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(54) **Title:** ECCENTRIC STABILIZER FOR SYNCHRONOUS ROTARY STEERABLE SYSTEM

(57) **Abstract:** A method and apparatus for steering a drilling assembly during drilling operations for oil and gas. The steering assembly being disposed in a borehole and comprising a drill bit attached to a drill collar having an eccentric stabilizer disposed thereupon. The eccentric stabilizer either in an engaged state whereupon rotating concentrically with the drill collar, or in a released state whereupon as the drill collar rotates the eccentric stabilizer is positioned eccentrically relative to the drill collar creating a lateral deflection in the borehole that may be used for changing the direction of the drilling assembly.



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Eccentric Stabilizer for Synchronous Rotary Steerable System

-by-

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Prov. Appl. 61/943,770, filed 24-FEB-2014.

BACKGROUND OF THE DISCLOSURE

[0002] The complex trajectories and multi-target oil wells require the directed placement of a borehole's path and the ability to continually to control or "steer" the direction or path of the borehole during the drilling operation. Preferably, the path can be rapidly controlled during the drilling operation at any depth and target as the borehole is advanced by the drilling operation.

[0003] Directional drilling is complicated by the necessity to operate a drill bit steering device within harsh borehole conditions. The steering device is typically disposed near the drill bit, which terminates a lower or "downhole" end of a drillstring. Many types of devices known in the prior art have been used to control the direction of a drill bit. Some devices use stabilizers having ribs or extensions for engaging the wall of a borehole and controlling the direction of the drill bit as it bores through the ground. Other devices may use rotational valve systems for employing fluid to steering pads, may use magnetic switches to control directional changes, or may use non-rotatable sleeves for applying lateral force to a borehole to adjust drilling trajectories. Examples of some devices used to direct the trajectory of a drill bit can be found in U.S. Pat. Nos. 4,319,649; 6,840,336; and 7,503,408.

[0004] Many of the devices known in the art either require stopping the drillstring and/or moving the drillstring in one or two specified positions to create lateral forces within a borehole. Also, some devices require the use of motors downhole for drilling in directions relative to specific positioning of the drill bit, or employ pistons, pads, or other mechanics for creating lateral forces in the borehole.

[0005] Unfortunately, there are problems associated with many of the directional drilling techniques mentioned above. Particularly, having to stop the drillstring during

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drilling for either positioning purposes or for using a downhole motor is inefficient. Besides the apparent inconvenience of having to stop and start the drill string and/or position the drillstring relative to preset positions of the non-rotating component, most systems also require sliding the drillstring, after having stopped, in the new drilling direction determined by the direction drilled using the downhole motor.

[0006] Because of the friction induced on the drillstring and tools downhole, these methods may be inefficient or even damaging to downhole components. Further, because of the complexity of using hydraulic valves to employ pistons, or other methods, a simpler method for achieving a similar goal may be preferred.

[0007] The subject matter of the present disclosure is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

SUMMARY OF THE DISCLOSURE

[0008] A method and apparatus for steering a drilling assembly during drilling operations for oil and gas. The steering assembly being disposed in a borehole and comprising a drill bit attached to a drill collar having an eccentric stabilizer disposed there upon. The eccentric stabilizer either in an engaged state whereupon rotating concentrically with the drill collar, or in a released state whereupon as the drill collar rotates the eccentric stabilizer is positioned eccentrically relative to the drill collar creating a lateral deflection in the borehole that may be used for changing the direction of the drilling assembly.

[0009] The foregoing summary is not intended to summarize each potential embodiment or every aspect of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1A illustrates a drilling system having a drilling assembly disposed in a borehole according to the present disclosure.

[0011] Fig. 1B illustrates the drilling assembly in more detail.

[0012] Fig. 2A illustrates a more detailed view of an eccentric stabilizer component of the drilling assembly in an engaged state.

[0013] Fig. 2B illustrates the stabilizer component of the drilling assembly in a released state.

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[0014] Fig.3A illustrates a perspective view of the disclosed drilling assembly having an eccentric section offset from a central rotational axis of the drilling assembly.

[0015] Fig.3B illustrates a cross-sectional view of the drilling assembly in Fig.3A having the eccentric section offset from the central axis of the drilling assembly.

[0016] Fig.4A illustrates the drilling assembly disposed in the borehole and having the stabilizer component disposed and released near the drill bit.

[0017] Fig.4B illustrates the drilling assembly disposed in the borehole and having the stabilizer component disposed and released a distance away from the drill bit.

[0018] Fig. 5 illustrates another drilling assembly having an eccentric stabilizer component according to the present disclosure.

[0019] Figs. 6A-6C illustrate various views of the drilling assembly in different states of assembly.

[0020] Fig. 6D illustrates a schematic end view of the downhole assembly showing the eccentricity of its components.

[0021] Figs. 7A-7B illustrate a side view and an end view of the disclosed drilling assembly oriented for concentric drilling.

[0022] Fig. 8 illustrates the disclosed drilling assembly during an initial stage of activation.

[0023] Figs. 9A-9B illustrate a side view and an end view of the disclosed drilling assembly during eccentric activation.

[0024] Figs. 10A-10B illustrate a side view and an end view of the disclosed drilling assembly oriented for eccentric drilling.

[0025] Fig. 11 illustrates a side view of the disclosed drilling assembly during an initial stage of deactivation.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0026] Fig. 1A illustrates a drilling system 20 having a drilling assembly 200 suspended in a borehole 10 penetrating an earth formation. At the surface, a derrick structure 22 supports the downhole assembly 200 on a drillstring 110 and has a crown block at the top. A traveling block is moveably connected to the crown block and serves to connect to the drillstring 110, which is raised and lowered into the borehole 10 by a cable connected to a drawworks 24. The drawworks 24 is used to release or retract

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cable, allowing the traveling block to be raised or lowered, which in turn raises or lowers the drillstring 110. Finally, a rotary table 26 may serve to control rotation of the drillstring 110.

[0027] The drilling assembly 200 connected to the drillstring 110 is terminated by a drill bit 120. During drilling operations, the rotary table 26 imparts rotation to the drill bit 120 by rotating the drillstring 110 and the drilling assembly 200. For its part, the drill bit 120 of the drilling assembly 200 may be a polycrystalline diamond compact (PDC) bit, a rotary drilling bit rotated by a mud motor and shaft, or any other suitable type of drill bit 120.

[0028] In addition to the drill bit 120, the drilling assembly 200 can have one or more stabilizer components 220 that are used for both stabilizing the drilling assembly 200 within the borehole 10 during drilling operations and creating a lateral force in the borehole 10 for directing the drilling assembly 200 in a particular direction downhole.

[0029] As shown in more detail in Fig. 1B, the drilling assembly 200 disposed on the drillstring 110 has a controller section 204, an actuator and sensor section 202, a stabilizer component 220, an eccentric section 210, an engagement mechanism 230, and the drill bit 120. As its name implies, the controller section 204 can have control circuitry, memory, battery power, telemetry components, and the like to control operation of the drilling assembly 200. The control section 204 can have sensors for determining near-bit inclination and azimuth for directional drilling. The actuator and sensor section 202 can house one or more actuators and position sensors that operate in conjunction with the control section 204 to control operation of the drilling assembly 200.

[0030] The stabilizer component 220 can have the form of a sleeve or the like disposed on the eccentric section 210 of the drilling assembly 200. The eccentric section 210 is offset from the central rotational axis C of the assembly 200 to that the stabilizer component 220 is eccentrically located on the assembly 200.

[0031] The engagement mechanism 230 is operated by the actuator and sensor section 114 to either engage or release the stabilizer component 220. When engaged by the mechanism 230, for example, the stabilizer component 220 rotates with the assembly 200 and the rotation imparted to it. When released by the mechanism 230,

however, the stabilizer component 220 can rotate relative to the assembly 200. As discussed below, synchronizing the engagement and release of the eccentric stabilizer component 220 on the drilling assembly 200 during rotation can be used to direct drilling of the borehole 10.

[0032] Referring now to Fig. 2A, an embodiment of the stabilizer component 220 disposed on the drilling assembly 200 is shown in an engaged state. As noted above, the stabilizer component 220 is a sleeve disposed on the eccentric section 210. The stabilizer component 220 may be composed of high-strength steel or any other material suitable for use as a stabilizer for a downhole tool in a borehole. The stabilizer component 220 may also have coatings of even harder material for additional durability. Moreover, the diameter of the stabilizer component 220 may vary depending on the application. For example, the stabilizer component 220 can be the same diameter of the diameter of the drilling assembly 200; however, the diameter of the stabilizer component 220 may be larger or smaller than the diameter of the drilling assembly 200.

[0033] As noted above, the stabilizer component 220 is disposed on the eccentric section 210, which passes through the stabilizer component 220. The eccentric section 210 may be an extension of the drilling assembly 200, having been machined with an inner diameter different than the diameter of the drilling assembly 200, or may be otherwise designed, or even be removably connectable to the drilling assembly 200.

[0034] One or more engagement mechanisms 230 may be disposed within the drilling assembly 200. In one embodiment, the engagement mechanism 230 serves to release or lock the stabilizer component 220. The engagement mechanism 230 may either release or lock the stabilizer component 220 at revolution intervals needed to maintain the desired drill path. The control parameters can be modified by communication from the surface and/or autonomously by directives preloaded into the downhole electronics either at the surface using an engagement control communicating with the engagement mechanism 230 downhole, or by programming a controller downhole.

[0035] The engagement mechanism 230 preferably takes a minimal amount of effort and uses as minimal electrical energy as possible to engage and re-engage the stabilizer component 220 with the drilling assembly 200. Some mechanisms that may be used

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include hydraulic systems with pistons and/or valves, a slip clutch mechanism, or any disposable object that can be used to lock the stabilizer component 220 to the drilling assembly 200.

