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(71) Applicant: CREATIVE MOTION CONTROL, INC.
[—/US]; 2891 152nd Avenue NE, Redmond, WA 98052 (US).

(72) Inventors: LAWLOR, Shawn; 2891 152nd Avenue NE, Redmond, WA 98052 (US). CORNELIUS, Charles; 6225 Lake Washington Blvd, No. 310, Kirkland, WA 98033 (US).

(74) Agent: CRAINE, Dean, A.; 9 Lake Bellevue Drive, Ste 208, Bellevue, WA 98005 (US).

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(54) Title: TOOL WITH LINEAR DRIVE MECHANISM

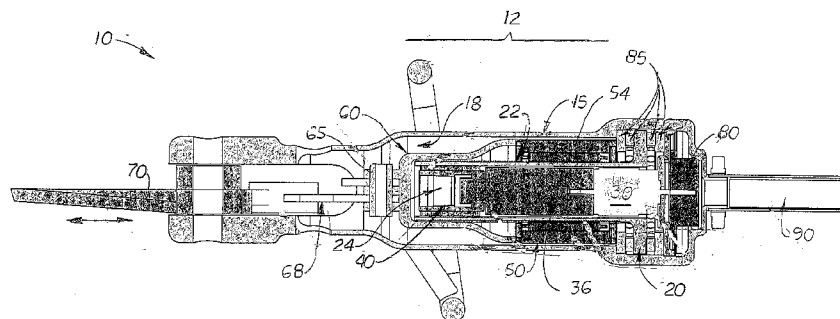


FIG. 1

(57) Abstract: A hand tool with a mechanical linear drive mechanism coupled to a linear activated working implement. The drive mechanism includes a geared planetary roller screw that includes a torque tube connected to a roller screw's nut body. The planetary roller screw includes a fixed outer race, a rotating set of grooved rollers axially aligned inside the outer race, a cylindrical nut body located inside the set of grooved rollers, a plurality of inner rollers axially aligned and inside the nut body, a threaded shaft axially aligned and inside the inner rollers, and a torque tube axially aligned inside the inner rollers.

5 **TITLE: TOOL WITH LINEAR DRIVE MECHANISM****TECHNICAL FIELD**

The present invention relates to voltage detectors, and more particularly, to voltage detectors that include a flashlight. This invention relates to linear drive
10 mechanisms, and more particularly to linear drive mechanism that are portable and compact.

BACKGROUND ART

Portable hand tools are commonly used by emergency personnel to bend,
15 spread or cut metal pieces to free drivers and passengers from their vehicles after accidents. The working implements on these hand tools are actuated by a linear mechanism coupled to a hydraulic cylinder. The hydraulic cylinder is coupled to a gas or electricity powered hydraulic pump.

One drawback with power hand tools that use hydraulic pumps is the
20 hydraulic pump's periodic inspection and maintenance requirements. Another drawback is the tool's housing is elongated to accommodate the hydraulic pump, the linear mechanism and the working implement.

What is needed is a portable hand tool with an electric, non-hydraulic linear drive mechanism coupled to a working implement.

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DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide a portable hand tool
lightweight, compact linear drive mechanism that uses a roller screw as a mechanical
linear drive mechanism coupled to the tool's working implement.

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The linear drive mechanism includes a roller screw threaded shaft with an external nut and rollers mounted over axially aligned threaded shaft longitudinally

5 aligned inside the tool's elongated body. In one embodiment, the proximal end of the threaded shaft is coupled to a gearbox that is coupled to an electric motor that can be operated in both forward and reverse directions. The gearbox includes a plurality of gears configured to reduce the RPM output from the electric motor. In the first embodiment, the gearbox is also coupled to a frictional clutch configured to engage
10 the inside surface of the roller screw shaft when rotated a specific amount. In a second embodiment, the frictional clutch is eliminated and replaced by a multiple stage gear box.

When the electric motor is activated, the frictional clutch or multiple stage gear box causes the threaded shaft to rotate. In the first embodiment, as the threaded
15 shaft is rotated, the roller screw's nut body moves longitudinally inside the tool's elongated body. In the second embodiment, the nut body is fixed axially inside the tool's outer housing so as the nut body is rotated, the threaded shaft moves axially inside the tool's outer housing.

Mounted distally inside the elongated body and adjacent to the distal end of
20 the roller nut is a tool implement coupler that attaches to the tool implement that extends from tool's distal end. The tool implement may include two pivoting cutting jaws, two pivoting spreader jaws, or a ram bar. A rechargeable battery is attached to the proximal end of the elongated housing to energize the electric motor.

In the second embodiment, the mechanical linear drive is a geared planetary
25 roller screw that includes a torque tube connected to a roller screw's nut body. The planetary roller screw includes a fixed outer race, a rotating set of grooved rollers axially aligned inside the outer race, a cylindrical nut body located inside the set of grooved roller, a plurality of threaded inner rollers axially aligned and inside the nut body, a threaded shaft axially aligned and inside the inner rollers, and a torque tube

5 fixed to the nut body. The nut body operates as an inner race for the grooved inner rollers. The torque tube is connected at one end to the gear box coupled to an electric motor. When electric motor is activated, the torque tube is rotated which causes a threaded shaft in the tool to move axially inside the tool. A working implement is coupled to the distal end of the threaded shaft.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional side elevational view of a first embodiment of a tool two cutting jaws and a linear drive mechanism.

Fig. 2 is a side elevational view of a second embodiment of a tool with two
15 cutting jaws and a geared planetary roller screw used as a linear drive mechanism.

Fig. 3 is a sectional side elevational view of the tool shown in Fig. 2.

Fig. 4 is an enlarged, partial sectional side elevational view of the geared planetary roller screw located inside the tool shown in Figs. 2 and 3.

Fig. 5 is an end sectional view taken along line 5-5 in Fig. 3.

20 Fig. 6 is an end sectional view taken along line 6-6 in Fig. 3.

Fig. 7 is an end sectional view taken along line 7-7 in Fig. 3.

Fig. 8 is an end sectional view taken along line 8-8 in Fig. 3.

Fig. 9 is an end sectional view taken along line 9-9 in Fig. 3.

Fig. 10 is an exploded view of the dowel pin, the outer race, the grooved roller
25 located inside the outer race, the snap ring, the nut body located inside the grooved roller, the inner threaded roller, ring gear, the wiper seal, and the threaded shaft.

