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(54) Titre : ENSEMBLE POUVANT ETRE DIRIGE ROTATIF INHIBANT UN TOURBILLONNEMENT DANS LE SENS
INVERSE DES AIGUILLES D'UNE MONTRE PENDANT UN FORAGE DIRECTIONNEL
(54) Title: ROTARY STEERABLE ASSEMBLY INHIBITING COUNTERCLOCKSEWHIRL DURING DIRECTIONAL
DRILLING

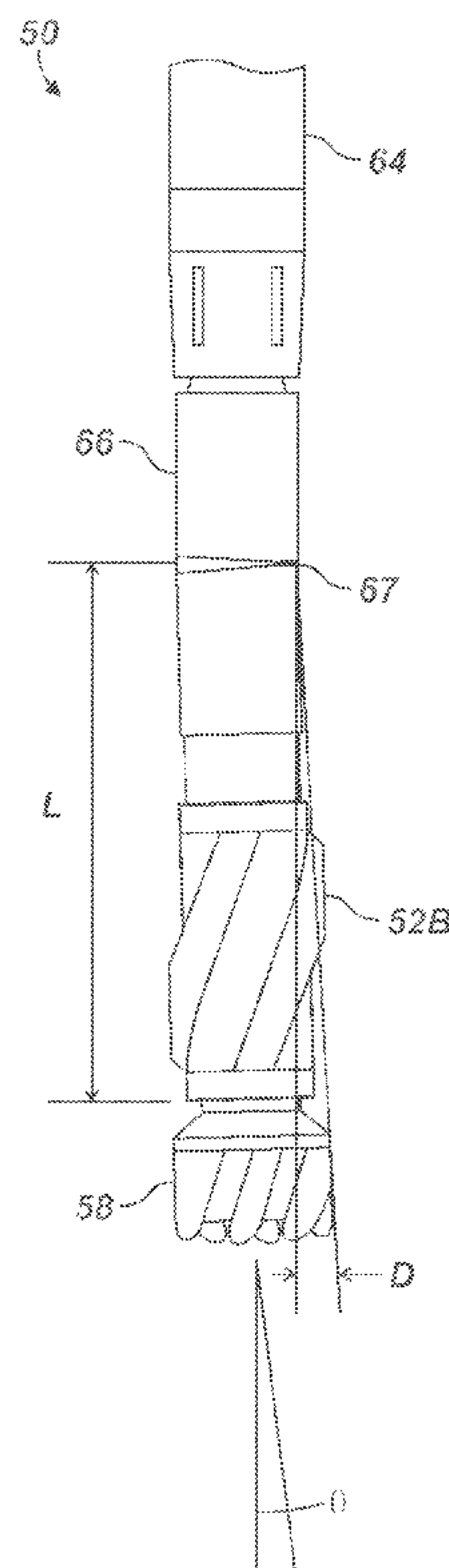


FIG. 4A

(57) **Abrégé/Abstract:**

A bottom hole assembly avoids damaging vibrations that can develop during directional drilling with a rotary steerable system. The assembly has a drill bit, a first collar that rotates with the bit, a rotary steerable tool that controls the bit's trajectory, and a second



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

collar that rotates with the drill string. The first collar between the bit and the tool defines a bend that deflects the bit from the first collar's axis. During operation, this bend causes portion of the assembly to engage the borehole wall to inhibit counterclockwise (CCW) bit whirl by promoting clockwise whiri in the assembly, generating friction against the borehole wall, and dampening vibrations. By inhibiting CCW bit whirl, other damaging vibrations such as CCW whirl in the drill string can also be prevented up the borehole.

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[Continued on next page]

(54) Title: ROTARY STEERABLE ASSEMBLY INHIBITING COUNTERCLOCKWISEWHIRL DURING DIRECTIONAL DRILLING

(57) Abstract: A bottom hole assembly avoids damaging vibrations that can develop during directional drilling with a rotary steerable system. The assembly has a drill bit, a first collar that rotates with the bit, a rotary steerable tool that controls the bit's trajectory, and a second collar that rotates with the drill string. The first collar between the bit and the tool defines a bend that deflects the bit from the first collar's axis. During operation, this bend causes portion of the assembly to engage the borehole wall to inhibit counterclockwise (CCW) bit whirl by promoting clockwise whirli in the assembly, generating friction against the borehole wall, and dampening vibrations. By inhibiting CCW bit whirl, other damaging vibrations such as CCW whirl in the drill string can also be prevented up the borehole.

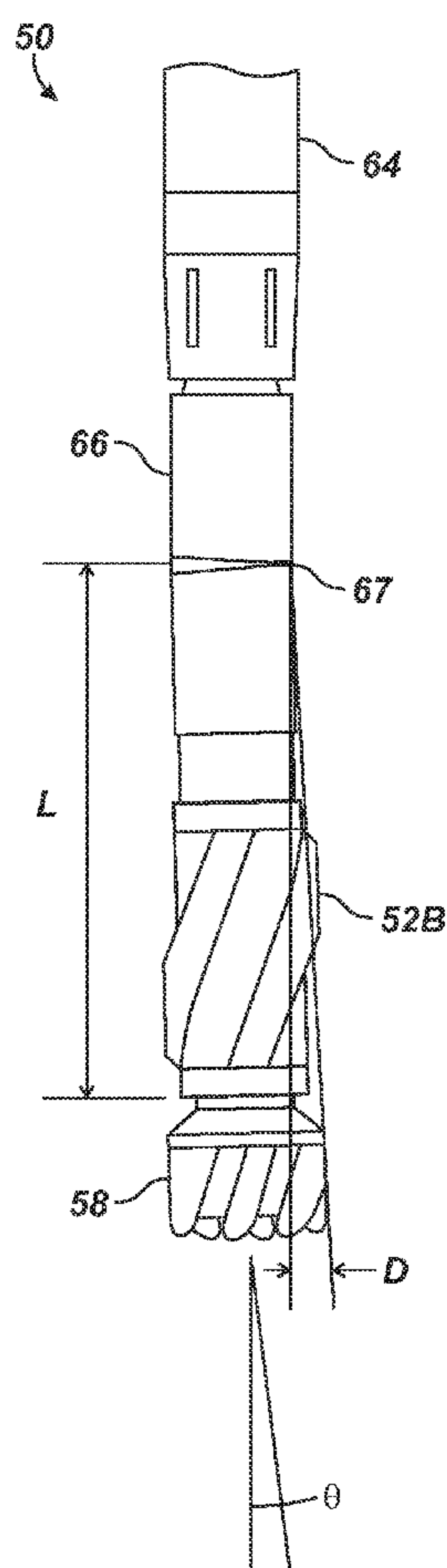


FIG. 4A



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**ROTARY STEERABLE ASSEMBLY INHIBITING
COUNTERCLOCKWISE WHIRL
DURING DIRECTIONAL DRILLING**

BACKGROUND

[Para 1] Some wells may need to be drilled using a complex trajectory to reach multiple target areas or to perform other operations. Therefore, operators must be able to precisely “steer” the drilling direction. To do this, operators can remotely operate a directional drilling device near the drill bit to control the drilling direction. Various types of directional drilling devices are known in the art. One such device uses a variable stabilizer, such as disclosed in U.S. Pat. No. 4,821,817, to control the drilling trajectory. The variable stabilizer has stabilizer blades that center the drill string within the borehole. Drilling mud pumped downhole is used to control the variable stabilizer by retracting the blades. When selected blades are retracted, the device permits the drilling angle of the drill bit to be changed.

