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(54) **Deviation resistant drilling guide rod**

(57) An elongate drilling guide rod (100) for percussive drilling comprising a deviation resistant section (107) extending axially along at least part of a main length section (106) of the rod (101). The deviation resistant section comprises a circumferentially non-uniform cross sectional wall thickness that includes two diametrically opposed thick regions and two diametrically opposed thin regions. A guide rod is provided being appreciably stiffer and having a larger area moment of inertia in one axis perpendicular to the longitudinal axis of the rod.

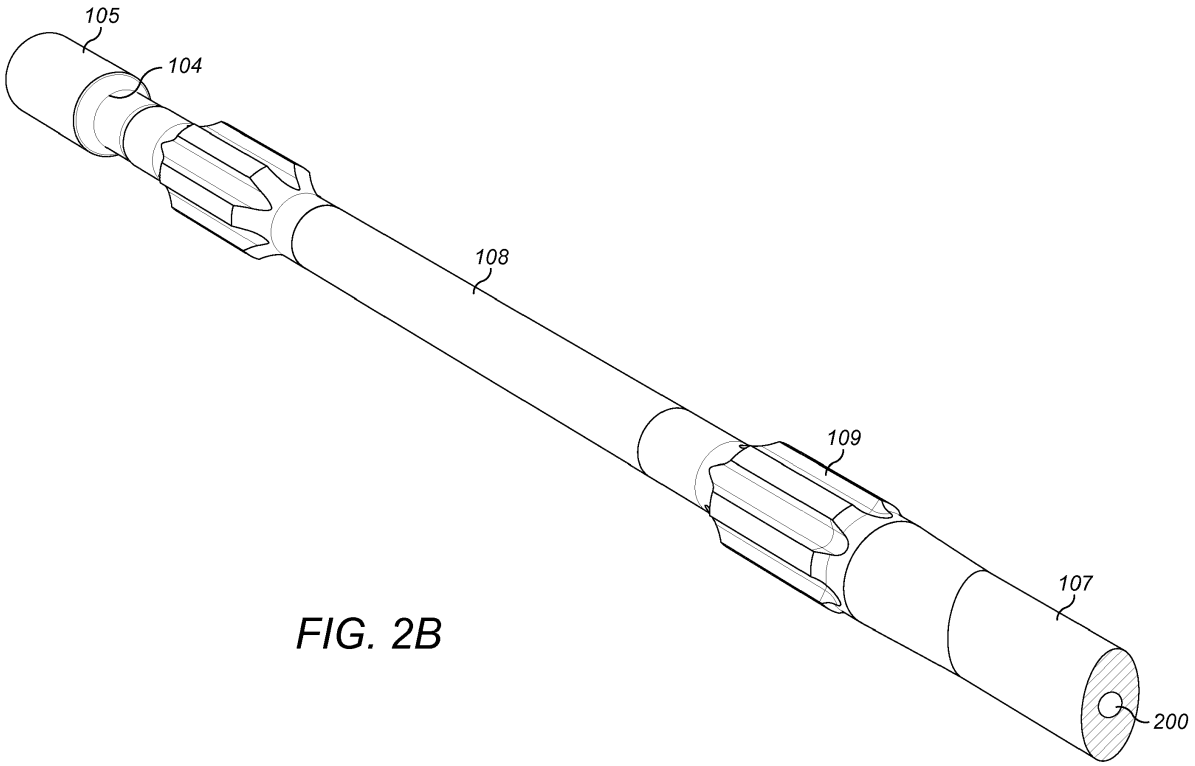

FIG. 2B

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Description

Field of invention

[0001] The present invention relates to an elongate drilling guide rod for percussive drilling to facilitate straight drilling.

Background art

[0002] Percussion drilling is used to create a long borehole via a plurality of elongate drill string rods coupled together end-to-end by interconnected male and female threaded ends. The well-established technique breaks rock by hammering impacts transferred from the rock drill bit, mounted at one end of the drill string, to the rock at the bottom of the borehole. Typically, the energy required to break the rock is generated by a hydraulically driven piston that contacts the end of the drill string (via a shank adaptor) to create a stress (or shock) wave that propagates through the drill string and ultimately to the base rock level. Example drilling apparatus are described in GB 721,261; GB 776,892; DE 2602021; EP 0066891; GB 2090891; RU 2029850.

[0003] Specifically with regard to percussive drilling it is well established that lateral (sideways) deviation of the drill bit and drill string results from the difference in the breaking characteristics of the rock surrounding the drill bit and also the Poisson effect associated with the elongate steel bit. That is, as the bit is compressed and expands in the perpendicular direction, the bit deviates progressively into the softer rock. Accordingly, it is desirable to provide drill rods being as stiff as possible and one way of achieving this is to provide rods with a large outside diameter. However, this diameter is limited by the dimensions of the borehole wall (ultimately the bit diameter) and the requirement to transport rearwardly rock cuttings from the drill bit past the drill rods. Accordingly, what is required is a drill guide rod configured to impart deviation resistance to the drill bit.

Summary of the Invention

[0004] It is an objective of the present invention to provide a drilling guide rod for percussive drilling to impart lateral deviation resistance to a drill bit mounted at one end of the rod whilst i) not affecting and in particular changing the shockwave characteristics of the drill string and ii) allowing the rearward transport of rock cuttings from the drill bit. It is a further specific objective to provide a guide rod through which a flushing fluid may be transported without changing the operating parameters by which the fluid is transported through the drill string to the drill bit from an external region of the borehole.

[0005] The objectives are achieved by providing a drill rod configured as a drilling guide rod for attachment to an axially rearward end of a drill bit and an axially forwardmost end of a drill string rod configured to impart deviation resistance to the drill bit during forward drilling and advancement of the drill string into the rock. In particular, the present guide rod comprises a deviation resistant axial section that comprises a circumferentially non-uniform cross sectional wall thickness having two diametrically opposed thick regions and two diametrically opposed thin regions (relative to the thick regions). Such a configuration is advantageous to provide the drill rod with a larger area moment of inertia in an axis perpendicular to the rod axis (between certain rotational degrees) relative to a corresponding circular cross sectional shape profile. This larger area moment of inertia is effective to stiffen the rod considerably in an axis perpendicular to the longitudinal axis of the rod compared to conventional cylindrical rod configurations. Such an arrangement is effective to reduce and in particular eliminate lateral (axially perpendicular) deviation resultant from the transmission of the shockwave to the drill bit.

