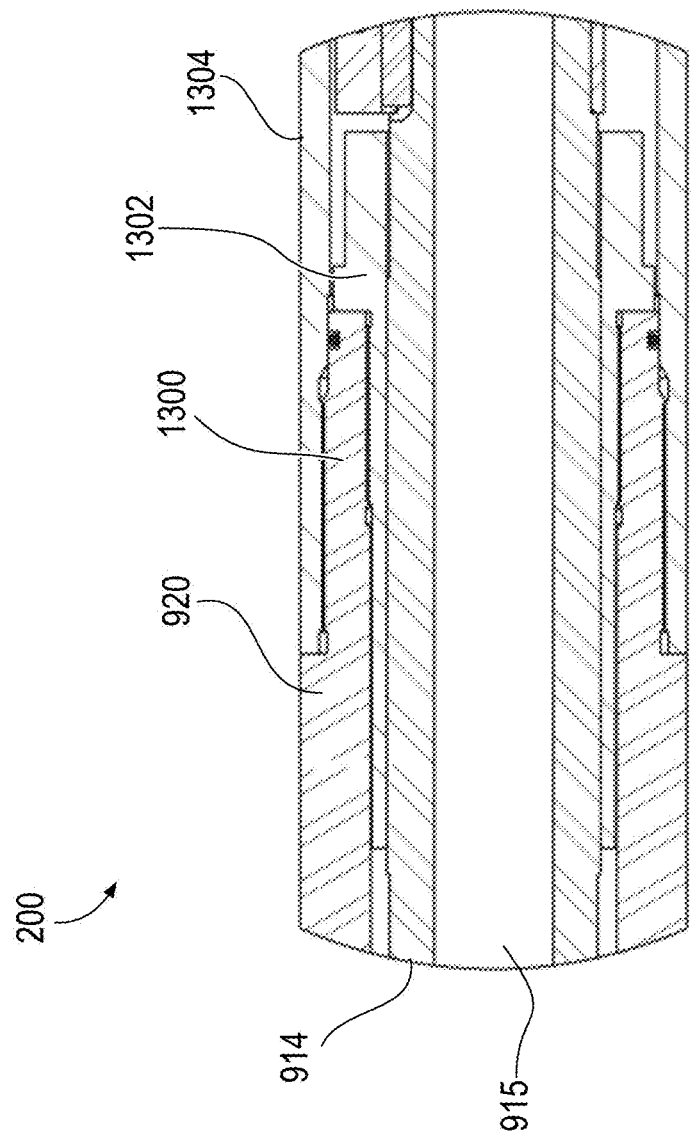


FIG. 13

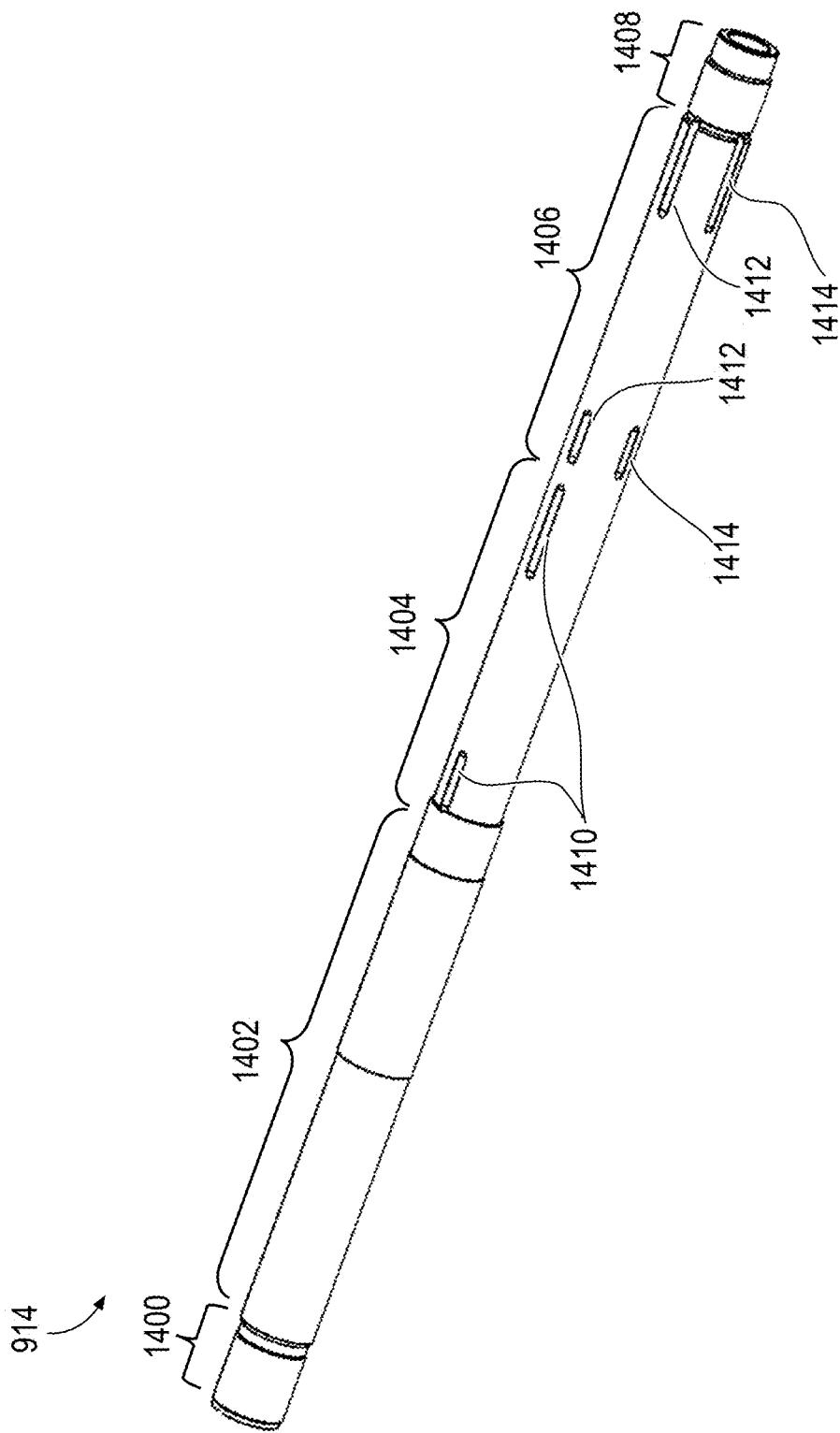


FIG. 14

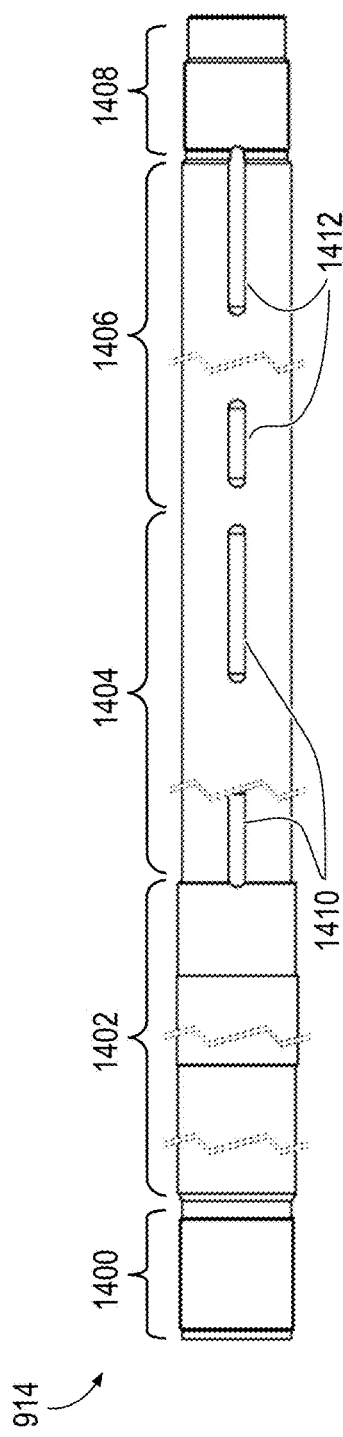


FIG. 15

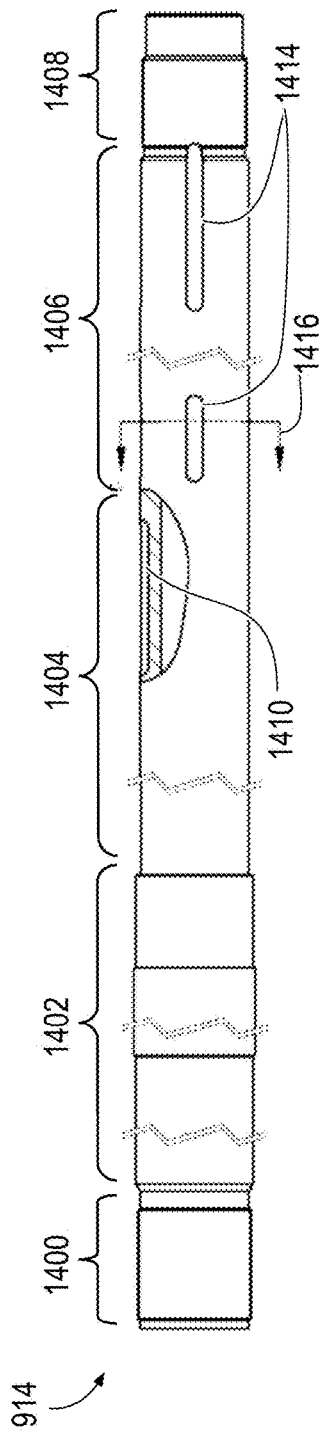


FIG. 16