[Para 2] Another directional drilling device is commonly referred to as a bent housing mud motor. This device uses a mud motor disposed on a housing that has an axis displaced from the axis of the drill string. In use, circulated drilling fluid hydraulically operates the mud motor, which has a shaft connected to a rotary drill bit. By rotating the drill bit with the motor and simultaneously rotating the motor and bit with the drill string, the device produces an advancing borehole trajectory that is parallel to the axis of the drill string. However, by rotating the drill bit with the motor but not rotating the drill string, the device can produce a borehole trajectory deviated from the axis of the non-rotating drill string. By alternating these two methodologies, operators can control the path of the borehole.

[Para 3] Another directional drilling device is a rotary steerable system that can change the orientation of the drill bit to alter the drilling trajectory but does not require rotation of the drill string to be stopped. One type of rotary steerable system is disclosed in U.S. Pat. No. 6,116,354, which is incorporated herein by reference. Although effective, rotary steerable systems during certain operations can suffer from vibrations and oscillations that can be extremely damaging and

hard to control. These uncontrolled vibrations can especially occur when the rotary steerable system is run below a high torque mud motor with a reasonably high speed (*i.e.*, a total bit RPM of about 110). Generally the higher the RPM, the higher the likelihood of CCW whirl.

[Para 4] In particular, a bottom hole assembly having a rotary steerable system essentially acts as a series of rotating cylindrical spring mass systems with variable support points (typically stabilizers or extended blades). The natural frequencies of these spring mass systems can create a variety of damaging vibrations during operation. Ideally, the bottom hole assembly experiences concentric rotation so that drill bit has sliding contact with the borehole wall. Although the assembly may initially be in sliding contact, the assembly eventually tries to ride up the wall in a horizontal borehole, but gravity and bending strain tend to throw the assembly back downslope.

[Para 5] The riding and dropping of the assembly in the borehole can intensify and becomes more violent with increasing impact loads propelling the assembly back and forth across the borehole. Eventually, the multiple impacts can develop into counterclockwise (CCW) bit whirl in which the drill bit is in continuous rolling contact with the borehole wall. At this stage, the frequency of the whirl action jumps dramatically, and the bottom hole assembly oscillates in a counterclockwise direction opposite to the rotation of the drill string. In general, the resulting motion can be defined by a Hypocycloid sub form of general Hypotrochoids. (This is true for a point on the outer surface of the BHA because the center describes a circle of diameter equal to the borehole clearance). The whirl action from the drill bit can travel up the drill string and can affect multiple points on the assembly.

[Para 6] As expected, counterclockwise bit whirl can unevenly wear the drill bit's cutters and can create fatigue in the various components of the bottom hole assembly and drill string. For this reason, operators need a way to reduce or minimize the development of counterclockwise bit whirl in a bottom hole assembly having a rotary steerable system or any other rotary drilling assembly.

SUMMARY

[Para 7] A bottom hole assembly for directional drilling avoids damaging vibrations that conventional assemblies may experience during operation. The assembly has a drill bit, a first collar that rotates with the drill bit, a rotary steerable tool that can control the trajectory of the drill bit, and a second collar that rotates with the drill string used to deploy the assembly.

[Para 8] The rotary steerable tool can use point-the-bit or push-the-bit technology. For example, the rotary steerable tool can have a center shaft that drives the drill bit and can have a non-rotating sleeve disposed about the center shaft and configured to remain rotationally stationary relative to the shaft. Hydraulically actuated pistons on a mandrel disposed in the sleeve can deflect the center shaft relative to the sleeve to direct the drill bit, and a stabilizer disposed on the first collar can act as a fulcrum point for the tool. During operation, both the drill string and the bit are rotated, and a mud motor on the assembly can impart rotation to the drill bit.

[Para 9] In one arrangement, the first collar coupled between the drill bit and the rotary steerable tool defines a bend that deflects the drill bit from an axis of the first collar. The bend can be predefined in the collar or can be adjustable. During operation, this bend causes a portion of the bottom hole assembly to engage the borehole wall. In this way, the bend can inhibit counterclockwise (CCW) bit whirl from developing at the drill bit by promoting clockwise whirl in a portion of the bottom hole assembly, generating friction against the borehole wall, and dampening vibrations generated at the assembly. By inhibiting or even preventing CCW bit whirl at the bottom hole assembly, other damaging vibrations such as CCW whirl in the drill string can also be prevented from forming up the borehole. In other arrangements, only the second collar between the tool and the drill string can define a bend, or both the first and second collars can define bends.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 10] FIG. 1 illustrates a bottom hole assembly having a rotary steerable tool according to the present disclosure.

[Para 11] FIG. 2A illustrates the bottom hole assembly with the rotary steerable tool in a first orientation.

[Para 12] FIG. 2B illustrates an internal cross-section of the rotary steerable tool in FIG. 2A.

[Para 13] FIG. 3A illustrates the bottom hole assembly with the rotary steerable tool in a second orientation.

[Para 14] FIG. 3B illustrates an internal cross-section of the rotary steerable tool in FIG. 3A.

[Para 15] FIG. 4A illustrates an isolated view of the lower end of the bottom hole assembly showing the bend in the lower collar.

[Para 16] FIG. 4B illustrates an isolated view of the lower end of the bottom hole assembly showing an adjustable bend in the lower collar.

[Para 17] FIG. 4C illustrates the deflection of the drill bit's rotational path produced by the bend in the lower collar.

[Para 18] FIG. 5A illustrates a bottom hole assembly having a bend in the collar disposed above the rotary steerable tool.

[Para 19] FIG. 5B illustrates a bottom hole assembly having bends in the collars both above and below the rotary steerable tool.

DETAILED DESCRIPTION

[Para 20] A directional drilling system 10 in FIG. 1 has a bottom hole assembly 50 deployed on a drill string 22 in a borehole 40. Although shown vertical, this borehole 40 can have any trajectory. The assembly 50 has an upper collar 52, a rotary steerable tool 60, a lower collar 66, and a drill bit 58. In general, the upper collar 52 can house a control electronics insert having batteries, directional sensors (*e.g.*, magnetometers, accelerometers, gamma ray sensors, inclinometers, etc.), a processing unit, memory, and downhole telemetry components. The bottom hole assembly 50 can also have a mud motor 56 positioned in this upper

collar 52 or elsewhere so that the mud motor 56 can provide torque to the drill bit 58 via a shaft (not shown) passing through the rotary steerable tool 60.

[Para 21] During operation, a rotary drilling rig 20 at the surface rotates the drill string 22 connected to the bottom hole assembly 50, and a mud system 30 circulates drilling fluid or "mud" through the drill string 22 to the bottom hole assembly 50. The mud operates the mud pump 56, providing torque to the drill bit 58. As the drill string 22 rotates, the drill bit 58 and lower collar 66 also rotate. Eventually, the mud exits through the drill bit 58 and returns to the surface via the annulus.

[Para 22] During drilling, the rotary steerable tool 60 can be operated to direct the drill bit 58 in a desired direction using point-the-bit technology discussed later so that the bottom hole assembly 50 can change the drilling path. As noted previously, however, the bottom hole assembly 50 with the rotary steerable tool 60 can suffer from undesirable vibrations in some circumstances, and the resulting motion from the vibrations can be extremely damaging and hard to control, especially when the rotary steerable tool 60 is run below a high torque mud motor 56 with a reasonably high speed (*i.e.*, a total drill bit RPM of about 110). It is believed that damaging vibrations that begin as counterclockwise (CCW) bit whirl starting at the bottom hole assembly 50 and that can travel up the assembly 50 and drill string 22. The frequencies involved in CCW bit whirl can be at least an order of magnitude higher than the drill string's RPM and can be a function of the borehole's diameter, the drill bit's diameter, and dimensions of other components of the bottom hole assembly 50 that act as the driving surfaces for whirl.