[0006] The relative *'thin'* wall thickness of the rod at the deviation resistant section is advantageous to allow the passage of rock cuttings and the flushing fluid around the external surface of the rod so as to not affect the flushing characteristics of the rod and the drilling apparatus. Additionally, the present guide rod comprises respective cross sectional areas at various axial sections of the rod that are substantially equal to mitigate disruption or change in the shockwave that is transmitted through the guide rod from the drill string to the drill bit. Advantageously, a cross sectional area of the rod wall at the deviation resistant section is substantially equal to a corresponding cross sectional area of the rod wall at other regions of the rod including in particular a cylindrical segment and respective annular end faces that provide the shockwave transmission via abutment with either a forwardmost drill rod and the drill bit.

[0007] According to a first aspect of the present invention there is provided an elongate drilling guide rod for percussive drilling comprising: a first end having a coupling for releasable attachment to a drill bit and having an end surface suitable to transmit a shockwave to the bit; a second end having a coupling for releasable attachment to a drill string and having an end surface suitable to receive a shockwave from a drill rod of the drill string; a main length section extending between the first and second ends; a bore extending continuously and centrally through the rod and having a uniform radius between the first and second ends; characterised by: a deviation resistant section extending axially along at least a part of the main length, the deviation resistant section having a circumferentially non-uniform cross sectional wall thickness that includes two diametrically opposed thick regions and two diametrically opposed thin regions relative to the thick regions.

[0008] Optionally, the deviation resistant section extends axially within an axial half of the main length closest to the first end. Optionally, the deviation resistant section may extend continuously and over the full axial main length between the first and second ends. Optionally, the

deviation resistant section extends over an axial length being approximately equal to substantially half the main length or in the range 10 to 50% of the main length between the first and second ends. Positioning the deviation resistant section in the first half of the main length closest to the first end (that mounts the drill bit) is advantageous to impart maximum deviation resistance to the drill bit due to the reduced axial separation between the bit and deviation resistant section.

[0009] Preferably, the deviation resistant section comprises an external surface having an elliptical profile and the bore extends centrally through the deviation resistant section and comprises a circular cross sectional profile. An elliptical profile is preferred to provide the *'stiffening'* of the rod in an axis perpendicular to the longitudinal axis of the rod whilst allowing the transport of flushings past the relatively '*thinner*' regions of the rod. An elliptical profile is also advantageous to reduce stress concentrations in the rod due to the circumferentially non-uniform wall thickness and the torque transferred through the rod. Preferably, a mass of each of the two diametrically opposed thick regions are substantially equal.

[0010] Optionally, the deviation resistant section does not extend over the complete main length and the main length comprises an axial segment having a cross section with a substantially circular external surface such that the axial segment comprises a circumferentially uniform cross sectional wall thickness. The axial length of the deviation resistant section is determined so as to be sufficient only to mitigate lateral displacement of the drill bit due to the Poisson effect. As will be appreciated, the present rod may comprise different axial lengths of the deviation resistant section being selected to suit drilling into particular rock types or categories.

[0011] Preferably, a cross sectional area of the wall of the rod at the deviation resistant section and the axial segment are substantially equal. Such a configuration is advantageous to maintain to a minimum any change in the characteristics of the shockwave transmitted through the drill rod.

[0012] Preferably, the rod further comprises at least one guide section extending along a part of the main length, the guide section having a plurality of ridges extending radially outward beyond the deviation resistant section. More preferably, the present rod comprises at least two guide sections spaced apart axially at the main length. Optionally, the rod may comprise three to six guide sections spaced apart axially between the first and second ends. The guide sections may comprise a spline configuration with parallel ridges and troughs or may comprise helical ridges and troughs centred around a longitudinal axis of the rod.

[0013] The flushing bore is accordingly positioned concentrically within the rod relative to the outside surface of the rod at the deviation resistant section to provide a mass balanced rod in the perpendicular section to eliminate lateral deviation due to any mass difference.

[0014] Preferably, the coupling at the first end comprises a threaded spigot and the coupling at the second end comprises an internally threaded female sleeve.

[0015] As will be appreciated, the present rod may comprise different coupling types at the first and second ends. Alternatively, the rod may comprise the same coupling types being male and male or female and female. Male first couplings and female second couplings are preferred to provide a rod that is compatible with existing drill bits and drill rods.

[0016] Optionally, an axial length of the spigot and the sleeve are terminated by the respective end surfaces. The present rod may be configured for conventional '*shoulder*' or *'bottom'* contact transmission of the shockwave. Preferrably, the sleeve at the female coupling may comprise a larger outside diameter than the main length while the spigot at the male coupling may comprise a diameter smaller than the main length. The couplings at the first and second ends are configured to mate with respective male and female threaded couplings of conventional drill rods and drill bits.

[0017] To minimise any change in the shockwave characteristics during transmission through the drill rod, preferably the rod comprises a cross sectional area at each of the end surfaces that is substantially equal to a cross sectional area of the wall of the rod at the deviation resistant section.

[0018] According to a second aspect of the present invention there is provided percussive drilling apparatus comprising: a plurality of drill rods coupled end-to-end to form a drill string; a guide rod as claimed herein attached to an endmost drill rod of the drill string via the second end of the guide rod; a drill bit attached to the first end of the guide rod.

[0019] Preferably, each drill rod comprises a main length, respective couplings at first and second ends of the main length and a central bore extending between the first and second ends wherein a cross sectional area of the wall of the guide rod at the deviation resistant section is substantially equal to a cross sectional area of the wall at the main length of each drill rod. Preferably, each drill rod further comprises an end face at each of the first and second ends to transmit a shockwave through the drill string wherein a cross sectional area of each end face of each drill rod is substantially equal to the cross sectional area of each end face of the guide rod. The corresponding cross sectional areas are configured to preserve the desired shockwave characteristics including for example wavelength, amplitude, intensity, shape profile.