Fig. 11 is a side elevational view of a tool with two spreader jaws

Fig. 12 is a side elevation view of the tool shown in Fig. 11 with the front section of the outer housing removed to show the linkage arms coupled to the

5 spreader arms.

Fig. 13 is a side elevational view of a tool with a ram bar extending longitudinally from the front section.

BEST MODE FOR CARRYING OUT THE INVENTION

10 A tool 10 with a lightweight linear drive mechanism 12 in the tool's elongated body 15 and designed to provide 70,000 to 120, 000 lbs of force to the tool's working implement 70. Fig. 1 discloses a first embodiment of the tool 10 that includes a roller screw assembly shown and described in U.S. Patent No. 7,044, 017 and incorporated herein. The roller screw assembly roller screw shaft 20 and a nut body 50 mounted
15 over the outer surface of the roller screw shaft 20. Disposed inside the nut body is a plurality of longitudinally aligned rollers 54 designed to remain in constant contact with formed grooves on the outer surface of the roller screw shaft 22 and grooves formed on the interior surface of the nut body 50 during operation. The rollers 54, however, can shift axially and be re-positioned with respect to both the nut body 50
20 and the roller screw shaft 22 as the roller screw shaft 22 is rotated while remaining in rolling contact with the nut body 50.

The grooves on the nut body 50 are helical over most of the inside surface of the nut body 50. Over a small region of the inside surface of the center bore, hereinafter referred to as the cross-over region, the grooves extend radically outward
25 and axially. Located inside the nut body 50 is a plurality of longitudinally aligned rollers 54. Formed over the outer surface of the rollers 54 are non-helical grooves that mesh with a plurality of closed, partially helical grooves on the nut body 50 and with the helical threads on the roller screw shaft 20 that extends through the nut body 50. When the rollers 54 travel through the cross-over region, two compression rings on

5 the opposite ends of the rollers 54 force the rollers 54 radially outward so they maintain engagement with the grooves on the nut body 50.

Because the grooves in the cross-over region extend axially, the rollers 54 are shifted axially regarding the nut body 50 and roller screw shaft 22 when centrally disposed in the cross-over region. As the rollers 54 leave the cross-over region, they
10 are extended axially and returned to the original starting point of the grooves on the nut body 50.

The grooves on the rollers 54 are non-helical and designed to engage both the closed grooves on the nut body 50 and on the open helical threads on the roller screw shaft 20. The diameter of the roller screw shaft 20, the nut body 50, and rollers 54 are
15 sufficient in size so that when the grooves on the rollers engage the grooves on the nut body 50 in the cross-over region, they progressively disengage from the helical threads on the shaft enabling the rollers 54 to move axially with respect to the nut body 50. As the rollers 54 leave the cross-over region, they travel axially and re-engage the helical threads on the roller screw shaft 20. With each rotation of the
20 roller screw shaft 22 inside the nut body 50, the rollers 54 are in constant rolling contact with the grooves on the nut body 54.

The above described roller screw assembly 12 is longitudinally aligned inside the hollow cavity 18 formed in the hand tool's elongated body 15. The roller screw shaft 20 is coaxially aligned inside the cavity and includes a longitudinally aligned
25 cavity 24. Mounted inside the cavity 24 and adjacent to the proximal end of the roller screw shaft 20 is an electric motor 30. Mounted adjacent to the electric motor 30 and inside the cavity 24 is a gearbox 36. The gearbox 36 is coupled to the drive shaft on the electric motor 30 and configured to reduce the RPM output from the electric motor 30.

5 The opposite end of the gearbox 36 is coupled to a frictional clutch 40 also located inside the distal end of the cavity 24. When the electric motor 30 is activated, the gear box 36 causes the frictional clutch 40 to rotate that eventually engage the exposed section of the inside surface of the roller screw shaft 20 and causing the roller screw shaft 20 to be rotated inside the roller nut 50.

10 Longitudinally aligned and located distally inside the elongated body 16 is an elongated push cap 60. The push cap 60 includes a wide proximal section and a narrow front neck section. The distal end of the roller screw shaft 20 extends into the center bore formed in the push cap. When assembled, the end surface of the proximal section abuts the distal end surface of the roller screw nut 50. When roller screw
15 shaft 20 is rotated, the roller screw nut 50 travels longitudinally inside the elongated body 15 in a fore or aft direction depending on the direction of rotation of the electric motor 30.

 Mounted on the distal end of the push cap 60 is a pivot pin 65 coupled to
toggle linkage 68. The toggle linkage 68 is connected to one or more cutter or
20 spreader blades 70 used on the working implement.

 The roller screw shaft 20 is held coaxially inside the elongated body 20 and the push cap 60 by bearings 85. The roller screw shaft 20 includes a perpendicular aligned base that fits inside the proximal wide end section of the elongated body 20. The electric motor 30 is held inside the proximal end the roller screw shaft 20 by a
25 transverse member that extends across the proximal end opening. The electric motor 30 includes a secondary shaft coupled to an electrical brake 30 mounted on the proximal end of the elongated body 15.

 A rechargeable battery 90 may be attached to the proximal end of the elongated body 15 to energize the electric motor 30.

5 Figs. 2-10 show a second embodiment of the tool 200 with lightweight linear drive mechanism that uses an electric motor assembly 205 coupled to a multiple stage gear box 220 used in place of the frictional clutch. Coupled to the gear box 220 is a geared planetary roller screw 250 that is in place of the roller screw assembly described above. The geared planetary roller screw 250 is similar to the roller screw
10 shown in U.S. Patent No. 2,683,379 (Strandgren) which is now incorporated herein.

The geared planetary roller screw 250 includes a fixed cylindrical, fixed outer race 260 axially aligned inside the tool's outer housing 210. The outer race 260 includes a plurality of internal, non-helical grooves 264. A dowel pin 268 is inserted in between the outer housing 210 and the outer race 260 to hold the outer race 260
15 inside the tool 200. A set screw 270 is used to retain the dowel pin 268 in the outer housing 210.