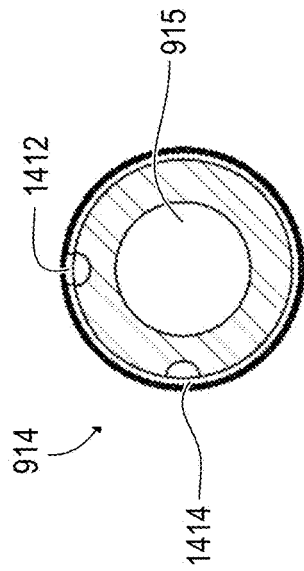


FIG. 17

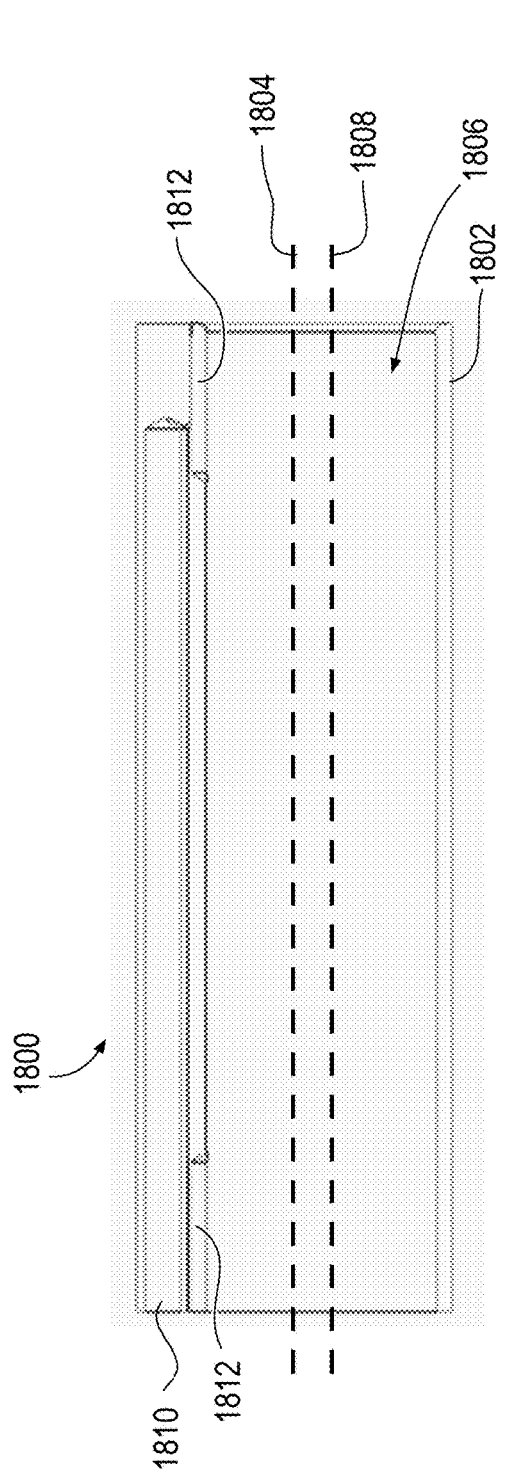


FIG. 18

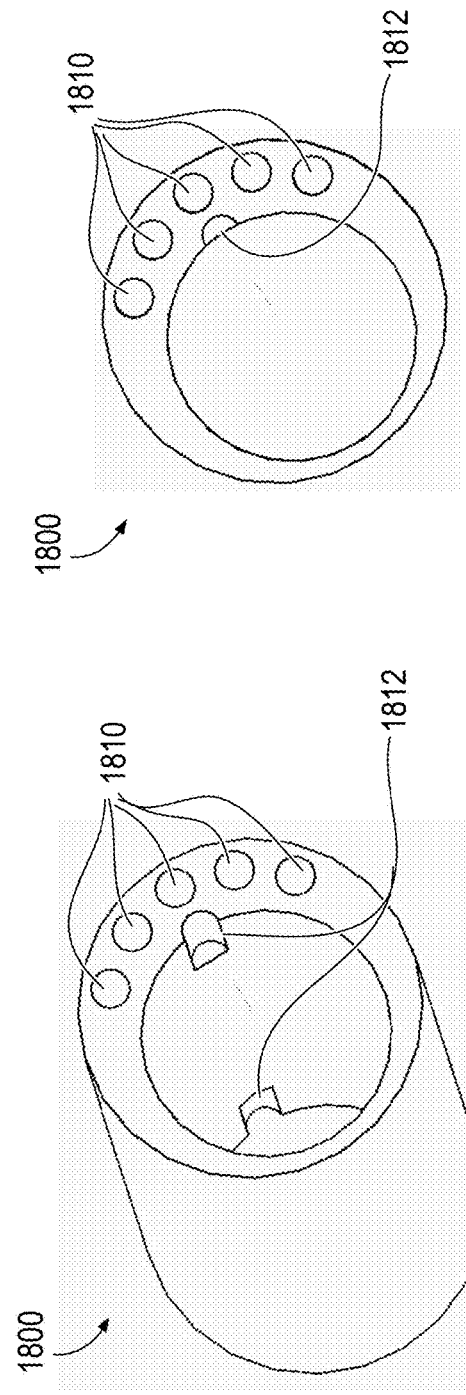
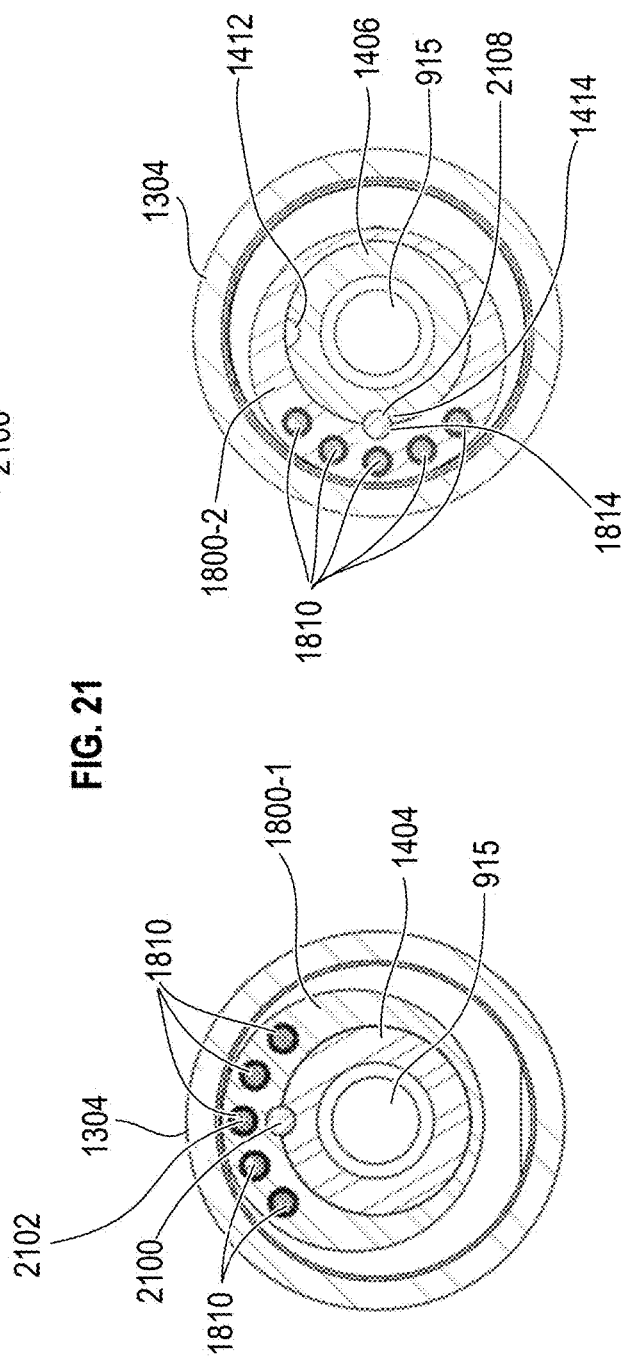
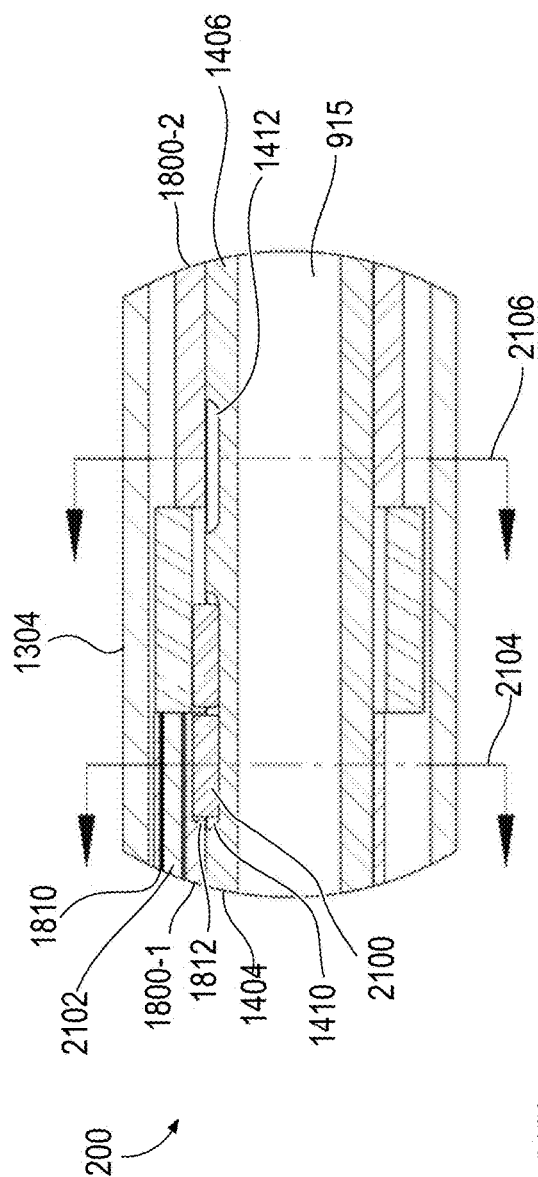


