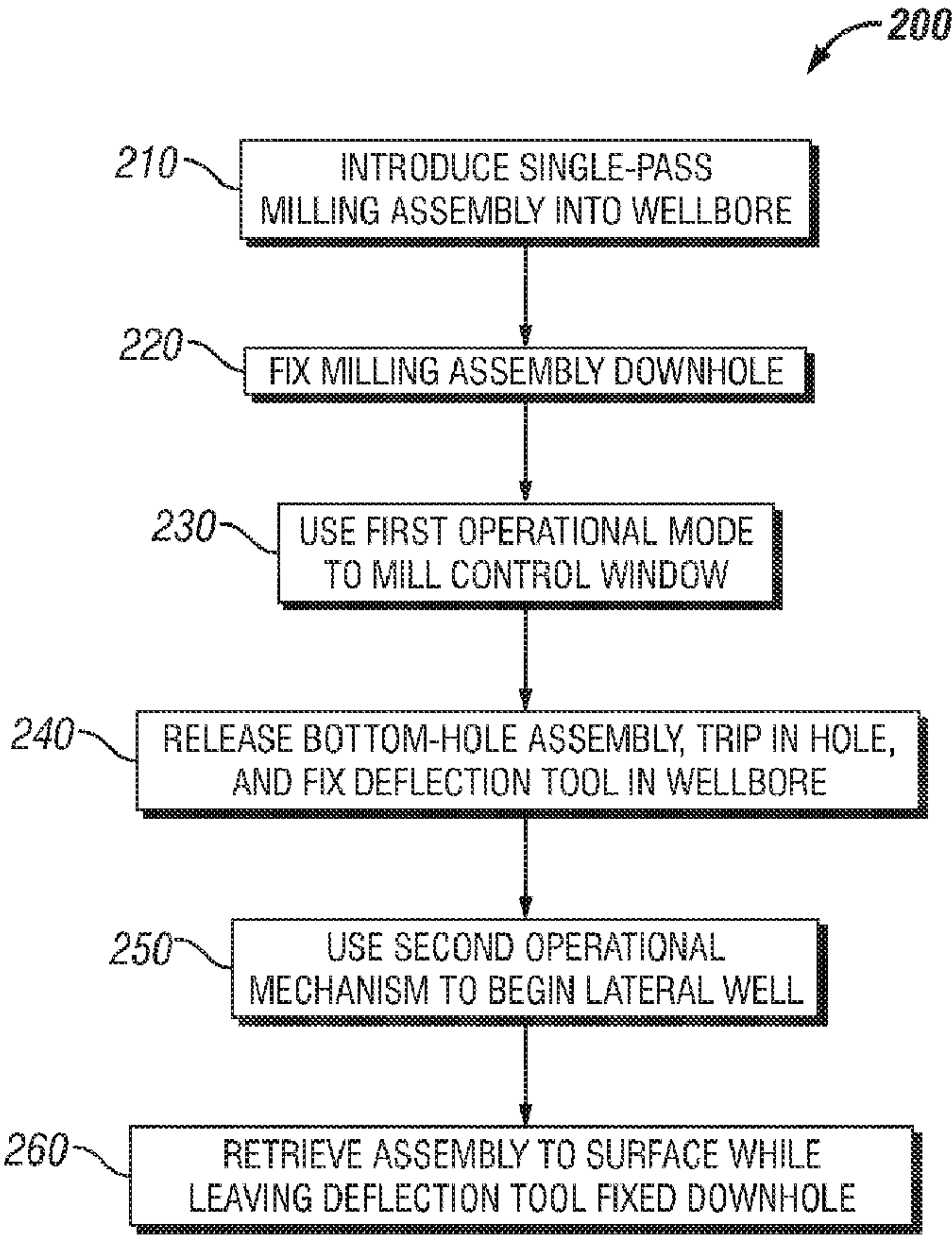




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(54) **Titre : ENSEMBLE DE BROYAGE A PASSAGE UNIQUE**
(54) **Title: SINGLE-PASS MILLING ASSEMBLY**



(57) **Abrégé/Abstract:**
The disclosed embodiments include a single-pass milling assembly for use in multilateral systems. In one embodiment, a first operational mode may be used to create a controlled window in a wellbore casing and a second operational mode may be used to

(57) Abrégé(suite)/Abstract(continued):

begin a lateral wellbore through the controlled window. In certain embodiments, the first operational mode may convert hydraulic energy from a fluid flow to mechanical energy (e.g., using an agitator and power section) to push and rotate a radial mill to create the controlled window. The second operational mode may rotate a drill string to cause an axial mill to mill a rathole through the controlled window. The assembly may create the controlled window and begin the lateral wellbore using only one trip in the wellbore, leaving downhole a fixed deflection tool to provide support for another process that may continue to drill the lateral wellbore.

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(54) **Title:** SINGLE-PASS MILLING ASSEMBLY

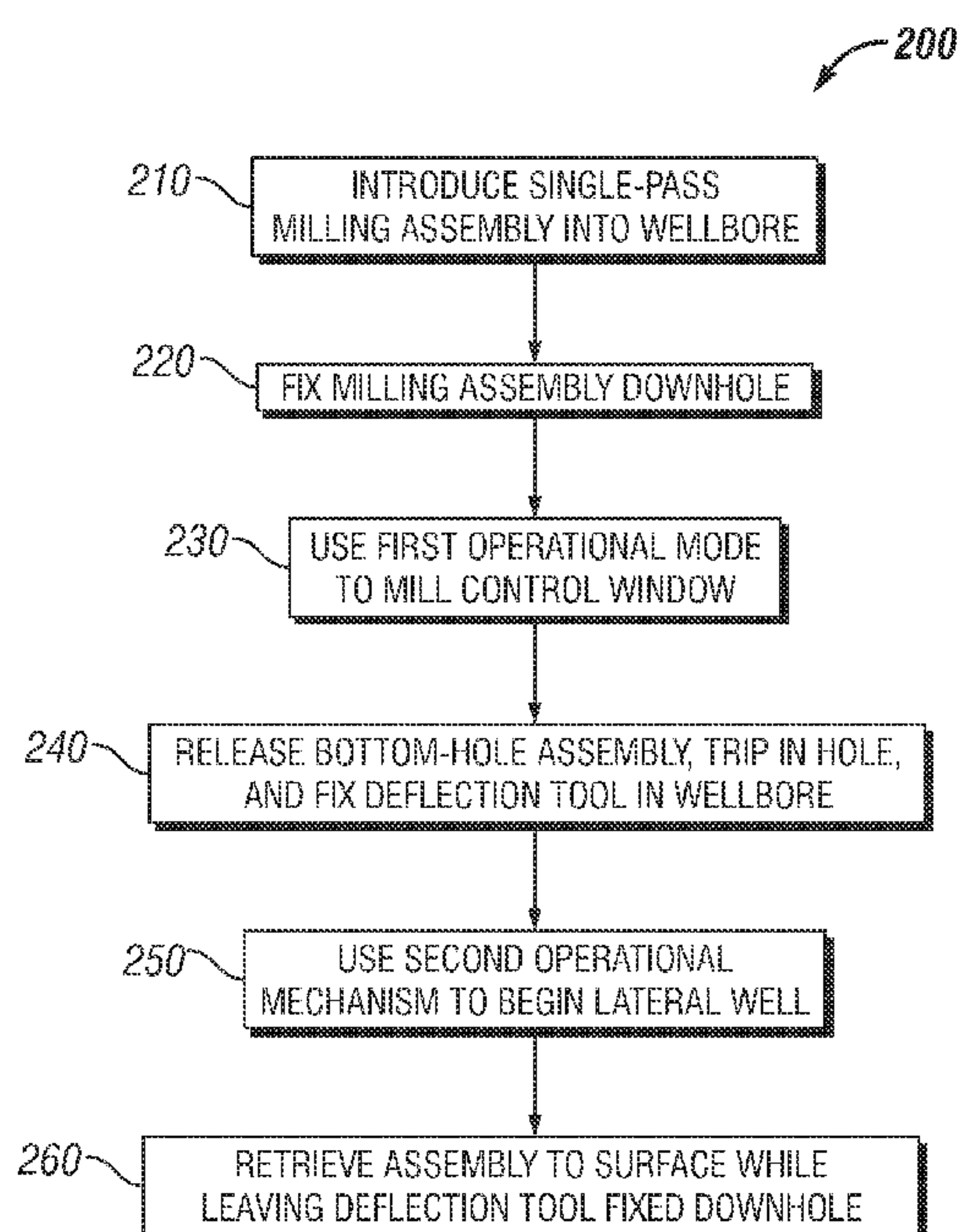


FIG. 2

(57) **Abstract:** The disclosed embodiments include a single-pass milling assembly for use in multilateral systems. In one embodiment, a first operational mode may be used to create a controlled window in a wellbore casing and a second operational mode may be used to begin a lateral wellbore through the controlled window. In certain embodiments, the first operational mode may convert hydraulic energy from a fluid flow to mechanical energy (e.g., using an agitator and power section) to push and rotate a radial mill to create the controlled window. The second operational mode may rotate a drill string to cause an axial mill to mill a rathole through the controlled window. The assembly may create the controlled window and begin the lateral wellbore using only one trip in the wellbore, leaving downhole a fixed deflection tool to provide support for another process that may continue to drill the lateral wellbore.

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SINGLE-PASS MILLING ASSEMBLY

BACKGROUND

The present disclosure relates generally to well drilling operations and, more particularly, to a single-pass milling assembly for multilateral systems.

During well drilling operations, it may be necessary to drill a lateral wellbore off of an existing cased wellbore or to modify the trajectory of a wellbore after a casing has been set. Often in such circumstances, before drilling out the lateral path, wellsite operators use a first mill to create a controlled window in the casing and then a second mill to create a small rathole that begins the lateral path. This typically requires multiple trips of the drill string through the wellbore, which can be time-consuming and expensive.

