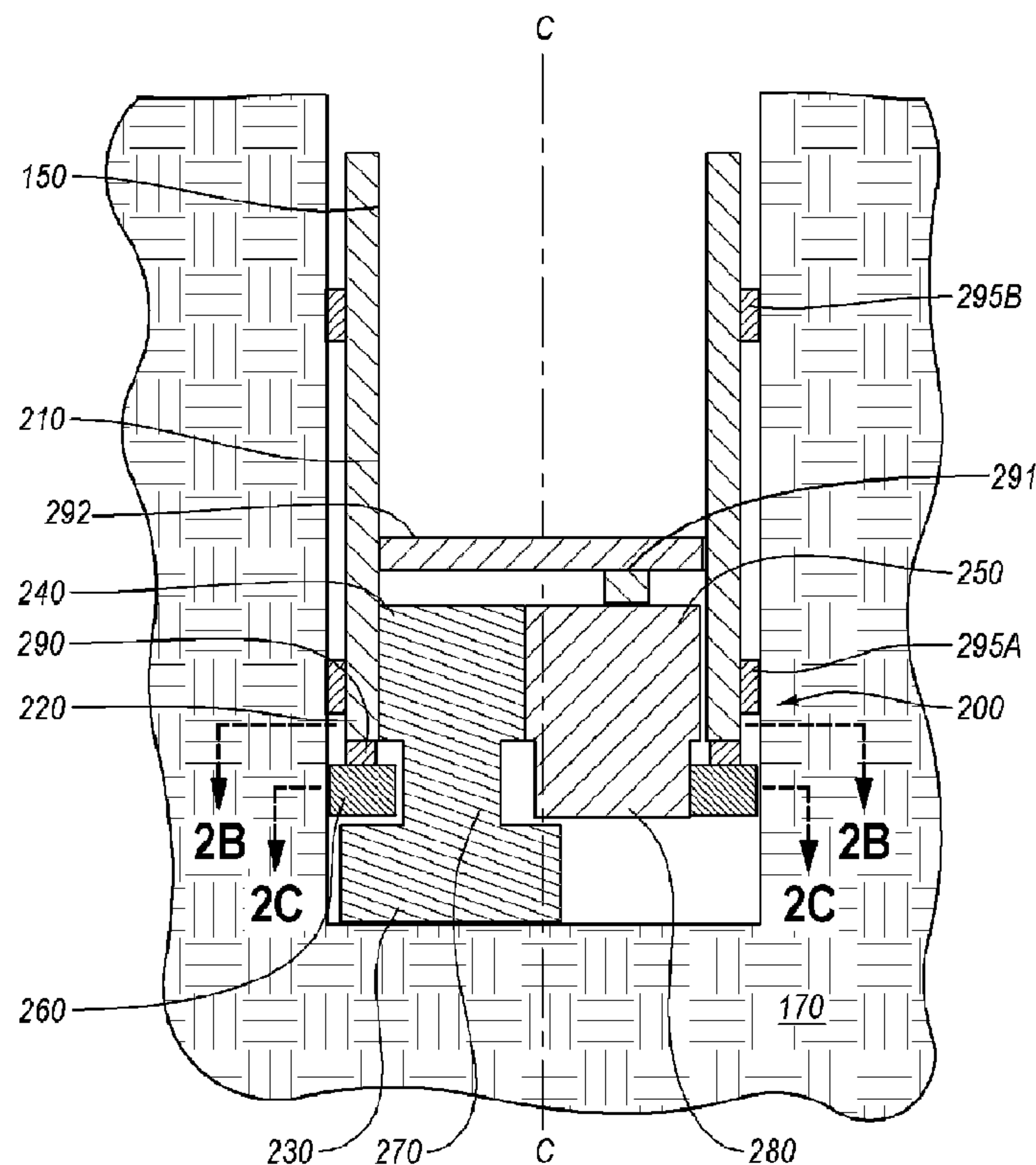




(86) Date de dépôt PCT/PCT Filing Date: 2010/03/26
(87) Date publication PCT/PCT Publication Date: 2010/09/30
(45) Date de délivrance/Issue Date: 2013/04/02
(85) Entrée phase nationale/National Entry: 2011/09/14
(86) N° demande PCT/PCT Application No.: US 2010/028862
(87) N° publication PCT/PCT Publication No.: 2010/111613
(30) Priorités/Priorities: 2009/03/26 (US61/163,760);
2010/03/25 (US12/732,106)

(51) Cl.Int./Int.Cl. *E21B 17/22* (2006.01),
E21B 3/02 (2006.01), *E21B 7/02* (2006.01)
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(54) Titre : APPAREIL, SYSTEMES ET PROCEDES DE FORAGE HELICOIDAL
(54) Title: HELICAL DRILLING APPARATUS, SYSTEMS, AND METHODS



(57) Abrégé/Abstract:

A down-the-hole assembly includes a housing having a central axis and a mechanical gear box positioned within the housing. The mechanical gear box is coupled to the housing such that rotation of the housing at a first rotational rate provides a rotary input to the mechanical gear box. A rotary cutting bit is coupled to the mechanical gear box. The mechanical gear box is configured to rotate said rotary cutting bit at a second rotational rate in response to that rotary input from the housing. The second rotational rate is greater than the first rotational rate. The mechanical gear box is also further configured to cause the rotary cutting bit to orbit about the central axis of the housing.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
30 September 2010 (30.09.2010)(10) International Publication Number
WO 2010/111613 A1

(51) International Patent Classification:

E21B 17/22 (2006.01) *E21B 7/02* (2006.01)
E21B 3/02 (2006.01)

(21) International Application Number:

PCT/US2010/028862

(22) International Filing Date:

26 March 2010 (26.03.2010)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/163,760 26 March 2009 (26.03.2009) US
12/732,106 25 March 2010 (25.03.2010) US