FIG. 20

FIG. 19



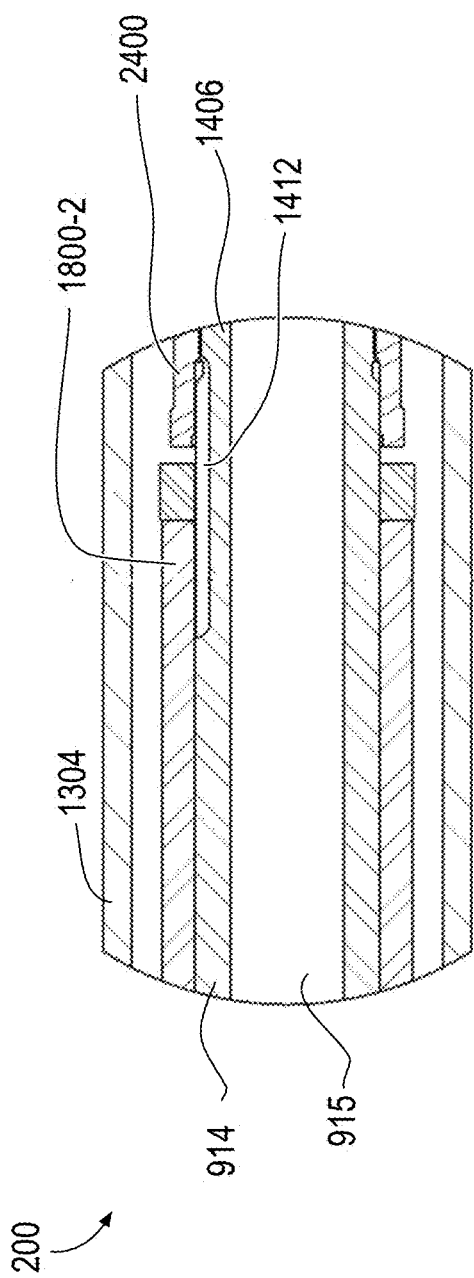


FIG. 24

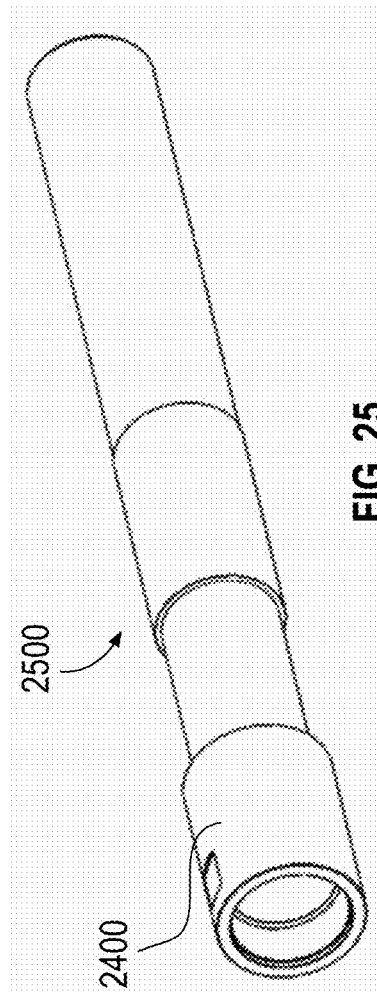


FIG. 25

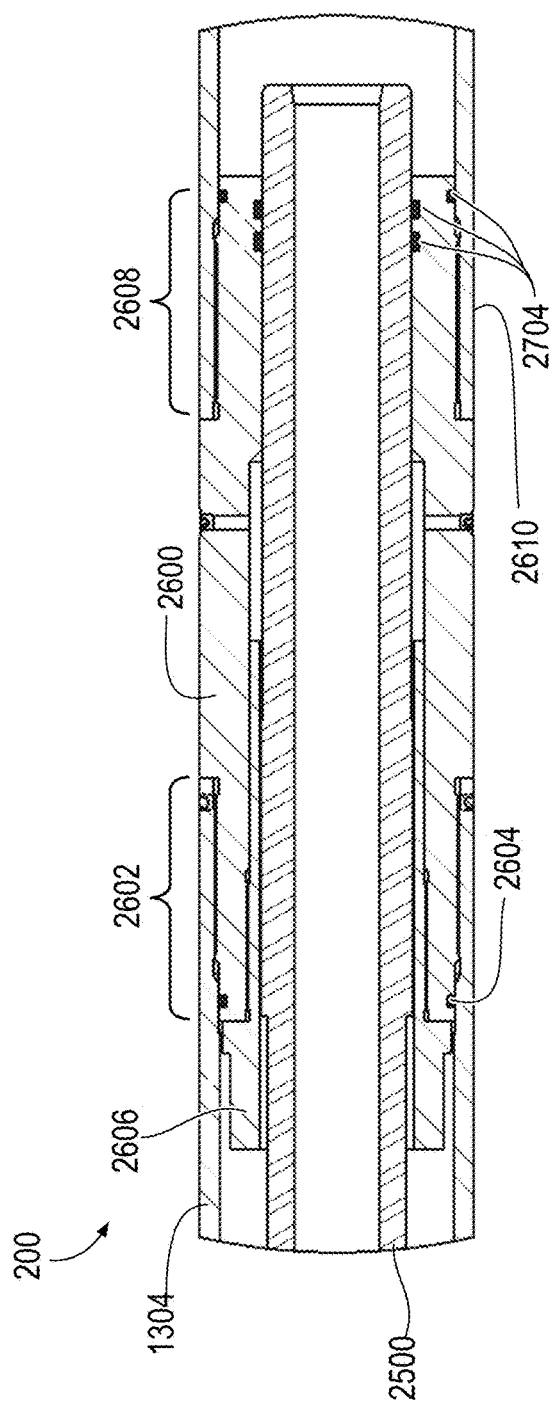


FIG. 26

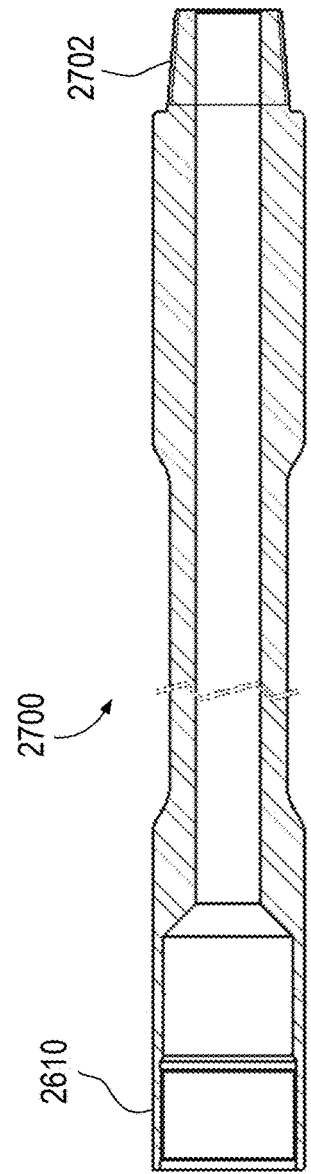


FIG. 27

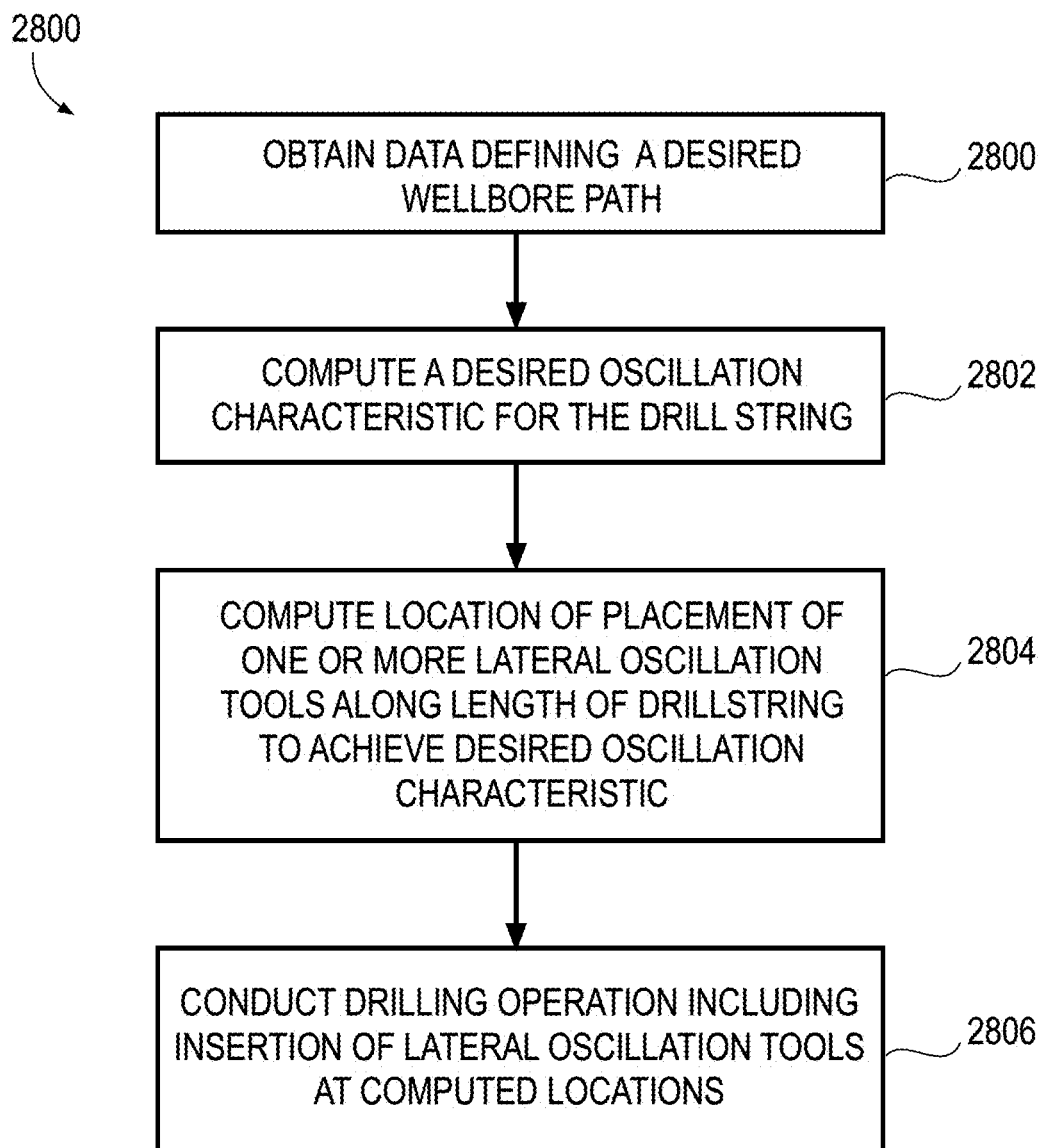


FIG. 28

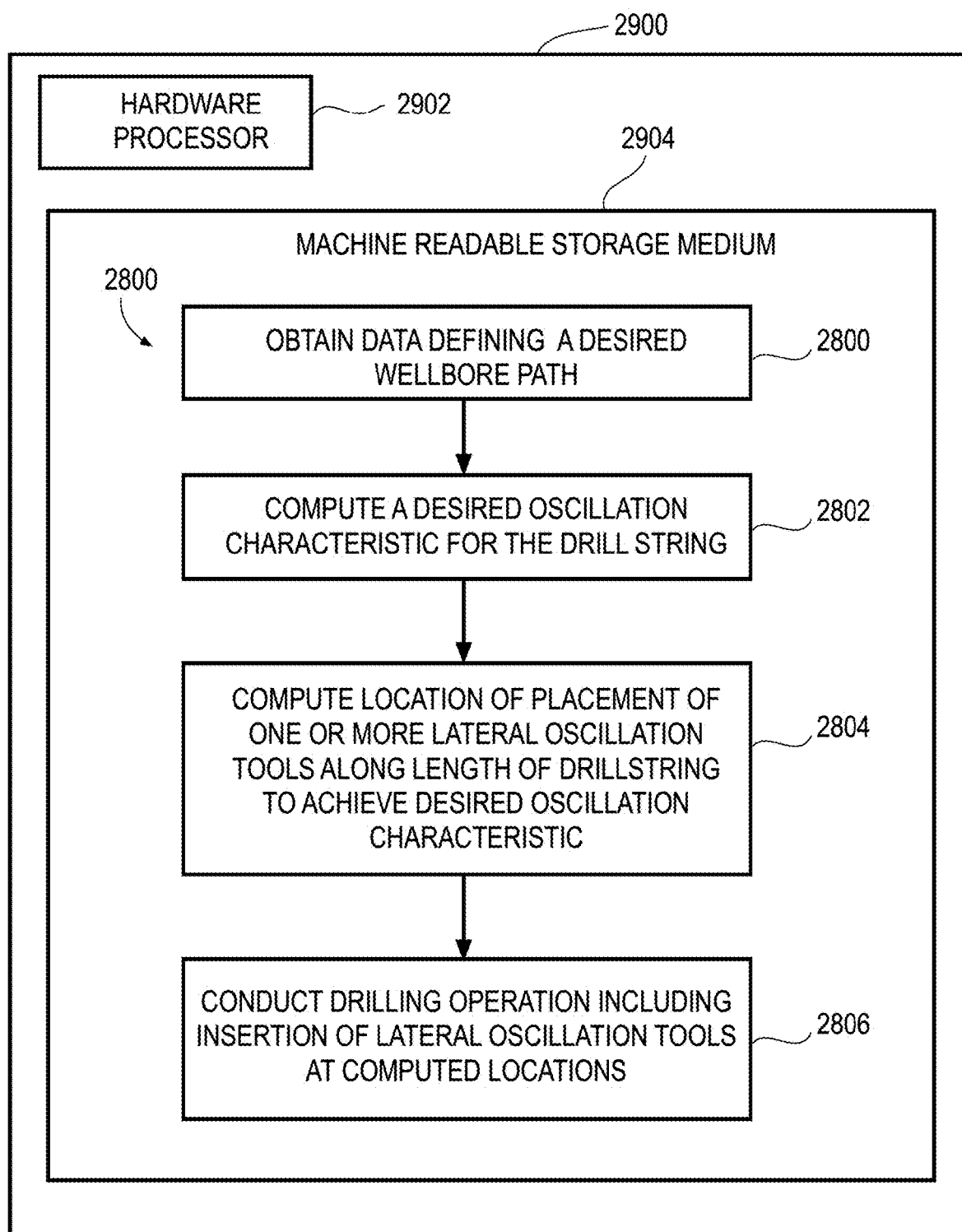


FIG. 29

TORSIONAL OSCILLATION CONTROL TOOL GENERATING HIGH-AMPLITUDE AT VARIABLE FREQUENCIES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority of prior provisional U.S. Patent Application No. 63/027,409 filed on May 20, 2020, the contents of which being incorporated herein by reference in its entirety.

BACKGROUND

[0002] In hydrocarbon exploration and production drilling operations, a wellbore is formed using a drill string to bore a hole into a subsurface formation. A drill string may include a bottom hole assembly having a drill bit attached a lower end of a string of tubular members. The tubular members may include drill collars, drill pipe, and other drilling tools. A drill string may extend thousands of meters from the surface. The drill string may be rotated from the surface, such as with a top drive, to advance the drill string into a formation. Directional wells may include vertical or near-vertical sections as well as horizontal or near-horizontal sections that kick off of from the vertical or near-vertical sections.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The present disclosure is best understood from the following detailed description when read with the accompanying figures, wherein:

[0004] FIG. 1 is a schematic illustration of a drilling system according to one or more examples;

[0005] FIG. 2 is an isometric view illustrating a lateral oscillation tool according to one or more examples;

[0006] FIG. 3 is an exploded side cross-sectional view of the lateral oscillation tool of FIG. 2;

[0007] FIG. 4 is a side cross-sectional view of a top flex sub in the lateral oscillation tool of FIG. 2;

[0008] FIG. 5 is a side cross-sectional view of a stator in the lateral oscillation tool of FIG. 2;

[0009] FIG. 6 is a side cross-sectional view of a rotor in the lateral oscillation tool of FIG. 2;