SUMMARY

In accordance with a general aspect, there is provided a method comprising: introducing an assembly into a first wellbore, wherein said assembly comprises a deflection tool; using a first operational mode of said assembly to create a controlled window in a casing of said first wellbore; fixing said deflection tool in said first wellbore; and using a second operational mode of said assembly to begin a second wellbore through said controlled window.

In accordance with another aspect, there is provided a system comprising: an axial mill coupled to a radial mill, in which said system is operable: (1) in a first operational mode, in which said radial mill creates a controlled window in a casing of a first wellbore; and (2) in a second operational mode, in which said axial mill begins a second wellbore through said controlled window.

In accordance with a further aspect, there is provided a system comprising: a drill string coupled to an axial mill; a whipstock coupled to said drill string; a rotating string disposed within said whipstock; and a radial mill coupled to said rotating string.

FIGURES

Some specific exemplary embodiments of the disclosure may be understood by referring, in part, to the following description and the accompanying drawings.

Figure 1 is a diagram illustrating an offshore oil and gas platform that may employ an exemplary single-pass milling system, according to aspects of the present disclosure.

Figure 2 is a flowchart illustrating an example method for single-pass milling, according to aspects of the present disclosure.

Figures 3A-D are diagrams illustrating a sequence of steps for using an exemplary single-pass milling assembly, according to aspects of the present disclosure.

Figures 4A-B are diagrams illustrating a first operational mode of a single-pass milling assembly, according to aspects of the present disclosure.

FIGS. 5A-C are diagrams illustrating the movement of a radial mill and a displaceable string during a first operational mode of a single-pass milling assembly, according to one or more embodiments.

While embodiments of this disclosure have been depicted and described and are defined by reference to exemplary embodiments of the disclosure, such references do not imply a limitation on the disclosure, and no such limitation is to be inferred. The subject matter disclosed is capable of considerable modification,

alteration, and equivalents in form and function, as will occur to those skilled in the pertinent art and having the benefit of this disclosure. The depicted and described embodiments of this disclosure are examples only, and not exhaustive of the scope of the disclosure.

5

DETAILED DESCRIPTION

The present disclosure relates generally to well drilling operations and, more particularly, to a single-pass milling assembly for multilateral systems.

Illustrative embodiments of the present disclosure are described in detail herein. In the interest of clarity, not all features of an actual implementation may be described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the specific implementation goals, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of the present disclosure.

The terms “couple” or “couples” as used herein are intended to mean either an indirect or a direct connection. Thus, if a first device couples to a second device, that connection may be through a direct connection, or through an indirect electrical or mechanical connection via other devices and connections. The term “upstream” as used herein means along a flow path towards the source of the flow, and the term “downstream” as used herein means along a flow path away from the source of the flow. The term “uphole” as used herein means along the drill string or the hole from the distal end towards the surface, and “downhole” as used herein means along the drill string or the hole from the surface towards the distal end.

It will be understood that the term “oil well drilling equipment” or “oil well drilling system” is not intended to limit the use of the equipment and processes described with those terms to drilling an oil well. The terms also encompass drilling natural gas wells or hydrocarbon wells in general. Further, such wells can be used for production, monitoring, or injection in relation to the recovery of hydrocarbons or other materials from the subsurface. This could also include geothermal wells intended to provide a source of heat energy instead of hydrocarbons.

For purposes of this disclosure, an information handling system may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system may be a personal computer, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. The information handling system may include random access memory (“RAM”), one or more processing resources such as a central processing unit (“CPU”) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. The information handling system may further include a microcontroller, which may be a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Additional components of the information handling system may include one or more disk drives, one or more network ports for communication with external devices as well as various input and output (“I/O”) devices, such as a keyboard, a mouse, and a video display. The information handling system may also include one or more buses operable to transmit communications between the various hardware components.

For the purposes of this disclosure, computer-readable media may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Computer-readable media may include, for example, without limitation, storage media such as a direct access storage device (e.g., a hard disk drive or floppy disk drive), a sequential access storage device (e.g., a tape disk drive), compact disk, CD-ROM, DVD, RAM, ROM, electrically erasable programmable read-only memory (“EEPROM”), and/or flash memory; as well as communications media such as wires.

To facilitate a better understanding of the present disclosure, the following examples of certain embodiments are given. In no way should the following examples be read to limit, or define, the scope of the disclosure. Embodiments of the present disclosure may be applicable to horizontal, vertical, deviated, multilateral, u-tube connection, intersection, bypass (drill around a mid-depth stuck fish and back into the well below), or otherwise nonlinear wellbores in any type of subterranean

formation. Embodiments may be applicable to injection wells, and production wells, including natural resource production wells such as hydrogen sulfide, hydrocarbons or geothermal wells; as well as borehole construction for river crossing tunneling and other such tunneling boreholes for near-surface construction purposes or borehole u-
5 tube pipelines used for the transportation of fluids such as hydrocarbons. Embodiments described below with respect to one implementation are not intended to be limiting.

FIG. 1 illustrates an offshore oil and gas platform 100 that may employ an exemplary single-pass milling system as described herein, according to one or
10 more embodiments. Even though FIG. 1 depicts an offshore oil and gas platform 100, it will be appreciated by those skilled in the art that the various embodiments discussed herein are equally well suited for use in conjunction with other types of oil and gas rigs, such as land-based oil and gas rigs or rigs located at any other geographical site. In the illustrated embodiment, however, the platform 100 may be a
15 semi-submersible platform 102 centered over a submerged oil and gas formation 104 located below the sea floor 106. A subsea riser or conduit 108 extends from the deck 110 of the platform 102 to a wellhead installation 112 arranged on the sea floor 106 and including one or more blowout preventers 114. The platform 102 has a hoisting apparatus 116 and a derrick 118 for raising and lowering pipe strings, such as a drill
20 string 120, within the subsea conduit 108.

As depicted, a main wellbore 122 has been drilled through the various earth strata, including the formation 104. The terms “parent” and “main” wellbore are used herein interchangeably to designate a wellbore from which another wellbore is drilled. It is to be noted, however, that a parent or main wellbore does not necessarily
25 extend directly to the earth's surface, but could instead be a branch of another wellbore. A casing string 124 is at least partially cemented within the main wellbore 122. The term “casing” is used herein to designate a tubular string used to line a wellbore. In some applications, the casing may be of the type known to those skilled in the art as “liner” and may be a segmented liner or a continuous liner, such as coiled
30 tubing.

As depicted, a branch or lateral wellbore 128 may be drilled according to one or more embodiments of the single-pass milling system and method discussed

below. The terms “branch” and “lateral” wellbore are used herein to designate a wellbore which is drilled outwardly from its intersection or junction with another wellbore, such as the parent or main wellbore 122. Moreover, a branch or lateral wellbore may have another branch or lateral wellbore drilled outwardly therefrom, without departing from the scope of the disclosure. A casing joint 126 may be interconnected between elongate portions or lengths of the casing string 124 and positioned at a desired location within the wellbore 122 where the branch or lateral wellbore 128 is drilled. Accordingly, the casing joint 126 effectively forms an integral part of the casing string 124.

10 A whipstock assembly 130, or another type of mill guide known to those skilled in the art, may be positioned within the casing string 124 and/or the casing joint 126. The whipstock assembly 130 may be configured to facilitate one or more cutting tools (i.e., mills) to define a casing exit 132 in the inner wall of the casing joint 126 at a desired circumferential location. The casing exit 132 provides a
15 “window” in the casing joint 126 through which one or more other cutting tools (i.e., drill bits) may be inserted in order to drill the lateral wellbore 128.

It will be appreciated by those skilled in the art that even though FIG. 1 depicts a vertical section of the main wellbore 122, the embodiments described herein are equally applicable for use in wellbores having other directional configurations including horizontal wellbores, deviated wellbores, slanted wellbores, combinations
20 thereof, and the like. Moreover, use of directional terms such as above, below, upper, lower, upward, downward, uphole, downhole, and the like are used in relation to the illustrative embodiments as they are depicted in the figures, the upward direction being toward the top of the corresponding figure and the downward direction being toward the bottom of the corresponding figure, the uphole direction being toward the
25 surface of the well and the downhole direction being toward the toe of the well.

FIG. 2 is a flowchart illustrating an example method for single-pass milling 200 as described herein, according to one or more embodiments. At step 210, a single-pass milling assembly may be introduced into a wellbore (such as wellbore
30 122 in the embodiment of FIG. 1).

At step 220, a single-pass milling assembly may be fixed downhole in the wellbore. The single-pass milling assembly may be fixed axially and radially into

a casing string (such as the casing string 124 in the embodiment of FIG. 1) at the proper and most efficient depth and orientation for the desired location of a controlled window in the casing string. The outside string of the single-pass milling assembly may act as a platform to create the controlled window. An anchor latch may be used
5 to fix the single-pass milling assembly and may include various tools and tubular lengths interconnected in order to rotate and align the milling tool (both radially and axially) to the exit angle orientation and axial well depth of the desired controlled window. In certain embodiments, the anchor latch may be a Sperry multilateral latch or coupling system available from Halliburton Energy Services, Inc. of Houston, TX,
10 USA. In other embodiments, the anchor latch may be a muleshoe orienting guide with a no-go and shear latch combination, or any other mechanical means known to those of skill in the art to locate the single-pass milling assembly both on specific depth within the main wellbore and at the desired exit angle orientation.