Brief description of drawings

[0020] A specific implementation of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a perspective view of drilling apparatus comprising a plurality of end-to-end coupled drill rods

and a drill guide rod that mounts a drill bit according to a specific implementation of the present invention;

Figure 2A is an external perspective view of the drill guide rod of figure 1;

Figure 2B is a perspective cross sectional view through a deviation resistant section of a main length of the guide rod of figure 2A;

Figure 3 is a further perspective cross sectional view of the deviation resistant section of the guide rod of figure 2B;

Figure 4 is an end view of the cross section of the deviation resistant section of figure 3;

Figure 5 is a perspective partial axial cross section through the guide rod of figure 1;

Figure 6 is a further external perspective view of the guide rod of figure 2A.

Detailed description of preferred embodiment of the invention

[0021] Referring to figures 1 to 3, a drill guide rod 100 comprises a main length indicated generally by reference 106 having a first end 103 attachable to a drill bit 102 and a second end 104 attachable to a drill string and in particular an endmost drill rod 101. Referring to figure 2A, first end 103 comprises a coupling in the form of a spigot 202 extending axially from end 103. Spigot 202 comprises external threads 201 configured to cooperate with corresponding threads 502 provided internally within an axially rearward facing region of the drill bit 102 as detailed with reference to figure 5. In particular, drill bit 102 comprises an axially extending internal bore to receive the threads 201 of spigot 202. Corresponding internally projecting threads 506 extend axially within the drill bit bore to allow bit 102 to be axially mounted and detached from spigot 202 at first end 103. First end 103 comprises an annular end surface 501 configured to abut and be maintained in mating contact with a corresponding annular end surface 503 that terminates the internal bore within bit 102 at its innermost end. The mated contact between annular surfaces 501, 503 is configured to allow transmission of a shockwave propagating through the drill string and guide rod 100 during percussive drilling as will be appreciated by those skilled in the art.

[0022] Referring to figures 1 to 2B and 6, the second coupling 105 is formed as an axially extending sleeve projective axially rearward from second end 104. Sleeve 105 is internally threaded along its axial length to comprise threaded turns 600 extending axially between an annular end surface 601 of sleeve 105 and a corresponding end surface 500 positioned axially at the junction with the rearwardmost end of main length 106 and the forwardmost end of sleeve 105. Sleeve 105 accordingly provides an internally threaded female coupling to receive a corresponding threaded male spigot extending axially from a forwardmost shoulder 111 of drill rod 101. The drill rod 101 also comprises a main length 112 extending axially between a forwardmost end 113 (provided at a rearward end of shoulder 111) and a second end (not shown) coupled axially to a neighbouring drill rod forming a part of the drill string.

[0023] The main length 106 of guide rod 100 is divided axially into a plurality of sections including a deviation resistant section 107, a plurality of guide sections 109 and an axial segment 108 that is not specifically adapted for drilling deviation resistance. Referring to figures 2A and 2B, guide sections 109 are spaced apart axially along main length 106 such that a first guide section is positioned axially mid-way between the first and second ends 103, 104 whilst a second guide section 109 is positioned a short distance from second end 104. The first and second guide sections 109 are separated axially by the main length axial segment 108. Each guide section 109 comprises radially outward projecting ridges 110 arranged axially parallel to one another and aligned parallel with a longitudinal axis 300 of guide rod 100 referring to figure 3. According to further embodiments, the splined guide sections 109 may alternatively comprise ridges 110 that extend along a helical path around axis 300 so as to facilitate guidance of the axial advancement of rods 101 during drilling.

[0024] Axial segment 108, referring to figure 3, comprises a cylindrical configuration having a circular external surface profile at a cross section in the x-y plane being perpendicular to the longitudinal axis 300 of rod 100 that extends along the z axis. Rod 100 also comprises a central bore 200 that extends continuously between the first and second ends 103, 104 and also the respective couplings 202, 105. In particular, central bore 200 comprises an internally facing wall surface 301 having a circular shape profile at a cross section in the x-y plane. A radius of bore 200 is substantially uniform over the complete axial length of the main length section 106 between ends 103, 104 including in particular the guide sections 109, axial segment 108 and deviation resistant section 107. The central bore of the same radius also extends through spigot 202. However, the radius of bore 200 may be considered to increase at the region of female sleeve 105 such that bore 200 at sleeve 105 may be considered to be defined by the radially inward extending helical turns 600.

[0025] Due to the difference in the breaking characteristics of the rock that surrounds guide rod 100 (during drilling) and also the Poisson effect associated with the shockwave transmission through the drill string and guide rod 100, the deviation resistant section 107 is specifically configured to reduce or eliminate the lateral deviation in the x-y plane (perpendicular to the axis of the string) of the drill string and the drill bit 102 during forward drilling. The present guide rod 100 is accordingly configured to

deviate less towards relatively *'softer'* rock during normal forward drilling by effectively increasing the bending stiffness of the rod particularly while indexing the bit and feeding the drill string axially forward. To increase the axial stiffness whilst not increasing the total wall thickness of the rod and accordingly the total cross sectional area of the rod 100 (at deviation resistant section 107), section 107 comprises an external surface having an elliptical cross sectional shape profile 302 (in the x-y plane) referring to figures 3 and 4. Accordingly, a wall thickness R' of a first region in the x axis is greater than a corresponding wall thickness of a second region R" in the y axis. In particular, and according to the specific implementation R" is in a range 55 to 60% of R' where the wall thickness R', R" are defined as the distance between internal bore surface 301 and the external surface 302 of deviation resistant section 107. Accordingly, R' is the maximum wall thickness and R" is the minimum wall thickness at section 107. The external surface 302 curves continuously according to the elliptical shape profile between the minimum R" and maximum R' wall thicknesses in the respective y and z axes. Advantageously, rock cuttings are still capable of being transported axially rearward past the elliptical deviation resistant section 107 due to the space available between the internal facing surface of the rock bore (created by bit 102) and the external surface 302 at the regions of the minimum rod wall thickness R".