[0010] FIG. 7 is an isometric view of the rotor from FIG. 6;

[0011] FIG. 8 is a side view of a flex shaft in the lateral oscillation tool of FIG. 2;

[0012] FIG. 9 is a side cross-sectional view of a flow diverter section of the lateral oscillation tool of FIG. 2;

[0013] FIG. 10 is an isometric view of a flow diverter in the lateral oscillation tool of FIG. 2;

[0014] FIG. 11 is a side cross-sectional view of an upper bearing housing in the lateral oscillation tool of FIG. 2;

[0015] FIG. 12 is an isometric cross-sectional view of the upper bearing housing of FIG. 11;

[0016] FIG. 13 is a side cross-sectional view of a section of the lateral oscillation tool of FIG. 2 including a portion of an upper bearing housing and a mandrel;

[0017] FIG. 14 is a perspective view of a mandrel in the lateral oscillation tool of FIG. 2;

[0018] FIG. 15 is a top view of the mandrel of FIG. 14;

[0019] FIG. 16 is a side view, partially cut-away view of the mandrel of FIG. 14;

[0020] FIG. 17 is an end cross-sectional view of the mandrel of FIG. 14;

[0021] FIG. 18 is a side cross-sectional view of an unbalanced mass in the lateral oscillation tool according to one or more examples;

[0022] FIG. 19 is an isometric view of the unbalanced mass of FIG. 18;

[0023] FIG. 20 is an end view of the unbalanced mass of FIG. 18;

[0024] FIG. 21 is a side cross-sectional view of a portion of an unbalanced mass section of the lateral oscillation tool of FIG. 2;

[0025] FIG. 22 is an end cross-sectional view of the unbalanced mass section of FIG. 21;

[0026] FIG. 23 is an end cross-sectional view of the unbalanced mass section of FIG. 21;

[0027] FIG. 24 is a side cross-sectional view of a section of the lateral oscillation tool of FIG. 2 including the mandrel from FIG. 14 and a washpipe;

[0028] FIG. 25 is an isometric view of a washpipe in the lateral oscillation tool of FIG. 2;

[0029] FIG. 26 is a side cross-sectional view of a section of the lateral oscillation tool of FIG. 2 including a lower bearing housing;

[0030] FIG. 27 is a side cross-sectional view of an end sub of the lateral oscillation tool of FIG. 2;