At step 230, a first operational mode of the single-pass milling
15 assembly may be used to mill the controlled window in a casing string (such as the casing string 124 in the embodiment of FIG. 1). The controlled window may be an opening of predetermined dimension, contour geometry, location, and orientation (such as the casing exit 132 in the embodiment of FIG. 2). In certain embodiments, the controlled window may be used to modify the trajectory of an existing wellbore
20 after a casing has been set. In other embodiments, the controlled window may be used as a branch point to drill a new lateral wellbore (such as the lateral wellbore 128 in the embodiment of FIG. 1) off of a parent wellbore.

At step 240, the latching mechanism may be released to allow the outside string of the single pass milling assembly to trip in the hole, and a deflection
25 tool (such as the whipstock 130 in the embodiment of FIG. 1) may be fixed in the wellbore so as to align a deflection angle of the deflection tool with the controlled window. The deflection tool may be fixed using any of the means discussed with respect to step 220, such as a Sperry multilateral latch or coupling system, to rotate and align the deflection tool (both radially and axially) to the controlled window.

30

At step 250, a second operational mode of the single-pass milling assembly may be used to begin a lateral wellbore at the controlled window milled in

step 220. In certain embodiments, beginning the lateral wellbore may comprise milling a rathole (e.g., a hole of 8-12 meters that may be used as a starter and/or guide for later drilling). This step may optionally include widening the controlled window milled in step 230.

5 At step 260, the single-pass milling assembly may be retrieved to the surface while the deflection tool, previously installed in step 240, remains fixed (axially and radially) downhole. The fixed deflection tool may provide an effective orientation exit for conventional drilling systems to complete the lateral wellbore (e.g., rathole) begun at step 250. In alternative embodiments, continuing the lateral
10 wellbore may be achieved using the single-pass milling assembly. In certain embodiments, this may be accomplished by continuing to employ the second operational mode of the single-pass milling assembly that was used to begin the lateral wellbore (step 250) or, alternatively, by using a third operational mode of the single-pass milling assembly.

15 The method steps of the embodiment of FIG. 2 may be performed in a different order than illustrated in FIG. 2. For example, fixing a deflection tool in the wellbore (step 240) does not necessarily occur between using the first operational mode of the single-pass milling assembly (step 230) and using the second operational mode of the single-pass milling assembly (step 250). Thus, in certain alternative
20 embodiments, fixing a deflection tool in the wellbore may occur before using the first operational mode (step 230) or after using the second operational mode (step 250).

FIGS. 3A-D illustrate a sequence of steps for using an exemplary single-pass milling assembly 300, according to one or more embodiments. In the exemplary embodiments of FIGS. 3A-D, a drill string 320 is shown deployed into a
25 wellbore 322, which is drilled into formation 304 and lined with casing string 324. The casing string 324 may be coupled to the formation 304 by a cement layer 323. In certain embodiments, drill string 320 may include an axial mill 350 and, optionally, a watermelon mill 352. The single-pass milling assembly may also include a deflection tool, shown in FIGS. 3A-D as a whipstock 330.

30 In the embodiment of FIGS. 3A-D, the whipstock 330 is shown with an integrated milling system comprising a radial mill 342 and a milling track 344. In at least one embodiment, the milling system 340 may be the First Pass MILLRITE®

system, commercially available from Halliburton Energy Services, Inc. of Houston, TX, USA. In other embodiments, however, the milling system 340 may be any multilateral milling system known to those skilled in the art. For example, the milling system 340 may be any milling system that is able to mill a casing exit 332 in the casing string 324 (and, optionally, the cement layer 323) and subsequently facilitate drilling into the surrounding subterranean formation 304 to form a lateral wellbore.

The whipstock 330 may be coupled to the drill string 320 so that they may be introduced together into the wellbore 322. In the embodiment of FIGS. 3A-C, the drill string 320 is coupled to the whipstock 330 via a sleeve 355 and a shear bolt 325. As discussed below in more detail with respect to the embodiment of FIG. 3D, the drill string 320 may be configured to decouple from the whipstock 330. The whipstock may have a latch 360 designed to interface with a first latch point 362 and a second latch point 364 of the casing string 324. In this way, the drill string 320 may be used to introduce the whipstock 330 into the wellbore 322, position the whipstock 330 by interfacing the latch 360 with either of the first latch point 362 or the second latch point 364, and then retract from the wellbore 322 while leaving the whipstock 330 fixed in place.

Referring now to FIG. 3A, the exemplary single-pass milling assembly 300 is shown to be deployed into the wellbore 322, with whipstock 330 positioned at first latch point 362. The first latch point 362 may be located in the hole such that when the whipstock 330 is latched to the first latch point 362, the milling system 340 (and particularly the radial mill 342) may align with a desired location to mill a controlled window in the casing string 324.

Referring now to FIG. 3B, the exemplary single-pass milling assembly 300 is shown to have used a first operational mode to cause the milling system 340 to mill a controlled window 332 in the casing string 324 and, optionally, the cement layer 323. In the embodiment shown, where the milling system 340 comprises the radial mill 342 and the milling track 344, the first operational mode may cause the radial mill 342 to rotate and mill the casing string 324 and the cement layer 323 across the length of the milling track 344. In this way, the controlled window 332 may be of the desired dimension, contour geometry, location, and orientation. Although a variety of techniques known to those of skill in the art may be used to achieve the first

operational mode of the single-pass milling assembly 300, an embodiment using fluid flow is described below in detail with respect to FIG. 4.

Referring now to FIG. 3C, the exemplary single-pass milling assembly 300 is shown to have repositioned the whipstock 330 at the second latch point 364. This may be accomplished by a surface operator pushing or pulling on the drill string 324 to unlatch the latch 360 from the first latch point 362 and then repositioning the drill string 324 to align the latch 360 with the second latch point 364. The second latch point 364 may be located in the hole such that when the whipstock 330 is latched to the second latch point 364, the deflection angle from the whipstock 330 aligns with the controlled window 332 in the casing string 324.

Referring now to FIG. 3D, the exemplary single-pass milling assembly 300 is shown to have used a second operational mode to cause the axial mill 350 and the watermelon mill 352 to mill a rathole 334 through the controlled window 332. Although a variety of techniques known to those of skill in the may be used to achieve the second operational mode of the single-pass milling assembly 300, the embodiment shown in FIG. 3D may use rotational and downward force from the drill string 320. In particular, a surface operator may cause the drill string 320 to rotate and push downhole with sufficient force to cause axial mill 350 to shear the shearbolt 325 and mill away the sleeve 355. In this way, the drill string 320 may be decoupled from the whipstock 330. To facilitate the decoupling, the sleeve 355 may be composed of a relatively weaker material that is susceptible to milling by the axial mill 350 (e.g., aluminum) while the whipstock 330 may be composed of a relatively stronger material that is not susceptible to milling by the axial mill 350 (e.g., carbide).

After milling the sleeve 355, the drill string 320 (along with the axial mill 350) may be deflected by the whipstock 330 into the controlled window 322. Continued downward force and rotation of the drill string 320 will cause the axial mill 350 to mill out of the controlled window 332, into the formation 304, and create the rathole 334. In embodiments where the drill string 320 also includes the watermelon mill 352, the second operational mode of the single-pass milling assembly may also widen the controlled window 332 and result in the rathole 334 having greater diameter.

In certain embodiments, the drill string 320 may be tripped out of the wellbore 322 after milling rathole 334, leaving behind whipstock 330. Another drill string, configured for drilling using any of the various means known to those of skill in the art, may then be introduced into the wellbore 322. That drill string may be
5 deflected off the whipstock 330 into the rathole 334 and then used to drill a lateral well.

Optionally, the whipstock 330 may include mechanisms (not shown) to facilitate later retrieval by using a washover. In certain embodiments, the outside edge of the whipstock 330, in the annulus between the whipstock 330 and the casing string
10 324, may include an elastomer such as hydrogenated nitrile (HNBR). The HNBR may be color-coded so that during washover operations, colors may be identified in the return flow of drilling fluid to determine the relative position of the washover to the whipstock 330. For example, a yellow-colored HNBR may be located near the top of the whipstock 330 so that when the washover makes initial contact with the whipstock
15 330 and effaces that layer of HNBR, the return flow of drilling fluid will be yellow. An orange-colored HNBR may be located further down the whipstock 330, etc. In this way, the whipstock 330 may be accurately located and gripped by a washover tool for removal from the wellbore 322.

FIGS. 4A-B illustrate an exemplary first operational mode of a single-
20 pass milling assembly 400, according to one or more embodiments. The embodiment of FIGS. 4A-B depict a formation 404, drill string 420, a wellbore 422, a cement layer 423, a casing string 424, a first latch point 462, a shear bolt 425, a whipstock 430, a milling system 440, a radial mill 442, a milling track 444, an axial mill 450, a watermelon mill 452, a sleeve 455, and a latch 460, one or more of which may be
25 similar to corresponding elements in the embodiments of FIGS. 3A-D.

In the embodiment of FIGS. 4A-B, the milling system 440 further comprises a guide 446 (also known as a “guide block,” “traveling guide block,” or a “mill block”), which may generally support and guide the radial mill 442 within the whipstock 430. As illustrated, the whipstock 430 may define or otherwise form a
30 milling track 444. As the radial mill 442 advances downhole, the guide 446 translates axially along the milling track 444, which may include a ramp portion (not shown) that gradually urges the rotating radial mill 442 into contact with an inner surface of

the casing string 424 and, optionally, the cement layer 423, thereby milling the formation of a controlled window. As the radial mill 442 continues advancing downhole, the guide 446 moves along the milling track 444 and the axial length or opening of the controlled window is correspondingly extended until the guide block
5 reaches the end of the milling track 444. In this way, the interaction of the guide 446 with the milling track 444 may control the dimensions of the controlled window to be milled into the casing string 424 and the cement layer 423.