[0026] To maintain to a minimum any interruption or change to the shockwave transmitted through guide rod 100, the cross sectional area in the x-y plane at the deviation resistant section 107 is substantially equal to the cross sectional area at the circular axial segment 108. Also, the cross sectional area at section 107 and segment 108 is substantially equal to the corresponding cross sectional area at the first and second ends 103, 104 and in particular end surfaces 501, 500.

Claims

1. An elongate drilling guide rod (100) for percussive drilling comprising:

   a first end (103) having a coupling (202) for releasable attachment to a drill bit (102) and having an end surface (501) suitable to transmit a shockwave to the bit (102);
   a second end (104) having a coupling (105) for releasable attachment to a drill string and having an end surface (500) suitable to receive a shockwave from a drill rod (101) of the drill string;
   a main length section (106) extending between the first (103) and second (104) ends;
   a bore (200) extending continuously and centrally through the rod (101) and having a uniform radius between the first (103) and second (104) ends;

   characterised by:

   a deviation resistant section (107) extending axially along at least a part of the main length (106), the deviation resistant section (107) having a circumferentially non-uniform cross sectional wall thickness that includes two diametrically opposed thick regions and two diametrically opposed thin regions relative to the thick regions.

2. The rod as claimed in claim 1 wherein the deviation resistant section (107) extends axially within an axial half of the main length (106) closest to the first end (103).

3. The rod as claimed in claims 1 or 2 wherein the deviation resistant section (107) comprises an external surface (302) having an elliptical profile and the bore (200) extends centrally through the deviation resistant section (107) and comprises a circular cross sectional profile.

4. The rod as claimed in any preceding claim wherein the deviation resistant section (107) does not extend over the complete main length (106) and the main length (106) comprises an axial segment (108) having a cross section with a substantially circular external surface such that the axial segment (108) comprises a circumferentially uniform cross sectional wall thickness.

5. The rod as claimed in claim 4 wherein a cross sectional area of the wall of the rod (101) at the deviation resistant section (107) and the axial segment (108) are substantially equal.

6. The rod as claimed in any preceding claim comprising at least one guide section (109) extending along a part of the main length (106), the guide section (109) having a plurality of ridges (110) extending radially outward beyond the deviation resistant section (107).

7. The rod as claimed in claim 6 comprising at least two guide sections (109) spaced apart axially at the main length (106).

8. The rod as claimed in any preceding claim wherein a mass of each of the two diametrically opposed thick regions are substantially equal.

9. The rod as claimed in any preceding claim wherein the coupling (202) at the first end (103) comprises a threaded spigot and the coupling (105) at the second end (104) comprises an internally threaded female sleeve.

10. The rod as claimed in claim 9 wherein an axial length of the spigot and the sleeve are terminated by the respective end surfaces (501, 500).

11. The rod as claimed in claim 10 wherein the sleeve comprises a larger outside diameter than the main length (106).

12. The rod as claimed in any preceding claim wherein a cross sectional area of the end surfaces (501, 500) are substantially equal to a cross sectional area of the wall of the rod (101) at the deviation resistant section (107).

13. Percussive drilling apparatus comprising:

a plurality of drill rods (101) coupled end-to-end to form a drill string;
a guide rod (100) as claimed in any preceding claim attached to an endmost drill rod (101) of the drill string via the second end (104) of the guide rod (100);
a drill bit (102) attached to the first end (103) of the guide rod (100).

14. The apparatus as claimed in claim 13 wherein each drill rod (101) comprises a main length (112), respective couplings (111) at first (113) and second ends of the main length (112) and a central bore extending between the first (113) and second ends wherein a cross sectional area of the wall of the guide rod (100) at the deviation resistant section (107) is substantially equal to a cross sectional area of the wall at the main length (112) of each drill rod (101).

15. The apparatus as claimed in claim 14 wherein each drill rod (101) further comprises an end face at each of the first (113) and second ends to transmit a shockwave through the drill string wherein a cross sectional area of each end face of each drill rod (101) is substantially equal to the cross sectional area of each end face (500, 501) of the guide rod (100).