[Para 23] Regardless of the frequencies involved, the whirl once CCW bit whirl develops can migrate up the drill string 22 where it changes frequencies as the casing/drill string traction diameters change. This migrating whirl can eventually lead to CCW whirl in the drill string 22. The frequency of this whirl is believed to be established by the relative diameter of tool joints and the casing's internal diameter and is believed to be driven by the bottom hole assembly's CCW bit whirl, which can occur at a different frequency.

[Para 24] To alleviate the problems associated with CCW whirl, the rotary steerable tool 60 has a bend 67 in its rotating lower collar 66 near the drill bit 58. As the collar 66 and bit 58 rotate, the bend 67 in the collar 66 can prevent CCW bit whirl from developing and evolving into other uncontrolled motions, such as whirl in the drill string 22 uphole. The bend 67 can prevent this evolution by clamping portions of the bottom hole assembly 50 in the borehole 40, creating friction between the assembly 50 and the borehole wall, creating clockwise (CW) whirl in the assembly 50, or producing a combination of these actions.

[Para 25] During operation, for example, the rotating bend 67 produces frictional damping as the bent collar 66 is forced straight in the borehole 40. This friction inhibits the drill bit 58 from moving into rolling contact with the borehole wall, which could lead to CCW bit whirl. In addition, the bend 67 preloads the assembly 50 against the borehole wall and dampens harmful vibrations that may develop during operation and attempt to travel uphole. When this bend 67 is forced straight in the borehole 40, for example, the bend 67 clamps portions of the bottom hole assembly 50 and adjacent drill string 22 against the borehole 40. This clamping prevents resonant frequencies from developing and makes it harder for bit whirl to develop and travel uphole, because the traction of the drill bit 58 around the borehole wall cannot be maintained for an entire 360 degrees.

[Para 26] Finally, by engaging the borehole wall, the bend 67 also tends to create clockwise (CW) whirl that inhibits the extremely damaging hypocycloidal CCW bit whirl from developing. As expected, CCW whirl of the bit 58 cannot coexist with CW whirl in the assembly 50 generated by the collar 66. In this way, any CW whirl created by the collar 66 occurring at the collar's rotational frequency forces the drill bit 58 out of continuous rolling contact with the borehole wall and breaks up any CCW bit whirl that may develop.

[Para 27] As shown in more detail in FIGS. 2A-2B, the bottom hole assembly 50 coupled to the drill string 22 has a drill string stabilizer 52A, the upper collar 54, the rotary steerable tool 60, the lower collar 66, a near-bit stabilizer 52B, and the drill bit 58. The drill string stabilizer 52A provides a contact point to control deflection of the tool 60, and the near-bit stabilizer 52B provides a fulcrum point

for deflecting the rotary-steerable tool 60 so that the axis of the drill bit 58 can be oriented to change the drilling trajectory as discussed below.

[Para 28] A suitable system for the rotary steerable tool 60 is the Revolution® Rotary Steerable System available from Weatherford. As shown, the rotary steerable tool 60 has an upper end 62 coupled to the upper collar 54. A center shaft (72; Fig. 2B) extending from components at the upper end 62 passes through the non-rotating sleeve 64 and couples to the lower collar 66, to which the near-bit stabilizer 52B and drill bit 58 couple. Both the non-rotating sleeve 64 and the rotating pivot stabilizer 52B are close to the gage of the borehole 40 to maximize the directional performance of the tool 60. The rotating shaft 72 running through the sleeve 64 transmits torque and weight through the tool 60 to the drill bit 58. However, the non-rotating sleeve 64 is intended to engage the borehole 40 using a number of blades and anti-rotational devices to keep it from rotating.

[Para 29] As shown in the cross-section of FIG. 2B, a mandrel 70 positions within the non-rotating sleeve 64 and has the shaft 72 passing through it. The shaft 72 has a hollow bore for drilling mud to pass through the shaft 72 to the drill bit (58). A plurality of pistons 76 surround the mandrel 70 and engage the inside wall of the sleeve 64. Several banks of these pistons 76 run along the length of the mandrel 70 and shaft 72. These pistons 76 can be operated by high pressure hydraulic fluid HF pumped by a hydraulic system (not shown) driven by the relative rotation between the shaft 72 and the non-rotating sleeve 64.

[Para 30] As shown in FIGS. 2A-2B, the rotary steerable tool 60 operates in a neutral position to drill a straight section of borehole 40. In this neutral position, the tool's shaft 72 is concentric with the non-rotating sleeve 64 (*See* Fig. 2B). To control the drilling direction, however, the rotary steerable tool 60 can be deflected as shown in FIGS. 3A-3B. In particular, onboard navigation and control electronics (not shown) monitor the orientation of the tool 60 and its components. When changes in borehole direction are desired, the control electronics activate a solenoid valve (not shown) to pump hydraulic fluid to selected pistons 76 when a commutating valve 74 on the shaft 72 turns relative to the pistons 76. The hydraulic fluid HF pumped to selected pistons 76 causes them to extend outward

from the mandrel 70 and to move the mandrel 70 internally relative to the non-rotating sleeve 64. In turn, the moved mandrel 70 deflects the shaft 72 in a direction opposite to the desired trajectory, and the near-bit stabilizer 52B acts as a fulcrum for the shaft 72 to point the drill bit 58 in the desired direction.

[Para 31] As shown in FIGS. 2A and 3A, the bend 67 in the lower collar 66 essentially loads portions of the bottom hole assembly 50 against the borehole wall, clamping portions of the assembly 50 to the borehole 40, and promoting rotational friction and CW whirl to prevent or reduce the occurrence of CCW whirl and other vibrations as discussed herein. Details of the bend 67 in the lower collar 66 are illustrated in FIG. 4A. The bend 67 can be predefined in an integral collar 66 as shown in FIG. 4A or can be produced between joints of modular components of the collar 66 connected together. Alternatively, an adjustable bend 67' as shown in FIG. 4B can be used. This adjustable bend 67' can operate in a way similar to jointed bends found in bent housing mud motors, such as used on Weatherford's PrescisionDrill™ motor. The adjustable bend 67' can be set at a desired angle between 0 to 3-degrees and can use an internal universal joint.

[Para 32] In one arrangement, the bend 67 may be disposed a length (L) of a several feet or less from the drill bit 58, although the actual distance may vary given a particular implementation, size of the assembly 50, etc. In general, the bend 67 may define an angle (θ) of from 0 to 3-degrees, although the angle may depend on variables of the particular implementation. In addition, the bend 67 may deflect the drill bit 58 by a deflection (D) of about 3/16 inch off axis or more. For example, the deflection (D) of the drill bit 58 may be about 1/4-inch from axis of the tool 60, although again the deflection (D) depends on the particular implementation.

[Para 33] Given the deflection (D) by the bend 67, the drill bit 58 when rotated sweeps a circular path that drills a borehole slightly larger than the diameter of the drill bit 58. As shown in FIG. 4C, for example, the rotational path of the drill bit 58 deflected by the bend (67) will produce a borehole 80 that has a diameter approximately 2xD (e.g., 1/2-inch) larger than the borehole 82 that would be produced with a non-deflected drill bit. Operators can take the amount of

deflection (D) produced by the bend 67 into account when selecting the size of drill bit 58, stabilizers 52A-B, desired gage of the borehole, etc.