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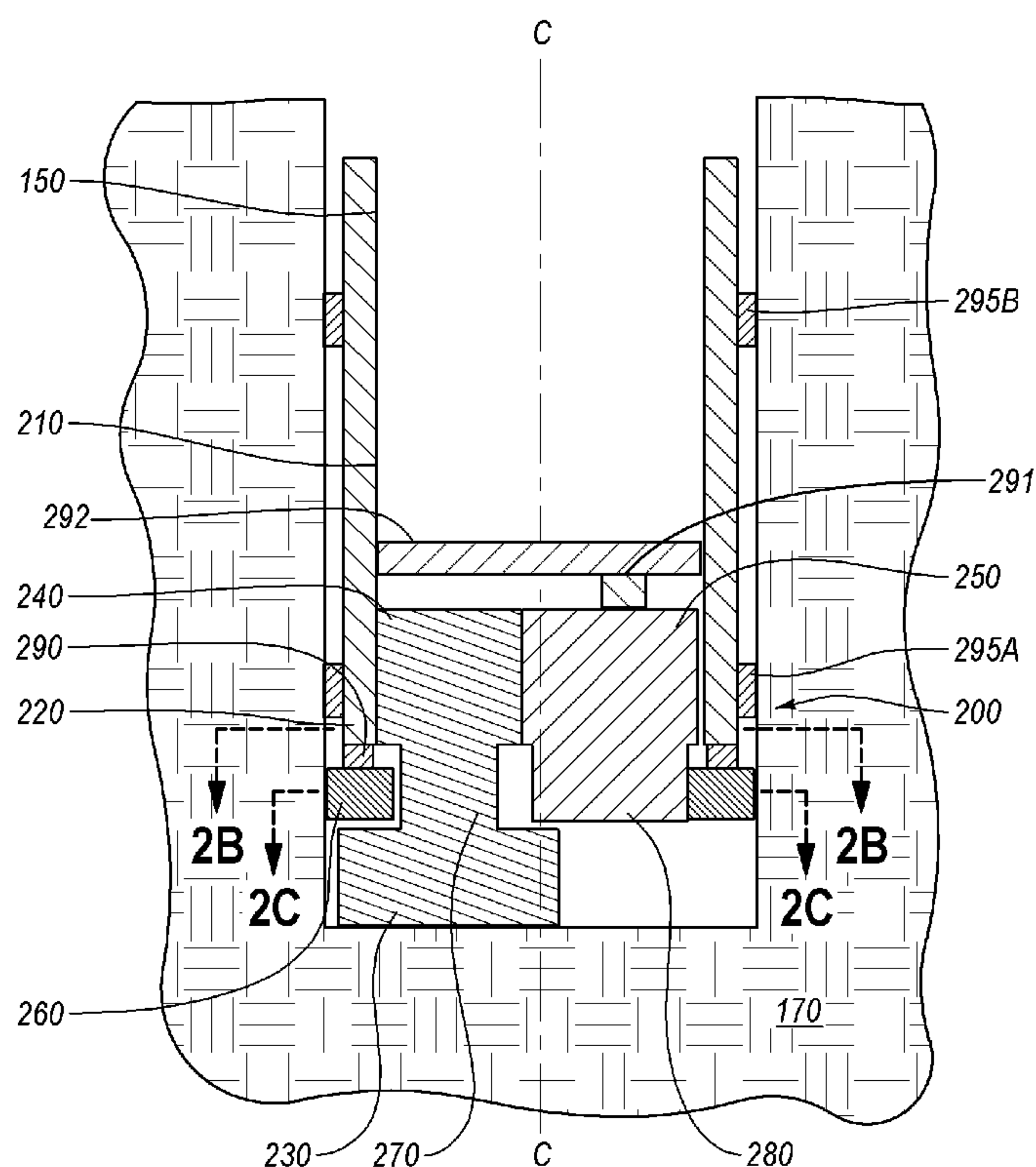
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kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD,
SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: HELICAL DRILLING APPARATUS, SYSTEMS, AND METHODS

**Fig. 2A**

(57) Abstract: A down-the-hole assembly includes a housing having a central axis and a mechanical gear box positioned within the housing. The mechanical gear box is coupled to the housing such that rotation of the housing at a first rotational rate provides a rotary input to the mechanical gear box. A rotary cutting bit is coupled to the mechanical gear box. The mechanical gear box is configured to rotate said rotary cutting bit at a second rotational rate in response to that rotary input from the housing. The second rotational rate is greater than the first rotational rate. The mechanical gear box is also further configured to cause the rotary cutting bit to orbit about the central axis of the housing.

WO 2010/111613 A1

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

HELICAL DRILLING APPARATUS, SYSTEMS, AND METHODS

BACKGROUND OF THE INVENTION

1. The Field of the Invention

The present invention relates to down-the-hole tools and to down-the-hole drilling
5 mechanisms in particular.

2. The Relevant Technology

While many different drilling processes are used for a variety of purposes, in most
drilling process a drill head applies axial forces (feed pressure) and rotational forces to drive
10 a drill bit into a formation. More specifically, a bit is often attached to a drill string, which is
a series of connected drill rods that are coupled to the drill head. The drill rods are
assembled section by section as the drill head moves and drives the drill string deeper into
the desired sub-surface formation. One type of drilling process, rotary drilling, involves
positioning a rotary cutting bit at the end of the drill string. The rotary cutting bit often
15 includes (tungsten carbide or optimally, synthetic diamonds, TSD or PCD cutters) that are
distributed across the face of the rotary cutting bit.

The rotary cutting bit is then rotated and ploughed into the formation under
significant feed pressure. The velocity of each cutting element depends on the angular
rotational rate of the bit and the radial distance of the element from the center of the bit. On
20 a solid drill bit, the angular rotational rate will be the same for the entire bit. Accordingly, at
any given speed those cutting elements nearer the outer edge will be travelling faster than
those near the center of the bit.

As the drill string rotates the rotary cutting bit, the drill string can distort due to
whirling or helical buckling. Helical buckling can cause the drill string to contact the walls
25 of the hole, thereby generating frictional forces between the drill string and the walls.
Accordingly, the rotational rate of the drill string can be controlled to control the frictional
forces between the drill string and the walls of the hole.

In broken or unconsolidated formations that are difficult to drill, the hole walls can be
sensitive to lateral pressure from the drill string and therefore speed is often limited to avoid
30 whirling and helical buckling of the drill string which can damage the hole. This can in turn
prevent the drill string from moving the cutting elements near the center of rotation at a

The subject matter claimed herein is not limited to embodiments that solve any disadvantages or that operate only in environments such as those described above. Rather, this background is only provided to illustrate one exemplary technology area where some embodiments described herein may be practiced.

BRIEF SUMMARY OF THE INVENTION

In an illustrative embodiment, a down-the-hole assembly includes a housing having a central axis and a mechanical gear box positioned within the housing. The mechanical gear box is coupled to the housing such that rotation of the housing at a first rotational rate provides a rotary input to the mechanical gear box. A rotary cutting bit is coupled to the mechanical gear box. The mechanical gear box is configured to rotate said rotary cutting bit at a second rotational rate in response to that rotary input from the housing. The second rotational rate is greater than the first rotational rate. The mechanical gear box is also further configured to cause the rotary cutting bit to orbit about the central axis of the housing.

Another illustrative embodiment provides a down-the-hole assembly including a housing having a central axis, and a mechanical gear box positioned within the housing. The mechanical gear box is coupled to the housing such that rotation of the housing at a first rotational rate provides a rotary input to the mechanical gear box. The mechanical gear box includes a ring gear operatively associated with the housing, a bit gear operatively associated with the ring gear, and a grounding ring operatively associated with the bit gear. The assembly further includes an isolation mechanism for separating rotation of the housing from the grounding ring. The assembly further includes a rotary cutting bit coupled to the mechanical gear box. The mechanical gear box is configured to rotate the rotary cutting bit at a second rotational rate in response to the rotary input from the housing. The second rotational rate is greater than the first rotational rate. The mechanical gear box is further configured to cause the rotary cutting bit to orbit about the central axis of the housing.

Another illustrative embodiment provides a down-the-hole drilling assembly adapted to be secured to a drill string that is rotated by a drill rig. The assembly includes a housing having a central axis, the housing being adapted to be coupled and rotationally fixed to the drill string. The assembly further includes a mechanical gear box positioned at least partially
5 inside the housing, and a rotary cutting bit coupled to the mechanical gear box. Rotation of the drill string at a first rotational rate causes the housing to rotate at the first rotational rate thereby causing the mechanical gear box to rotate the rotary cutting bit at a second rotational rate. The second rotational rate is greater than the first rotational rate. The mechanical gear box is further adapted to cause the rotary cutting bit to orbit about the central axis of the
10 housing.