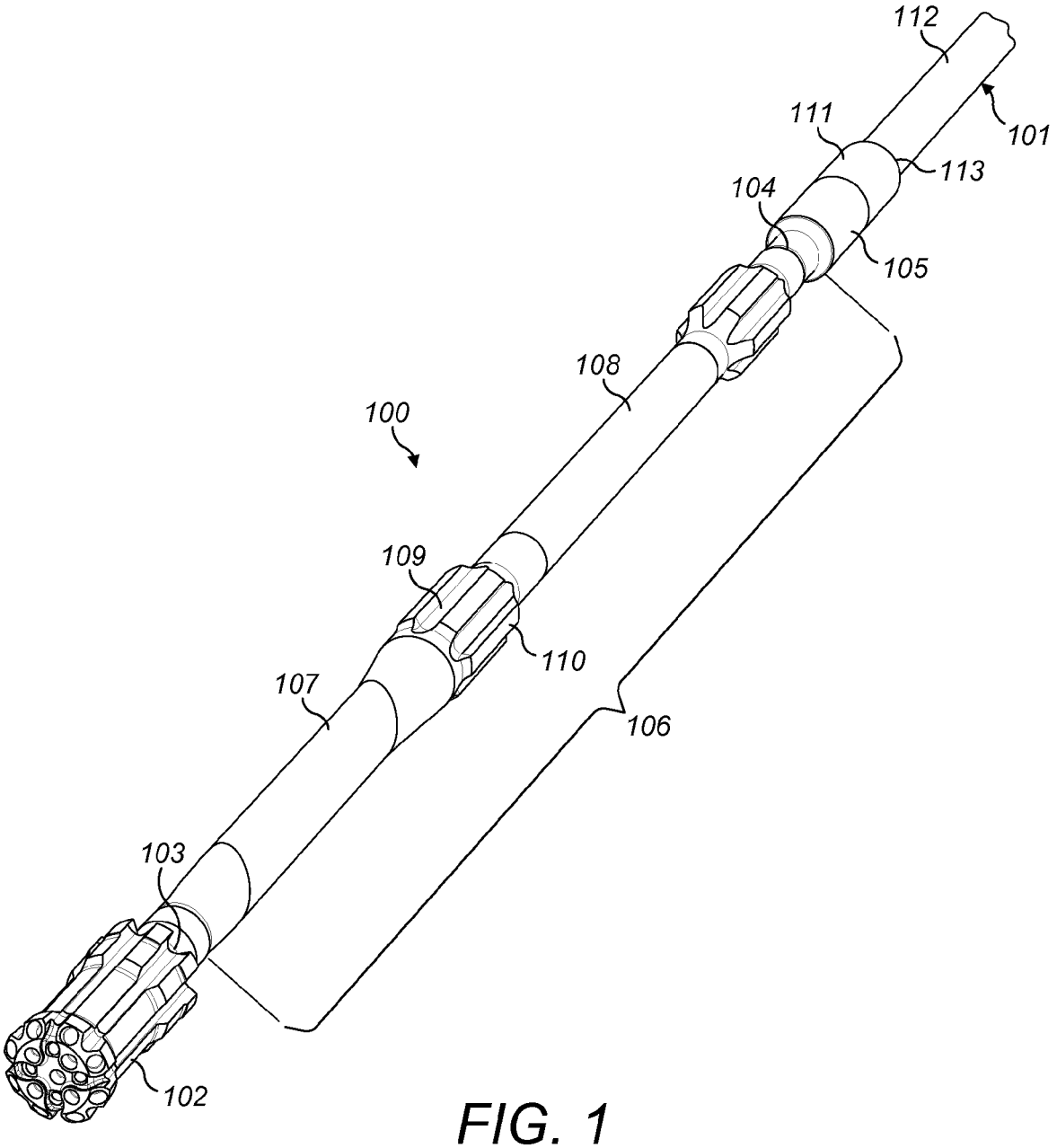

FIG. 1

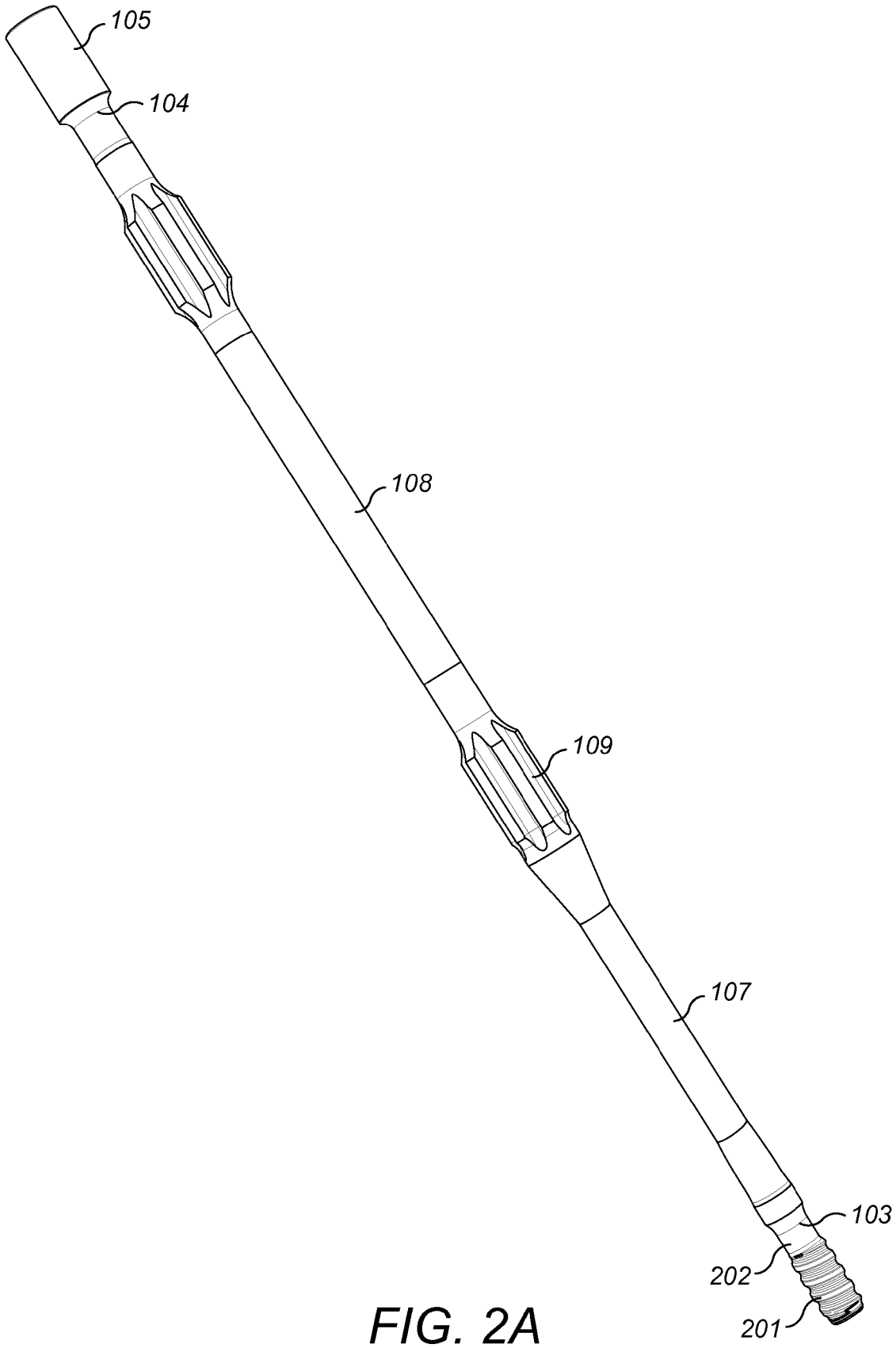

FIG. 2A

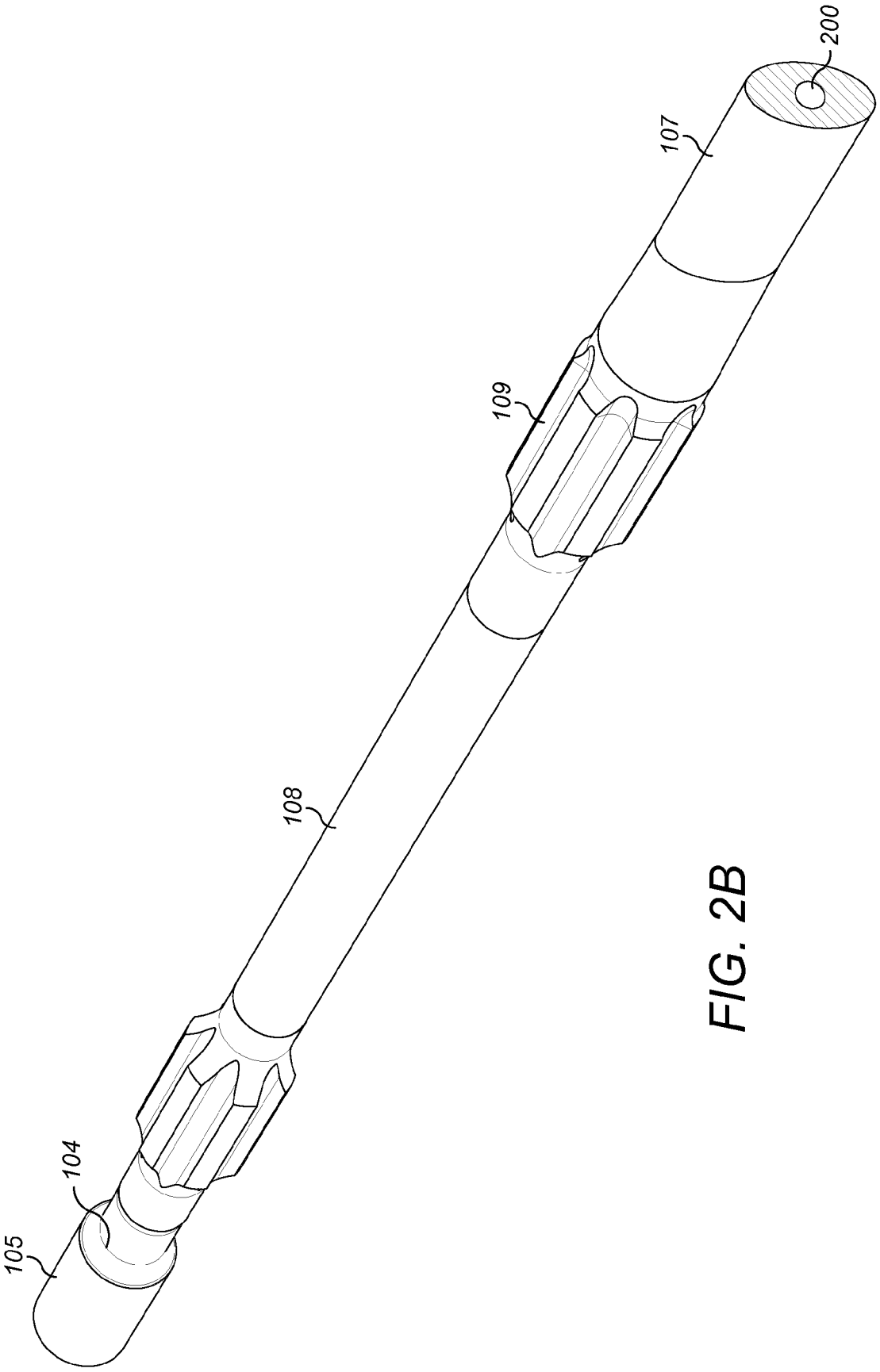