Located adjacent inside the outer race 260 is a plurality of outer grooved rollers 275. Formed on each end of the outer grooved rollers 275 are axially aligned axles 278 that engage bores formed on two spacer rings 280 coaxially aligned inside
20 the outer housing 210. Each grooved roller 275 includes a plurality of non-helical grooves 282 configured to mesh with the non-helical grooves 264 formed on the outer race 260. During operation, the set of grooved rollers 275 and two spacer rings 280 rotate inside the outer housing 210.

Located adjacent and inside the grooved rollers 275 is a cylindrical nut body
25 288 configured to rotate inside the outer housing 210. The nut body 288 includes a plurality of external non-helical threads 290 that mesh with the non-helical grooves 282 on the grooved rollers 275. The nut body 288 acts as an inner race for the outer groove rollers 275. The nut body 288 also includes a plurality of internal helical threads 292. The non-helical threads 290 on the external surface of the nut body 288

- 5 allow the nut body 288 to rotated but prevent the nut body 288 from moving axially inside the outer housing 210.

Located adjacent and inside the nut body 288 is a plurality of axially aligned inner rollers 300. Each inner roller 300 includes external helical threads 304 that mesh with the internal helical threads 292 on the inside surface of the nut body 288.

- 10 Each inner roller 300 includes at its opposite ends a set gear teeth 306 that engage two ring gears 310 aligned transversely inside the outer housing 210. Formed on the two ring gears 310 are a plurality of external teeth that mesh with the gear teeth 306 on opposite ends of the inner rollers 300. During operation the inner rollers 300 individually rotate on their longitudinally axis and rotate around a threaded shaft 310
15 that extends coaxially and inside the outer housing 210.

- The threaded shaft 310 includes a plurality of helical external threads 314 that extend substantially the entire length and mesh with the helical threads 304 on the inner rollers 300. In the embodiment shown herein, the threaded shaft 310 is approximately twice as long as the inner rollers 300. The threaded shaft 310 is hollow
20 with a proximal end and a distal end. Attached to the distal end is a combination end cap/clevis 320.

- Disposed inside the outer housing 210 is a torque tube 330 that includes a narrow cylindrical hollow neck 334 and a wide cylindrical body 338. The neck 334 is configured to surround the rear portion of the threaded shaft 310 that extends
25 rearward from the inner rollers 300. The wide body 38 is configured to extend outward and partially extend around the exterior surface of the nut body 288. Formed the inside surface of the wide body 328 and the adjacent surface of the nut body 288 is keyway. A complementary key 340 is inserted into the two keyways to affix the torque tube 330 to the nut body 288. Formed on the proximal end of the

5 torque tube 330 are one or more receiving bores that receive pegs 222 that extend longitudinally inward from the gear box 220.

During operation, the electric motor 210 is activated which causes the pegs 222 on the gear box 220 to rotate. The rotation of the pegs 222 on the gear box 220 causes the torque tube 330 to rotate which causes the nut body 288 to rotate. Because
10 the grooved rollers prevent the nut body 288 from moving longitudinally inside the outer housing 210, the inner rollers 300 rotate which engage the threads 304 on the threaded shaft 310 causing the threaded shaft 310 to move longitudinally inside the outer housing 210.

Figs. 2 and 3 show the tool implement 350 with two cutting jaws 360, 380
15 extending from the distal end of the outer housing 210. The two cutting jaws 360, 380 include cutting blade edges 366, 386 and middle sections 365, 385, respectively, rotatingly coupled together by a rigid front pin 390. The rear section 361, 381 of each jaws 360, 380, respectively, is pivotally connected to a linkage arm 350, 355, respectively. The rear end of each linkage arm 350, 355 is connected to a combination
20 end cap/clevis 320 (shown in Fig. 4) which is connected to the end cap 320. During use, the thread shaft moves axially inside the outer housing 210 causing the rear sections of the two jaws 360, 380 to move towards or away from the front pin 390 and thereby opening and closing the jaws 360, 380.

Figs 11 and 12 are side elevational views of a tool implement 400 with two
25 spreader jaws 410, 420 that extend from the distal end of the tool housing. The spreader jaws 410, 420 are connected to linkage arms 350, 355 and operate in a manner that enable the spreader arms 410, 420 to open and close.

Fig. 13 is a side elevational view of a tool implement 500 with a ram bar 510 extending longitudinally from the distal end of the tool housing. The ram bar 510 is

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5 connected directly to the distal end of the end cap 320 or to the threaded shaft 310.

INDUSTRIAL APPLICABILITY

This invention has application in the portable hand tool and emergency
equipment industries, and more particularly in such industries that need tools and
10 equipment to convert rotation movement from an electric motor to a linear activated
tool implement.

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CLAIMSWe claim:

1. A linear drive mechanism for a compact lightweight tool with a linear actuated working implement, comprising:

- 10 a. a tool housing;
- b. a geared planetary roller screw disposed inside said tool housing and configured to convert rotary motion from an electric motor to linear movement;
- c. an electric motor;
- 15 d. a gearbox disposed between said electric motor and said geared planetary roller screw configured to reducing the output rotation of said electric motor;
- e. a friction clutch;
- f. toggle linkage coupled to clevis and to a working implement, and,
- 20 f. an electricity source connected to the electric motor

2. The linear drive mechanism as recited in Claim 1, wherein the linear actuated working implement is a pair of cutting blades coupled to said toggle linkage.

25 3. The linear drive mechanism as recited in Claim 1, wherein the electricity source is a rechargeable battery.

4. A tool with a linear actuated working implement, comprising,

- a. a tool housing with a front end;
- 30 b. geared planetary roller screw disposed inside said tool housing, said

5 roller screw includes:

a fixed outer race axially aligned inside said outer housing, said outer race includes a plurality of internal non-helical grooves;

a plurality of axially aligned grooved rollers radially aligned over the inside surface of said outer race and rotated as a set around said outer race,
10 each said grooved roller includes external non-helical grooves that mesh with said non-helical grooves on said outer race;

a cylindrical nut body axially aligned with and located inside grooved roller bearings, said nut body includes a plurality of external non-helical threads that mesh with said non-helical grooves on said grooved roller, said
15 nut body includes a plurality of internal helical threads, said nut body configured to rotate inside said outer housing and not move longitudinally inside said outer housing;

a plurality of rollers axially aligned and located inside said nut body, each said roller includes external helical threads that mesh with said threads on
20 said nut body, each said roller includes a set gear teeth located at each end that engage two ring gears aligned transversely inside said outer housing with a plurality of teeth that mesh with said gear teeth on said rollers;

a threaded shaft axially aligned with said outer race, said threaded shaft includes a plurality of helical external threads that mesh with said helical
25 threads on said rollers, said threaded shaft includes a proximal end and a distal end;

a torque tube axially aligned with said outer race, said torque tube includes a narrow neck coaxially aligned around said proximal end of said torque shaft and a wide body that at least partially extends around and coupled