Another illustrative embodiment provides a down-the-hole drilling assembly adapted to be secured to a drill string that is rotated by a drill rig. The assembly includes a housing defining a lumen having a central axis. The housing is adapted to be coupled and rotationally fixed to the drill string. The assembly further includes a ring gear formed on an inner surface
15 of the housing, the ring gear being in communication with the lumen. The assembly further includes a first gear operatively associated with the ring gear, a second gear operatively associated with the ring gear, and a third gear operatively associated with each of the first gear and the second gear. The third gear is positioned at least partially between the first gear and the second gear. The assembly further includes a rotary cutting bit coupled to the first
20 gear. Rotation of the drill string at a first rotational rate causes the housing to rotate at the first rotational rate thereby causing the first gear to rotate at a second rotational rate. The second rotational rate is greater than the first rotational rate. The rotation of the housing causes the first gear and the rotary cutting bit to orbit about the central axis.

Another illustrative embodiment provides a method of drilling, including coupling a
25 helical drilling device to a drill string by rotationally fixing a housing of the helical drilling device to the drill string. The helical drilling device includes a mechanical gear box positioned within the housing and a rotary cutting bit coupled to the mechanical gear box. The method further includes positioning the rotary cutting bit in a bore hole in a formation. The bore hole has a face diameter, and the rotary cutting bit has a diameter less than the face
30 diameter. The method further includes rotating the drill string at a first rotational rate thereby causing the housing to rotate at the first rotational rate. Rotation of the housing at the first

rotational rate causes the mechanical gear box to rotate the rotary cutting bit at a cutting rotational rate greater than the first rotational rate. The method further includes orbiting the rotary cutting bit to drill the face diameter in response to rotation of the drill string.

5 This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential characteristics of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

10 To further clarify the above and other advantages and features of illustrative embodiments of the present invention, a more particular description of such embodiments will be rendered by reference to specific examples which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical examples of the invention and are therefore not to be considered limiting of its scope. Examples will be described and
15 explained with additional specificity and detail through the use of the accompanying drawings in which:

Fig. 1 illustrates a drilling system including a helical drilling apparatus according to one example;

Fig. 2A illustrates a cross-sectional schematic view of a helical drilling apparatus
20 taken along section 2A-2A of Fig. 1;

Fig. 2B illustrates a cross-sectional schematic view of a helical drilling apparatus taken along section 2B-2B of Fig. 2A;

5 Fig. 2C illustrates a cross-sectional schematic view of a helical drilling apparatus taken along section 2C-2C of Fig. 2A; and

 Fig. 3 illustrates a perspective view of a helical drilling apparatus according to one example.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 A down-the-hole apparatus is provided herein that is configured to follow a generally helical path. In at least one example, the down-the-hole apparatus is coupled to a drill rod or drill string. The down-the-hole apparatus includes an integral gearbox, such as an integral mechanical gear box that utilizes the rotation of the drill string as an input to drive a rotary cutting bit. In particular, the mechanical gear box can include a gear
15 train that increases the rotational rate of the rotary cutting bit relative to the rotational rate of the input provided by the drill string. Further, the mechanical gear box can cause the rotary cutting bit to orbit about a central axis of the down-the-hole apparatus. As a result, as a drilling system moves the drill string and the attached down-the-hole apparatus into a formation by applying feed pressure while rotating the drill string, the rotary cutting bit
20 rotates at an increased speed while it travels along a generally helical path. Such a configuration and process can increase the cutting speed of the down-the-hole apparatus while drilling a hole larger than the diameter of the rotary cutting bit.

 In particular, such a configuration can increase speed of all the cutting elements across the face of the hole end while maintaining drill string rotational speeds within
25 acceptable levels. By adding a gearbox, the down-the-hole apparatus can provide significantly higher speeds to all the cutting elements (not just some of the elements) to thereby achieve unlimited penetration rates. For example, in a 45mm diameter hole design utilizing a 2.6:1 gear ratio, a down-the-hole apparatus can achieve a minimum element speed of 1.27 times that of the fastest outer diameter element on a conventional
30 rotary boring bit. In other examples, higher gear ratios can be provided to take advantage of available cutting element capacities and rig feed pressures all while maintaining torsional loads and frictional loads below acceptable levels.

 Fig. 1 illustrates a drilling system 100 that includes a drill head assembly 110. The drill head assembly 110 can be coupled to a mast 120 that in turn is coupled to a drill
35 rig 130. The drill head assembly 110 is configured to have a drill rod 140 coupled thereto. The drill rod 140 can in turn couple with additional drill rods to form a drill string 150. In turn, the drill string 150 can be coupled to a helical drilling apparatus 200 configured to interface with the material to be drilled, such as a formation 170.

5 In at least one example, the drill head assembly 110 is configured to rotate the drill string 150. In particular, the rotational rate of the drill string 150 can be varied as desired during the drilling process. Further, the drill head assembly 110 can be configured to translate relative to the mast 120 to apply an axial force to the drill head assembly 110.

10 In at least one example, as the drill head assembly 110 axially and rotationally drives the drill string 150 and thus the helical drilling apparatus 200 into the formation 170, the helical drilling apparatus 200 drives a rotary cutting bit at an increased rotational rate relative to rotational rate of the drill string 150 and causes the rotary cutting bit to travel along a generally helical path. Such a configuration and process can increase the
15 cutting speed of the down-the-hole apparatus 200 while drilling a hole larger than the diameter of the rotary cutting bit. While a continuous drill string is shown that carries the helical drilling apparatus to interface with the formation 170, it will be appreciated that the helical drilling apparatus 200 can also be used with other systems, such as wireline system or other type of system.

20 Fig. 2A illustrates cross-sectional view of the example helical drilling apparatus 200 taken along section 2A-2A of Fig. 1. As illustrated in Fig. 2A, the helical drilling apparatus 200 can generally include a housing 210 that is coupled to the drill string 150 in such a manner that rotation of the drilling string 150 also rotates the housing 210. In the illustrated example, the housing 210 can be generally hollow to thereby define a lumen
25 therein.

In at least one example, a ring gear 220 can be coupled to or integrated with an inner surface of a bit end of the housing 210. The helical drilling apparatus 200 also includes a rotary cutting bit 230, a bit gear 240, an orbital gear 250, a grounding ring 260, a bit shaft 270, a grounding shaft 280, and a bearing 290. In the illustrated example, the
30 bit gear 240 may be coupled to or integrated with the bit shaft 270 and the rotary cutting bit 230 such that the rotary cutting bit 230, the bit gear 240, and the bit shaft 270 rotate together. The example grounding shaft 280 may be coupled to or integrated with orbital gear 250 such that the orbital gear 250 and the grounding shaft 280 rotate together. In the illustrated example, the bearing 290 couples the grounding ring 260 to the housing 210
35 and/or the ring gear 220 in such a manner as to at least partially isolate the grounding ring 260 from direct rotation of the housing 210. The example ring gear 220 is driven by the rotation of the housing 210, which in turn may rotate in response to rotation of the drill string 150.

5 As illustrated in Fig. 2B, teeth on the ring gear 220 mesh with teeth on the bit gear 240 such that rotation of the ring gear 220 drives the bit gear 240. Teeth on the bit gear 240 also mesh with teeth on the orbital gear 250 such that the rotation of the bit gear 240 drives the orbital gear 250 and thus the grounding shaft 280 (Fig. 2C). As illustrated in Fig. 2C, teeth on the grounding shaft 280 mesh with teeth on the grounding ring 260. As
10 shown in Fig. 2A, the grounding ring 260 in turn may be in contact with a relatively stationary objection, such as the formation 170 (Fig. 2A).