[0036] Other mechanisms for locking and releasing the stabilizer component 220 may be used. For example, the engagement mechanism 230 may use a pin and spring mechanism for engaging the stabilizer component 220. The pin of the mechanism 230 can extend and retract relative to the stabilizer component 220 and may engage and disengaged from one or more slots 226, stops, locks or the like on the component 220. In another embodiment, the engagement mechanism 230 may be a multi-plate clutch mechanism, a ball/release mechanism, or any other suitable feature to lock and release the stabilizer component 220 relative to the drilling assembly 200.

[0037] When the engagement mechanism 230 is engaged (*i.e.*, the engagement mechanism 230 has been configured to lock the stabilizer component 220 in an engaged state) the stabilizer component 220 will be disposed on the drilling assembly 200 being symmetrically aligned with the center of the drilling assembly 200 (*i.e.*, in a concentric state). In this configuration, the stabilizer component 220 is connected to the drilling assembly 200. When the drilling assembly 200 is rotated as a result of rotating the connected drillstring 110, the stabilizer component 220 will likewise rotate. In this state, the stabilizer component 220 may help stabilize the downhole assembly 200, but will significantly direct drilling.

[0038] During drilling, the stabilizer component 220 can engage the borehole (10) using both friction and drag. Friction acting on the stabilizer component 220 in a neutral position concentric on the assembly 110 may assist in persuading the stabilizer component 220 to cam out from the eccentric section 210 once the engagement mechanism 230 has been released.

[0039] This camming action may be achieved by physical force (*e.g.*, flow turbulence) upon the stabilizer 220, or by some mechanical, electrical, and/or magnetic inducement (*e.g.*, using motors, or other such devices internal or external) to the drilling assembly 200. Moreover, once the stabilizer component 220 begins camming outward, additional drag may act on the stabilizer component 220 causing the stabilizer component 220 to eventually reach maximum eccentricity. Further, to increase friction and/or aid in

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creating the drag on the stabilizer component 220, the stabilizer component 220 may contain other friction inducing surfaces or mechanisms to increase the ability of the stabilizer component 220 to engage the borehole (10) once released.

[0040] Fig. 2B illustrates the stabilizer component 220 disposed on the drilling assembly 200 in a released state. As shown by the left rotation arrow (L), the stabilizer component 220 is movably connected to the drilling assembly 200, and is only held in a concentric state with the drilling assembly 200 when locked by the engagement mechanism 230. Thus, as illustrated, when the stabilizer component 220 is activated (i.e., when the engagement mechanism 230 is in a released state), the stabilizer component 220 will engage the borehole 10, while the drilling assembly 200 is allowed to continue rotation in a right rotation direction, as shown by the right rotation arrow (R). The above illustration assumes the drillstring 110 is rotating in the (R) direction (clockwise). The stabilizer will apparently be rotating to the left (L) direction (counterclockwise), but it is actually remaining relatively stationary as it is unlocked from the drillstring. As shown in Figs. 2A-2B, the external surface 222 of the stabilizer component 220 can include spiraling ribs, contours, or other features.

[0041] As previously described, the external surface 222 serves to contact the inside of the borehole (10) when the stabilizer component 220 is in the released state. However, although regular re-latching of the stabilizer component 220 will minimize errors with the stabilizer component 220 slipping in the borehole (10), due to conditions in the borehole(10), additional friction generating substances or mechanisms may be used to increase the ability of the stabilizer component 220 to engage the borehole (10) when released.

[0042] Figs. 3A and 3B better illustrate the drilling assembly 200 having the eccentric section 210 offset from the central axis C of the drilling assembly 200. As revealed, the flow passage 205 through the drilling assembly 200 communicates with flow passage 215 through the eccentric section 210 so that drilling fluid can be communicated from the drillstring 110 to the drill bit 120. Because the stabilizer component (220) is disposed on the eccentric section 210 with the eccentric section 210 having an offset from the central axis C of the drilling assembly 200, the stabilizer component 220 in a released state creates a lateral deflection within the borehole (10).

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[0043] As described above with reference to Figs. 2A and 2B, the stabilizer component 220 is movably connected to the drilling assembly 200 by way of the eccentric section 210. Also, the eccentric section 210 is offset from the central axis C of the drilling assembly 200. When the stabilizer component 220 is in a released state and rotates relative to the eccentric section 210, the stabilizer component 220 will be in an eccentric position relative to the drilling assembly 200. As will be discussed further below, this eccentric state allows the stabilizer component 220 to be forced between the drilling assembly 200 and the borehole 10, thus inducing a lateral force on the drilling assembly 200.

[0044] Referring to the positioning of the eccentric section 210 relative to the drilling assembly 200 in Figs. 3A and 3B, the eccentric section 210 is not aligned in the center axis C of the drilling assembly 200. Instead, the eccentric section 210 is offset from the central axis C by some amount. Again, this offset allows the stabilizer component 220 to be in an eccentric position with respect to the drilling assembly 200. Also, the eccentricity of the stabilizer component 220 when released relative to the drilling assembly 200 may depend on the amount the eccentric section 210 is offset from the central axis C of the drilling assembly 200. Further, as shown in Figs. 3A and 3B, the engagement mechanism 230 may also be offset from the central axis C of the drilling assembly 200.

[0045] Referring now to Figs. 4A-4B, two arrangements of the disclosed stabilizer component 220 are discussed. As described above, releasing the stabilizer component 220 while rotating the drilling assembly 200 creates a lateral deflection in the borehole 10, which in turn can be used to direct the trajectory of the drilling assembly 200. In other words, the displacement of the one or more stabilizer components 220 from the drill bit 120 may cause the drilling assembly 200 trajectory to vary.

[0046] Fig. 4A illustrates one example of the drilling assembly 200 disposed in the borehole 10. The assembly 200 has the stabilizer component 220 disposed and released near the drill bit 120 by a distance D_1 . The stabilizer component 220 may preferably be released at the low side of the borehole 10 but may be released at any disposition in the borehole 10 for creating lateral deflection in any direction of the borehole 10.

[0047] If the stabilizer component 220 is disposed near the drill bit 120 at a close distance D_1 as shown, and the engagement mechanism 230 is released as shown, then the friction of the external surface 222 of the stabilizer component 220 against the borehole 10 will begin stalling the stabilizer component 220 relative to the position of the rotating drilling assembly 200. This stalling creates additional friction on the stabilizer component 220 because of the camming effect discussed above.

[0048] The stabilizer component 220 will be at maximum friction when it reaches maximum eccentricity (*i.e.*, when the stabilizer component 220 rotates substantially near 180 degrees from its original concentric position). While approaching maximum eccentricity, the stabilizer component 220 is forced in the transverse direction (T) creating an opposite force or deflection in the opposite direction (B). In one embodiment, creating a force in the direction (B) due to the deflection created by the stabilizer component's eccentricity may preferentially direct the drill bit 120 of the drilling assembly 200 to drill on that side of the borehole 10 in that direction.

[0049] Further rotation of the drilling assembly 200 brings the stabilizer component 220 back into the concentric position where it may once again be arrested and locked by the engagement mechanism 230, and may continue rotating concentrically with the rest of the drilling assembly 200.

[0050] Fig.4B illustrates another example of the drilling assembly 200 disposed in the borehole 10. Here, the assembly 200 has the stabilizer component 220 disposed and release a greater distance D_2 away from the drill bit 120. As described above, releasing the stabilizer component 220 while rotating the drilling assembly 200 creates a lateral deflection in the borehole 10, which in turn can be used to direct the trajectory of the drilling assembly 200.

[0051] However, by disposing the stabilizer component 220 the distance D_2 farther away from the drill bit 120, the lateral deflection created by the eccentricity of the stabilizer component 220 may actually be used to bend the drill collar of the drilling assembly 200. This bend in the drill collar may cause the drill bit 120 to be forced in a similar direction (T') as the initial force in direction (T) created by the eccentricity of the stabilizer component 220. As a result, depending on the displacement D_2 between

the stabilizer component 220 and the drill bit 120, the resulting trajectory of the drilling assembly 200 may be different.

[0052] Although, as will be appreciated by those in the art, many different control techniques may be used to steer the drilling assembly 200 using the stabilizer component 220 and methods described above, one control technique is discussed below. In this technique, the engagement mechanism 230 may be activated every other rotation of the drilling assembly 200 so that the stabilizer component 220 is recaptured after each rotation to remain concentric. Recapture of the stabilizer component 220 may be necessary because, based on a plethora of mechanical and environmental variables downhole, the stabilizer component 220 may not necessarily remain synchronous with the rotation of the drilling assembly 200.

[0053] To obtain desired real-time directional control, the drilling assembly 200 preferably operates the steering remotely from the surface of the earth. Furthermore, the steering can be operated to maintain the desired path and direction while being deployed at possibly a great depth within the borehole and while maintaining practical drilling speeds. Finally, the steering can reliably operate under exceptional heat, pressure, and vibration conditions that can be encountered during the drilling operation.

[0054] Another control technique can release the engagement mechanism 230 when the desired "heading" of the drilling assembly 200 is directed to a calculated target. During the drilling operation, for example, control circuitry and sensors may monitor and record the toolface position when the sleeve of the stabilizer component 220 has reached maximum eccentricity. As an example, the sensing can be performed using a Hall Effect sensor or using torsional measurement. Once the stabilizer component 220 is in an eccentric position and the drillstring 110 is within a certain area of desired trajectory, locking the engagement mechanism 230 may be skipped so that the drilling may continue in the direction of the desired trajectory. Skipping activation of the mechanism 230 can be done for one revolution, which in reality may be only a partial revolution due to lag from the first activation. This re-synchronizes the stabilizer component 220 to the drilling assembly 200. This process is then repeated

multiple times for a time cycle (*e.g.*, 60 times if drilling at 120 rpm equating to one minute).

[0055] During the process, the activation toolface of the mechanism 230 is evaluated relative to the recorded position of the stabilizer component 220 at its peak eccentricity to determine any "slippage correction." Thus, if the drillstring 110 has slipped off of the desired trajectory, the stabilizer component 220 may be reengaged or locked to adjust the heading while the mechanism 230 is activated to compensate for the measured slippage during the previous time cycle.