[0031] FIG. 28 is a flow diagram of a method of performing a drilling operation according to one or more examples; and

[0032] FIG. 29 is a block diagram of a computing resource implementing a method performing a drilling operation according to one or more examples.

[0033] It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion or illustration.

DETAILED DESCRIPTION

[0034] Illustrative examples of the subject matter claimed below are disclosed. In the interest of clarity, not all features of an actual implementation are described in this specification. It will be appreciated that in the development of any such actual implementation, numerous implementation-specific decisions may be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort, even if complex and time-consuming, would be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0035] As used herein, the article "a" is intended to have its ordinary meaning in the patent arts, namely "one or more." Herein, the term "about" when applied to a value generally means within the tolerance range of the equipment used to produce the value, or in some examples, means plus or minus 10%, or plus or minus 5%, or plus or minus 1%, unless otherwise expressly specified. Further, herein the term "substantially" as used herein means a majority, or almost all, or all, or an amount with a range of about 51% to about 100%, for example. Moreover, examples herein are intended to be illustrative only and are presented for discussion purposes and not by way of limitation.

[0036] As used herein, to “provide” an item means to have possession of and/or control over the item. This may include, for example, forming (or assembling) some or all of the item from its constituent materials and/or, obtaining possession of and/or control over an already-formed item.

[0037] FIG. 1 illustrates schematically a drilling system 100 according to one or more examples. Drilling system 100 may include a drilling platform 102 having a derrick 104 and a hoist 106 to raise and lower a drill string 108. Hoist 106 may suspend a top drive 110 suitable for rotating drill string 108 and lowering drill string 108 through a well head 112.