Still referring to Fig. 2A, the bearing 290 may at least partially isolate the grounding ring 260 from direct rotation of the housing 210. For example, contact between the formation 170 and the grounding ring 260 may provide a frictional force that
15 acts to inhibit rotation of the grounding ring 260, thereby allowing the housing 210 to rotate while the grounding ring 260 remains relatively stationary or the grounding ring 260 at least rotates at a lower rate than the housing 210. If the grounding ring 260 is thus relatively stationary, rotation of the housing 210 may drive the grounding shaft 280 by way of the orbital gear 250, the bit gear 240, and the ring gear 220 as described above.

20 As shown in Fig. 2C, and as previously introduced, teeth on the grounding shaft 280 mesh with the teeth on the grounding ring 260. As a result, rotation of the grounding shaft 280 causes the teeth of the grounding shaft 280 to move into successive engagement with the teeth on the grounding ring 260. As the teeth of the grounding shaft 280 move into successive engagement with the grounding ring 260 the grounding shaft 280 moves
25 around the perimeter of the relatively stationary grounding ring 260. As the grounding shaft 280 moves about the relatively stationary grounding ring 260, the grounding shaft 280 orbits about axis C-C of the helical drilling apparatus 200. As previously discussed, the grounding shaft 280 rotates with the orbital gear 250.

As a result, as the grounding shaft 280 orbits about the central axis C-C, the orbital
30 gear 250 (Figs. 2A-2B) also orbits about the central axis C-C. In at least one example, the orbital gear 250 may be coupled to a bearing connection 291 which in turn may be coupled to a support plate portion 292 of the housing 210. The bearing connection and support plate portion 292 may cooperate to fix an axis of rotation of the orbital gear 250 to the central axis C-C without engagement between the orbital gear 250 and the ring gear
35 220. As a result, as shown in Fig. 2B the orbital gear 250 may not mesh with the ring gear 220 as desired.

As also shown in Fig. 2B, the orbital gear 250 meshes with the bit gear 240. As a result, as the orbital gear 250 orbits about the central axis C-C, the bit gear 240 also orbits

5 about the central axis C-C. The bit gear 240 also rotates in response to the rotation of the housing 210. As shown in Fig. 2A, as the bit gear 240 rotates and orbits, the bit shaft 270 and the rotary cutting bit 230 also rotate.

As a result, when the rotary cutting bit 230 orbits about the central axis C-C, the rotary cutting bit 230 drills out the entire face of the hole. In particular, the outer
10 perimeter of the face is cut by the exterior portions of the rotary cutting bit 230. As the rotary cutting bit 230 rotates and orbits about the central axis C-C, the rotary cutting bit 230 cuts a generally helical path in the formation 170. The cutting path of the rotary cutting bit 230 can have any desired width. In at least one example, the rotary cutting bit 230 can be as wide as or wider than approximately half the diameter of the housing. Such
15 a configuration allows the rotary cutting bit 230 to drill an entire surface of a hole as the helical drilling apparatus 200 causes the rotary cutting bit 230 to orbit relative to the central axis C-C. Further, the rotary cutting bit 230 can rotate at a higher rotational rate than the rotational rate of the drill string 150 as described above.

As illustrated in Fig. 2B, the ring gear 220 includes a larger diameter than the bit
20 gear 240. As a result, the ring gear 220 may have more teeth than the bit gear 250. The larger number of teeth on the ring gear 220 increases the rotational rate of the bit gear 240 relative to the rotational rate of the ring gear 220. In particular, the rotational rate of the bit gear 240 is substantially equal to the rotational rate of the ring gear 220 multiplied by the ratio of the number of teeth on the ring gear 220 to the number of teeth on the bit gear
25 240. In some examples, this ratio may be greater than about two, such that the rotational rate of the bit gear 240 can be greater than twice the rotational rate of the ring gear 220.

In at least one example, one or more sets of pads 295A, 295B can be used to stabilize a hole. In particular, the leading set of pads 295A can also contain traditional cutting elements to 'ream' or 'dress' the size and walls of the hole while trailing sets of
30 pads 295B may abrade against the drill hole wall in the formation 170 at the trailing edge, thereby supporting and guiding the helical drilling apparatus 200.

As discussed, the rotary cutting bit 230 rotates at a higher speed than the housing 210 and the drill string 150. The high speed cutting of the rotary cutting bit 230 can increase the cutting rate of the drilling system at a given rotation of the drill string 150 by
35 increasing the speed of each of the cutting elements relative to the housing 210.

Accordingly, such a configuration can increase speed of all the cutting elements across the face of the hole end in which the material is extremely hard or difficult to drill. By eliminating a stationary centre of rotation, and adding a gearbox, the down-the-hole

5 apparatus can provide significantly higher speeds to all the cutting elements (not just some of the elements) to thereby achieve unlimited penetration rates. For example, in a 45mm diameter hole design utilizing a 2.6:1 gear ratio, a down-the-hole apparatus can achieve a minimum element speed of 1.27 times that of the fastest outer diameter element on a conventional rotary boring bit. In other examples, higher gear ratios can be provided
10 to take advantage of available cutting element capacities and rig feed pressures all while maintaining torsional loads and frictional loads below acceptable levels.

In the illustrated example, one configuration is illustrated and discussed. It will be appreciated that any mechanism, including any combination and location of gear trains can be used to increase or multiply the rotation of a rotary cutting bit relative to the drill
15 string. Further, any combination and location of mechanisms, including above and/or below the bit gear, can be used to cause the rotary cutting bit to orbit a central axis. In addition, any number of bit gears and rotary cutting bits can also be utilized. Further, any number of stabilizing or other types of members can be utilized to stabilize, ream, and/or dress a wall of a borehole.

20 One such example is illustrated in more detail Fig. 3. Fig. 3 illustrates a top perspective view of another exemplary helical drilling apparatus 300. As illustrated in Fig. 3, the example helical drilling apparatus 300 can generally include a housing 310 that is coupled to the drill string 150 (Fig. 1) in such a manner that rotation of the drilling string 150 also rotates the housing 310 as described above. The helical drilling apparatus
25 300 can further include a ring gear 320, a rotary cutting bit 330, a bit gear 340, orbital gears 350A, 350B, stabilizing members 360A, 360B, and an center gear 365.

The example ring gear 320 may be coupled to or integrated with the housing 310 as desired. The bit gear 340 is coupled to the ring gear 320 as well as the center gear 365 such that rotation of the ring gear 320 rotates the bit gear 340. In at least one example,
30 the bit gear 340 may also be coupled to or integrated with the rotary cutting bit 330. As a result, the rotation of the bit gear 340 described above results in similar rotation of the rotary cutting bit 330. This motion may cause the rotary cutting bit 330 to cut a material with which it is in contact. As will be discussed in more detail below, the stabilizing members 360A, 360B and the orbital gears 350A, 350B may cooperate with the ring gear
35 320, the center gear 365, and/or the formation to cause the rotary cutting bit 330 to orbit about a central axis (not shown) of the helical cutting apparatus 300.