[Para 34] The bend 67 may even tend to dampen string vibration even in over gage holes. For example, the bottom hole assembly 50 having a 1/4-inch off axis bend 67 may be effective even in a 3/8-inch over gage borehole. The bend 67 may also dramatically reduce the tendency of the assembly 50 to engage in stick slip oscillation, which are pumped rotational oscillations caused by forcing functions at the drill bit 58. Although the actual amount of deflection required to be effective depends on the stiffness of the bottom hole assembly 50, the deflection load is preferably sufficient to assure that at least a portion of the bottom hole assembly 50 engages and stays in contact with the borehole wall.

[Para 35] As discussed above, the lower collar 66 near the near-bit stabilizer 52B can define the bend 67. In an alternative shown in FIG. 5A, the bottom hole assembly 50 can have a bend 57 in the upper collar 54 disposed above the rotary steerable tool 60. As shown, this bend 57 can be positioned between the drill string stabilizer 52A and the rotary steerable tool's sleeve 64. For example, the bend 57 can be applied in the collar 54 or mud motor 56 immediately above the rotary steerable tool 60, although other locations are possible. In one arrangement, the bend 57 can be located a distance of greater than 5-ft. from the bit 58 and can define an angle of about 1 to 1.5 degrees. In this way, the bend 57 can cause the upper section of the rotary steerable tool 60, the mud motor 56, and the assembly's collar 52 immediately above the rotary steerable tool 60 to be loaded against a borehole even in 1-inch over gage boreholes.

[Para 36] In another alternative shown in FIG. 5B, the bottom hole assembly 50 can have a bend 57 in the upper collar 54 above the rotary steerable tool 60 and can have a bend 67 in the lower collar 66. The upper bend 57 will rotate with the drill string's rotation, while the lower bend 67 will rotate with the drill bit's rotation. This offset in the rotation and contact of these bends 57 and 67 may have benefits in particular implementations.

[Para 37] In this specification, terms such as "upper", "lower" and "bottom" may be used for convenience to denote parts which have such an orientation in the drill

string when the drill string extends vertically in a borehole. However, it will be understood that these parts may have a different orientation when the bottom hole assembly is in a section of borehole that deviates from the vertical and may even be horizontal.

[Para 38] Although discussed as being used with the rotary steerable tool 60 that uses point-the-bit technology (namely a center shaft deflected by a mandrel with pistons in a non-rotating sleeve), the teachings of the present disclosure are also applicable to rotary steerable tools that use push-the-bit technology. A push-the-bit rotary steerable tool can use external pads extendable from a non-rotating sleeve to engage the borehole wall to direct the drill bit. Thus, this form of tool can have a center shaft driving the drill bit and can have a sleeve disposed about the center shaft that is configured to remain rotationally stationary relative to the shaft. At least one pad disposed on the sleeve is extendable therefrom to engage the borehole wall to change the trajectory of the drill bit.

[Para 39] 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. 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.