In the embodiment of FIGS. 4A-B, a displaceable string 470 may be located within the sleeve 455. A rotating string 480 may be located within the
10 displaceable string 470 and may be coupled to the displaceable string 470 and to the radial mill 442. The displaceable string 470 and the rotating string 480 may be held in place using a locking mechanism 474 that may couple to the sleeve 455 or the whipstock 430. In certain embodiments, the rotating string 480 may not be a separate string from the displaceable string 470, but instead may be a rotatable section of the
15 displaceable string 470.

In certain embodiments of the first operational mode of the single-pass milling assembly 400, the locking mechanism 474 may be unlocked, allowing the displaceable string 470 and rotating string 480 to displace in a downhole direction. Additionally, while displacing in a downhole direction, rotating string 480 may rotate.
20 In certain embodiments, the conversion of hydraulic energy to mechanical energy may generate the force causing the downhole displacement of the displaceable string 470 and the downhole displacement and rotation of the rotating string 480.

FIG. 4B illustrates one embodiment where hydraulic energy may be provided by a fluid flow 490, which may be a flow of drilling fluid (such as drilling
25 mud) controlled by a surface operator and pumped down the drill string 420. The flow of fluid flow 490 may be facilitated by sleeve 455, which may create a differential pressure in the fluid flow 490 by preventing commingling between the fluid flow 490 flowing downhole through sleeve 455 and the fluid flow 490 flowing uphole through wellbore 422. The sleeve 455 may optionally include a section of relatively narrow
30 diameter in order to maintain or increase that differential pressure.

In FIG. 4B, the pressure from the fluid flow 490 is shown to have unlocked the locking mechanism 474. Axial seals 472 may be provided in the annulus

between the displaceable string 470 and the sleeve 455 in order to prevent the flow of the fluid flow 490 from entering the annulus as the displaceable string 470 and the rotating string 480 displace downhole. In this way, the differential pressure of the fluid flow 490 may be maintained and the fluid flow 490 may be directed into the displaceable string 470 and, subsequently, into the rotating string 480 as shown in FIG. 4B.

In certain embodiments of the first operational mode, the rotating string 480 may include a mechanism for converting hydraulic energy to axial force, such as an agitator 484. The rotating string 480 may also include a mechanism for converting hydraulic energy to torque, such as a power section 486. The flow of fluid flow 490 through the rotating string 480, including the agitator 484 and the power section 486, may therefore cause the agitator 484 to generate a downhole force and the power section 486 to generate torque. The downhole force generated by the agitator 484 may result in the downhole displacement of the displaceable string 470 and the rotating string 480. Similarly, the torque generated by the power section 486 may result in the rotation of rotating string 480. The rotating string 480 may optionally include a float valve 482, which may limit the fluid flow 490 to a one-way flow into the rotating string 480 from the displaceable string 470. In certain embodiments, this may facilitate keeping the agitator 484 and power section 486 lubricated by preventing leaks of the fluid flow 490 out of the rotating string 480 and back into the displaceable string 470.

As a result of the rotating string 480 displacing downhole and rotating, the radial mill 442 may also rotate while displacing downhole along the milling track 444 until the guide 446 reaches the end of the milling track 444. In this way, the first operational mode of the single-pass milling assembly 400 may cause the radial mill 442 to mill a controlled window in the casing string 424 and, optionally, the cement layer 432 along the milling track 444. The coupling between the rotating string 480 and the radial mill 442 may optionally include a transmission 492 to facilitate the smooth transmission of axial and rotational force from the rotating string 480 to the radial mill 442. Similarly, the coupling between the rotating string 480 and the radial mill 442 may optionally include a bearing section 494 to facilitate the smooth rotation of radial mill 442. In certain embodiments, the bearing section 494 may be fluid-

lubricated, and in such embodiments at least some amount of the fluid flow 490 may be directed through the bearing section 494. In alternative embodiments, other types of bearings known to those of skill in the art may be used (e.g., oil bearings).

During milling, the fluid flow 490 may capture debris and return it to the surface by flowing uphole through whipstock 430 and wellbore 422. When the guide 446 reaches the end of the milling track 444, a surface operator may observe a decrease in differential pressure and thereby know that the controlled window has been milled. The surface operator may subsequently stop pumping fluid and, if desired, proceed toward initiating a second operational mode of the single-pass milling assembly 400.

FIGS. 5A-C illustrate the movement of a radial mill 542 and a displaceable string 570 during an exemplary first operational mode of a single-pass milling assembly 500, according to one or more embodiments. The embodiment of FIGS. 5A-C depict a formation 504, a wellbore 522, a cement layer 523, a casing string 524, a whipstock 530, a milling system 540, a radial mill 542, a milling track 544, a guide 546, a sleeve 555, a latch 560, a first latch point 562, axial seals 572, a locking mechanism 574, a rotating string 580, a float valve 582, an agitator 584, a power section 586, a transmission 592, and a bearing section 594, one or more of which may be similar to corresponding elements in the embodiments of FIGS. 4A-B.

In the embodiment of FIG. 5A, the radial mill 542 and the displaceable string 570 are shown prior to the initialization of the first operational mode. The radial mill 542 is shown to be at the beginning of the milling track 544 such that the radial mill 542 is not in contact with the casing string 542. The displaceable string 570 is shown to not have displaced within the sleeve 555, and the locking mechanism 574 may be locked.

In the embodiment of FIG. 5B, the radial mill 542 and the displaceable string 570 are shown during the first operational mode. The displaceable string 570 is shown to have displaced in a downhole direction within the sleeve 555. The displacement of the displaceable string 570 may cause the radial mill 542 to displace in a downhole direction along the milling track 544. The milling track 544 may include a first ramp 547 to cause the radial mill 542 to displace toward the formation 504 as it travels along the milling track 544. The first ramp 547 may be of sufficient

height to cause the radial mill 542 to mill a controlled window 532 of desired depth in the casing string 524 and, optionally, the cement layer 523. As also shown in FIG. 5B, one or more components of the single-pass milling assembly 500 may be sufficiently flexible to accommodate the outward displacement of the radial mill 542.

5 In the embodiment of FIG. 5C, the radial mill 542 and the displaceable string 570 are shown after the completion of the first operational mode. The displaceable string 570 is shown to have further displaced in a downhole direction within the sleeve 555. The further displacement of the displaceable string 570 may cause the radial mill 542 to displace in a downhole direction along the milling track
10 544 until the guide 546 reaches the end of the milling track 544. The milling track 544 may include a second ramp 548 to cause the radial mill 542 to displace away from the formation 504 as it travels further along the milling track 544. The second ramp 548 may be of sufficient height to cause the radial mill 542 to no longer contact the casing string 542. In this way, the heights of the first ramp 547 and the second ramp 548 may
15 be used to control the depth of the controlled window 532, and the distance between the first ramp 547 and the second ramp 548 may be used to control the length of the controlled window.

 According to aspects of the present disclosure, an embodiment is a method comprising introducing an assembly into a first wellbore, wherein the
20 assembly comprises a deflection tool; using a first operational mode of the assembly to create a controlled window in a casing of the first wellbore; fixing the deflection tool in the first wellbore; and using a second operational mode of the assembly to begin a second wellbore through the controlled window.

 In certain embodiments, the second operational mode may further
25 comprise rotating a drill string coupled to the assembly. In certain embodiments, the first operational mode may further comprise causing a fluid to flow through the drill string and into the assembly. In certain embodiments the first operational mode further comprises converting hydraulic energy from the fluid to rotational force.

 In any one of the embodiments described in the preceding two
30 paragraphs, the method may further comprise decoupling the drill string from the deflection tool. In certain embodiments, the deflection tool may be a whipstock. In any one of the embodiments described in the preceding two paragraphs, the method

may further comprise repositioning the deflection tool in the first wellbore between using the first operational mode and using the second operational mode.

According to aspects of the present disclosure, an embodiment is a system comprising an axial mill coupled to a radial mill, in which the system is operable: (1) in a first operational mode, in which the radial mill creates a controlled window in a casing of a first wellbore; and (2) in a second operational mode, in which the axial mill begins a second wellbore through the controlled window.

In certain embodiments, the second operational mode may further comprise rotating a drill string coupled to the axial mill. In certain embodiments, the first operational mode may further comprise rotating the radial mill using a differential pressure. In certain embodiments, the first operational mode may further comprise creating the differential pressure by causing a fluid to flow through a drill string coupled to the radial mill. In certain embodiments, the first operational mode may further comprise converting hydraulic energy of the fluid to a rotational force.

An embodiment is a system comprising a drill string coupled to an axial mill, a whipstock coupled to the drill string, a rotating string disposed within the whipstock, and a radial mill coupled to the rotating string.

In certain embodiments, the rotating string may further comprise a power section. In certain embodiments, the rotating string may further comprise an agitator. In certain embodiments, the rotating string may be coupled to a displaceable string. In certain embodiments, one or more fluid seals may be disposed in an annulus between the displaceable string and the whipstock.

In any of the embodiments of the preceding two paragraphs,, the rotating string may further comprise a float valve. In any of the embodiments of the preceding two paragraphs,, the radial mill may be coupled to the rotating string via a transmission. In any of the embodiments of the preceding two paragraphs, the radial mill may be coupled to the transmission via a bearing section.

Therefore, the present disclosure is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are

intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present disclosure. Also, the terms in the claims

5 have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. The indefinite articles “a” or “an,” as used in the claims, are defined herein to mean one or more than one of the element that it introduces. Additionally, the terms “couple” or “coupled” or any common variation as used in the detailed description or claims are not intended to be limited to a direct coupling. Rather, two

10 elements may be coupled indirectly and still be considered coupled within the scope of the detailed description and claims.