- 5 to said nut body, whereby when said torque tube is rotated, said nut body rotates inside said grooved roller bearings causing said grooved rollers bearings to individually rotate around said threaded shaft causing said threaded shaft to move axially with respect to said nut body;
- c. an electric motor;
- 10 d. gearbox disposed between said distal end of said torque tube and said electric motor and configured to adjust the RPM output from the electric motor;
- e. a clevis coupled to said distal end of said threaded shaft;
- f. a tool implement linkage coupled to said distal end of said threaded
- 15 shaft;
- g. a linear activated tool implement coupled to said tool implement linkage extending from said front end of said tool; and.
- h. an electricity source connected to the electric motor.
- 20 5. The tool, as recited in Claim 4, wherein said tool implement is a pair of cutting implements extending from said front end of said tool housing, each cutting implement coupled to one said toggle linkage and includes a forward extending blade with a cutting edge configured to cut through material placed transversely in between said blades when pressed together with sufficient longitudinal force created by said
- 25 roller screw and said electric motor.
6. The tool, as recited in Claim 4, wherein said torque tube and said nut body are locked together with a key inserted into a keyway formed between said torque tube and said nut body.

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5 7. The tool, as recited in Claim 4 where said tool implement is a pair of cutting
jaws that open and close when said threaded shaft moves axially.

8. The tool, as recited in Claim 4 where said tool implement is a pair of spreader
jaws that open and close when said threaded shaft moves axially.

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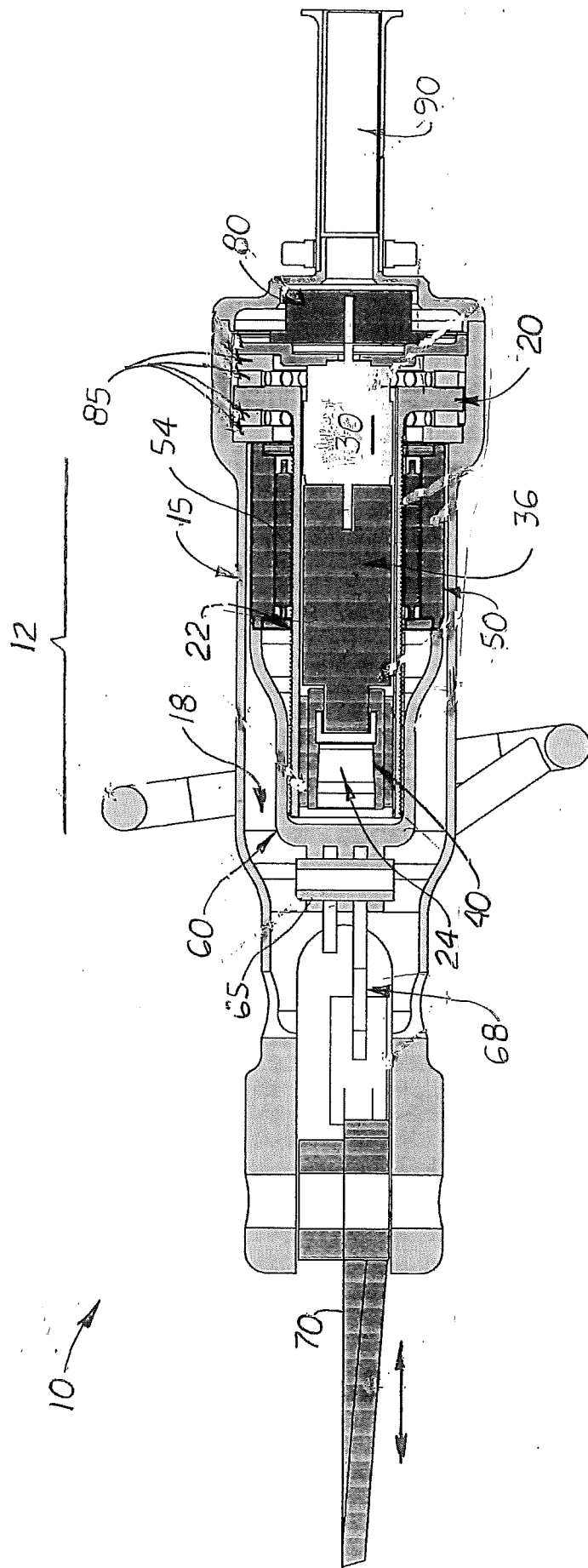