[0056] The entire process may be repeated many times, or modified to obtain the required trajectory. The stabilizer component 220 may be locked continuously within the borehole 10 if building an angle or changing direction of the drilling assembly 200 is not wanted.

[0057] For this embodiment having the eccentric sleeve of the stabilizer component 220 on the corresponding eccentric section 210, the drill bit 120 has an active "cutting" face that remains the same. The cutting face is determined by the random position of the bit 120 when it is put onto the assembly 200 and is the side of the bit 120 positioned opposite where the eccentric sleeve 220 reaches its maximum eccentricity. During operations, the active cutting face will take the brunt of the wear.

[0058] Turning now to Fig. 5, another drilling assembly 300 has an eccentric stabilizer component 340 according to the present disclosure disposed thereon. In contrast to the previous embodiment; this drilling assembly 300 can allow the drill bit 120 to experience more distributed wear during operations. Also, the drill path created with this assembly 300 may follow a more uniform trajectory with less lobe shapes produced during directional changes.

[0059] As before, this drilling assembly 300 includes a drill body or collar 310 with a drill bit 320 on its distal end. The drill collar 310 is coupled to an actuator assembly 330, which has a linear actuator 332, a torque clutch 334, and position sensors 336. The position sensors 336 in the assembly 330 determine the position of an actuator 350 so it can be coordinated to the toolface of the drilling assembly 300 and the eccentric offset that can be achieved with the stabilizer component 340.

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[0060] The actuator assembly 330 is coupled to a control assembly 338 that houses control circuitry 339a and sensors 339b, such as near-bit inclination and azimuth sensors. The entire drilling assembly 300 extends from the drillstring 110, which imparts rotation to the assembly 300.

[0061] The eccentric stabilizer component 340 includes the actuator 350 disposed on the drill collar 310. As previously noted, the actuator 350 is operatively coupled to the actuator assembly 330, which can move the actuator 350 axially with the linear actuator 332 and can turn or torque the actuator 350 about the axis of the drill collar 310 with the clutch 334.

[0062] The stabilizer component 340 includes an inner eccentric sleeve 360 disposed on the drill collar 310, an outer eccentric sleeve 370 disposed on the inner sleeve 360, and a stabilizer body 380 disposed on the outer sleeve 370. As will be described in more detail below, the actuator 350 is engaged with the inner sleeve 360 and is selectively engageable in first and second conditions with the outer sleeve 370.

[0063] During one form of operation, for example, the actuator 350 moved to the first condition can selectively engage with the outer sleeve 370 and can orient the combined eccentricity E of the inner and outer sleeves 360, 370 concentrically on the drill collar 310. In this way, the stabilizer component 340 is concentric to the central rotational axis C of the drill collar 310. During another form of operation, however, the actuator 350 moved to the second condition can selectively engage with the outer sleeve 370 and can orient the combined eccentricity E of the inner and outer sleeves 360, 370 eccentrically on the drill collar 310. Controlling these states can achieve directional drilling.

[0064] Figs. 6A-6C show the stabilizer component 340 in more detail in the partial disassembled views. As best shown in Fig. 6C, the eccentric stabilizer component 340 includes the inner eccentric sleeve 360 disposed on the drill collar 310, which passes through an eccentric passage 361 of the inner sleeve 360. The actuator 350 includes an axial member or slide bar 352 disposed in a longitudinal slot 362 of the inner sleeve 360 so that the actuator 350 and the inner sleeve 360 can rotate together depending on how the actuator assembly 330 with its clutch (334) operates the actuator 350.

[0065] In some situations during operation, the clutch (334) of the assembly 330 allows the actuator 350 to be driven by the rotation of the drill collar 310 with an amount of torque. In other situations during operation, the clutch (334) of the assembly 330 is operated so that there is less torque on the actuator 350. The assembly 330 can therefore use the clutch (334) to selectively control the extent that the actuator 350 is driven by the drill collar 310. The clutch (334) as disclosed herein may use static friction element(s) that will encourage the camming action of the external sleeve 370.

[0066] As disclosed herein, the actuator's slide bar 352 is travelling with the eccentric sleeves 360, 370, and the slide bar 352 can be activated in any relationship to the drill collar 310. Once the slide bar 352 is actuated, camming out the outer sleeve 370 can use a stalling force on the inner sleeve 360 relative to the drill collar 310 and can also use a stalling force on the outer sleeve 370 relative to the borehole to cause the sleeves 360, 370 to move differentially to each other. The outer sleeve 370 may have a spring-loaded wear pad to provide additional friction, even in an over-gauged borehole.

[0067] The inner sleeve 360 can be magnetically coupled to the drill collar 310 to produce constant drag, while still allowing the two pieces to constantly rotate. For example, the magnetic drag can be produced in the ring portion of the actuator 350, which is coupled with the inner sleeve 360. When the actuator 350 is slid by the linear actuator (332), magnetic elements between the ring of the actuator 350 and the drill collar 310 can overlap and create the desired drag between the actuator 350 (coupled to the inner sleeve 360) and the drill collar 310.

[0068] Alternatively, there also may be some other type of clutching mechanism in that same area. Overall, the actuator 350 may only need to be actuated linearly (and possibly use a spring return) for the required clutching to occur. All of the other needed forces can be generated by that one action. As will be appreciated, too much differential loading between the outer sleeve 370 and the inner sleeve 360 can make it more difficult for the actuator 350 to operate.

[0069] As best shown in Fig. 6B, the eccentric stabilizer component 340 further includes the outer eccentric sleeve 370 disposed on the inner sleeve 360, which passes through an eccentric passage 371 of the outer sleeve 370. The outer sleeve 370 does not include a longitudinal slot. However, a concentric stop 376 on the outer sleeve 370

is capable of engaging a distal stop 356 on the slide bar 352 of the actuator 350. Additionally, the outer sleeve 370 includes an eccentric stop 374 capable of engaging a proximal stop 354 on the actuator 350.

[0070] Depending on the axial and radial position of the slide bar 352 described below, its stops 354, 356 can selectively engage the outer sleeve's stops 374, 376. In general, the stops 374, 376 on the sleeve 370 can include tabs or the like extending from opposite ends of the sleeve 370. The slide bar's stops 354, 356 can be tabs extending upward from the surface of the bar 352. Other features for the stops 354, 356, 374, and 376 can be used.

[0071] Finally, as best shown in Fig. 6A, a stabilizer body 380 is disposed external to the outer sleeve 370. The stabilizer component 340 is intended to be non-rotating in the borehole so the stabilizer body 380 can include conventional features for non-rotation as found in non-rotating rotary steerable systems, such as disclosed in US Pat. Pub. 2014/0262507, which is incorporated herein by reference.

[0072] It will be appreciated that the views of the stabilizer component 340 do not show many of the components required for the stabilizer component 340 to operate downhole during drilling operations. In other words, protective bodies, seals, bearings, etc. are not depicted for simplicity. With the benefit of the present disclosure, however, one skill in the art will recognize the use and necessity of these and other such features.

[0073] The drill collar 310, the inner sleeve 360, the outer sleeve 370, and the stabilizer body 380 can be oriented concentrically and eccentrically depending on operation of the actuator 350 by the actuator assembly 330, as described in more detail below. The concentric arrangement of these components is schematically illustrated in Fig. 6D. The inner sleeve 360 is oriented in the inner passage 371 of the outer sleeve 370 so that the two eccentric sleeves 360, 370 when combined cancel each other. Thus, the stabilizer body 380 is oriented concentric to the rotational axis C of the drill collar 310.

[0074] The inner sleeve 360 can move (rotate) relative to the drill collar 310, and the outer sleeve 370 can move (rotate) relative to the inner sleeve 360. The stabilizer body 380 can be part of or connected to the outer sleeve 370 so that they move together, or the stabilizer body 380 can move (rotate) relative to the outer sleeve 370. Friction and

torque may allow the various components to move (rotate) relative to one another, and various features, such as bearings, bushings, etc. found on rotary steerable system can allow for the relative rotation.

[0075] Having an understanding of the elements of the stabilizer component 340, its use in directional drilling will now be discussed. Turning to Figs. 7A-7B, the disclosed drilling assembly 300 is illustrated in a side view and an end view oriented for concentric drilling. In this condition, the stabilizer component 340 is oriented with the two sleeves 360, 370 concentrically arranged on the drill collar 310 so that the drill bit 320 rotate with the rotational axis C of the assembly 300. Rotation of the drill collar 310 and bit 320 is illustrated in direction R_A .

[0076] The actuator 350 is retracted so that its distal stop 356 on the slide bar 352 engages the concentric stop 376 on the outer sleeve 370. Thus, the outer sleeve 370 along with the stabilizer body 380 is coupled for rotation with the actuator 350. Meanwhile, the inner sleeve 360 with the slide bar 352 passing there through is also coupled for rotation with the actuator 350. Because the stabilizer component 340 can move (rotate) relative to the drill collar 310, the component 340 may remain rotationally stationary in the advancing borehole. Alternatively, depending on the torque applied to the actuator 350 by the actuator assembly 330, the component 340 may be allowed to rotate relative to the drill collar 310. In any event, relative movement either positive or stationary for the component 340 is depicted as opposite rotation R_B for illustrative purposes. In other words, if the component 340 is to be non-rotating in the borehole during concentric drilling, it remains stationary while the drill collar 310 rotates.

[0077] As expected, the concentric drilling arrangement in Figs. 7A-7B allow the drilling assembly 300 to advance a borehole following along the central rotational axis C of the assembly 300. The positive rotation R_A can be imparted to the drill collar 310 and the drill bit 320 via drillstring rotation. Moreover, if applicable for the implementation, the positive rotation R_A can be imparted to the drill collar 310 and/or the drill bit 320 via a mud motor (not shown).