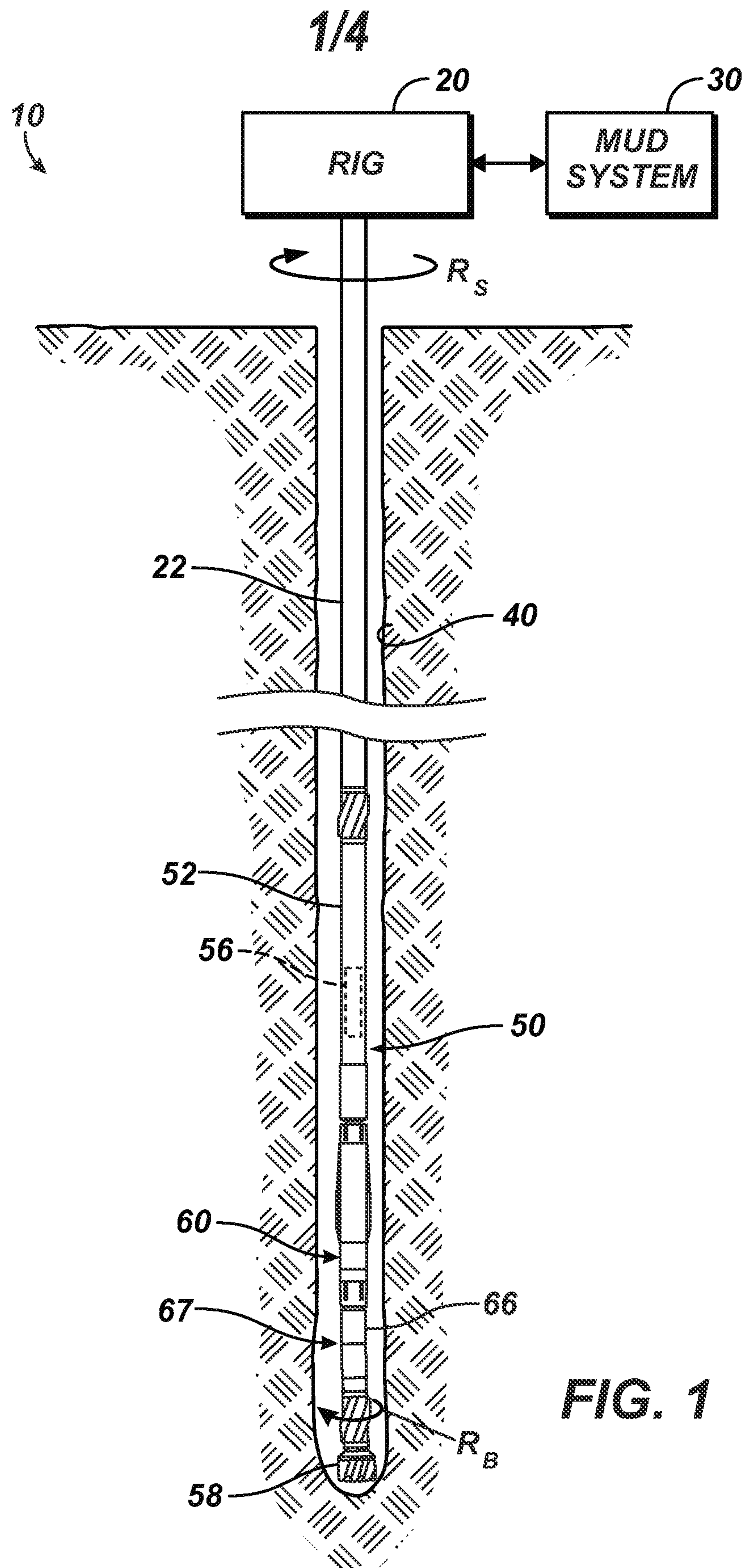
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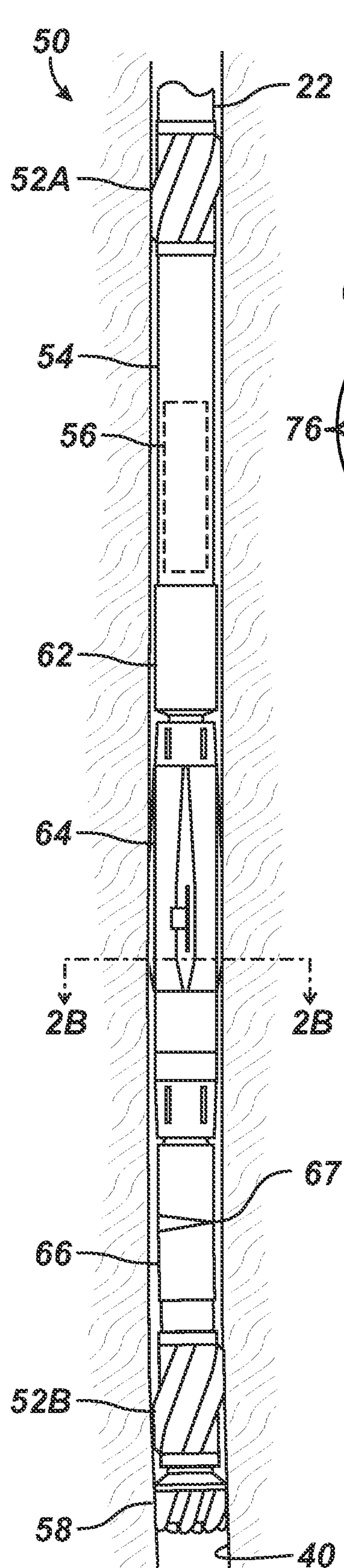
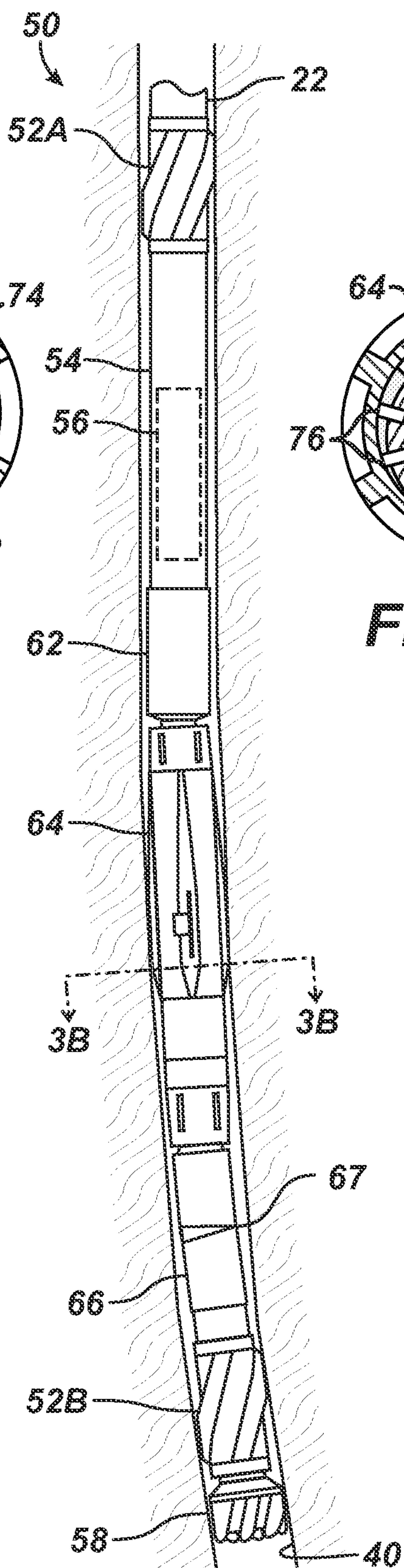
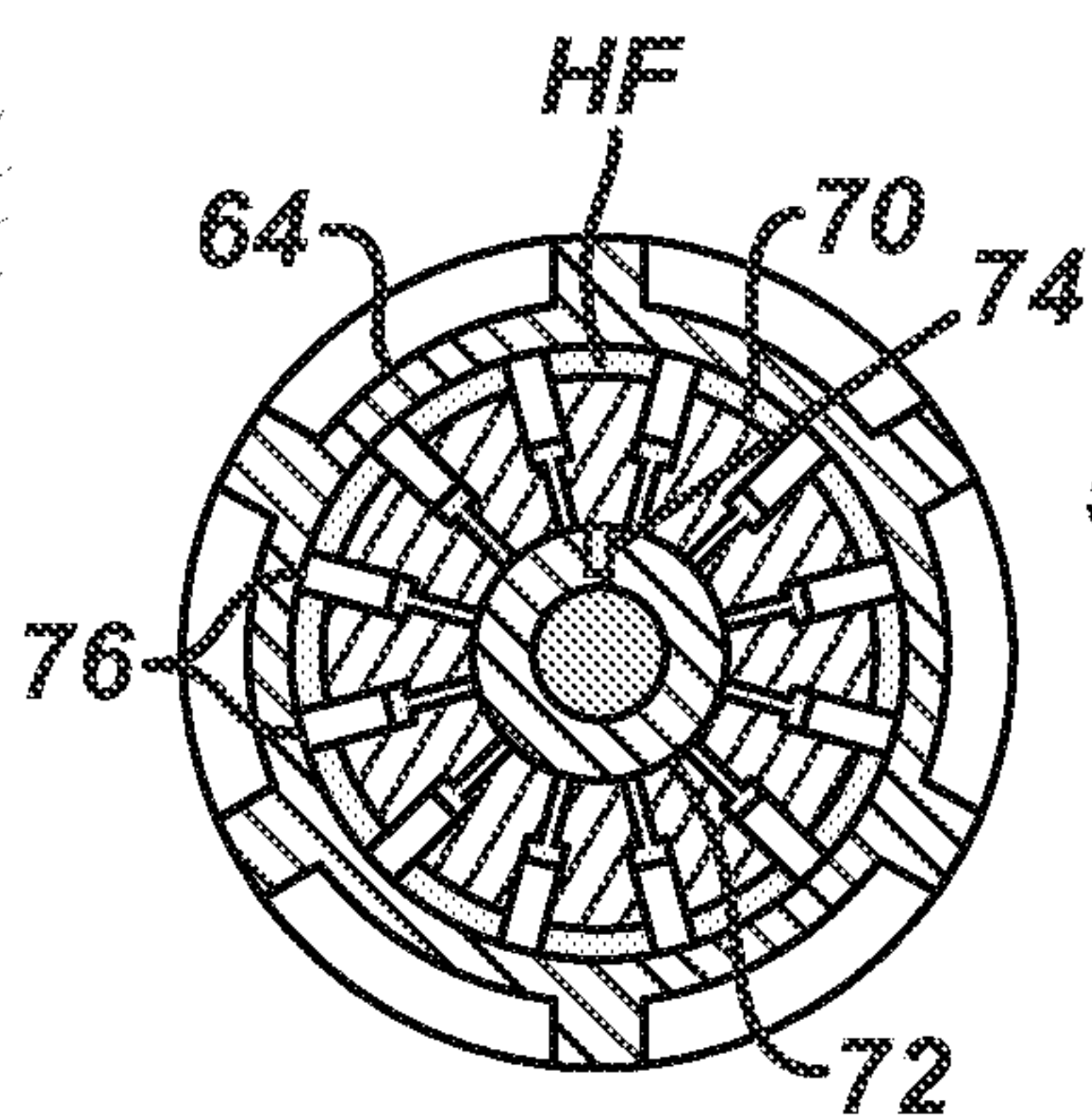
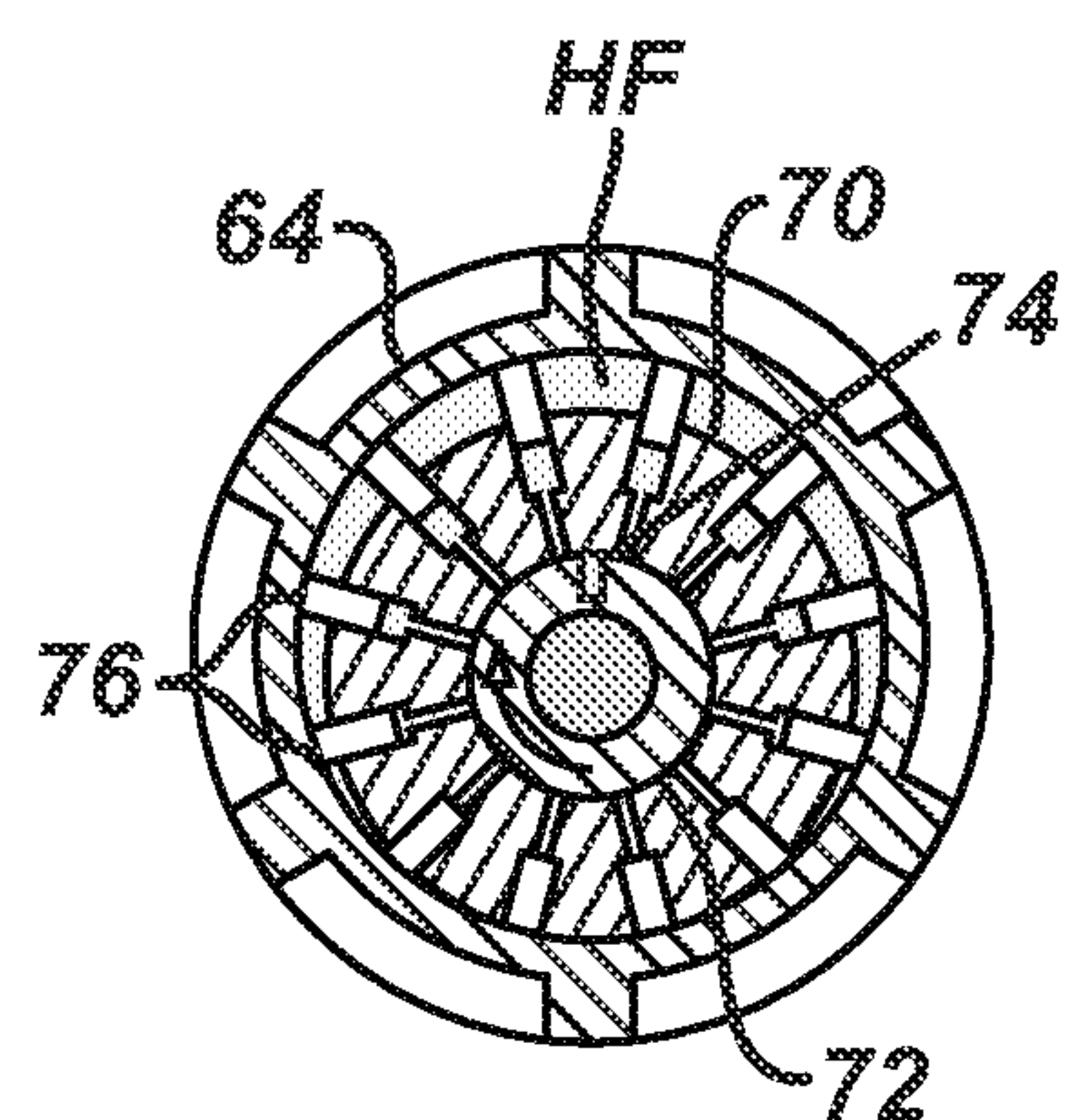
1. A bottom hole assembly for directional drilling, comprising:
a drill bit;
a first collar coupled to the drill bit and rotatable therewith, the first collar defining a first bend;
a rotary steerable tool coupled to the first collar and being operable to change a trajectory of the drill bit; and
a second collar coupled to the rotary steerable tool, the second collar coupled to a drill string and being rotatable therewith,
wherein the first bend deflects the drill bit from an axis of the first collar and causes a portion of the bottom hole assembly to engage a borehole wall when disposed therein.
2. The assembly of claim 1, wherein the first bend inhibits counterclockwise bit whirl of the drill bit.
3. The assembly of claim 1, wherein the first bend promotes clockwise whirl in a portion of the bottom hole assembly.
4. The assembly of claim 1, wherein the first bend is fixed.
5. The assembly of claim 1, wherein the first bend is adjustable.
6. The assembly of claim 1, wherein the second collar defines a second bend, the second bend deflecting the drill bit from an axis of the second collar and causing a portion of the bottom hole assembly to engage the borehole wall when disposed therein.
7. The assembly of claim 1, wherein the first collar has a stabilizer disposed thereon and rotatable therewith.