FIG. 1

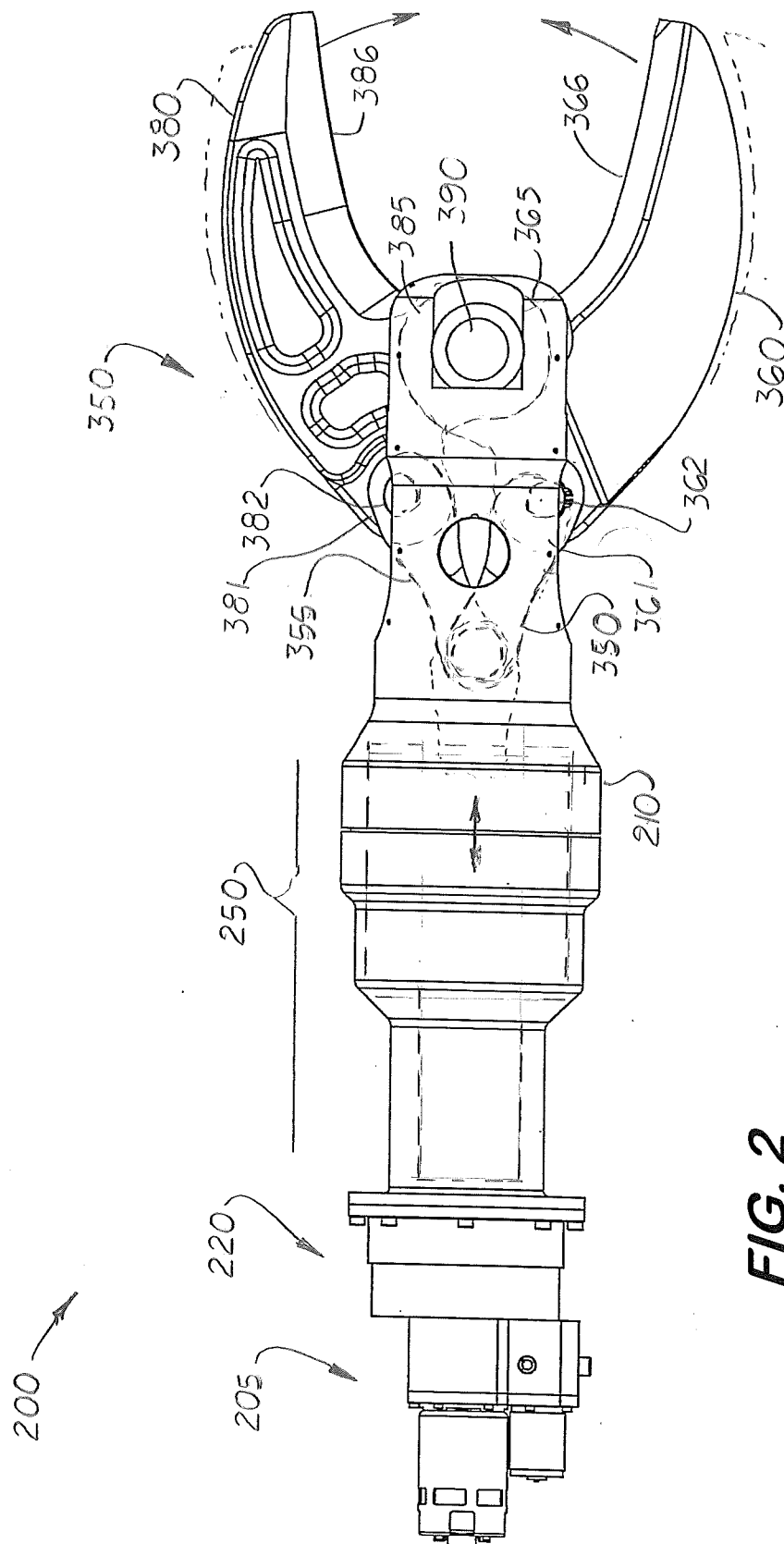


FIG. 2