[0078] When it is desired to use the stabilizer component 340 for directional drilling purposes, the actuator 350 is activated by operation of the actuator assembly 330. As

shown in Fig. 8, the linear actuator (332) of the actuator assembly 330 moves the actuator 350 along the drill collar 310 as depicted in direction S_A . The distal stop 356 on the slide bar 352 comes free of the concentric stop 376 on the outer sleeve 370. Accordingly, the inner sleeve 360 is still configured to move (rotate) with the actuator 350, but the outer sleeve 370 is free to move (rotate) relative to the inner sleeve 360. Torque applied by the clutch (334) of the actuator assembly 330 allows the actuator 350 and the inner sleeve 360 to rotate in direction R_C with the assembly's rotation R_A (*i.e.*, the clutch (334) allows part of the collar's rotation R_A to be imparted to the actuator 350 and inner sleeve 360). Meanwhile, the outer sleeve 370 and the stabilizer body 380 can remain "non-rotating" by maintaining its relative counter rotational direction R_B .

[0079] Eventually, the proximal stop 354 on the actuator 350 rotates around to engage the eccentric stop 374 on the outer sleeve 370. Fig. 9A illustrate a side view of the disclosed drilling assembly 300 rotated about 180-degrees from the other depictions so the engagement of the proximal stop 354 with the eccentric stop 374 can be viewed. This eccentric activation orients the component 340 eccentric to the rotation axis C of the drilling assembly 300 so that the drill bit 320 as shown in Fig. 9B is offset in a displacement direction D.

[0080] To directionally drill, the offset direction D can be oriented in the borehole so that the drill bit 320 advances toward a desired trajectory. Using the inclination, azimuth, toolface, and other information, the actuator assembly 330 can be controlled to orient the offset direction D as needed. As shown in Figs. 10A-10B, the clutch (334) of the actuator assembly 330 can apply torque to the actuator 350 to orient the offset direction D relative to the toolface T_F . Because the actuator 350 is engaged with the eccentric stop 374, torque applied in rotational direction R_D can orient the offset direction to the desired toolface T_F , essentially by dragging the stabilizer component 340 around in the borehole. Drilling can then continue with the offset direction D oriented as desired. Changes to the trajectory can be made with the actuator 350 operated by the actuator assembly 330 adjusting the toolface T_F of the offset direction D.

[0081] When a straight trajectory is again desired, the operational steps for activating the offset direction D can be reversed. For example, Fig. 11 illustrates a side view of the

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disclosed drilling assembly 300 during an initial stage of deactivation. The linear actuator (332) of the actuator assembly 330 retracts the actuator 350 so that its proximal stop 354 disengages from the eccentric stop 374 on the outer sleeve 370. Eventually, through a reverse operation of the activation steps, relative movement of the inner and outer sleeves 360, 370 can then orient the concentric stop 376 to engage the distal stop 356 of the actuator 350 so that the component 340 is arranged concentrically on the drill collar 310.

[0082] From this point, the activation and deactivation processes can be repeated as necessary to drill the borehole along a trajectory. Overall, operation of the eccentric stabilizer component 340 of Figs. 5-11 can follow and incorporate one or more aspects of the operation characterized above with respect to the previous embodiment of Figs. 1-4B. For the sake of brevity, such detail are not discussed again, but those detail would be appreciated with the benefit of the present disclosure.

[0083] The disclosed eccentric stabilizer components 200 and 340 can be used with any other directional drilling tool used on the drilling assembly 200 and 300. For example, the components 200 and 340 can be used with each other and/or with a directional drilling tool, such as a mud motor with a bent sub, a rotary steerable system, a point-the-bit system, a push-the-bit system, a targeted bit speed (TBS) tool, etc.

[0084] The foregoing description of preferred and other embodiments is not intended to limit or restrict the scope or applicability of the inventive concepts conceived of by the Applicants. It will be appreciated with the benefit of the present disclosure that features described above in accordance with any embodiment or aspect of the disclosed subject matter can be utilized, either alone or in combination, with any other described feature, in any other embodiment or aspect of the disclosed subject matter.

[0085] In exchange for disclosing the inventive concepts contained herein, the Applicants desire all patent rights afforded by the appended claims. Therefore, it is intended that the appended claims include all modifications and alterations to the full extent that they come within the scope of the following claims or the equivalents thereof.

WHAT IS CLAIMED IS:

1. A downhole assembly coupling to a drilling string for drilling a borehole, the assembly comprising:
 - a drill body rotating with the drillstring;
 - an engagement mechanism disposed on the drill body and operable between engaged and disengaged conditions;
 - a drill bit rotating with the drill body for drilling the borehole; and
 - a rotatable stabilizer eccentrically disposed on the drill body, the rotatable stabilizer rotating with the drill body when engaged by the engagement mechanism in the engaged condition, the rotatable stabilizer being rotatable eccentrically relative to the drill body when released by the engagement mechanism in the disengaged condition, the rotatable stabilizer eccentrically rotated relative to the drill body and creating a lateral force on the drill body to change drilling trajectory thereof.
2. The assembly of claim 1, wherein the drill body comprises an eccentric section on which the at least one rotatable stabilizer is rotatably disposed, the eccentric section offset from a rotational axis of the drill body.
3. The assembly of claim 2, wherein the rotatable stabilizer comprises a sleeve having an eccentric passage rotatably disposed on the eccentric section.
4. The assembly of claim 2, wherein the at least one rotatable stabilizer when engaged by the engagement mechanism positions concentrically relative to the drill body.
5. The assembly of claim 2, wherein the at least one rotatable stabilizer when disengaged by the engagement mechanism positions eccentrically relative to the drill body.
6. The assembly of claim 1, wherein the engagement mechanism comprises one or more of a pin, a clutch, a spring, a piston, a valve, a ball-release mechanism, a lock, a slot, or a combination thereof.
7. A downhole assembly coupling to a drilling string for drilling a borehole, the assembly comprising:
 - a drill body rotating with the drillstring;

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a drill bit rotating with the drill body for drilling the borehole;
an inner sleeve eccentrically disposed on the drill body and rotatable relative thereto;
an outer sleeve eccentrically disposed on the inner sleeve and rotatable relative thereto; and
an actuator disposed on the drill body and operable between first and second conditions, the actuator engaged with the inner sleeve and selectively engageable in the first and second conditions with the outer sleeve, the actuator in the first condition selectively engaged with the outer sleeve and orienting a combined eccentricity of the inner and outer sleeves concentrically on the drill collar, the actuator in the second condition selectively engaged with the outer sleeve and orienting the combined eccentricity of the inner and outer sleeves eccentrically on the drill collar.

8. The assembly of claim 7, wherein the actuator comprises an axial member slideably engaged with the inner sleeve.
9. The assembly of claim 8, wherein the actuator is linearly and rotationally movable relative to the drill body.
10. The assembly of claim 7, wherein the actuator comprises a first stop disposed thereon, the first stop engageable with a first portion of the outer sleeve when the actuator is in the first condition.
11. The assembly of claim 10, wherein the actuator in the first condition radially aligns the first stop with the first portion.
12. The assembly of claim 10, wherein the actuator comprises a second stop disposed thereon, the second stop engageable with a second portion of the outer sleeve when the actuator is in the second condition.
13. The assembly of claim 12, wherein the actuator in the second condition radially aligns the second stop with the second portion.
14. The assembly of claim 7, wherein the actuator comprises a linear actuator component operable to move a portion of the actuator linearly relative to the drill body.

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15. The assembly of claim 14, wherein the actuator comprises a clutch component operable to couple at least a portion of the rotation of the drill body to a portion of the actuator.

16. A method of drilling a borehole with a downhole assembly coupled to a drilling string, the method comprising:

- rotating a drill bit about a rotational axis of the downhole assembly;
- directing the rotational axis in the borehole by combining a first eccentricity of a sleeve relative to a second eccentricity of an eccentric section of the downhole assembly on which the rotatable sleeve is disposed;
- drilling a first trajectory by orienting the combined eccentricity of the sleeve and the eccentric section concentric to the rotational axis; and
- drilling a second trajectory offset from the first trajectory by orienting the combined eccentricity of the sleeve and the eccentric section eccentric to the rotational axis.

17. The method of claim 16, wherein drilling the first trajectory comprises orienting the eccentric section within an eccentric passage of the sleeve so that the sleeve is concentric to the rotational axis; and engaging the sleeve so oriented with the rotation of the drilling assembly.

18. The method of claim 17, wherein drilling the second trajectory offset from the first trajectory comprises disengaging the sleeve from the rotation of the drilling assembly; and orienting the eccentric section within the eccentric passage of the sleeve so that the sleeve is eccentric to the rotational axis.

19. A method of drilling a borehole with a downhole assembly coupled to a drilling string, the method comprising:

- rotating a drill bit about a rotational axis of the downhole assembly;
- directing the rotational axis in the borehole by combining a first eccentricity of a first rotatable sleeve relative to the downhole assembly with a second eccentricity of a second rotatable sleeve relative to the first rotatable sleeve;
- drilling a first trajectory by orienting the combined eccentricity of the first and second sleeves concentric to the rotational axis; and

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drilling a second trajectory offset from the first trajectory by orienting the combined eccentricity of the first and second sleeves eccentric to the rotational axis.

20. The method of claim 19, wherein drilling the first trajectory comprises orienting at least one of the first and second sleeves relative to the other of the first and second sleeves so that the combined eccentricity is concentric to the rotational axis.

21. The method of claim 19, wherein drilling the second trajectory offset from the first trajectory comprises orienting at least one of the first and second sleeves relative to the other of the first and second sleeves so that the combined eccentricity is eccentric to the rotational axis.