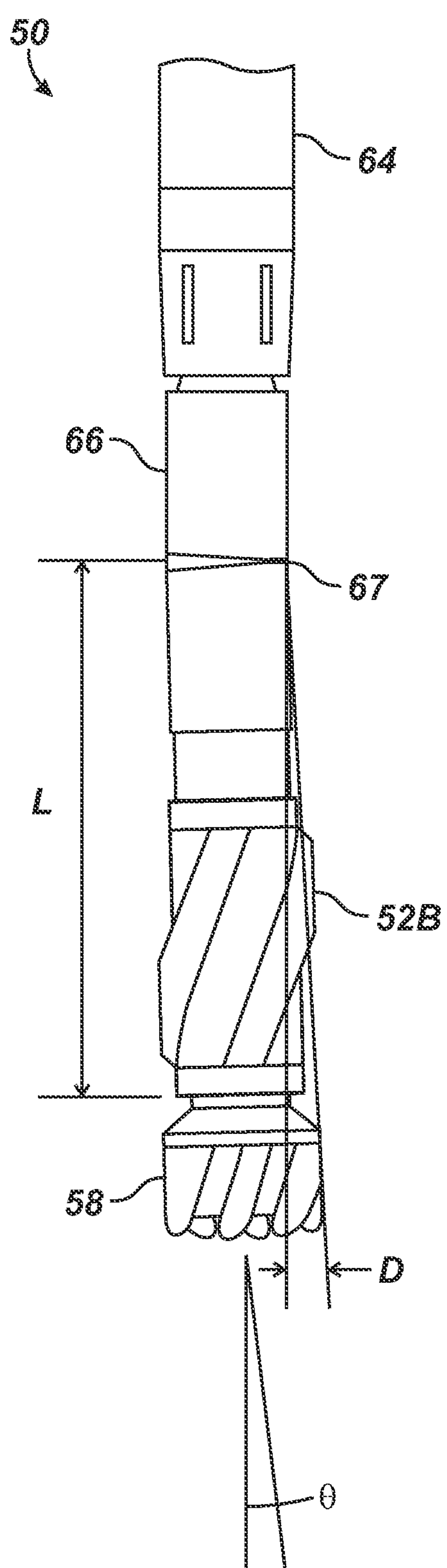
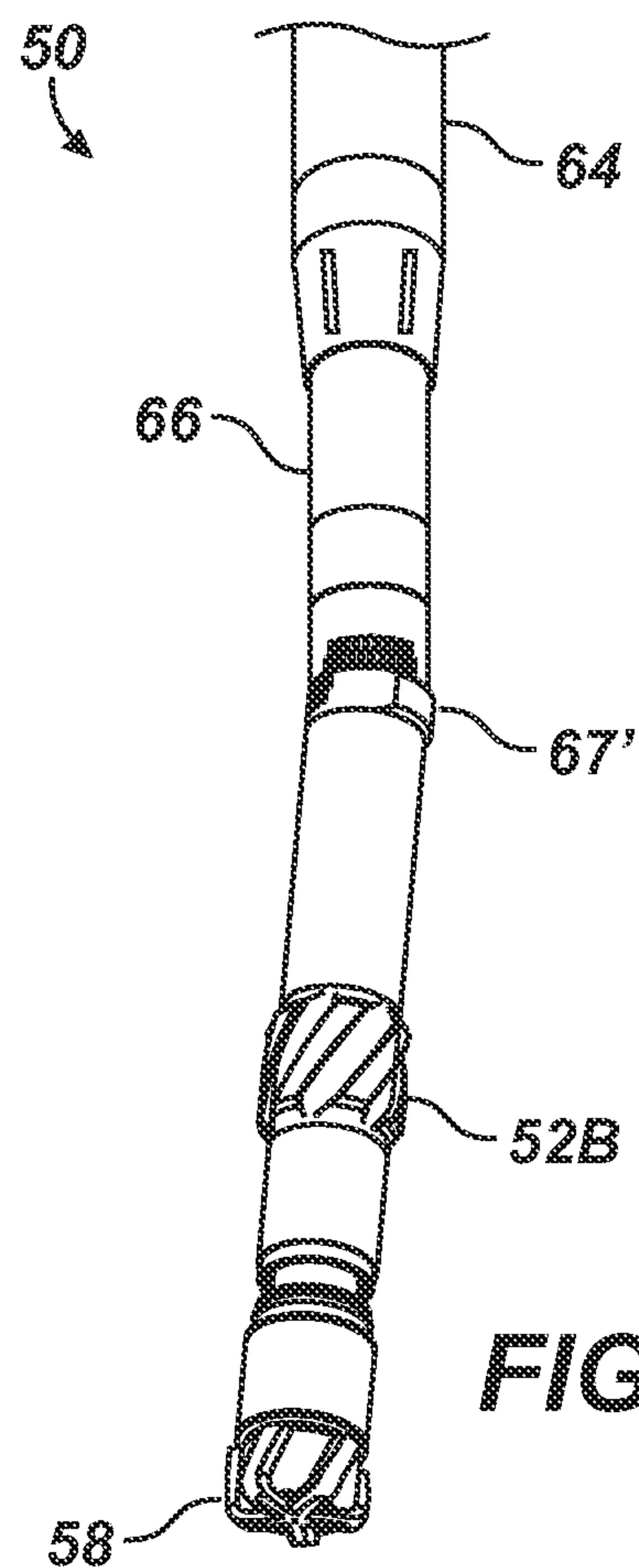
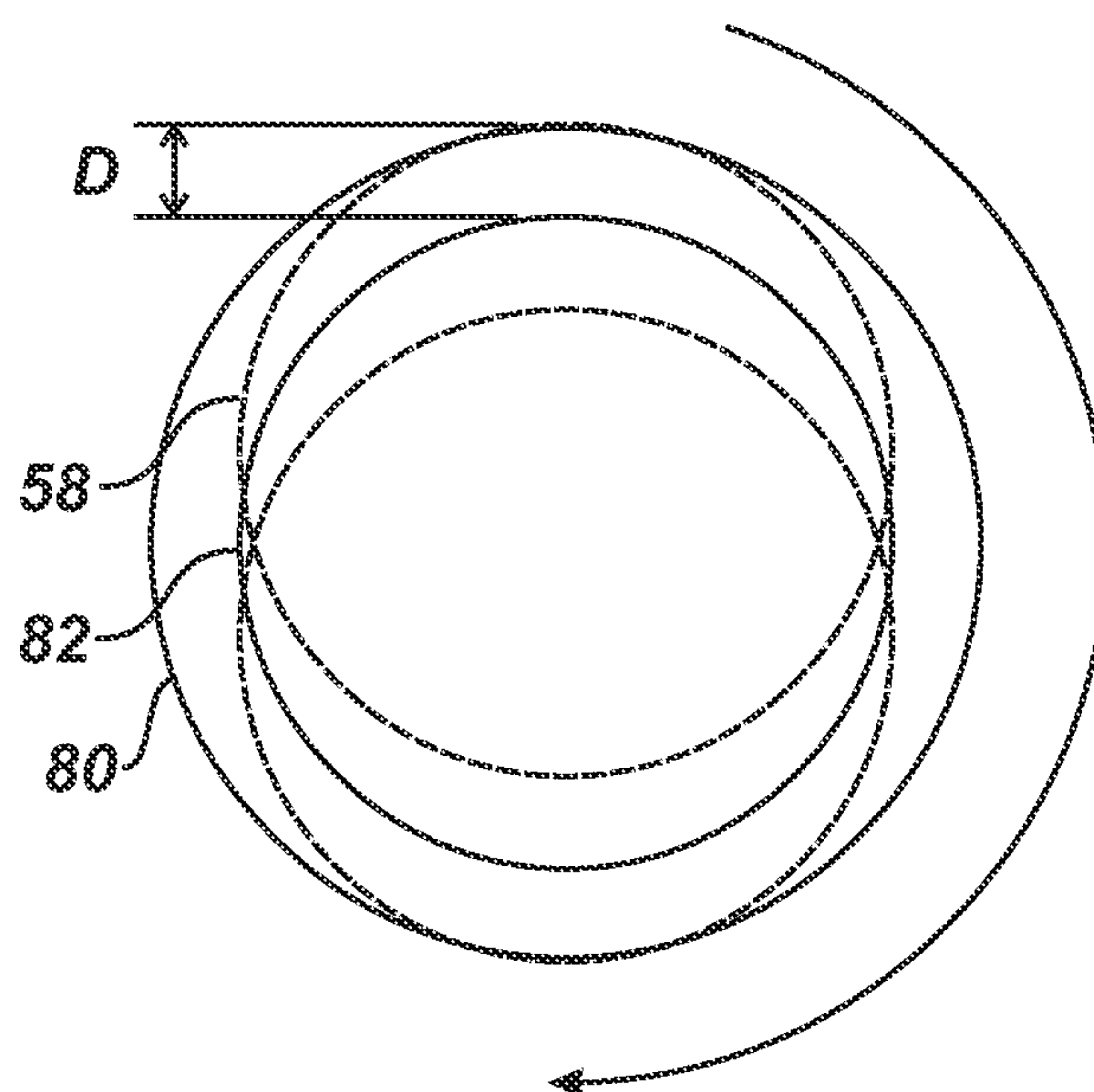
8. The assembly of claim 1, wherein the second collar has a stabilizer disposed thereon and rotatable therewith.
9. The assembly of claim 1, wherein the second collar houses a control electronics insert.
10. The assembly of claim 1, wherein the rotary steerable tool comprises a mechanism pointing the drill bit to a trajectory.
11. The assembly of claim 10, wherein the rotary steerable tool comprises:
 - a center shaft driving the drill bit;
 - a sleeve disposed about the center shaft and configured to remain rotationally stationary relative to the shaft; and
 - a mandrel disposed in the sleeve and about the center shaft, the mandrel having a plurality of hydraulic pistons operable to deflect the center shaft relative to the sleeve.
12. The assembly of claim 1, wherein the rotary steerable tool comprises a mechanism pushing the drill bit to a trajectory.
13. The assembly of claim 12, wherein the rotary steerable tool comprises:
 - a center shaft driving the drill bit;
 - a sleeve disposed about the center shaft and configured to remain rotationally stationary relative to the shaft; and
 - at least one pad disposed on the sleeve and being extendable therefrom to engage the borehole wall.
14. The assembly of claim 1, further comprising a mud motor disposed on the assembly and imparting rotation to the drill bit.