[0038] In examples, top drive 110 may support and rotate drill string 108 as it advances through well head 112 to rotate a bottom hole assembly 114 including a drill bit 116 disposed at a distal end of drill string 108 to create a borehole 118. A pump 120 may circulate drilling fluid through a supply pipe 122 to top drive 110, through an interior of drill string 108 and various components thereof, as herein described, to exit through drill bit 116 and back to the surface through borehole 118 and into a retention pit 124. The drilling fluid may transport cuttings generated by drill bit 116 into retention pit 124, and the flow of drilling fluid through drill string 108 may actuate various tools incorporated into drill string 108 as herein described.

[0039] In examples, various tools and components incorporated into drill string 108 as described herein may communicate operational data to a surface receiver 126, such as with mud pulse telemetry, radio frequency telemetry, and the like. A control and computing system 128 may have a connection 130 to surface receiver to obtain and process operational data and to control operation of drilling system 100. Connection 130 may be a wireless or hardwired connection or a combination thereof.

[0040] According to one or more examples, among the components which may be included along the length of a drill string such as drill string 108 from the example of FIG. 1 are one or more lateral oscillation tools for generating lateral (i.e., side-to-side) vibration of a drill string within a borehole. Such lateral vibration may reduce drill string stick/slip effects, increase rates of penetration of drill bits, reduce wear of bottom hole assemblies, reduce possible differential sticking along the drill string, and reduce well-bore fatigue.

[0041] FIG. 2 is an isometric view of a lateral oscillation tool 200 according to one or more examples. FIG. 3 is an exploded, side cross-sectional view of lateral oscillation tool 200. Referring to FIGS. 2 and 3, lateral oscillation tool 200 consists of a plurality of sections, including a top flex sub section 202, a motor power section 204, a flex shaft section 206, a flow diverter section 208, an unbalanced mass section 210, a lower bearing sub section 212, and a lower flex sub section 214.

[0042] FIG. 4 is a side cross-sectional view of top flex sub section 202 of lateral oscillation tool 200, including a threaded female coupling 402 for attachment to an upper section of a drill string, and an elongate flex shaft 404. Top flex sub section 202 further includes a male coupling 406 for attachment to a stator portion of positive displacement motor power section 204, as herein described. Top flex sub section 202 includes an internal annulus 408 allowing for passage of drilling fluid.

[0043] Motor power section 204 of tool 200 is provided for rotating an unbalanced mass (as described herein) in unbalanced mass section 210. In some examples, motor

power section 204 may include a fluid-driven positive displacement motor. In other examples, motor power section 204 may include a variable electric turbine powered motor receiving power and control signals through drill string 108.

[0044] FIG. 5 is a side cross-sectional view of a stator 500 in motor power section 204 of lateral oscillation tool 200 including a fluid-driven positive displacement motor. Stator 500 includes a threaded female coupling 502 for attachment to threaded male coupling 406 of top flex sub section 202 shown in FIG. 4. Stator 500 further includes an upper internal annulus 504 in which a displacement rotor (shown in FIGS. 6 and 7) is disposed, and a lower internal annulus 506 in which a flex shaft (shown in FIG. 8) is disposed. Stator 500 further includes a threaded female coupling 508 for attachment to an upper bearing housing included in flow diverter section 208.

[0045] FIG. 6 is a side cross-sectional view of a rotor 600 in motor power section 204 according to one or more examples. As illustrated in FIG. 6, rotor 600 includes helically-configured body section 602 and a threaded male coupling 604 for attachment to a flex shaft, as herein described. FIG. 7 is an isometric view of rotor 600. As shown in FIGS. 6 and 7, helically-configured body section 602 of rotor 600 includes a plurality of helical ribs 606 defining a plurality of helical channels 608 extending along helically-configured body section 602. As herein described, a flow of drilling fluid across rotor 600 in the direction indicated by arrow 610 in FIG. 7 causes axial rotation of rotor 600 as indicated by arrow 612 in FIG. 7.

[0046] FIG. 8 is a side view of a flex shaft 800 which is engaged at a threaded upper female coupling 802 with threaded male coupling 604 of rotor 600, such that rotation of rotor 600 as described with reference to FIG. 7 causes corresponding rotation of flex shaft 800. A threaded lower male coupling 804 attaches to a flow diverter (not shown in FIG. 8) in flow diverter section 208 of lateral oscillation tool 200.

[0047] FIG. 9 is a side cross-sectional view of a portion of flow diverter section 208 of lateral oscillation tool 200 from FIGS. 1 and 2. In particular, FIG. 9 shows a section of lateral oscillation tool 200 within dashed line 300 in FIG. 3. As shown in FIG. 9, threaded lower male coupling 804 engages with a flow diverter 900 positioned within stator 500. FIG. 10 is a perspective view of flow diverter 900. As shown in FIGS. 9 and 10, flow diverter 900 has a threaded female coupling end 902 for attachment with threaded lower male coupling 804 of flex shaft 800, and includes a plurality of diverter ports 904 leading from the exterior of flow diverter 900 to an internal fluid output bore 906.

[0048] An annulus 908 between flow diverter 900 and the inner wall of stator 500 permits the passage of fluid past threaded female coupling end 902. The fluid reaches flow diverter 900 after passage across rotor 600 to rotate rotor 600 and flex shaft 800. As indicated by arrow 910 in FIG. 9, fluid passes through diverter ports 904 and into fluid output bore 906.

[0049] With continued reference to FIGS. 9 and 10, flow diverter 900 has a threaded female coupling 912 for engagement with a hollow cylindrical mandrel 914 which has an internal bore 915 in fluid communication with fluid output bore 906 of flow diverter 900. An upper thrust bearing 916 is engaged between threaded female coupling 912 and the

interior wall of stator **500**. A lower thrust bearing **918** is engaged between mandrel **914** and the interior wall of stator **500**.

[0050] Mandrel **914** extends into an upper bearing housing **920** which is engaged with a threaded end coupling **922** of stator **500**. A plurality of O-rings **924** may be provided for a fluid seal between upper bearing housing **920** and mandrel **914** as mandrel **914** rotates within upper thrust bearing **916** and lower thrust bearing **918**. As herein described, in some examples the rotational rate of mandrel **914** may be determined in part by the rate of drilling fluid flow through drill string **108**.

[0051] FIG. **11** is a side cross-sectional view of upper bearing housing **920**. FIG. **12** is a perspective cross-sectional view of upper bearing housing **920**. Upper bearing housing **920** may include grooves **1100** for retaining O-rings **924** (not shown in FIGS. **11** and **12**).

[0052] FIG. **13** is a side cross-sectional view of a section of lateral oscillation tool **200** from FIG. **2**. In particular, FIG. **13** shows the section of lateral oscillation tool **200** within dashed line **302** in FIG. **3**. FIG. **13** shows mandrel **914** secured within a threaded lower coupling portion **1300** of upper bearing housing **920** with an upper radial bearing **1302**. As further shown in FIG. **13**, a cylindrical housing mates with upper bearing housing **920** and extends over unbalanced mass section **210** of lateral oscillation tool **200** as herein described.

[0053] FIG. **14** is a perspective view of mandrel **914** according to one or more embodiments. A threaded upper coupling section **1400** of mandrel **914** is engaged with threaded female coupling **912** of flow diverter **900**, as described with reference to FIG. **9**. A first intermediate section **1402** of mandrel **914** is engaged within upper bearing housing **920** as also described with reference to FIG. **9**. A second intermediate section **1404** and a third intermediate section **1406** of mandrel **914** each support an unbalanced mass for producing tunable lateral oscillating forces upon rotation of mandrel **914**, as described herein. A threaded lower coupling section **1408** of mandrel **914** engages with a washpipe element, not shown in FIG. **14**.

[0054] FIG. **15** is a top view of mandrel **914** according to one or more examples. FIG. **16** is a partially cut-away side view of mandrel **914**, and FIG. **17** is a cross-sectional end view of mandrel **914**. As shown in FIGS. **14** and **15**, a first set of axially-aligned half-cylindrical keyways **1410** are formed in second intermediate section **1404** of mandrel **914**. A second set of axially-aligned keyways **1412**, which are also aligned with keyways **1410**, are formed in third intermediate section **1406** of mandrel **914**. A third set of axially-aligned keyways **1414** are formed in third intermediate section **1406** of mandrel **914**. Axially-aligned keyways **1414** are positioned at a ninety-degree offset from axially-aligned keyways **1410** and **1412**. The cross section of FIG. **17** is located at the section mark indicated with reference numeral **1416** in FIG. **15**, in third intermediate section **1406**.