What is claimed is:

1. A method comprising:
 introducing an assembly into a first wellbore, wherein said assembly
 comprises a deflection tool;
 5 using a first operational mode of said assembly to create a controlled
 window in a casing of said first wellbore;
 fixing said deflection tool in said first wellbore; and
 using a second operational mode of said assembly to begin a second
 wellbore through said controlled window.
 10
2. The method of claim 1, wherein using said second operational mode
 further comprises rotating a drill string coupled to said
 assembly.
- 15 3. The method of claim 2, wherein using said first operational mode
 further comprises causing a fluid to flow through said drill
 string and into said assembly.
- 20 4. The method of claim 3, wherein using said first operational mode
 further comprises converting hydraulic energy from said fluid
 to rotational force.
5. The method of claim 1, 2, 3, or 4, further comprising decoupling said
 drill string from said deflection tool
 25
6. The method of claims 5, wherein said deflection tool is a whipstock.
7. The method of claim 1, 2, 3, or 4 further comprising repositioning said
 deflection tool in said first wellbore between using said first
 30 operational mode and using said second operational mode.
8. A system comprising:

an axial mill coupled to a radial mill, in which said system is operable:

(1) in a first operational mode, in which said radial mill creates a controlled window in a casing of a first wellbore; and

5 (2) in a second operational mode, in which said axial mill begins a second wellbore through said controlled window.

9. The system of claim 8, wherein said second operational mode comprises rotating a drill string coupled to said axial mill.

10 10. The system of claim 9, wherein said first operational mode further comprises rotating said radial mill using a differential pressure.

11. The system of claims 10, wherein said first operational mode further comprises creating said differential pressure by causing a fluid
15 to flow through a drill string coupled to said radial mill.

12. The system of claim 11, wherein said first operational mode further comprises converting hydraulic energy of said fluid to a rotational force.

20 13. A system comprising:
a drill string coupled to an axial mill;
a whipstock coupled to said drill string;
a rotating string disposed within said whipstock; and
25 a radial mill coupled to said rotating string.

14. The system of claim 13, wherein said rotating string further comprises a power section.

30 15. The system of claim 14, wherein said rotating string further comprises an agitator.

16. The system of claim 15, wherein said rotating string is coupled to a displaceable string.
17. The system of claim 16, wherein one or more fluid seals are disposed in an annulus between said displaceable string and said whipstock.
18. The system of claim 13, 14, 15, 16, or 17, wherein said rotating string further comprises a float valve.
19. The system of claim 13, 14, 15, 16, or 17, wherein said radial mill is coupled to said rotating string via a transmission.
20. The system of claim 19, wherein said radial mill is coupled to said transmission via a bearing section.

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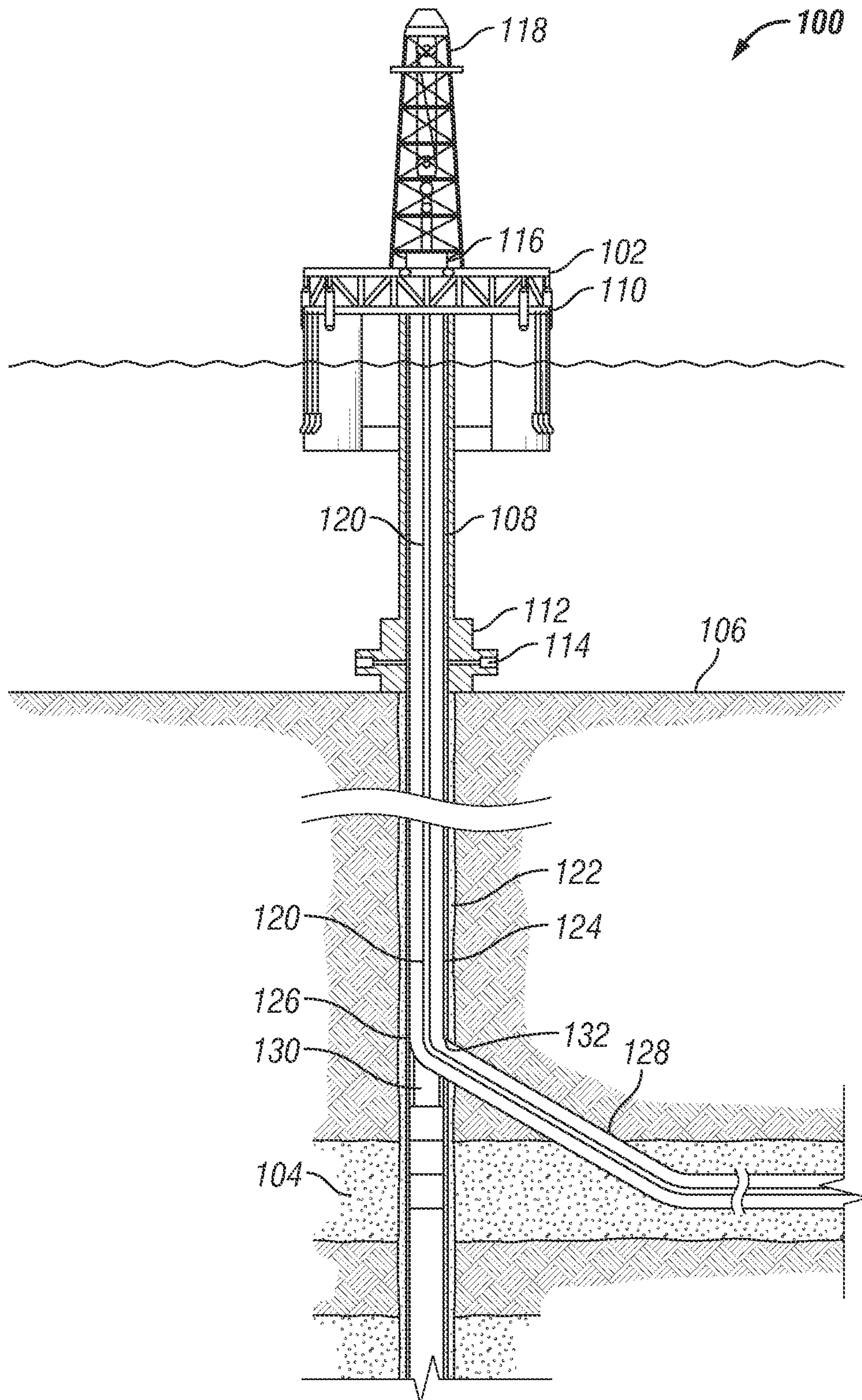


FIG. 1

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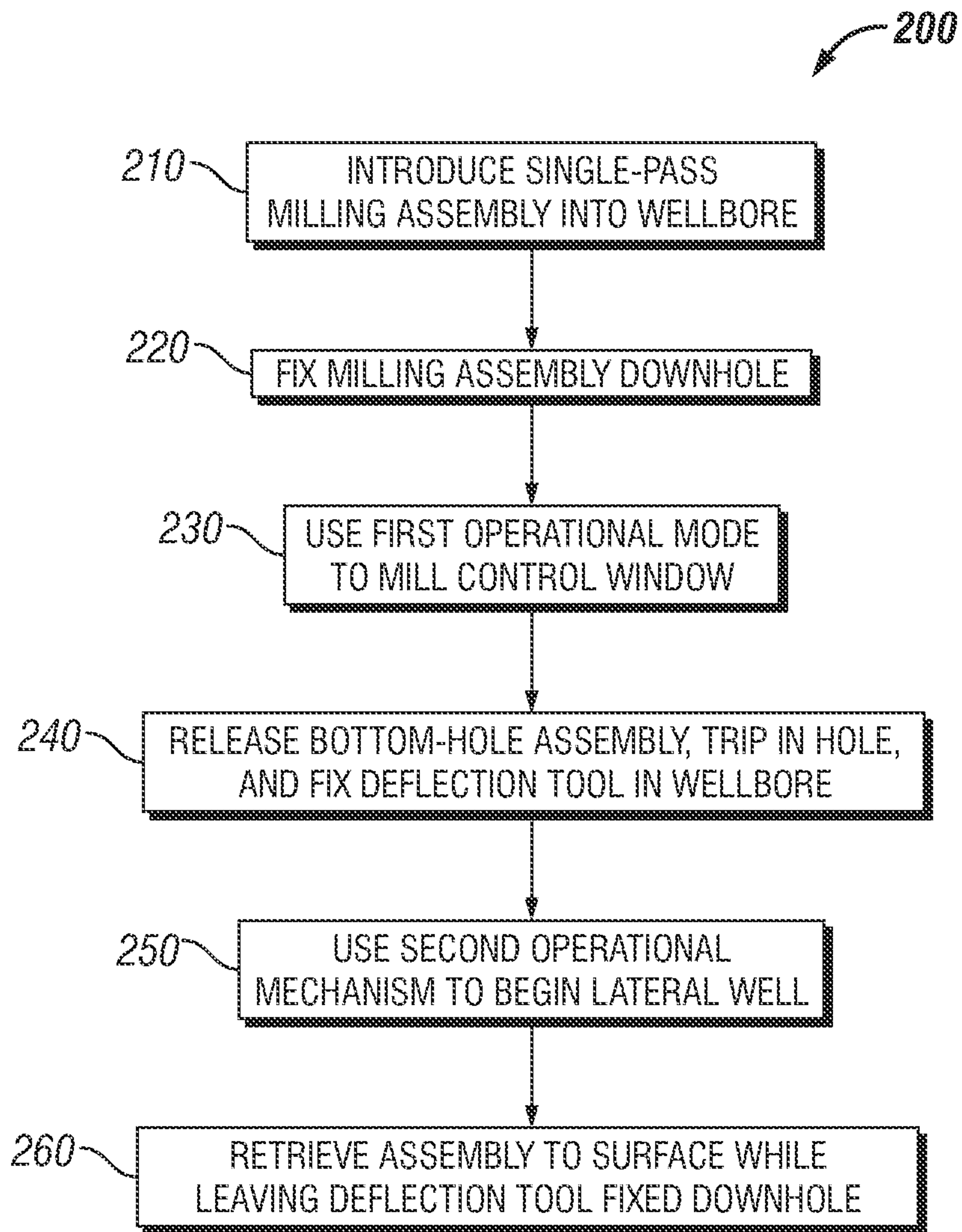