In at least one example, the center gear 365 may be prevented from rotating freely with respect to the ring gear 320. In other examples, the ring gear 320 may be prevented

5 from rotating freely with respect to the center gear 365. Either of these configurations can allow the bit gear 340 to orbit about the ring gear 320. It will also be appreciated that other configurations and interactions can be utilized to cause the bit gear 340 to orbit about the ring gear 320. For ease of illustration, the example helically drilling apparatus 300 as having a center gear 365 which does not rotate freely with respect to the ring gear
10 320. Further, for ease of reference, the center gear 365 will be described as being stationary relative to the ring gear 320, though it will be appreciated that the center gear 365 may not be completely stationary.

As a result, as the bit gear 340 rotates in response to the input provided by the ring gear 320, teeth of the bit gear 340 move into successive engagement with the center gear
15 365. This successive engagement can cause the bit gear 340 to orbit about the ring gear 320. As a result, the bit gear 340 rotates and orbits to cut a generally helical path in a face of a bore hole.

In a similar manner as discussed above, the larger number of teeth on the ring gear 320 increases the rotational rate of the bit gear 340 relative to the rotational rate of the
20 ring gear 320. In particular, the rotational rate of the bit gear 340 is substantially equal to the rotational rate of the ring gear 320 multiplied by the ratio of the number of teeth on the ring gear 320 to the number of teeth on the bit gear 340. Rotation of the bit gear 340 is transferred to the rotary cutting bit 330. The rotary cutting bit 330 can be as wide as or wider than approximately half the diameter of the housing. Such a configuration allows
25 the rotary cutting bit 330 to drill an entire surface of a hole as the helical drilling device 300 causes the rotary cutting bit 330 to orbit relative to the central axis C-C.

In the illustrated example, the orbital gears 350A, 350B are also coupled to the ring gear 320 as well as the center gear 365 such that rotation of the ring gear 320 rotates the orbital gears 350A, 350B and orbit about the ring gear 320 in a similar manner as
30 described above with reference to the bit gear 340. The orbital gears 350A, 350B can have any desired diameter. For example, the orbital gears 350A, 350B may be approximately the same diameter or may have different diameters. Further, the orbital gears 350A, 350B may have approximately the same diameter as the bit gear 340. In at least one example, the center gear 365 may have a diameter greater than one or more of
35 the bit gear 340 and the orbital gears 350A, 350B.

In at least one example, the stabilizing members 360A, 360B may be coupled to or integrally formed with the orbital gears 350A, 350B as desired. As a result, the rotation of the orbital gears 350A, 350B results in similar rotation of the stabilizing members

360A, 360B. This rotation can allow the stabilizing members 360A, 360B to dress or ream the hole at the same time the rotary cutting bit 330 cuts at the face of the borehole. Any number of rotary cutting bits 330 may also be used as desired.

5 In at least one example, one or more of the stabilizing members 360A, 360B can be used to stabilize a hole, in addition to providing the orbital movement described above. Further, the stabilizing members 360A, 360B can also contain traditional cutting elements to 'ream' or 'dress' the size and walls of the hole. It will also be appreciated that rotary cutting bits may be used in conjunction with the stabilizing members 360A, 360B in conjunction with the traditional cutting elements or instead of the traditional cutting elements as desired.

10 In the illustrated example, the relative sizes and/or configurations have been provided by way of example only. The relative sizes and the configurations are not necessarily to scale and may have been exaggerated for the sake of clarity and reference. It will be appreciated that the absolute and relative dimensions, including inner and outer dimensions, of each of the components can vary, including the dimension of the bit gear, the orbital gear, the bit shaft, the grounding shaft, and the
15 grounding ring. Further, the number of bit gears and associated rotary cutting bits, the number of orbital gears and associated grounding members, as well the number of other components can be selected as desired and/or omitted as desired or appropriate.

Accordingly, relative sizes, including gear ratios can vary, including gear ratios of the bit gear to the orbital gear, the orbital gear to the orbital shaft, the bit gear to the bit shaft, the ring gear
20 to the grounding shaft, and other gear ratios. Further, any other dimensions and ratios can be selected as desired to achieve a desired rotational and/or orbital speeds at selected inputs.

While specific embodiments have been described and illustrated, such embodiments should be considered illustrative only and not as limiting the invention as defined by the accompanying claims.

25

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A down-the-hole assembly, comprising:

5 a housing having a central axis;

a mechanical gear box positioned within said housing, said mechanical gear box further being coupled to said housing such that rotation of said housing at a first rotational rate provides a rotary input to said mechanical gear box, wherein said mechanical gear box includes:

10 a ring gear operatively associated with said housing,

a bit gear operatively associated with said ring gear, and

a grounding ring operatively associated with said bit gear;

an isolation mechanism for separating rotation of said housing from said grounding ring; and

15 a rotary cutting bit coupled to said mechanical gear box, said mechanical gear box being configured to rotate said rotary cutting bit at a second rotational rate in response to said rotary input from said housing, said second rotational rate being greater than said first rotational rate, said mechanical gear box being further configured to cause said rotary cutting bit to orbit about said central axis of said housing.

20 2. The assembly of claim 1, wherein said second rotational rate is more than twice said first rotational rate.

3. A down-the-hole drilling assembly adapted to be secured to a drill string that is
25 rotated by a drill rig, comprising:

a housing having a central axis, said housing being adapted to be coupled and rotationally fixed to the drill string;

a mechanical gear box positioned at least partially inside said housing; and

a rotary cutting bit coupled to said mechanical gear box;

30 wherein rotation of the drill string at a first rotational rate causes said housing to rotate at said first rotational rate thereby causing said mechanical gear box to rotate said

rotary cutting bit at a second rotational rate, said second rotational rate being greater than said first rotational rate;

said mechanical gear box being further adapted to cause said rotary cutting bit to orbit about said central axis of said housing.

5

4. The assembly of claim 3, wherein said mechanical gear box includes a ring gear operatively associated with said housing, a bit gear operatively associated with said ring gear, and an orbital gear operatively associated with said bit gear and with said ring gear.

10

5. The assembly of claim 4, further comprising a grounding ring operatively associated with at least one of said bit gear or said orbital gear in such a manner as to cause said bit gear to orbit about a central axis of said housing.

15

6. The assembly of claim 5, further including an isolation mechanism for separating said rotation of said housing from the grounding ring.

7. The assembly of claim 6, wherein the isolation mechanism includes a bearing assembly.

20

8. The assembly of claim 3, wherein said mechanical gear box includes a ring gear formed on an interior surface of said housing.

25

9. The assembly of claim 3, wherein said mechanical gear box includes a ring gear operatively associated with said housing, a bit gear operatively associated with said ring gear, at least one orbital gear operatively associated with said ring gear, and a central gear operatively associated with each of said orbital gear and said bit gear.

10. The assembly of claim 9, wherein said orbital gear rotates freely relative to said ring gear.

30

11. The assembly of claim 9, further comprising at least one stabilizer coupled to said orbital gear.

12. The assembly of claim 9, wherein said central gear is positioned between said bit gear
5 and said orbital gear.

13. A down-the-hole drilling assembly adapted to be secured to a drill string that is rotated by a drill rig, comprising:

10 a housing defining a lumen having a central axis, said housing being adapted to be coupled and rotationally fixed to the drill string;

a ring gear formed on an inner surface of said housing, said ring gear being in communication with said lumen;

a first gear operatively associated with said ring gear;

a second gear operatively associated with said ring gear;

15 a third gear operatively associated with each of said first gear and said second gear; said third gear further being positioned at least partially between said first gear and said second gear; and

20 a rotary cutting bit coupled to said first gear, wherein rotation of the drill string at a first rotational rate causes said housing to rotate at said first rotational rate thereby causing said first gear to rotate at a second rotational rate, said second rotational rate being greater than said first rotational rate and wherein said rotation of said housing causes said first gear and said rotary cutting bit to orbit about the central axis.