[0055] FIG. **18** is a side cross-sectional view of an unbalanced mass **1800** according to one or more examples. FIG. **19** is perspective view of unbalanced mass **1800**, and FIG. **20** is an end view of unbalanced mass **1800**. In various examples, one or more unbalanced masses **1800** may be installed on mandrel **914** in lateral oscillation tool in order for lateral oscillation tool **200** to create lateral oscillational forces along drill string **108**. As shown in FIGS. **18-20**, unbalanced mass **1800** has a cylindrical outer surface **1802**

centered around a first longitudinal axis **1804** and an inner cylindrical bore **1806** centered around a second longitudinal axis **1808** that is offset from first longitudinal axis **1804**. Also, unbalanced mass may have a half-cylindrical keyways **1812** formed at each end of cylindrical bore **1806**.

[0056] Further, unbalanced mass **1800** includes a plurality of cylindrical tuning channels **1810** formed therein. In examples, cylindrical tuning channels **1810** in unbalanced mass **1800** may be selectively filled with a high-density, high-weight filler material to alter the positional mass of unbalanced mass **1800**. In examples, cylindrical tuning channels may be filled with materials such as tungsten, in the form of tungsten rods or powdered tungsten. In other examples, other high-density materials may be used. In examples where powdered or granular materials, such as powdered tungsten are introduced into one or more tuning channels **1810**, a cap (not shown in the Figures) may be provided to seal the material in place.

[0057] In various examples, a first unbalanced mass **1800** may be installed on mandrel **914** in second intermediate section **1404** of mandrel **914**. Steel rods (not shown in the Figures) may be installed in keyways **1410** of mandrel **914**, to align with keyways **1812** of unbalanced mass **1800** such that unbalanced mass **1800** will rotate along with rotation of mandrel **914** during operation of lateral oscillation tool **200**. Prior to installation, unbalanced mass **1800** may be tuned by selective introduction of high-density material into one or more of its tuning channels **1810**. Thereafter, a second unbalanced mass **1800** may be installed on mandrel **914** in third intermediate section **1406**. In various examples, the second unbalanced mass **1800** may be installed with its keyways **1812** aligned either with keyways **1412** of mandrel **914**, or may be installed at a ninety-degree offset from the first unbalanced mass, with its keyways **1812** aligned with keyways **1414** of mandrel **914**. Further, the second unbalanced mass **1800** may be tuned differently than the first unbalanced mass by having a different selected number of tuning channels **1810** filled with high-density material.

[0058] In examples, the selection of the relative orientation of two unbalanced masses **1800** installed on mandrel **914**, as well as the selective tuning of each unbalanced mass **1800** through selective introduction of material into one or more of tuning channels **1810** gives rise to a wide range of possible oscillation frequencies and lateral oscillation forces generated by lateral oscillation tool **200**. The oscillation forces and frequencies may be further modulated according to the flow rate of drilling fluid through lateral oscillation tool **200**, which in turn modulates the speed of rotation of mandrel **914** caused by positive displacement motor power section **204**.

[0059] FIG. **21** is a side cross-sectional view of portions of unbalanced mass section **210** of lateral oscillation tool **200** from FIGS. **1** and **2**. In particular, FIG. **21** shows a section of lateral oscillation tool **200** within dashed line **304** in FIG. **3**. In FIG. **21**, an upper unbalanced mass **1600-1** is secured to second intermediate section **1404** of mandrel **914** with a steel pin **2100** inserted into keyway **1812** of mandrel unbalanced mass **1600-1** and keyway **1410** of mandrel **914**. In this example, high-density weight **2102** is installed in a cylindrical tuning channel **1810** of unbalanced mass **1800-1**. Housing **1304** surrounds unbalanced mass sections **208** and **210**.

[0060] FIG. **21** further shows a lower unbalanced mass **1800-2** installed on third intermediate section **1406** of man-

drel **914**. In this example, lower unbalanced mass **1800-2** is installed at a ninety-degree offset from upper unbalanced mass **1800-1**, such that no steel pin is present in keyway **1412** of mandrel **914**.

[0061] FIG. **22** is a side cross-sectional view of unbalanced mass section **210** of FIG. **21** at the location designated with reference numeral **2104** in FIG. **21**. FIG. **23** is a side cross-sectional view of the unbalanced mass section of FIG. **21** at the location designated with reference numeral **2106** in FIG. **21**. As shown in FIG. **23**, a steel pin **2108** is inserted into keyway **1414** of mandrel **914** and keyway **1814** of unbalanced mass **1800-2** to align unbalanced mass **1800-2** on third intermediate section **1406** of mandrel **914** at a ninety-degree offset relative to unbalanced mass **1800-1** as shown by comparison between FIGS. **22** and **23**.

[0062] FIG. **24** is a side cross-sectional view a section of lateral oscillation tool **200**. In particular, FIG. **24** shows a section of lateral oscillation tool **200** within dashed line **306** in FIG. **3**. FIG. **24** shows unbalanced mass **1800-2** from FIG. **21** installed on third intermediate section **1406** of mandrel **914**. Again, no pin is present in keyway **1412** of mandrel **914**, since unbalanced mass **1800-2** is installed at a ninety-degree offset relative to unbalanced mass **1800-1**, as described with reference to FIGS. **22** and **23**.

[0063] As further shown in FIG. **24**, mandrel is engaged with a threaded coupling end **2400** of a washpipe. A perspective view of a washpipe **2500** according to one or more examples is shown in FIG. **25**. In examples, washpipe **2500** is rigidly coupled to mandrel **914** and is thereby rotates along with mandrel **914**.

[0064] FIG. **26** is a side cross-sectional view of lower bearing sub section **212** of lateral oscillation tool **200**. In particular, FIG. **26** shows a section of lateral oscillation tool **200** within dashed line **308** in FIG. **3**. As shown in FIG. **26**, housing **1304** attaches to a lower bearing housing **2600** at a threaded coupling **2602** which may include an O-ring **2604**. Lower bearing housing **2600** holds a lower radial bearing **2606** against washpipe **2500** as washpipe **2500** rotates within lower bearing housing **2600**. At another threaded coupling section **2608**, lower bearing housing attaches to a threaded coupling portion **2610** of a bottom flex sub.

[0065] FIG. **27** is a side cross-sectional view of a bottom flex sub **2700** including threaded coupling section **2610** shown in FIG. **26**. Bottom drill string connection **2702** may be threaded to facilitate connection of tool **200** to a lower portion of drill string **108**. A plurality of O-rings **2704** may be provided in threaded coupling section **2608**.

[0066] In various examples, one or more lateral oscillation tools **200** may be incorporated into a drill string such as drill string **108** in order to induce lateral oscillation of drill string **108** according to desired oscillation characteristics. The desired oscillating characteristics can be tuned through adjustment of one or more variables, including: the number of lateral oscillation tools **200**; the position of placement of one or more lateral oscillation tools **200** along the length of drill string **108** (taking into account the overall length of the drill string); the selection of which of the cylindrical tuning channels **1810** of each unbalanced mass **1800** to be populated with high-density material to alter the weight balance of the respective unbalanced mass; the orientation of each pair of unbalanced masses **1800** in a given lateral oscillation tool **200** (i.e., either in alignment or ninety-degrees offset, as described herein); the flow rate (and density) of drilling fluid through drill string **108**, which modulates the rotational

speed of rotor **600** in positive displacement motor power section **204**; the overall rotational speed of drill string **108**. All of these variables can affect the overall oscillating characteristics of the drill string at particular nodal points along drill string **108**.

[0067] In some examples, placement planning software may be utilized to specify, within a given tolerance such as 60 meters, the correct placement of one or more lateral oscillation tools **200** along a drill string **108**. The software may factor in all of the foregoing variables in the context of a particular drilling operation involving a particular drill string having a particular steel grade and burst, stiffness, and connection type, a particular bottom hole assembly (BHA), such as ones having a rotary or positive displacement motor, a particular bit and BHA mass, stabilization tools including on the drill string, the natural frequency of the drill string, environmental factors (temperature, drilling fluid composition, drilling fluid flowrate, hydrogen sulphate (H₂S) concentration, under-balanced drilling (UBS) conditions, drill string rotations per minute (RPM), formation characteristics), well design (vertical, inclined, horizontal, or a combination thereof), and dogleg severity.