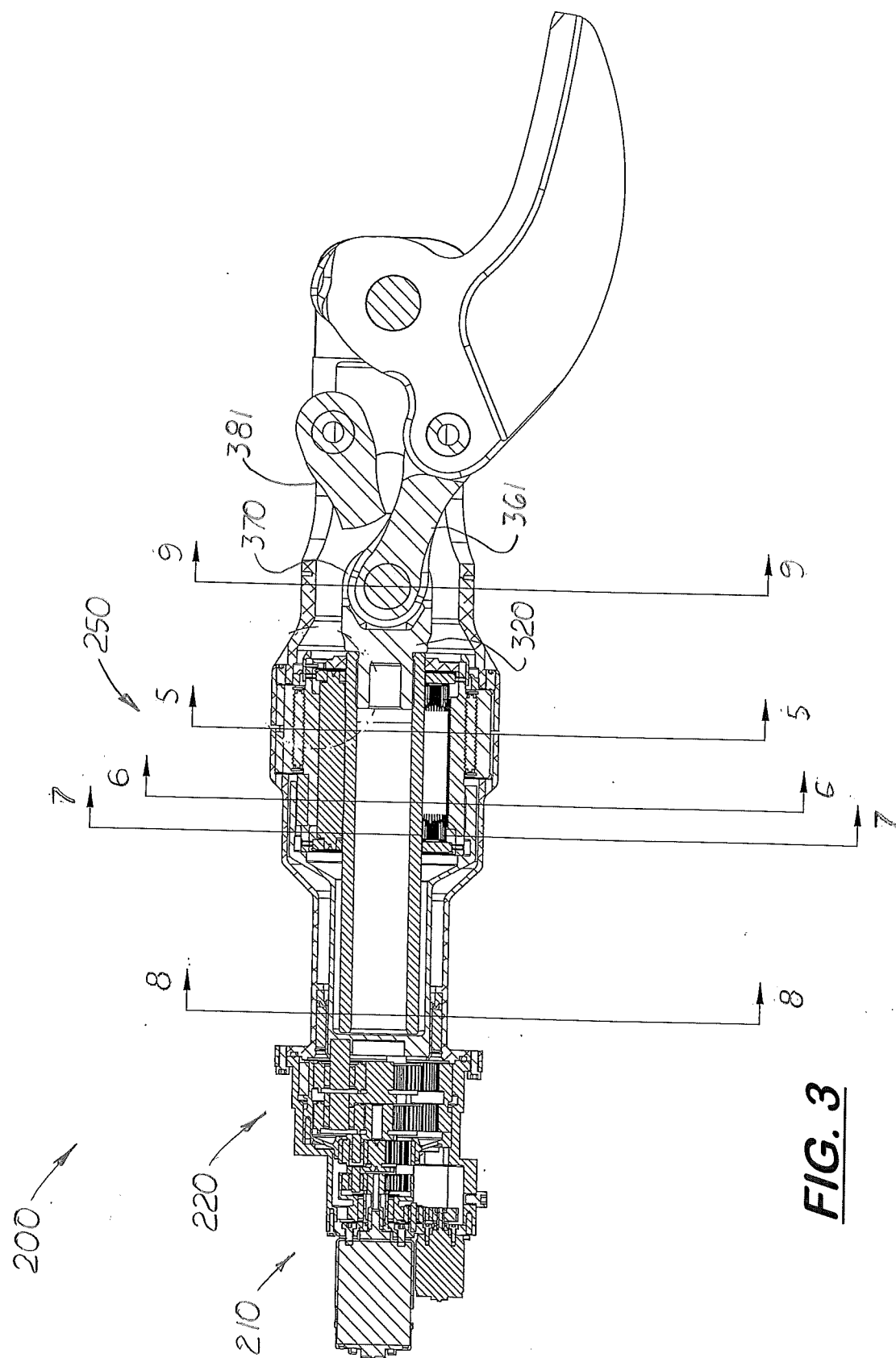
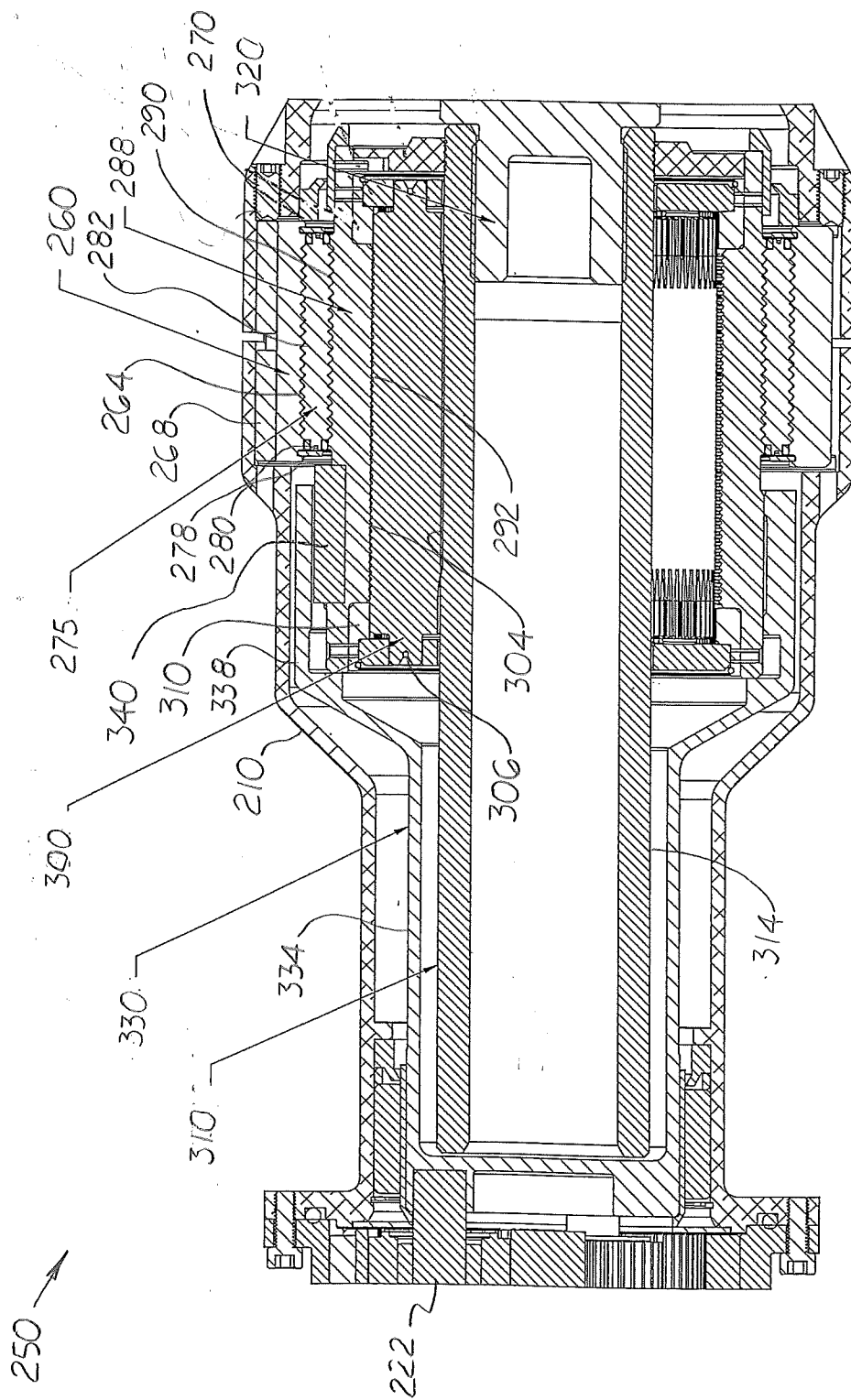