14. The down-the-hole drilling assembly of claim 13, wherein said housing rotates at a
25 different rotational rate than said third gear.

15. The down-the-hole drilling assembly of claim 13, further comprising a stabilizer member coupled to said second gear, said stabilizer member being configured to dress a wall of a bore hole.

30

16. The down-the-hole drilling assembly of claim 13, wherein said first gear has a first diameter, said second gear has a second diameter; and said third gear has a third diameter, said third diameter being greater than said first diameter and said second diameter.

5 17. The down-the-hole assembly of claim 16, wherein said first diameter is the same as said second diameter.

18. The down-the-hole assembly of claim 17, further comprising a fourth gear operatively associated with said ring gear and with said third gear, wherein said third gear is positioned
10 interior to each of said first gear, said second gear, and said fourth gear.

19. The down-the-hole assembly of claim 18, further comprising a first stabilizer member coupled to said second gear and a second stabilizer member coupled to said fourth gear, said first stabilizer member and said second stabilizer member each being configured to dress a
15 wall of a bore hole.

20. A method of drilling, comprising:

coupling a helical drilling device to a drill string by rotationally fixing a housing of said helical drilling device to said drill string, said helical drilling device including a
20 mechanical gear box positioned within said housing and a rotary cutting bit coupled to said mechanical gear box;

positioning said rotary cutting bit in a bore hole in a formation, said bore hole having a face diameter, wherein said rotary cutting bit has a diameter less than said face diameter;

rotating said drill string at a first rotational rate thereby causing said housing to rotate
25 at said first rotational rate;

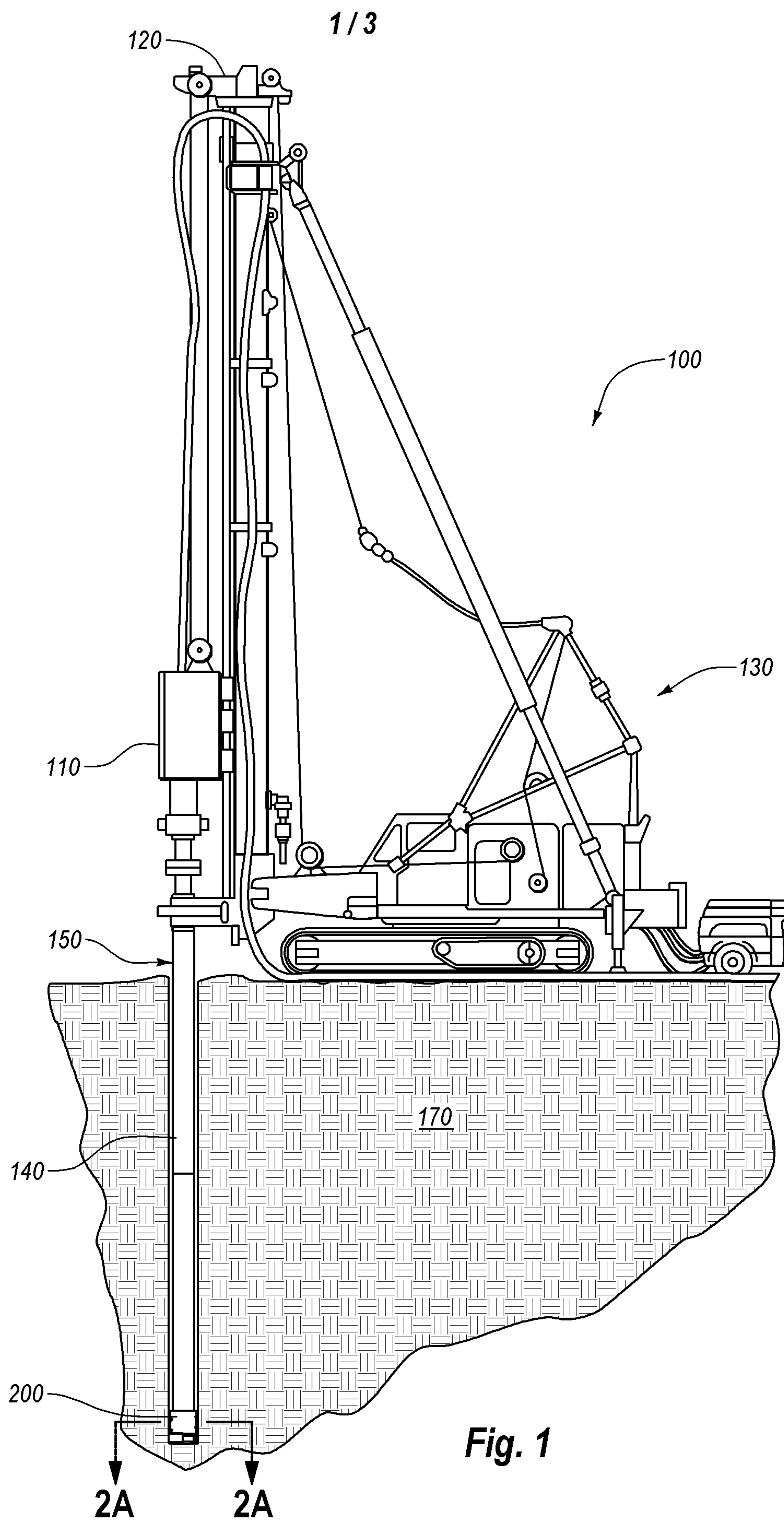
wherein rotation of said housing at said first rotational rate causes said mechanical gear box to rotate said rotary cutting bit at a cutting rotational rate greater than said first rotational rate; and

orbiting the rotary cutting bit to drill the face diameter in response to rotation of said
30 drill string.