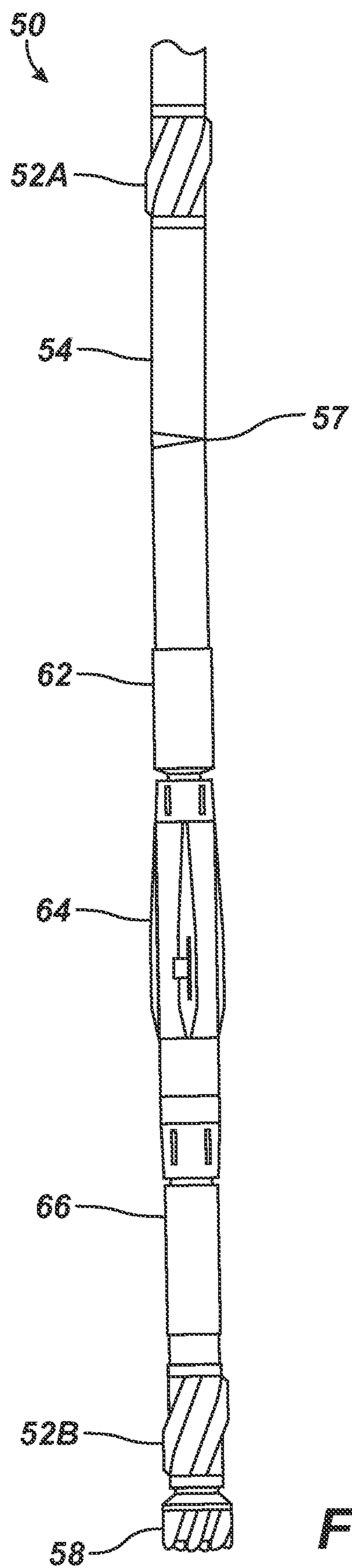
15. The assembly of claim 1, wherein the drill string and the drill bit are rotated simultaneously.
16. A bottom hole assembly for directional drilling, comprising:
a first collar coupled to a drill string and rotatable therewith, the first collar defining a first bend; and
a rotary steerable tool coupled to the first collar and being operable to change a trajectory of the drill bit, the rotary steerable tool having a second collar and a drill bit, the second collar being rotatable with the drill bit,
wherein the first bend deflects the drill bit from an axis of the first collar and causes a portion of the bottom hole assembly to engage a borehole wall when disposed therein.
17. A directional drilling method, comprising:
creating a borehole by advancing a rotating drill bit of a bottom hole assembly coupled to a rotating drill string, the bottom hole assembly having a rotary steerable tool coupled to the rotating drill bit and the rotating drill string and having at least one rotating collar coupled to the rotary steerable tool, the at least one collar defining at least one bend;
controlling a trajectory of the rotating drill bit by operating the rotary steerable tool; and
inhibiting counterclockwise bit whirl of the rotating drill bit by causing with the at least one bend a portion of the bottom hole assembly to engage the borehole wall.
18. The method of claim 17, wherein inhibiting counterclockwise bit whirl of the rotating drill bit comprises promoting with the at least one bend clockwise whirl in a portion of the bottom hole assembly.