FIG. 2

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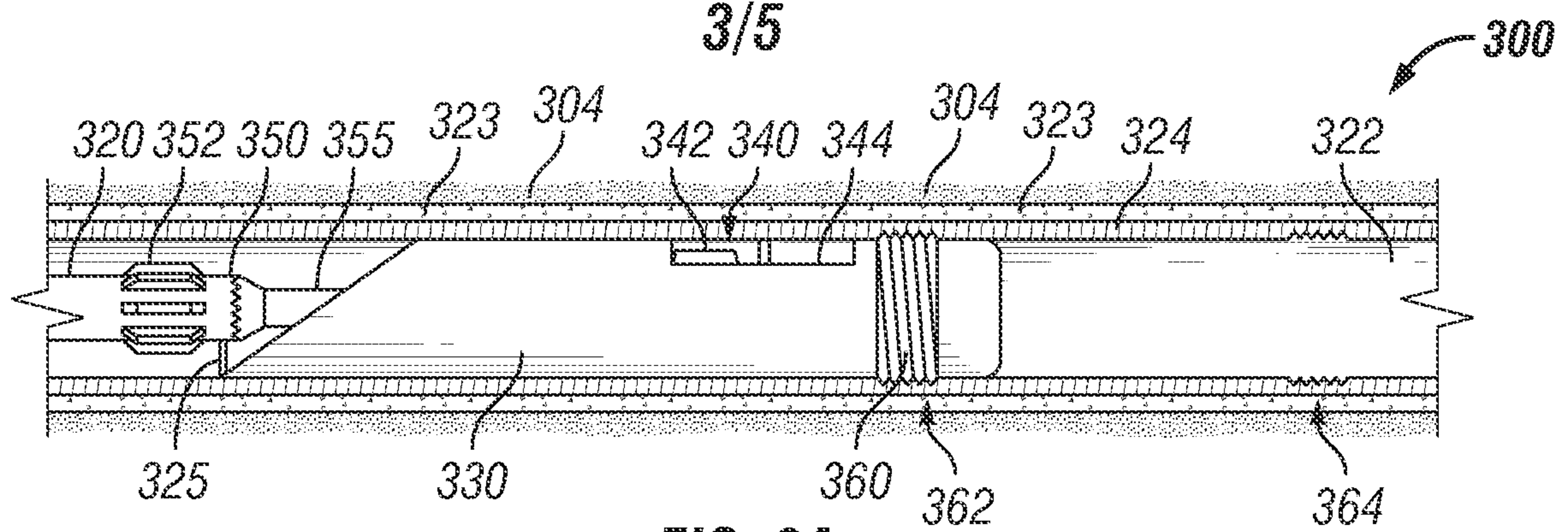