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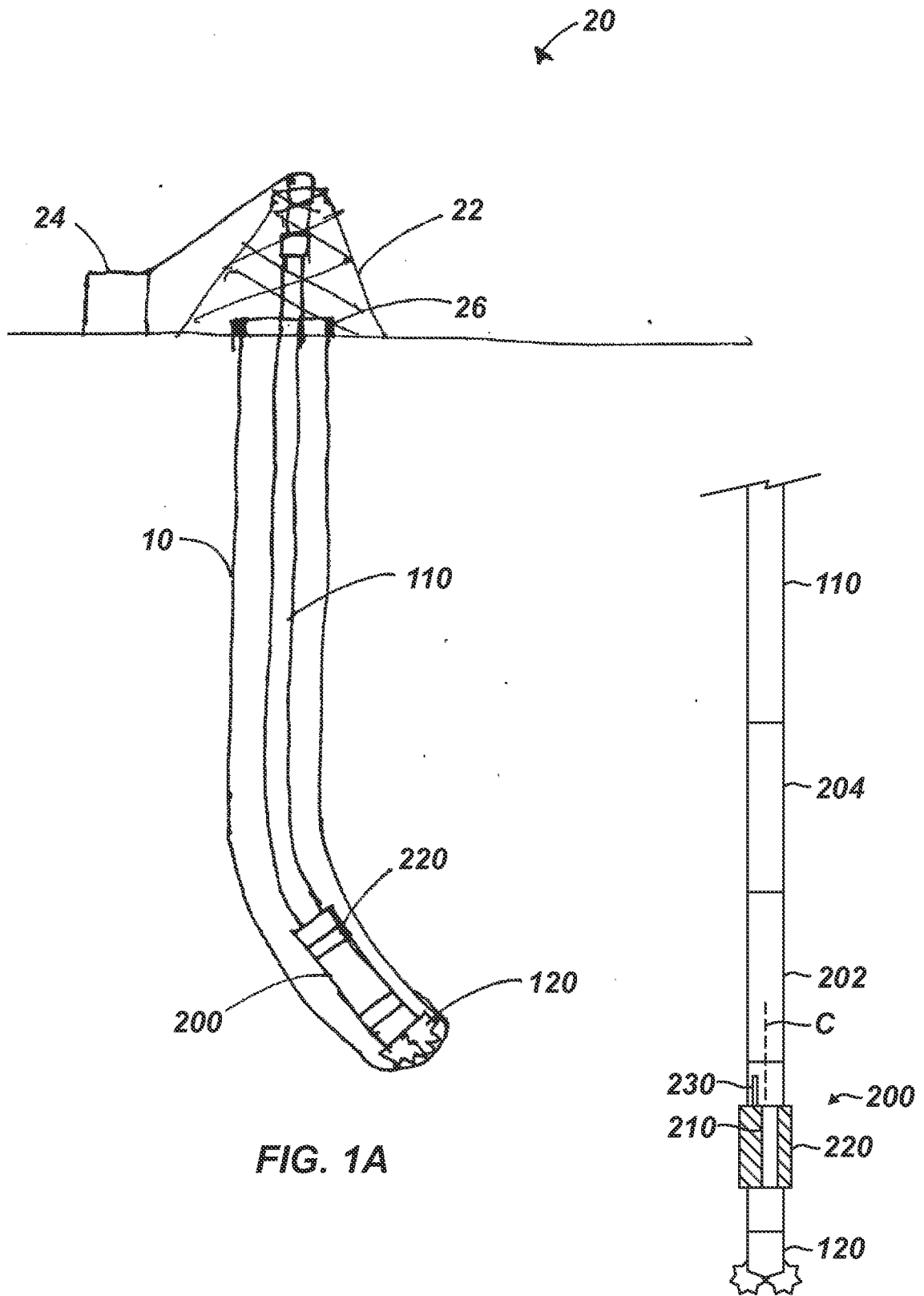


FIG. 1A

FIG. 1B

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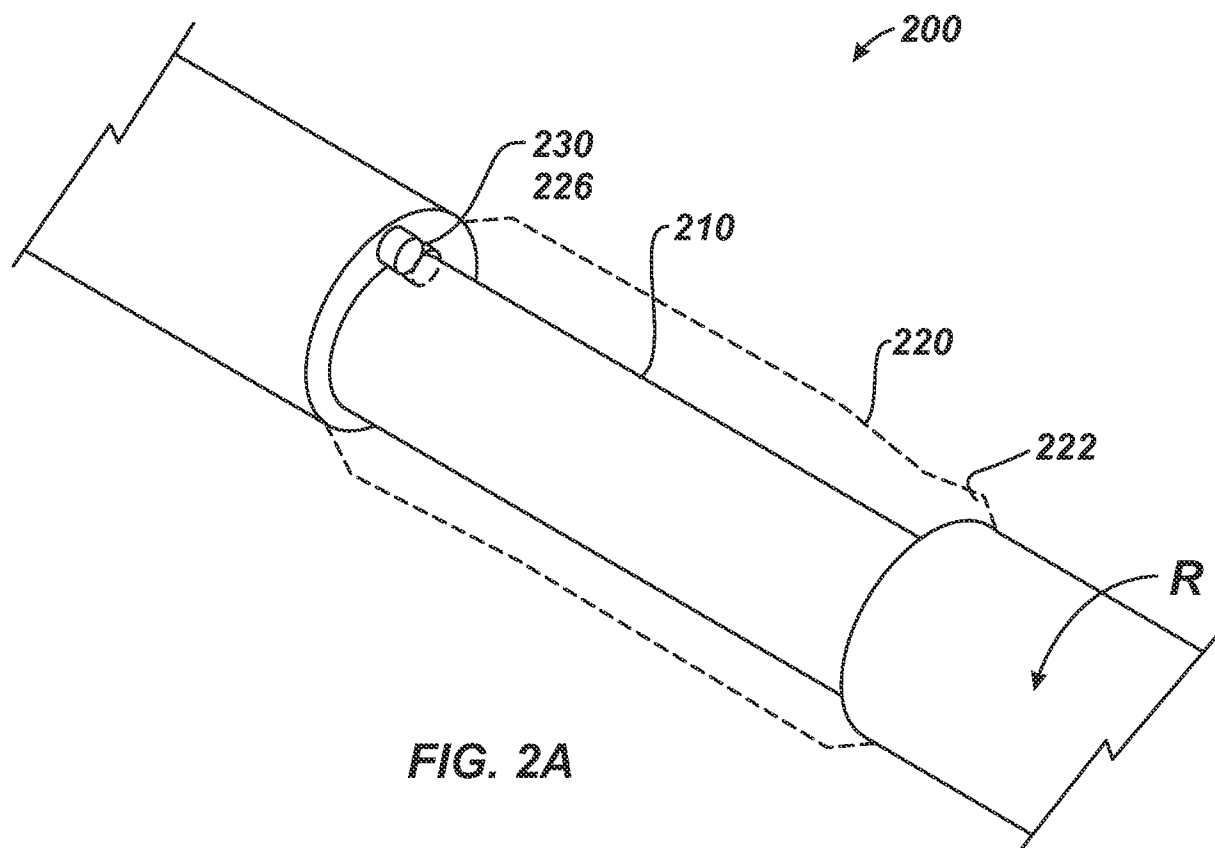