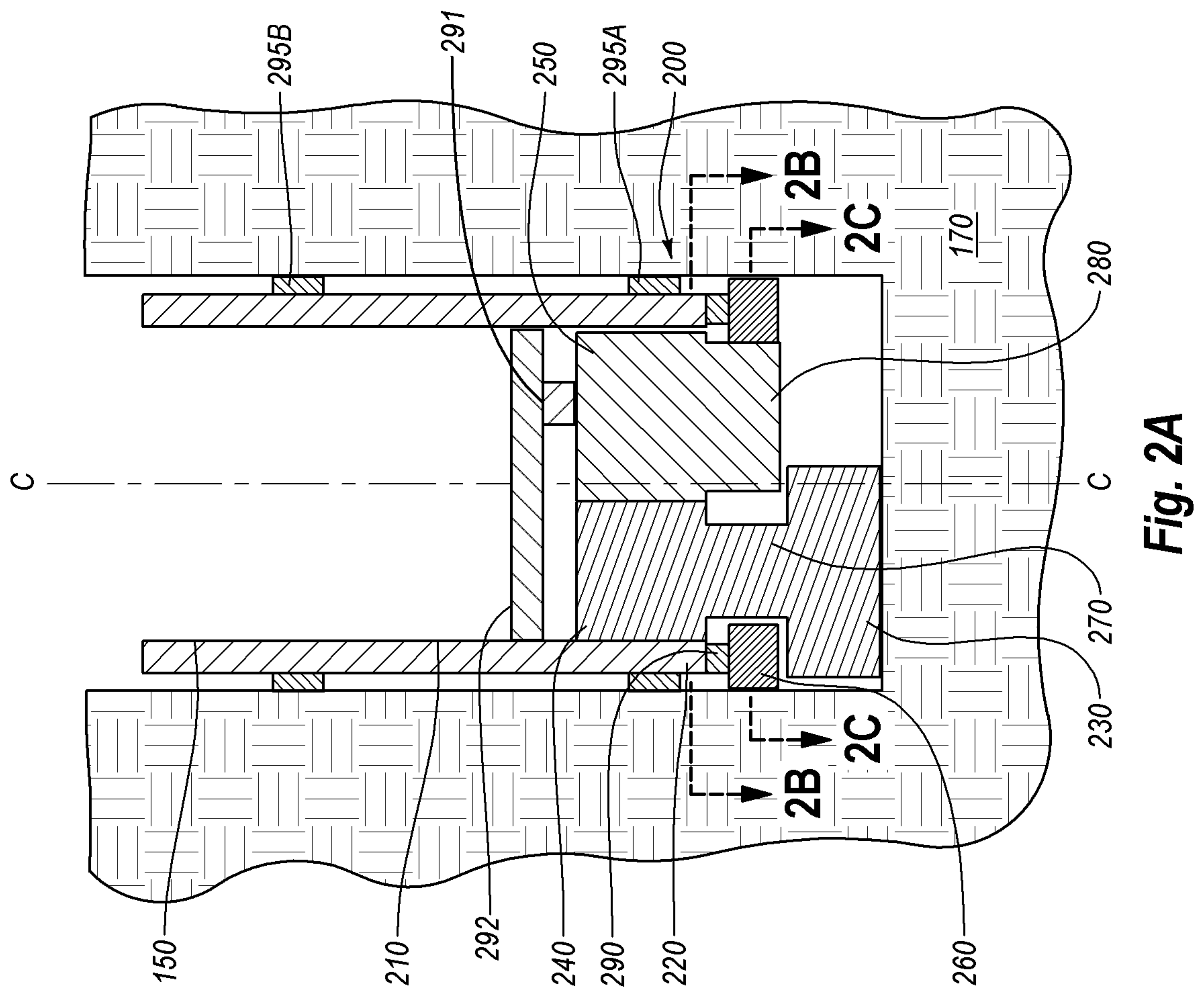
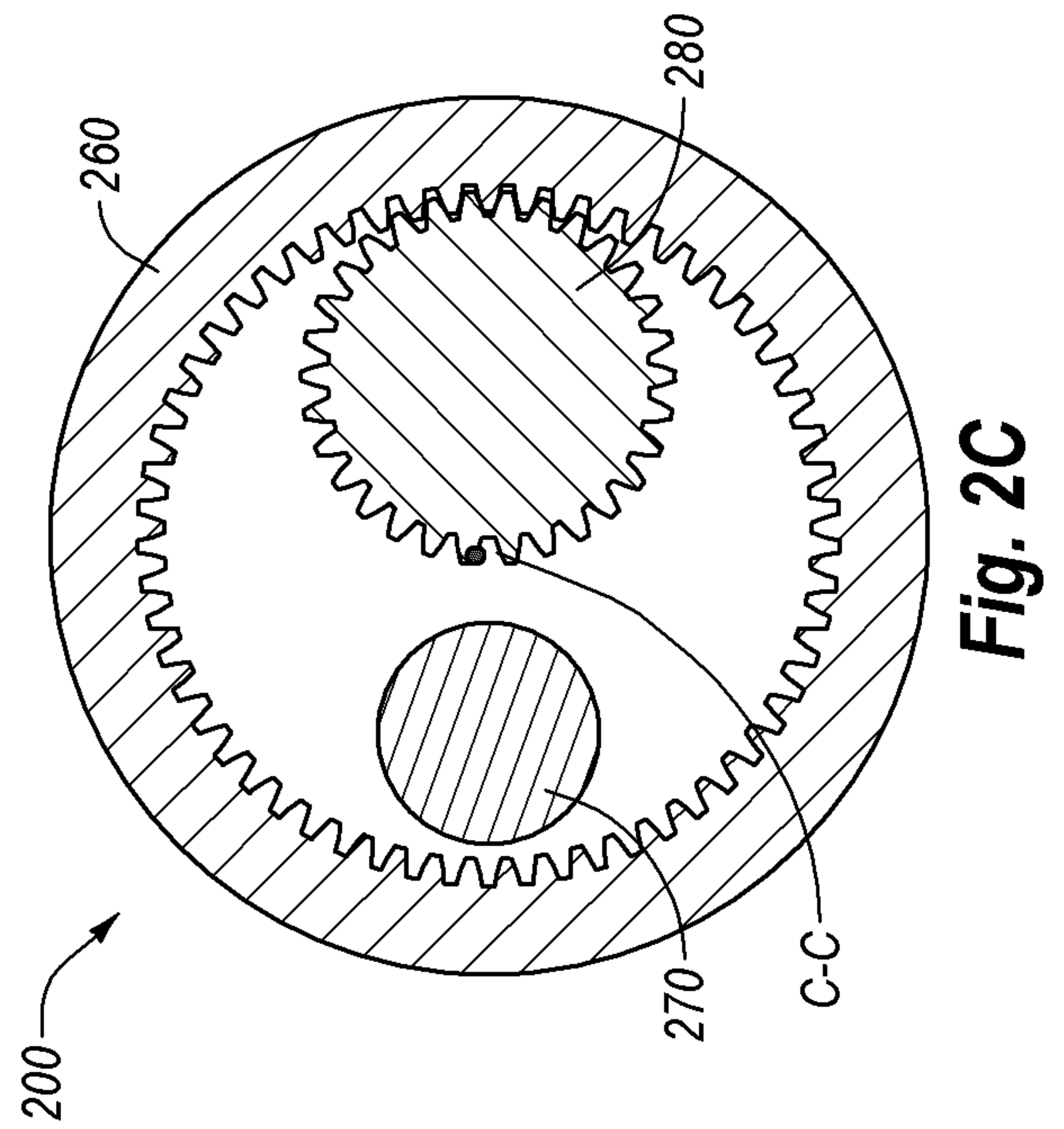
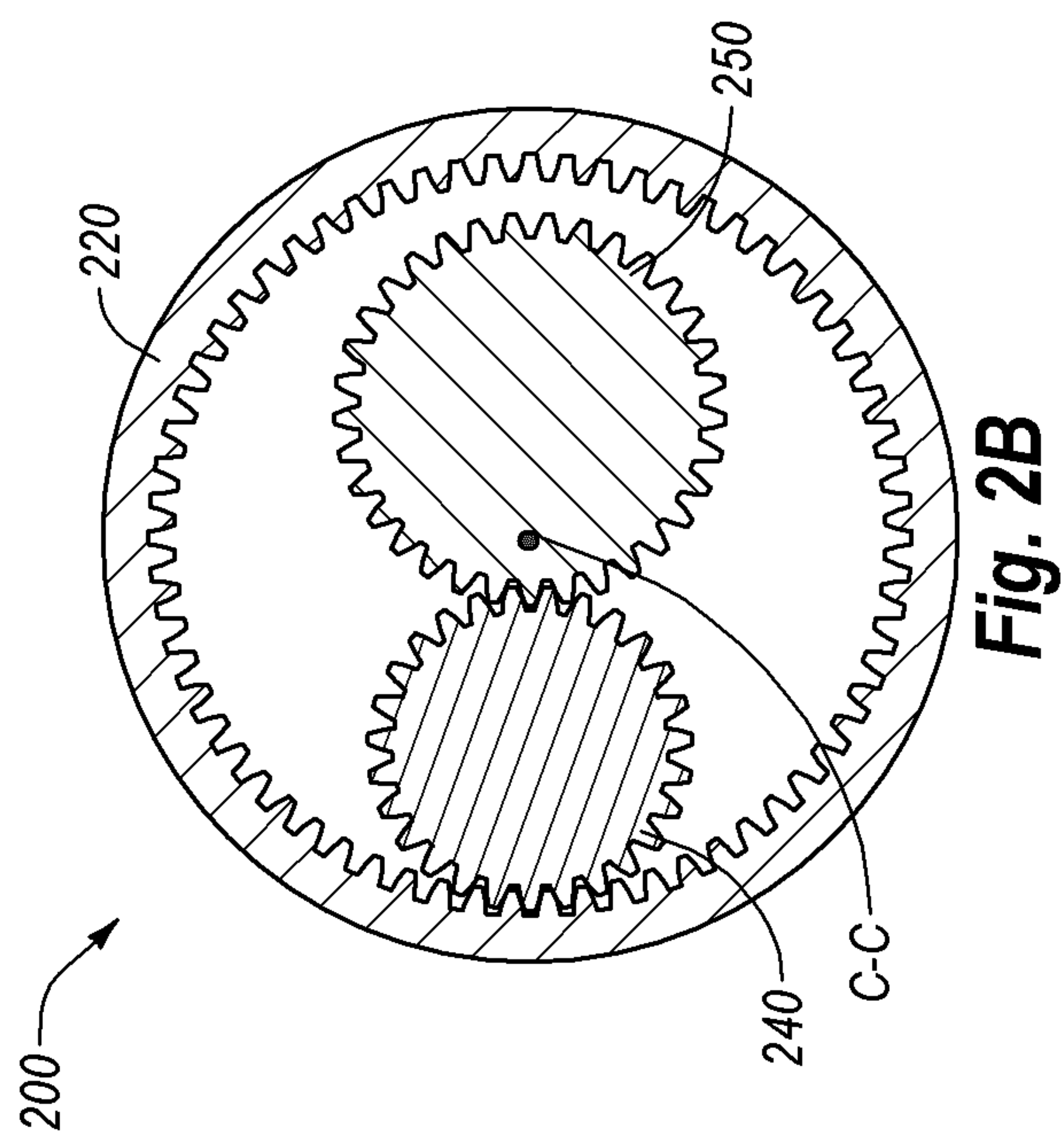
21. The method of claim 20, further comprising spinning a stabilizing member with said mechanical gear box in response to said rotation of said housing to ream a wall of said bore hole.