FIG. 3A

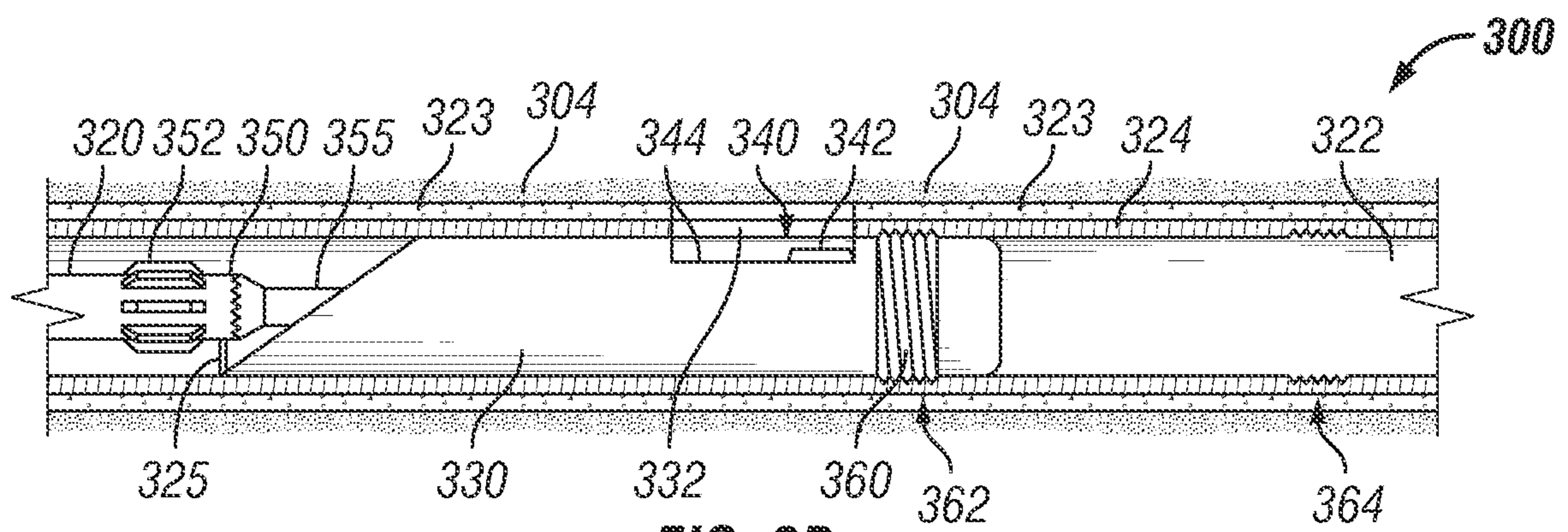


FIG. 3B

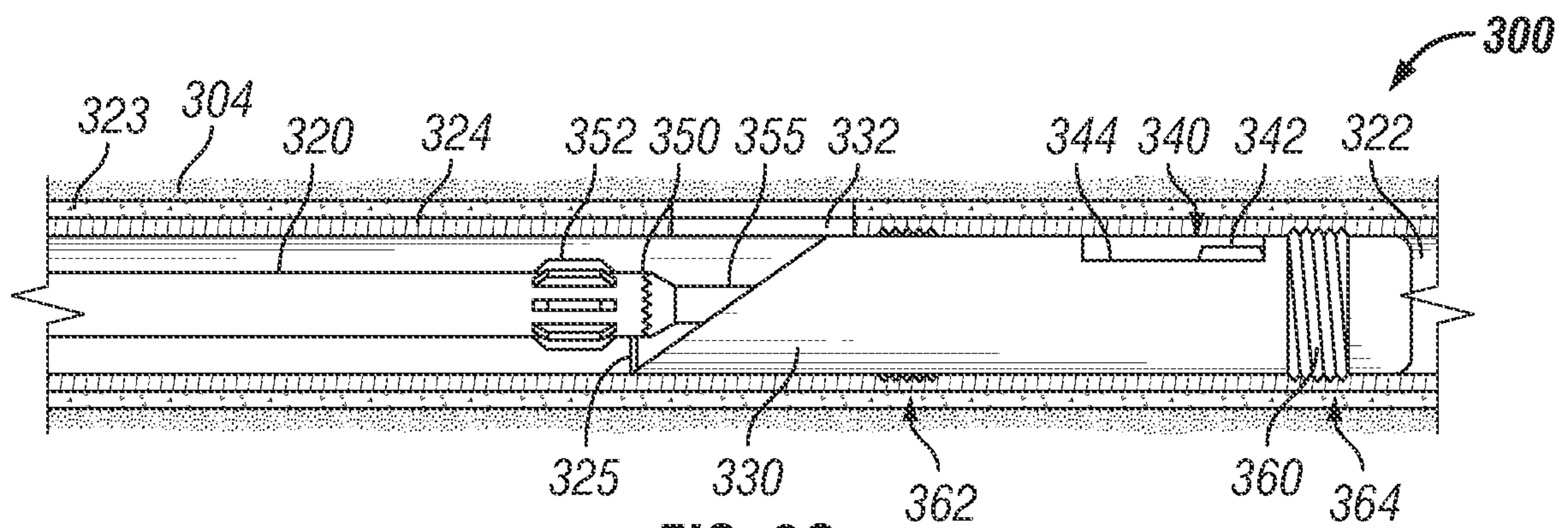


FIG. 3C

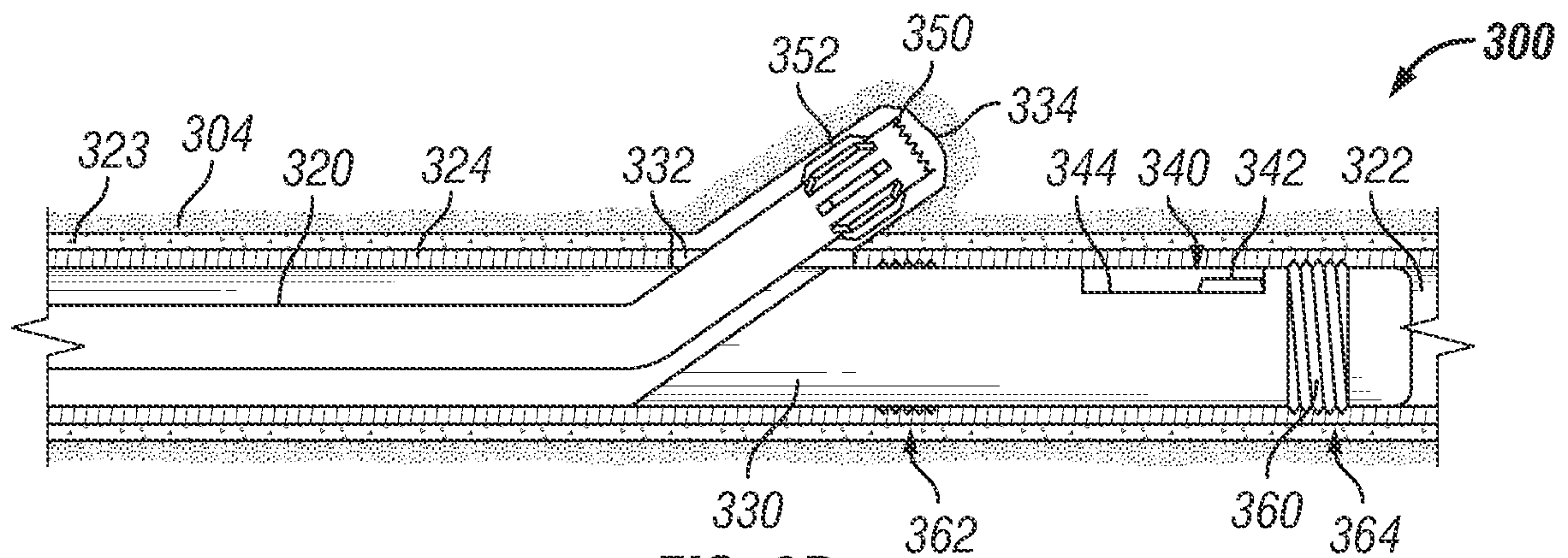


FIG. 3D

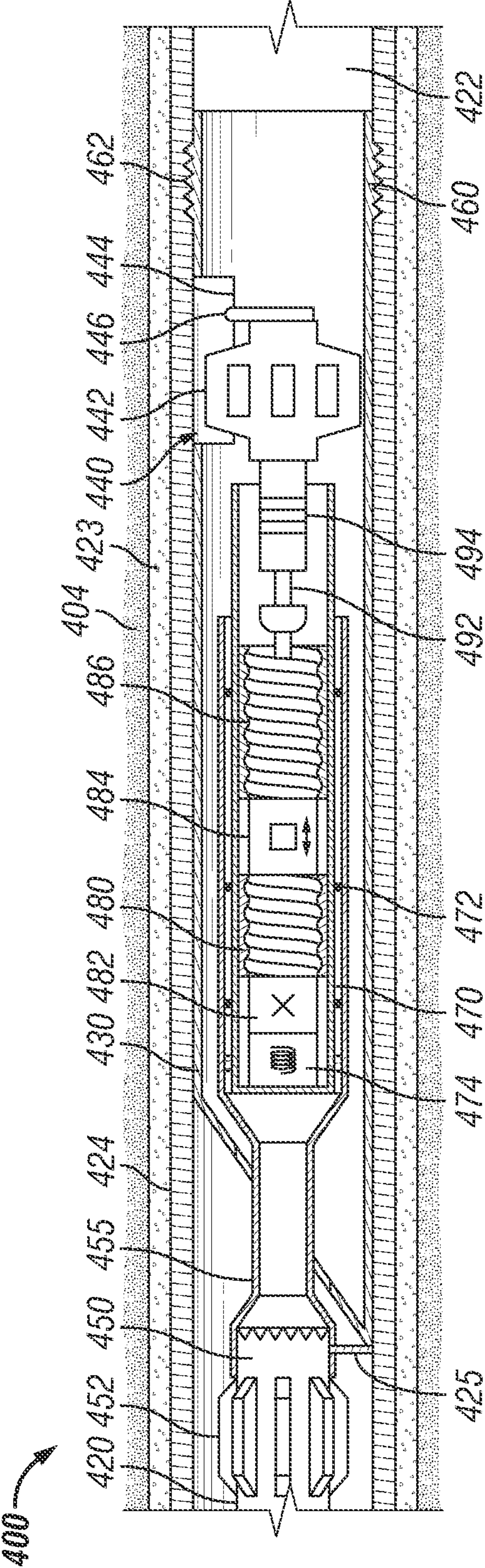


FIG. 4A

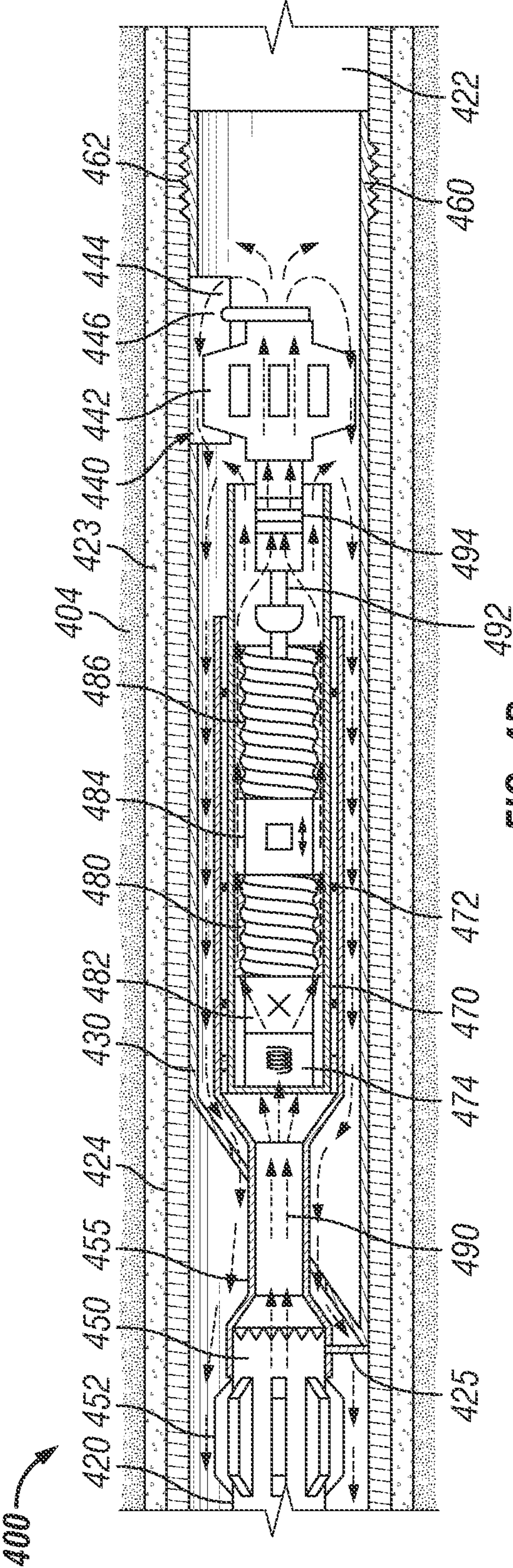