FIG. 2A

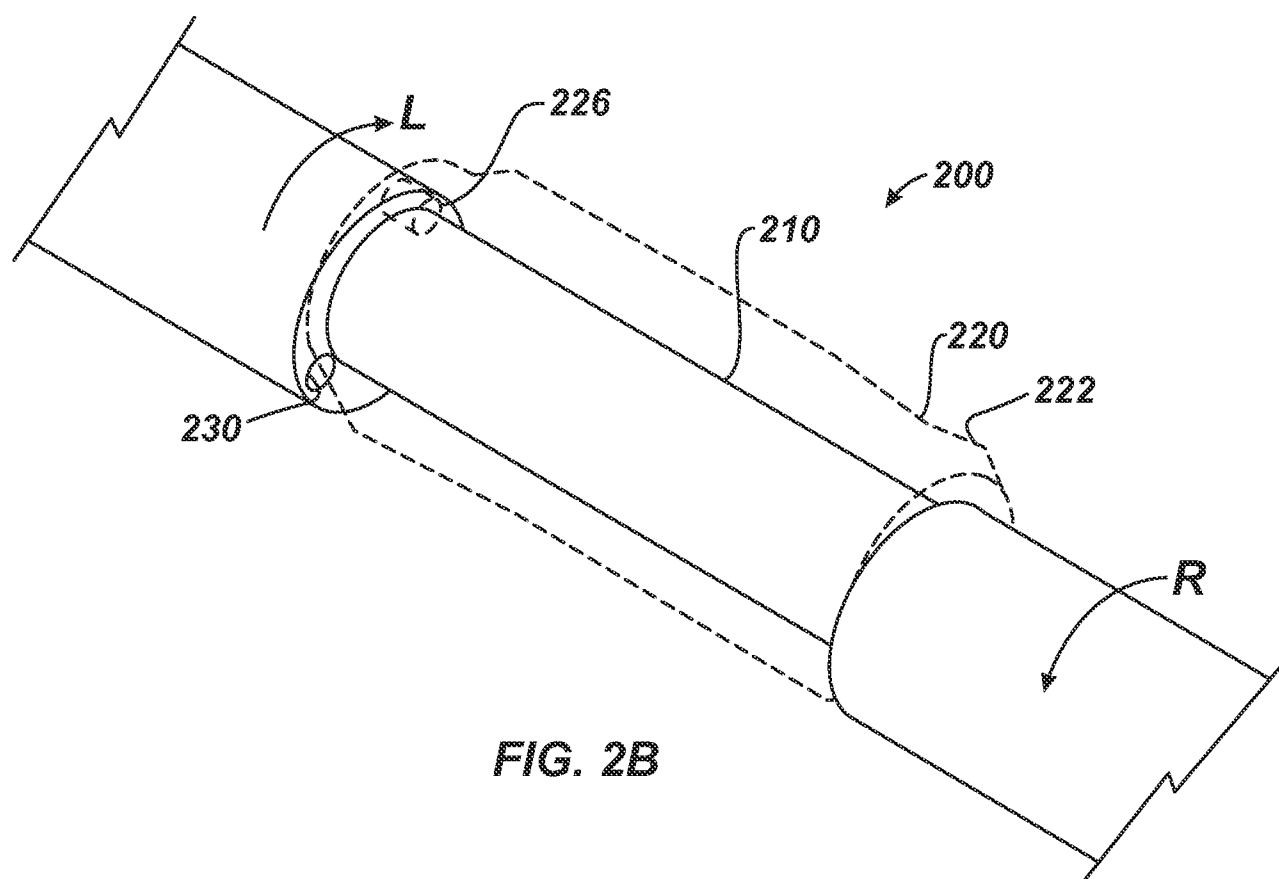
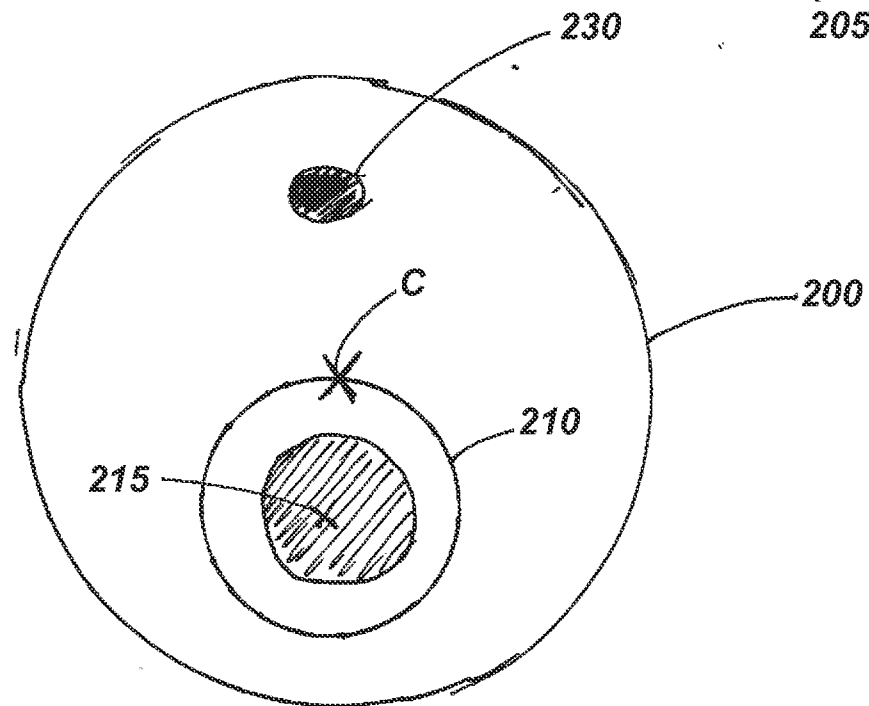
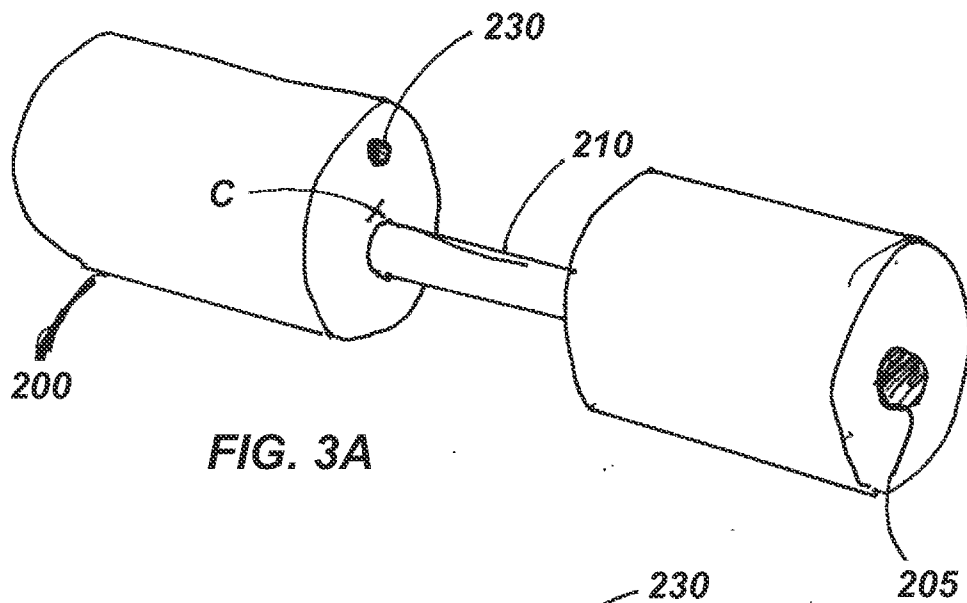
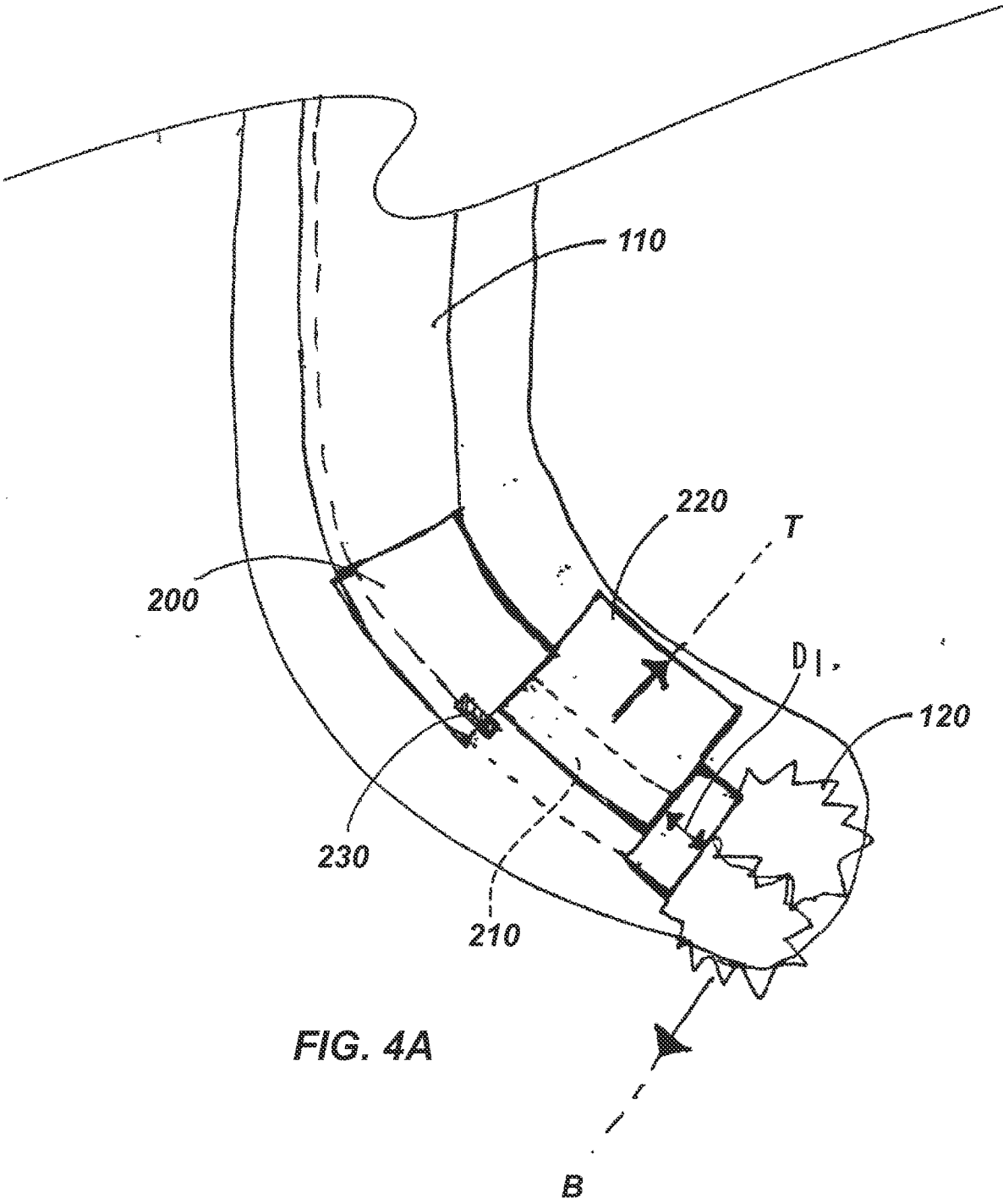