FIG. 2B

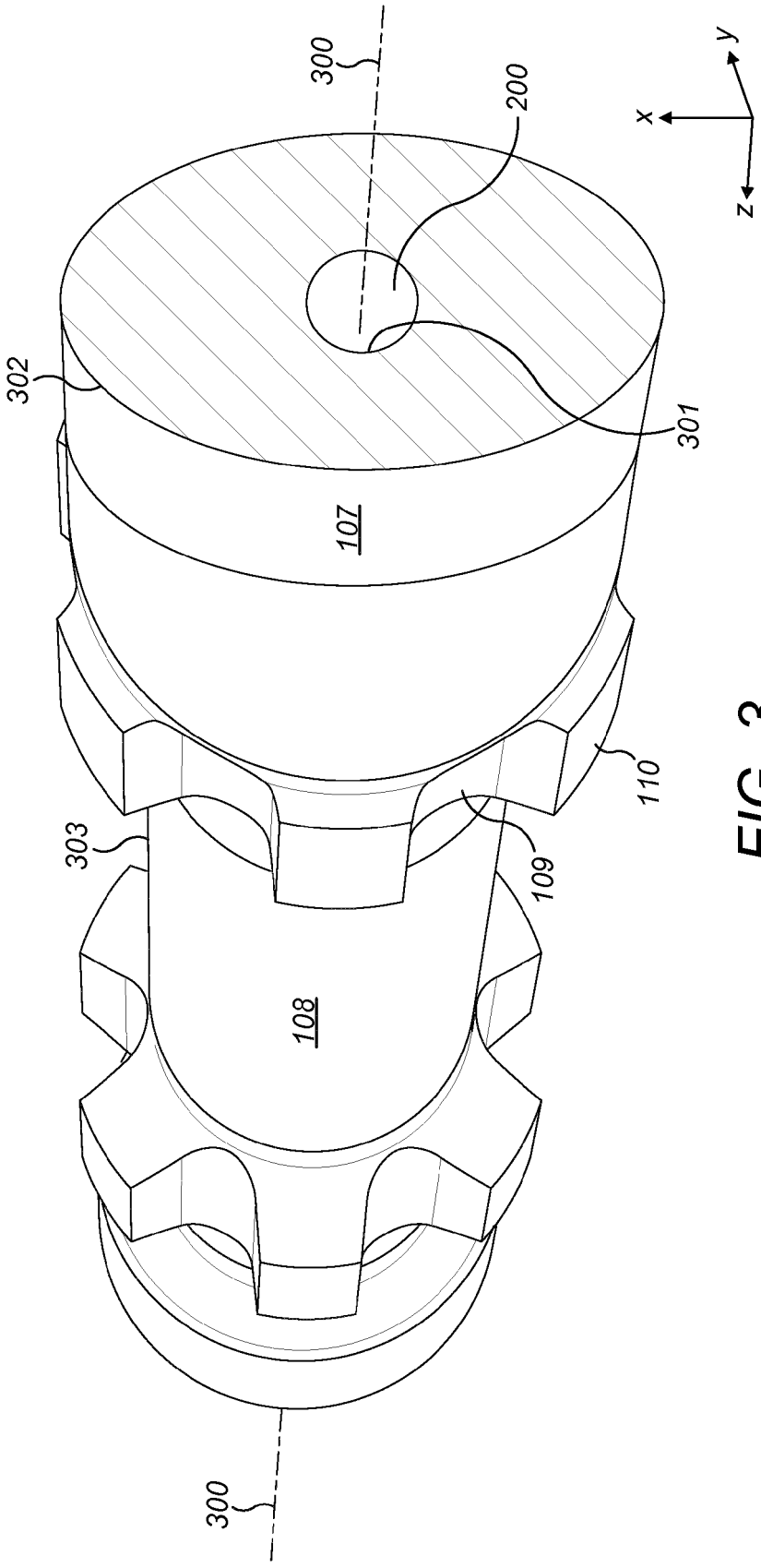

FIG. 3

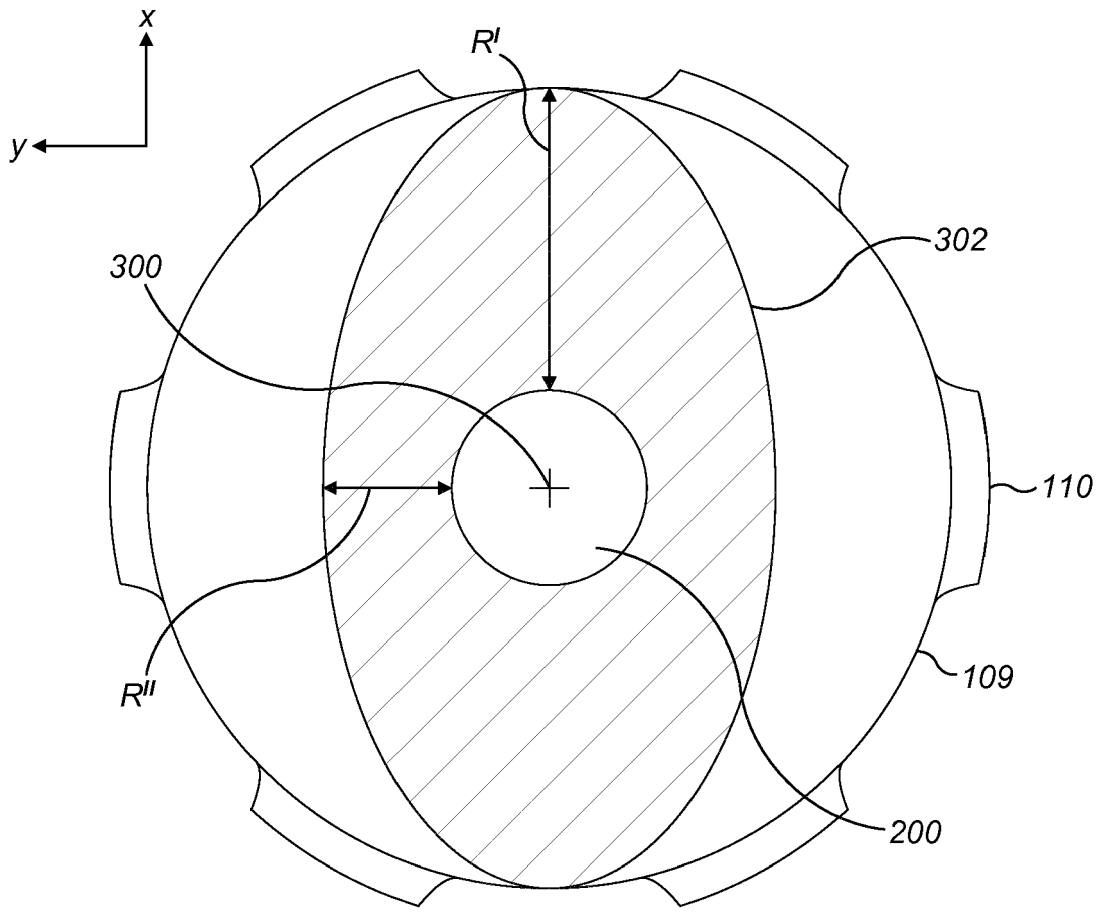

FIG. 4

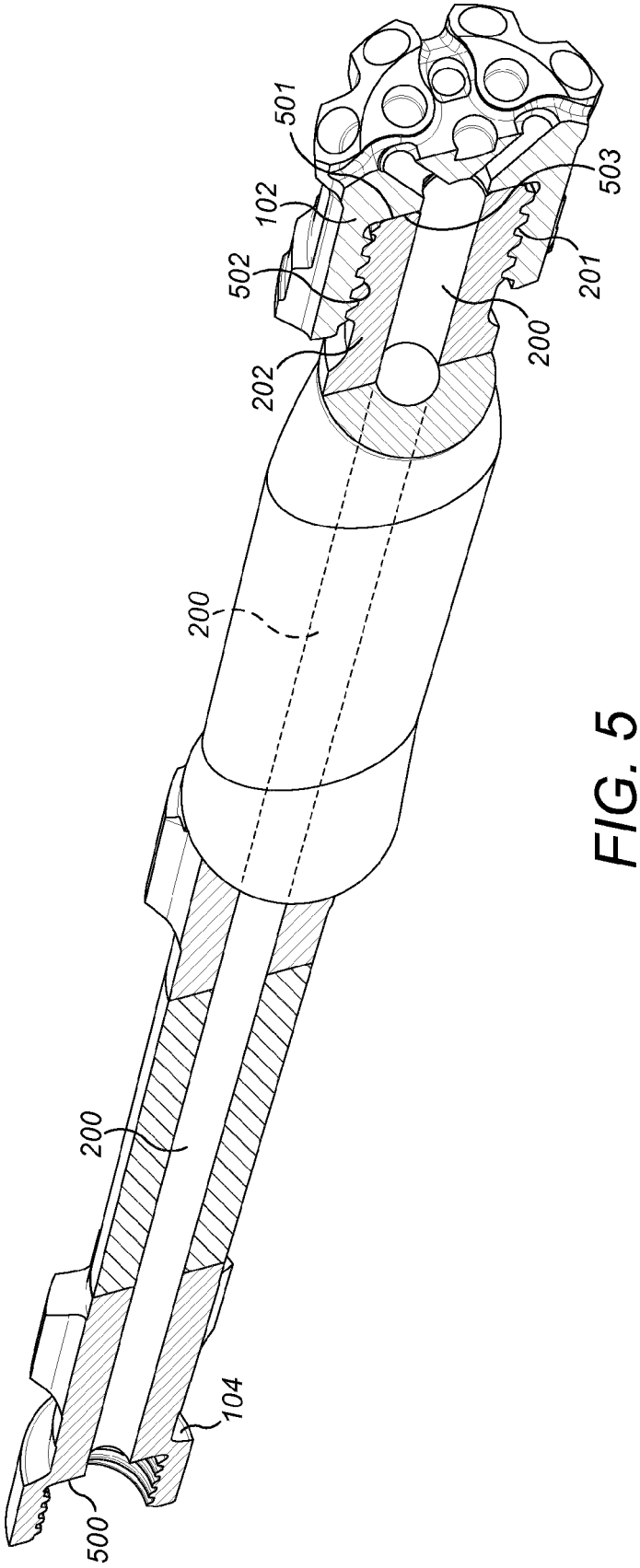