19. The method of claim 17, wherein the at least one bend comprises a first bend disposed in a first collar and deflecting the rotating drill bit from an axis of the first collar, the first collar coupled between the rotary steerable tool and the rotating drill bit and being rotatable with the rotating drill bit.
20. The method of claim 19, wherein the first collar has a stabilizer disposed thereon and rotatable therewith
21. The method of claim 17, wherein the at least one bend comprises a second bend disposed in a second collar and deflecting the rotating drill bit from an axis of the second collar, the second collar coupled between the rotary steerable tool and the rotating drill string and being rotatable with the rotating drill string.
22. The method of claim 21, wherein the second collar has a stabilizer disposed thereon and rotatable therewith.
23. The method of claim 17, wherein operating the rotary steerable tool comprises pointing the rotating drill bit to a trajectory.
24. The method of claim 17, wherein operating the rotary steerable tool comprises pushing the rotating drill bit to a trajectory.
25. The method of claim 17, further comprising imparting rotation to the rotating drill bit with a mud motor disposed on the bottom hole assembly.
26. The method of claim 17, wherein the drill string and the drill bit are rotated simultaneously.

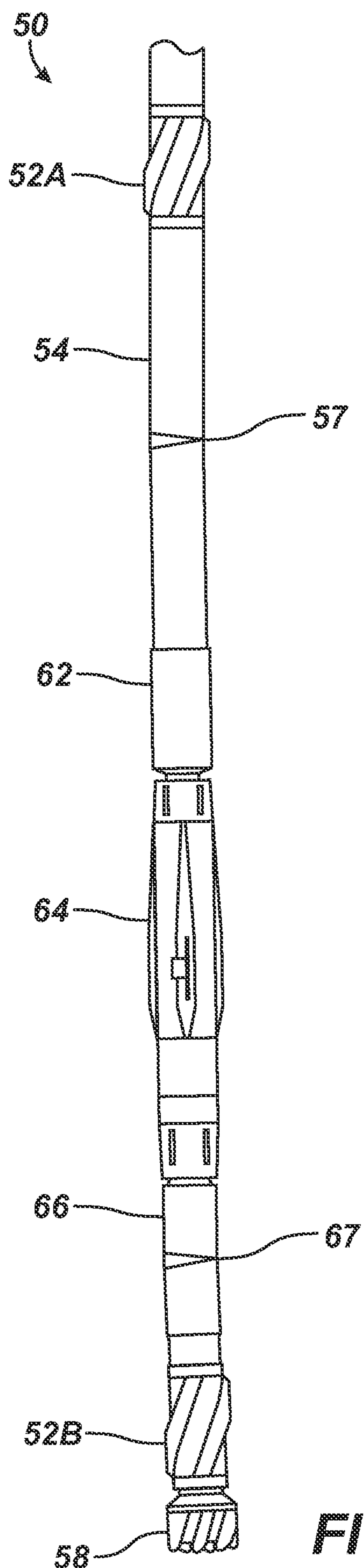


**FIG. 2B****FIG. 3B****FIG. 2A****FIG. 3A**

**FIG. 4A****FIG. 4B****FIG. 4C**



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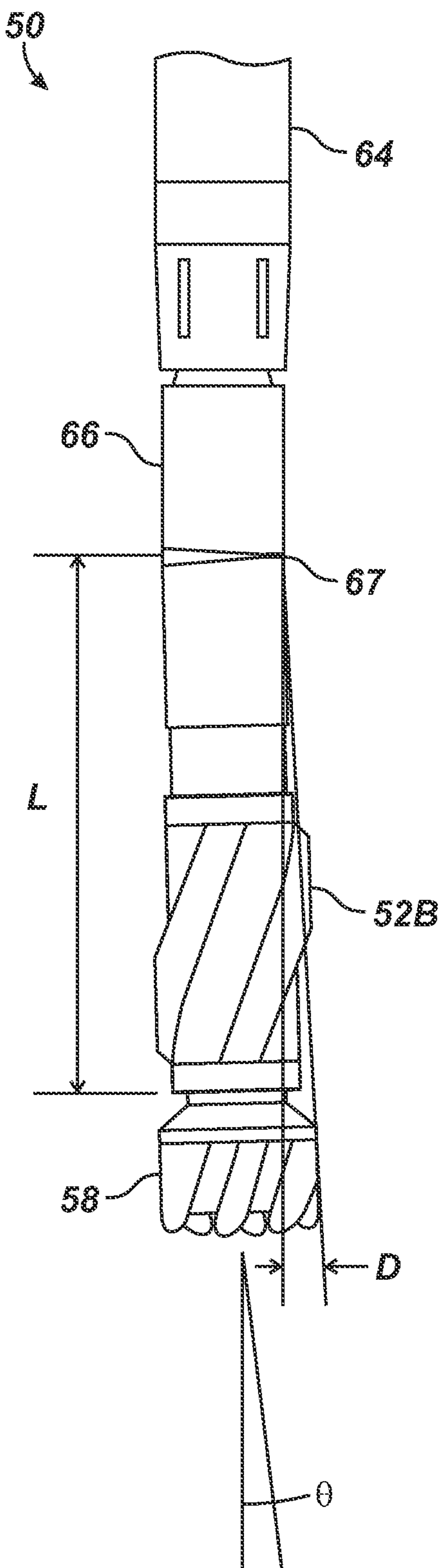


FIG. 4A