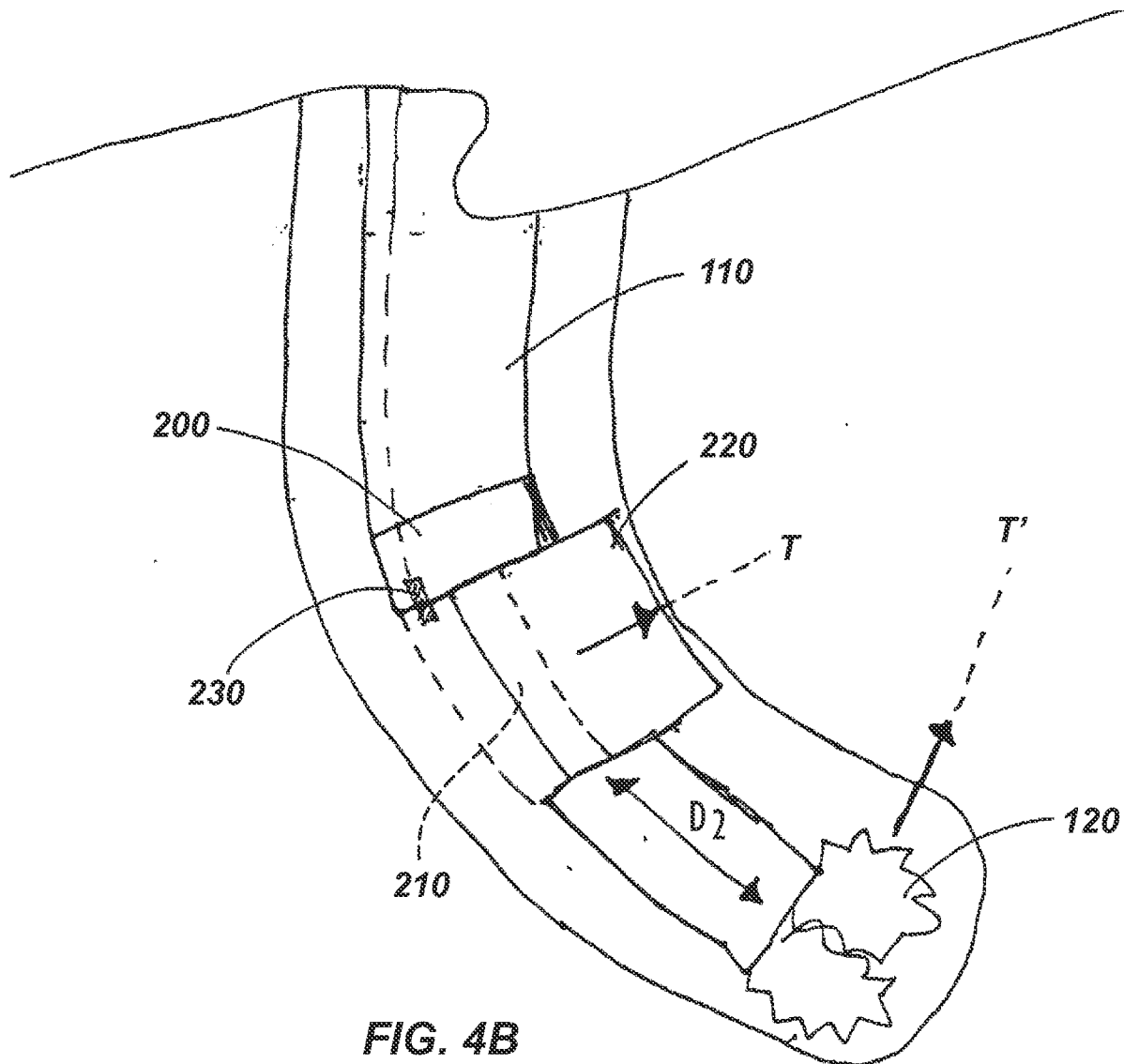
FIG. 2B

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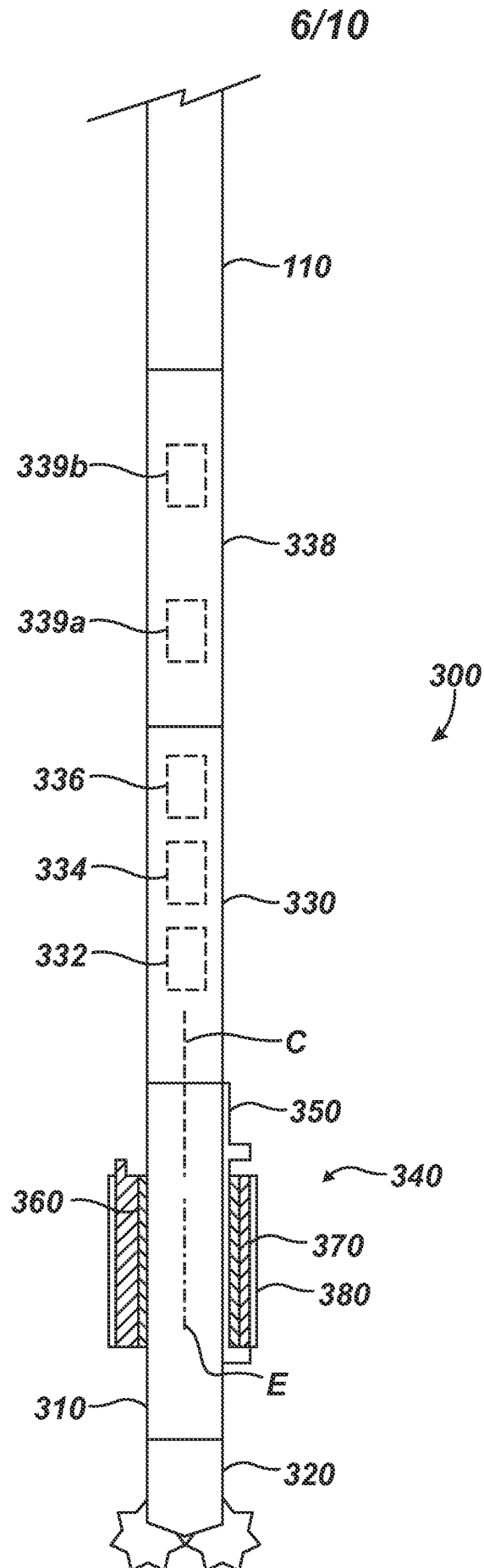


FIG. 5

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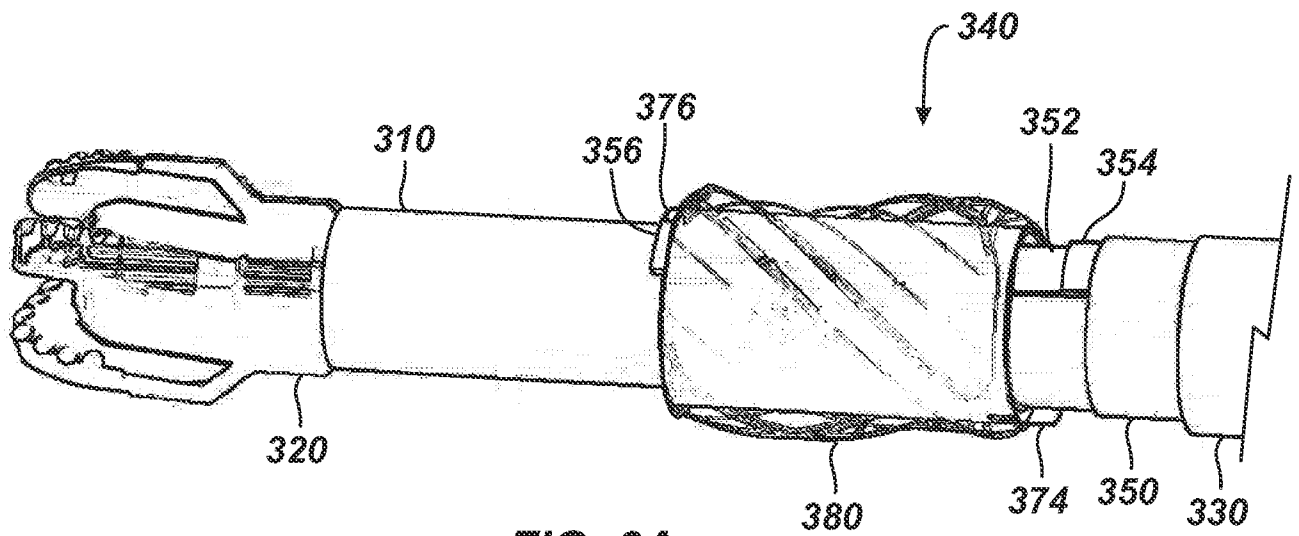