FIG. 3

**FIG. 4**

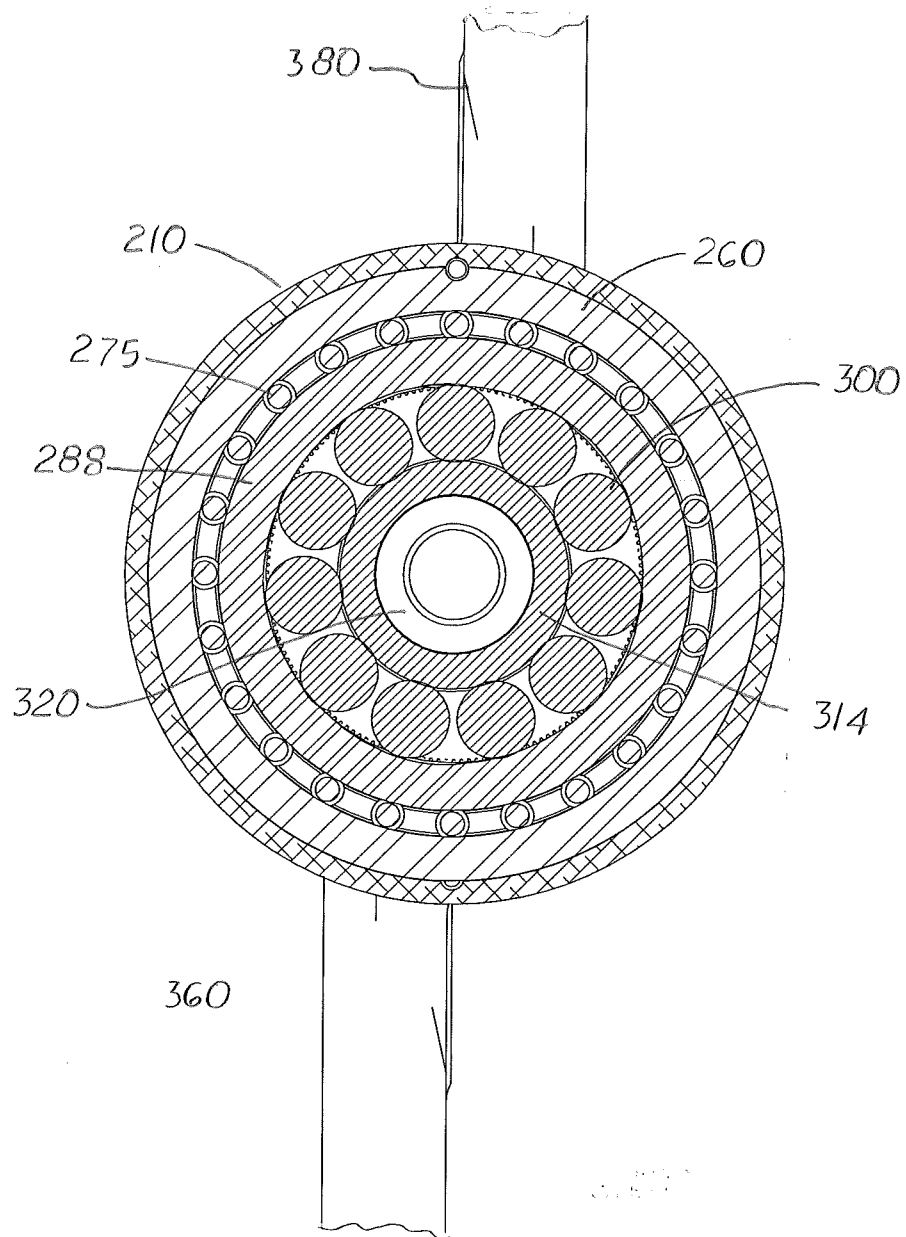
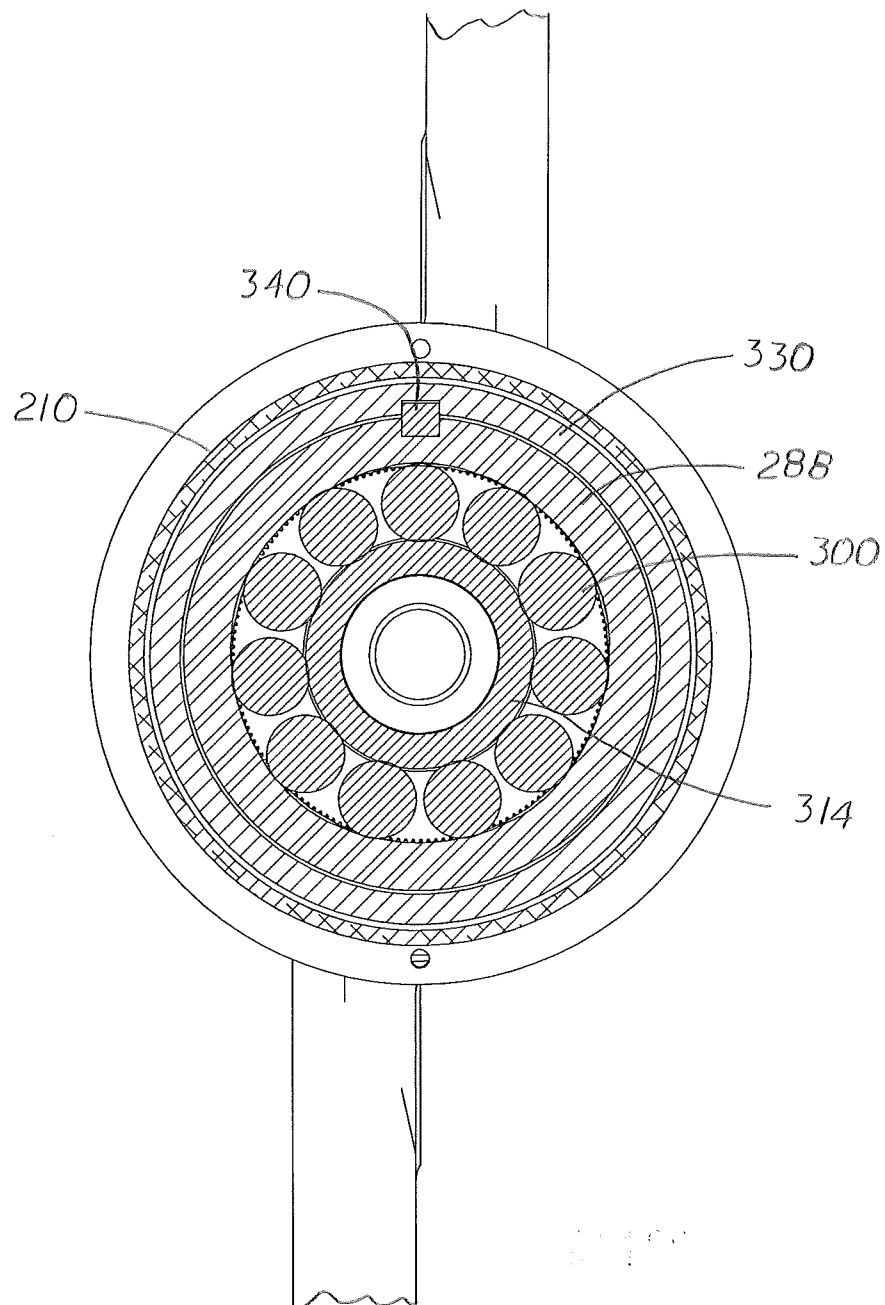