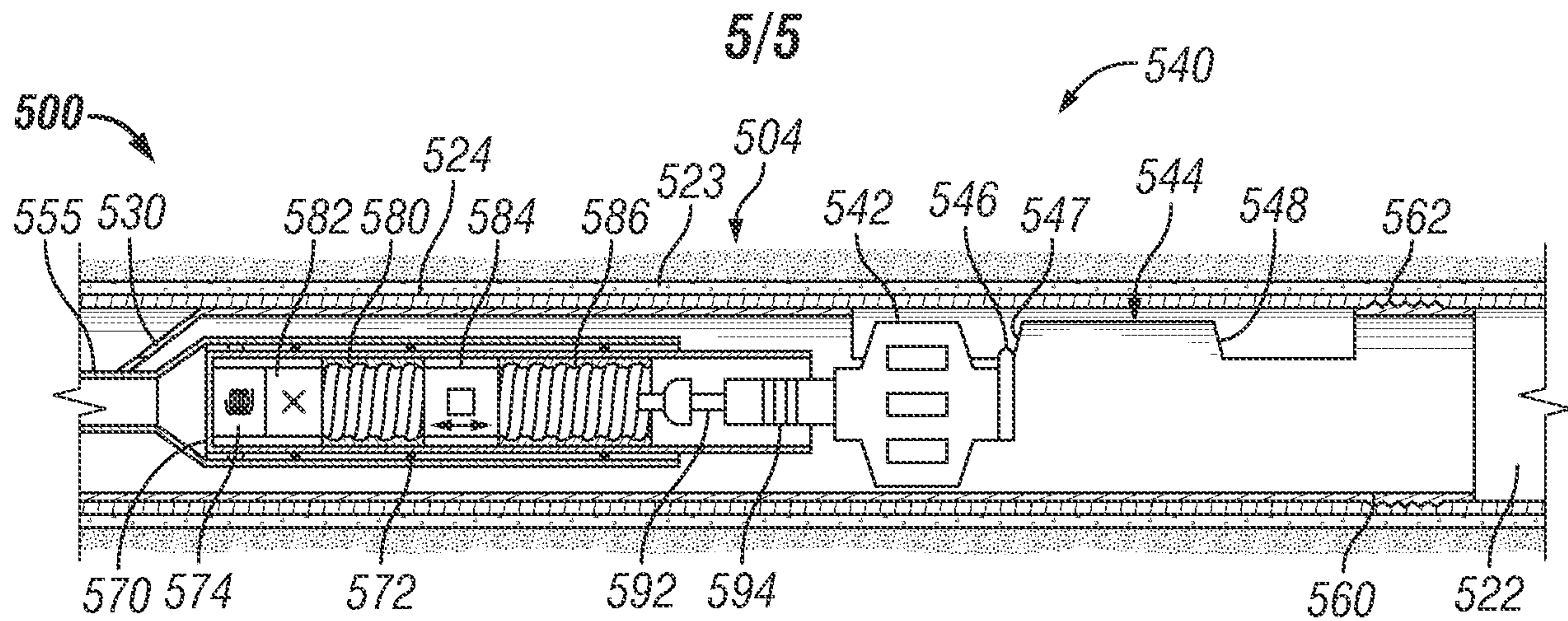
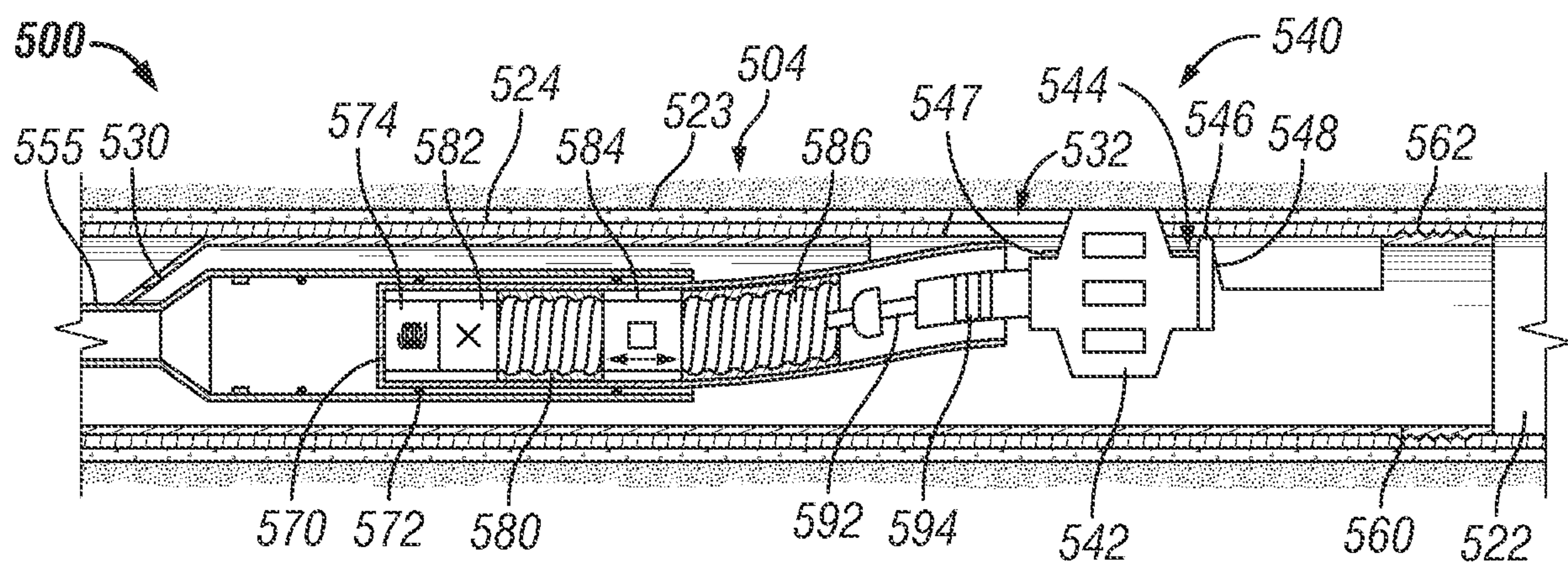
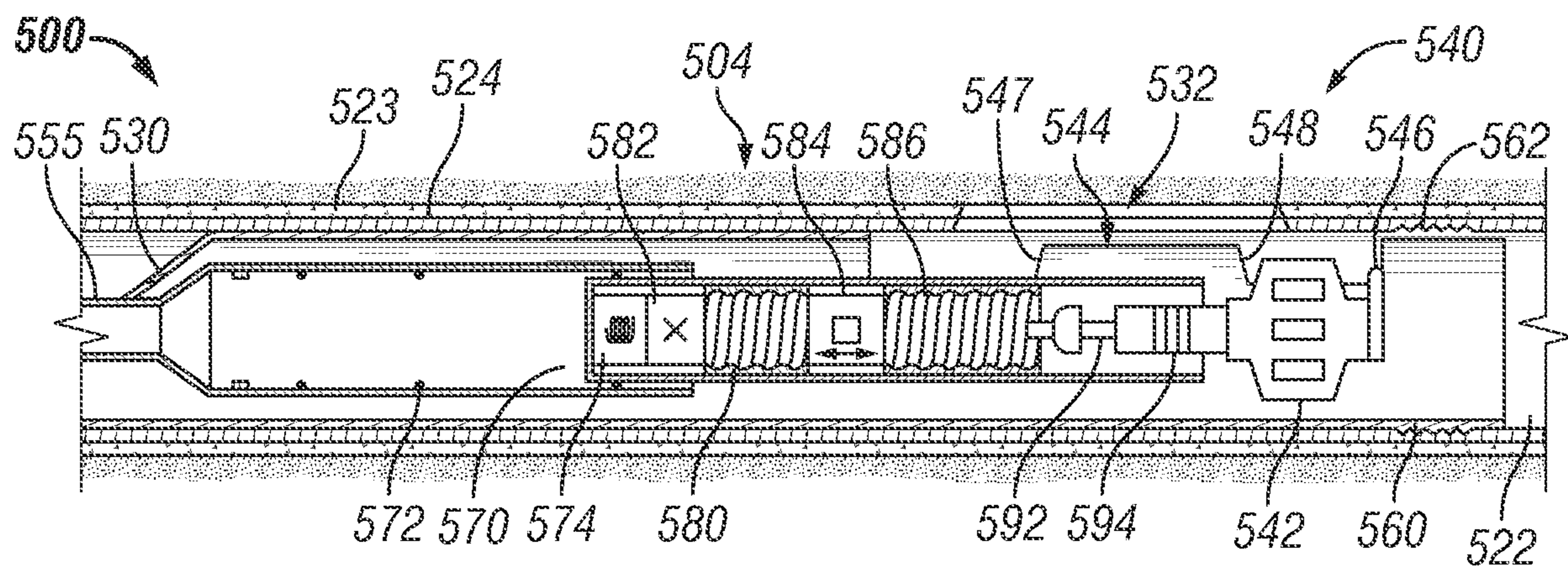


FIG. 4B

**FIG. 5A****FIG. 5B****FIG. 5C**

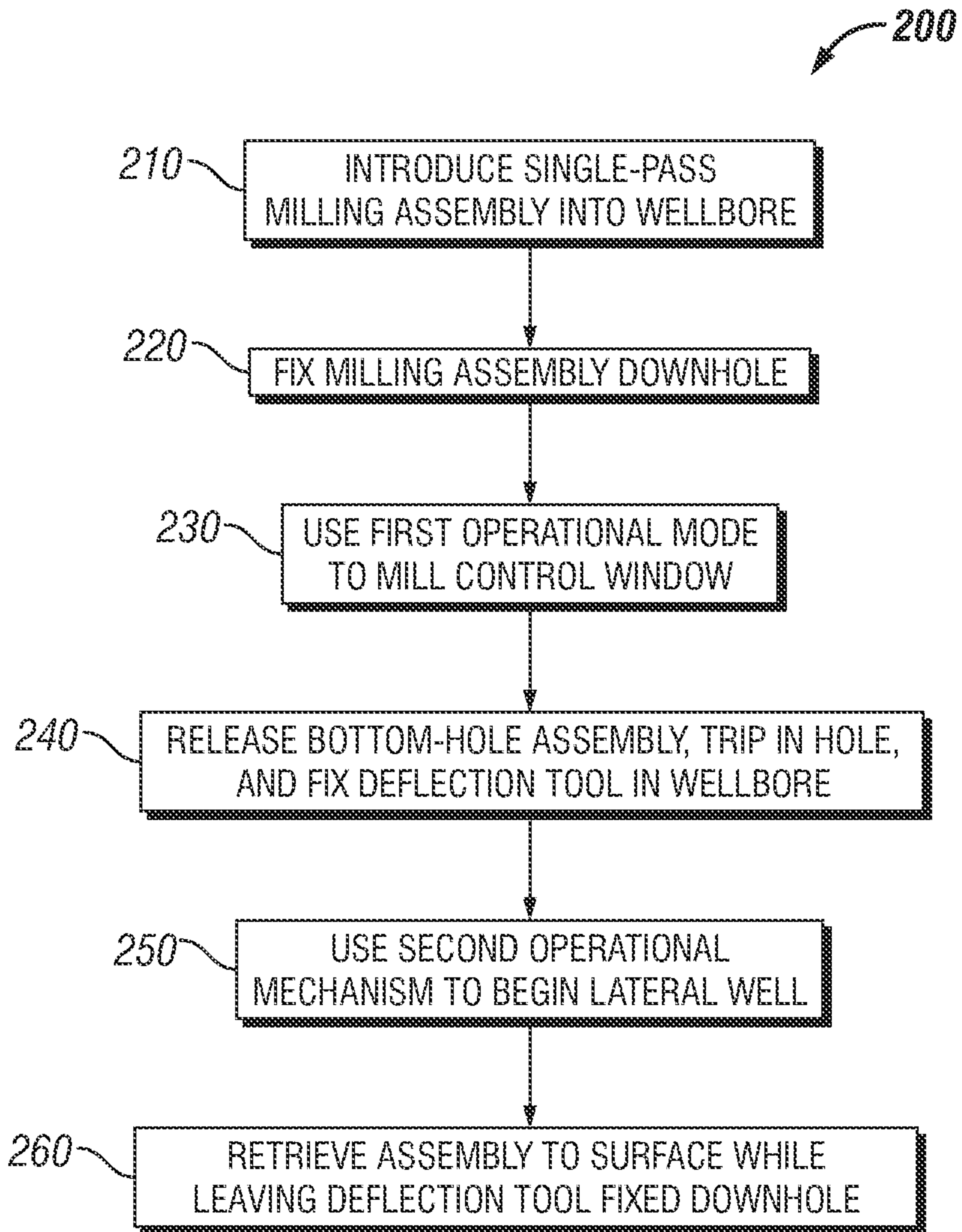


FIG. 2