FIG. 6A

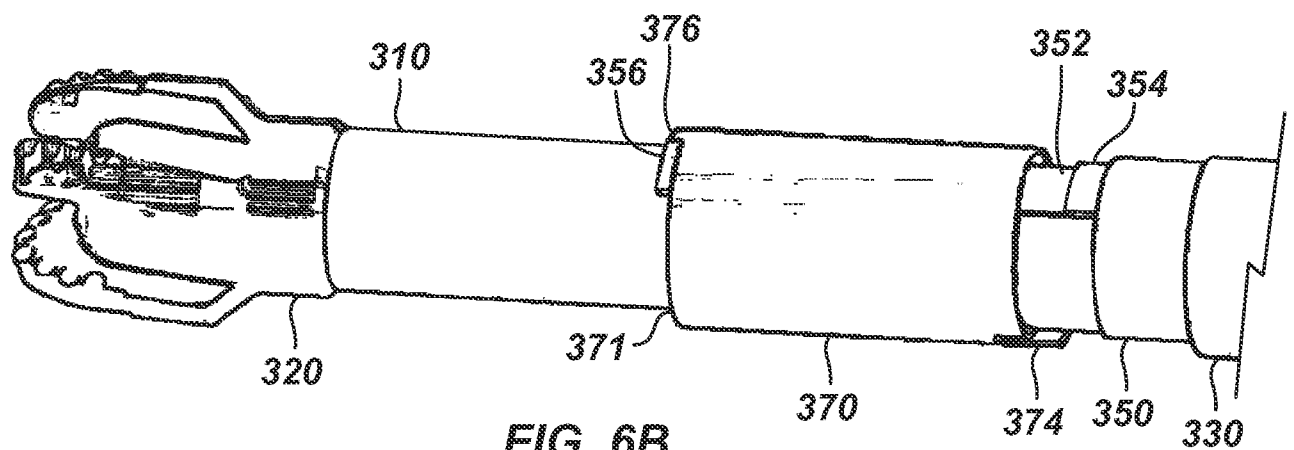


FIG. 6B

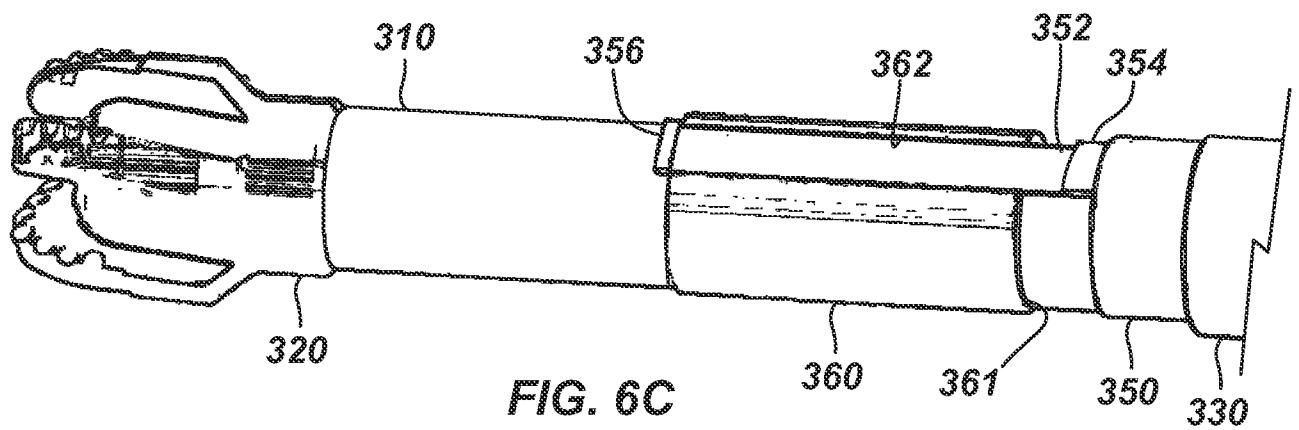
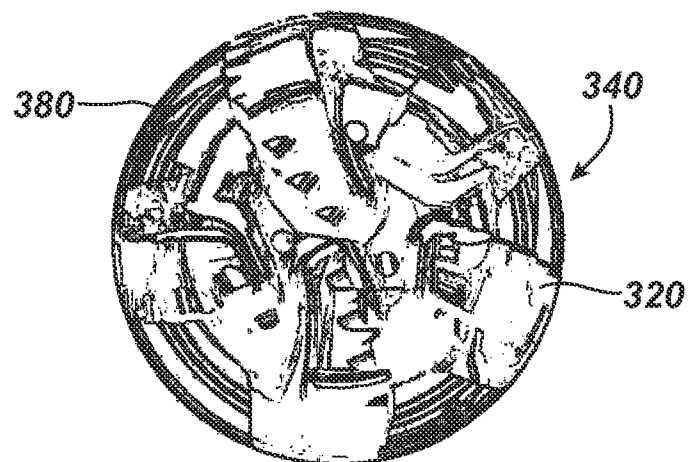
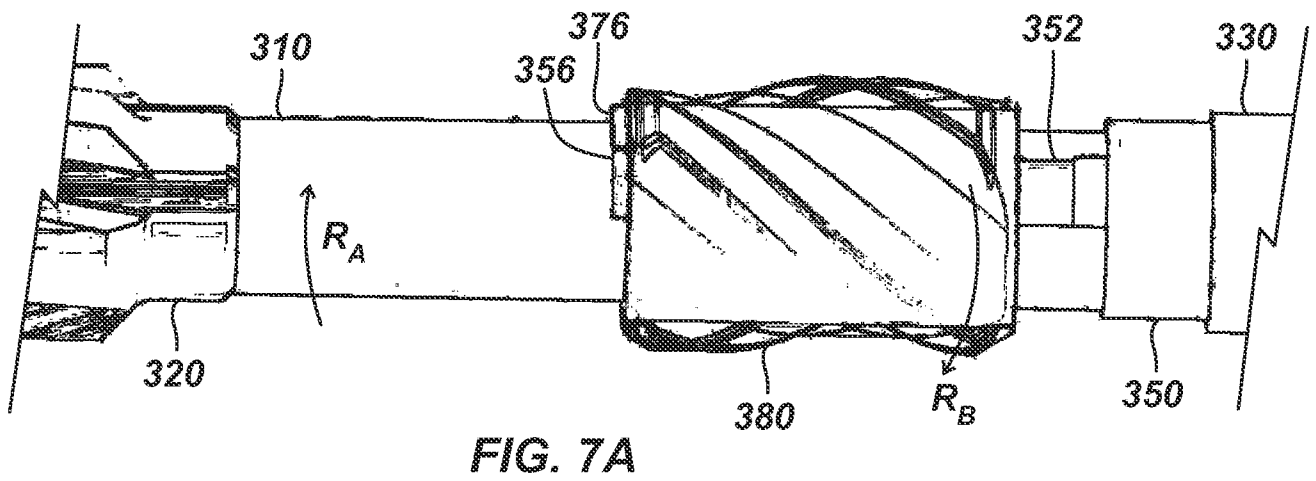
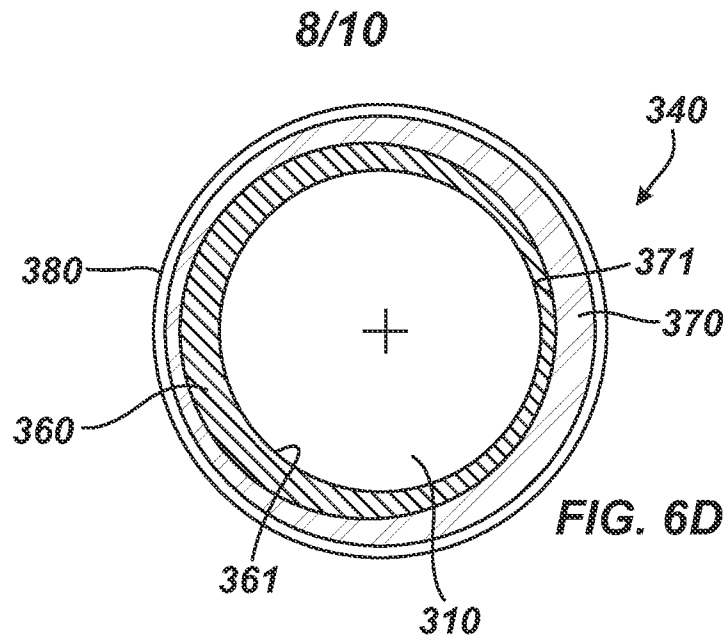
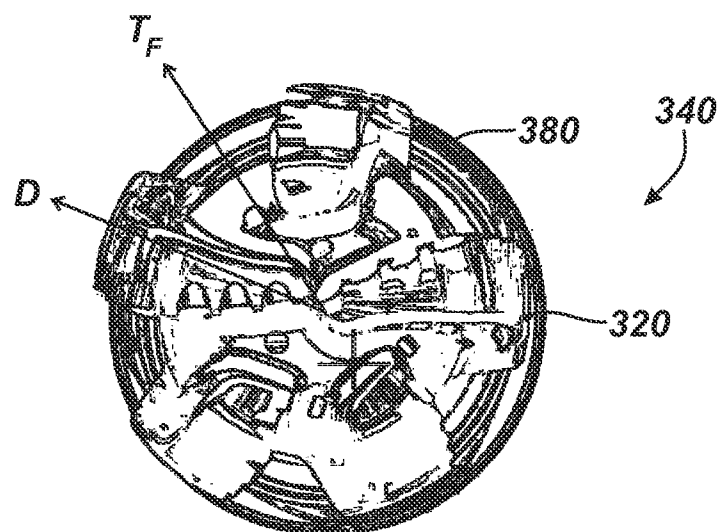
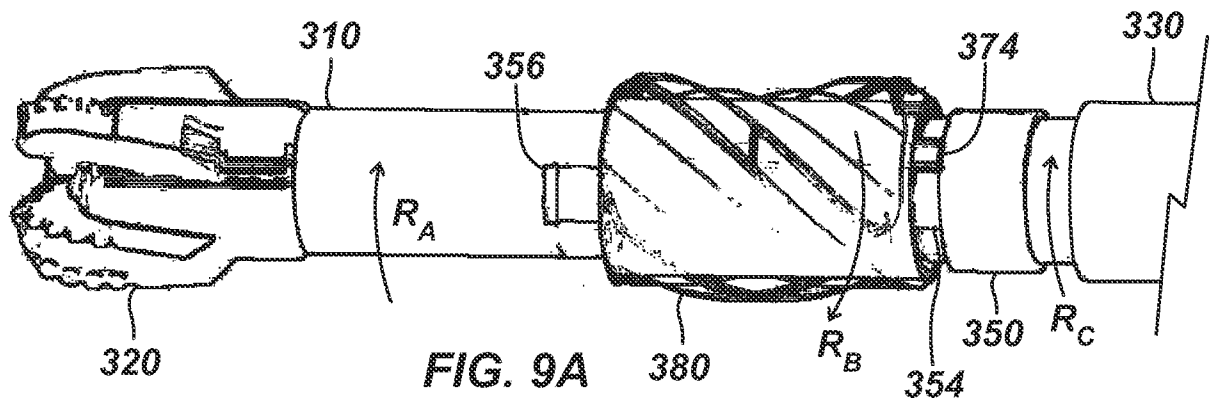
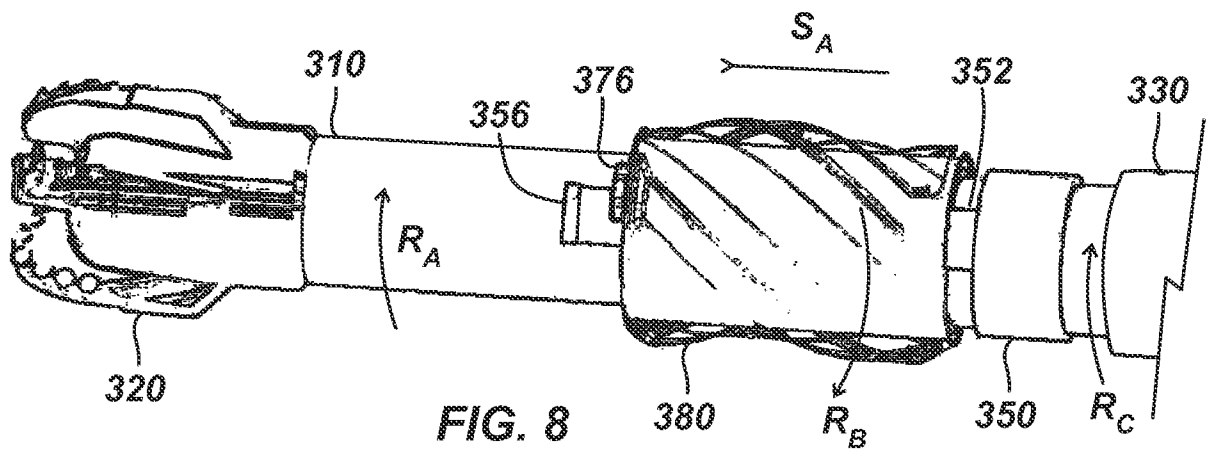


FIG. 6C



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