FIG. 5

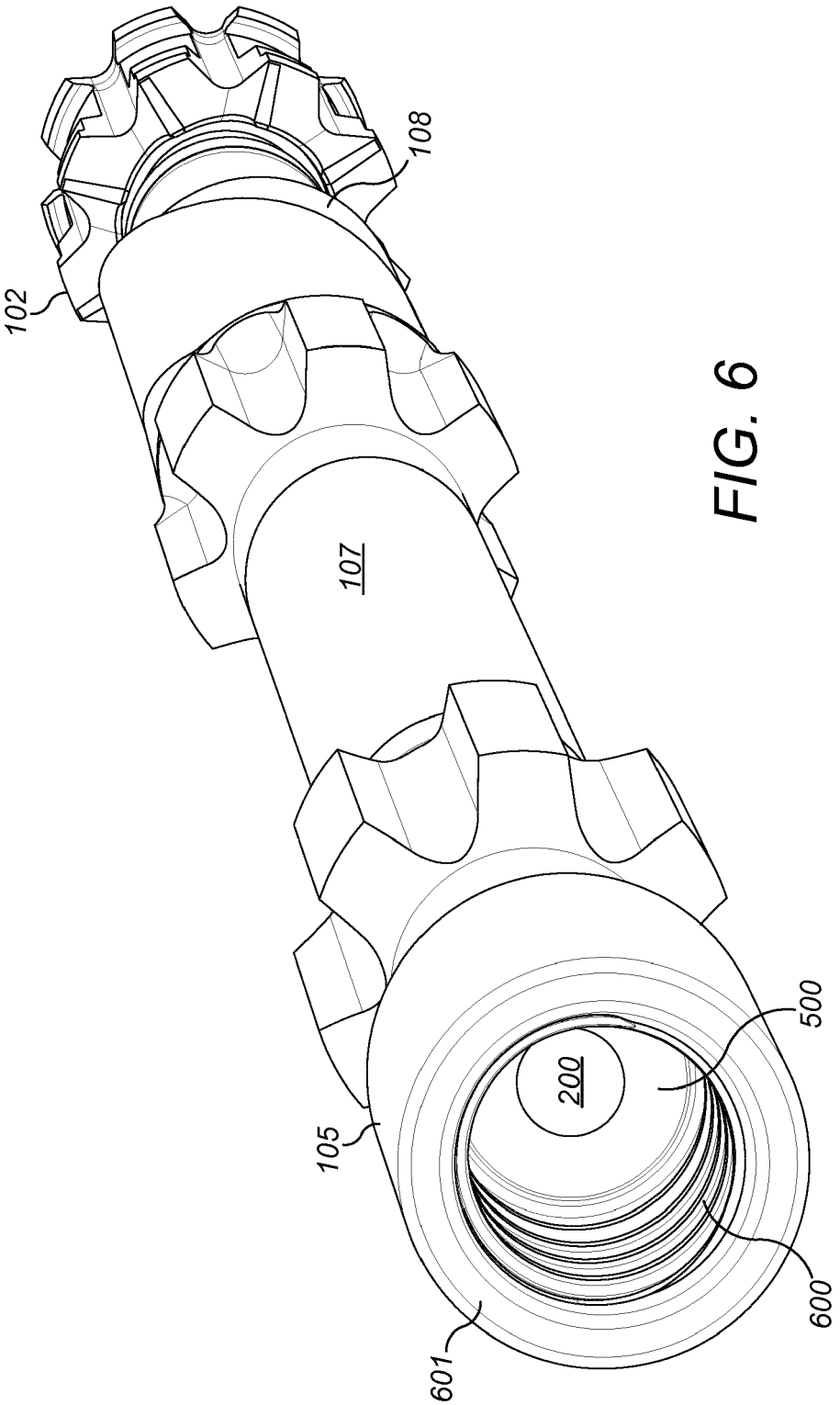

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 2431

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 June 2015	Hustedt, Bernhard

CATEGORY OF CITED DOCUMENTS

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