5 22. The method of claim 21, further comprising spinning a plurality of stabilizing members with said mechanical gear box in response to said rotation of said housing to ream a wall of said bore hole.

10 23. The method of claim 20, wherein said cutting rotational rate is more than twice said first rotational rate.



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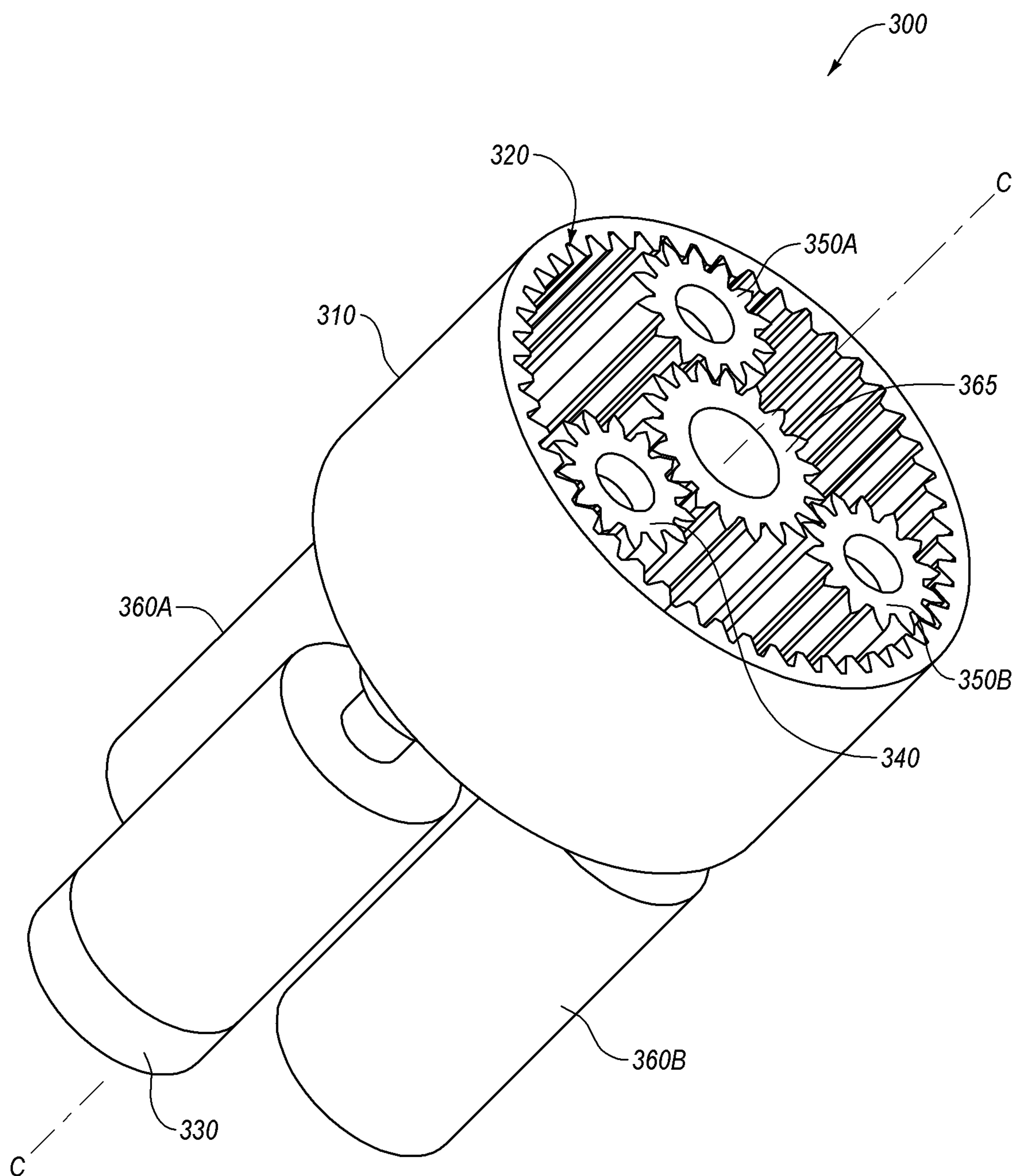


Fig. 3