[0068] Placement planning software may assess the entire drilling operation from drilling start to planned terminal depth. Placement planning may include an analysis of net effects of tool placement based on a range of rotational speeds (e.g., 0-350 rpm) while under particular drilling conditions, including without limitation, weight-on-bit, torque, and hydraulic mean specific energy. Variables may also include the local nodal points where the drill string wraps to store energy to pass up and down the drill string and unloads where the inertia is overcome, which is a function of mass and localized wellbore frictional co-efficient).

[0069] After placement planning is accomplished, a drilling operation may be conducted wherein one or more lateral oscillation tools **200** are incorporated into the drill string to achieve the desired oscillation characteristics during the drilling operation.

[0070] FIG. **28** is a flow diagram of a method **2800** for conducting a drilling operation according to one or more examples. In block **2802**, information defining a desired wellbore trajectory is identified. The wellbore trajectory may be defined based upon such factors as the surface location of drilling rig **104** relative to a subsurface formation to be accessed during the drilling operation.

[0071] In block **2802**, a desired oscillation characteristic for drill string **108** is computed. This computation may take into account many factors relating to the drill string and its operation, including, without limitation, including: the flow rate (and density) of drilling fluid through drill string **108**; the overall rotational speed of drill string **108**, the composition and material properties of the drill string, including the types of materials; the trajectory of the wellbore, which may include vertical, near-vertical, horizontal, and near-horizontal sections as well as one or more kick-off and other transition points between such sections; the subsurface geologic conditions existing between the surface and the formation to be accessed, and so on. The desired oscillation characteristics for drill string **108** may include identification of oscillational nodal points at one or more locations along the drill string, thereby establishing percussive forces against the borehole wall at desired locations along the drill string.

[0072] Next, in block **2804**, location(s) for placement of one or more lateral oscillation tools **200** may be computed. This computation may involve selective tuning of the one or more lateral oscillation tools **200** through selective filling of one or more cylindrical tuning channels **1810** in the one or more lateral oscillation tools **200**. This computation may also take into account other variables relating to the drilling operation, including, without limitation: the number of lateral oscillation tools **200** to be included in drill string **108**; the position of placement of one or more lateral oscillation tools **200** along the length of drill string **108** (taking into account the overall length of the drill string); the selection of which of the cylindrical tuning channels **1810** of each unbalanced mass **1800** to be populated with high-density material to alter the weight balance of the respective unbalanced mass; the orientation of each pair of unbalanced masses **1800** in a given lateral oscillation tool **200** (i.e., either in alignment or ninety-degrees offset, as described herein); the flow rate (and density) of drilling fluid through drill string **108**, which modulates the rotational speed of rotor **600** in motor power section **204**; and the overall rotational speed of drill string **108**.

[0073] Next, in block **2806**, a drilling operation may be conducted in which the one or more lateral oscillation tools **200** are inserted at the location(s) computed in block **2804** to achieve the desired oscillational characteristics of drill string **108**.

[0074] FIG. **29** is a block diagram representing a computing resource **2900** implementing a method performing a drilling operation, according to one or more examples. Computing resource **2900** may include at least one hardware processor **2902** and a machine-readable storage medium **2904**. As illustrated, machine readable medium **2904** may store instructions, that when executed by hardware processor **2902** (either directly or via emulation/virtualization), cause hardware processor **2902** to perform the method **2800** described above with reference to FIG. **28**.

[0075] The foregoing description, for purposes of explanation, uses specific nomenclature to provide a thorough understanding of the disclosure. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the systems and methods described herein. Various substitutions, modifications, and variations of the examples described herein may be made in a given implementation. For instance, in examples herein a fluid-driven positive displacement motor is utilized for rotation of one or more unbalanced masses **1800**. In other examples, and as noted above, a different motor, such as a variable electric turbine powered motor, may be utilized. In such examples, lateral impact forces may be adjusted real-time and through the downhole adaptive learning software.

[0076] The foregoing descriptions of specific examples are presented for purposes of illustration and description. Examples herein are not intended to be exhaustive of or to limit this disclosure to the precise forms described. Many modifications and variations are possible in view of the above teachings. The examples are shown and described in order to best explain the principles of this disclosure and practical applications, to thereby enable others skilled in the art to best utilize this disclosure and various examples with various modifications as are suited to the particular use contemplated. It is intended that the scope of this disclosure be defined by the claims and their equivalents below.

What is claimed is:

1. A lateral oscillation tool, comprising:
 - a motor;
 - a rotating mandrel coupled to the motor; and
 - a first unbalanced mass coupled to the rotating mandrel to generate lateral oscillation of the lateral oscillation tool.
2. The lateral oscillation tool of claim 1, wherein the rotating mandrel is coupled to the motor by a flex shaft.
3. The lateral oscillation tool of claim 1, wherein the first unbalanced mass comprises a cylindrical body having a first central axis and an inner annulus having a second central axis offset from the first central axis.
4. The lateral oscillation tool of claim 3, wherein:
 - the first unbalanced mass has a plurality of tuning channels therein, and
 - a high-density material is selectively introduced into one or more of the plurality of tuning channels.
5. The lateral oscillation tool of claim 4, further comprising a second unbalanced mass coupled to the rotating mandrel.
6. The lateral oscillation tool of claim 1, further comprising a flow diverter for diverting a flow of drilling fluid through a central annulus of the mandrel.
7. The lateral oscillation tool of claim 4, wherein the high-density material comprises tungsten.
8. A drill string for operations in a wellbore, the drill string comprising:
 - a plurality of assembled pipe sections;
 - a bottom hole assembly; and
 - at least one lateral oscillation tool disposed between two of the plurality of pipe sections, the lateral oscillation tool including:
 - a motor;
 - a rotating mandrel coupled to the motor; and
 - a first unbalanced mass coupled to the rotating mandrel to generate lateral oscillation of the lateral oscillation tool.
9. The lateral oscillation tool of claim 8, wherein the rotating mandrel is coupled to the motor by a flex shaft.
10. The lateral oscillation tool of claim 8, wherein the first unbalanced mass comprises a cylindrical body having a first central axis and an inner annulus having a second central axis offset from the first central axis.
11. The lateral oscillation tool of claim 10, wherein the first unbalanced mass has a plurality of tuning channels therein, wherein a high-density material is selectively introduced into one or more of the plurality of tuning channels.
12. The lateral oscillation tool of claim 11, further comprising a second unbalanced mass coupled to the rotating mandrel.
13. The lateral oscillation tool of claim 8, further comprising a flow diverter for diverting flow of drilling fluid through a central annulus of the mandrel.
14. The lateral oscillation tool of claim 11, wherein the high-density material comprises tungsten.
15. A method of performing operations in a wellbore, comprising:
 - providing a lateral oscillation tool in a drill string, the lateral oscillation tool comprising:
 - a motor;
 - a mandrel coupled to the motor; and
 - a first unbalanced mass coupled to the mandrel to generate lateral oscillation of the lateral oscillation tool; and

controlling rotation of the motor to cause rotation of the mandrel and the first unbalanced mass, such that lateral oscillation of the drill string is produced.

16. The method of claim **15**, further comprising coupling the rotating mandrel to the motor by a flex shaft.

17. The method of claim **16**, wherein the first unbalanced mass comprises a cylindrical body having a first central axis and an inner annulus having a second central axis offset from the first central axis.

18. The method of claim **17**, further comprising:
providing a plurality of tuning channels in the first unbalanced mass; and
selectively introducing a high-density material into one or more of the plurality of tuning channels.

19. The method of claim **15**, further comprising a second unbalanced mass coupled to the rotating mandrel.

20. The method of claim **1**, further comprising providing a flow diverter for diverting flow of drilling fluid through a central annulus of the mandrel.

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