FIG. 5

**FIG. 6**

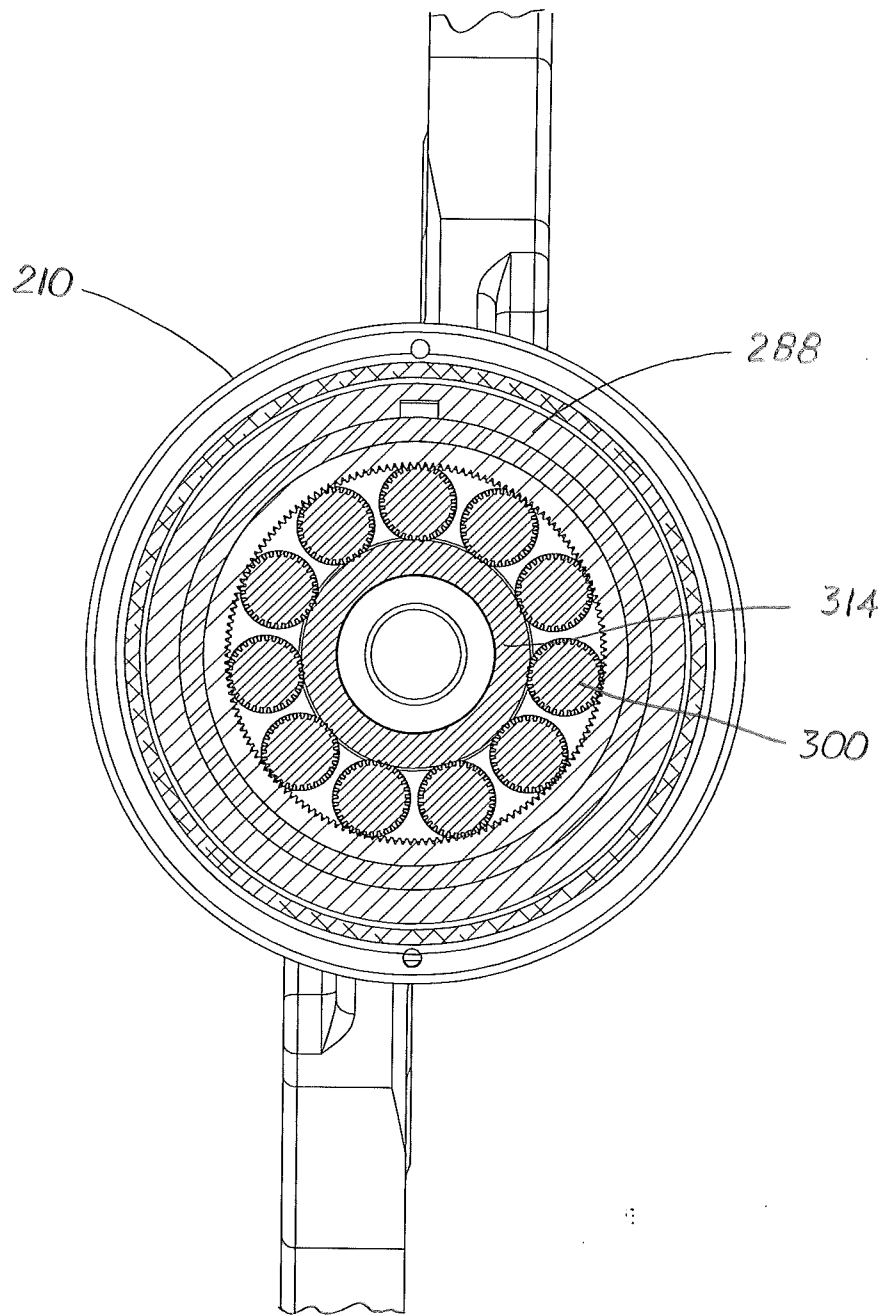


FIG. 7

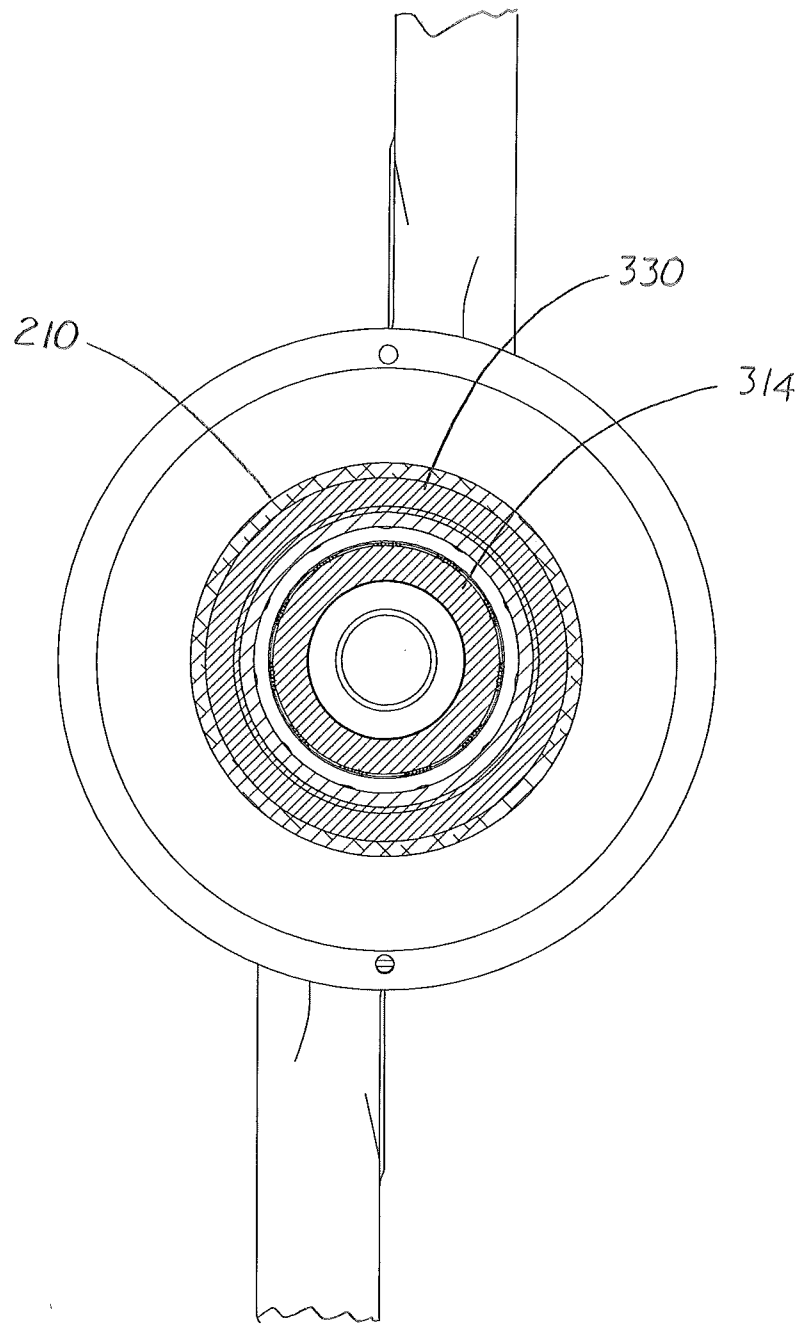
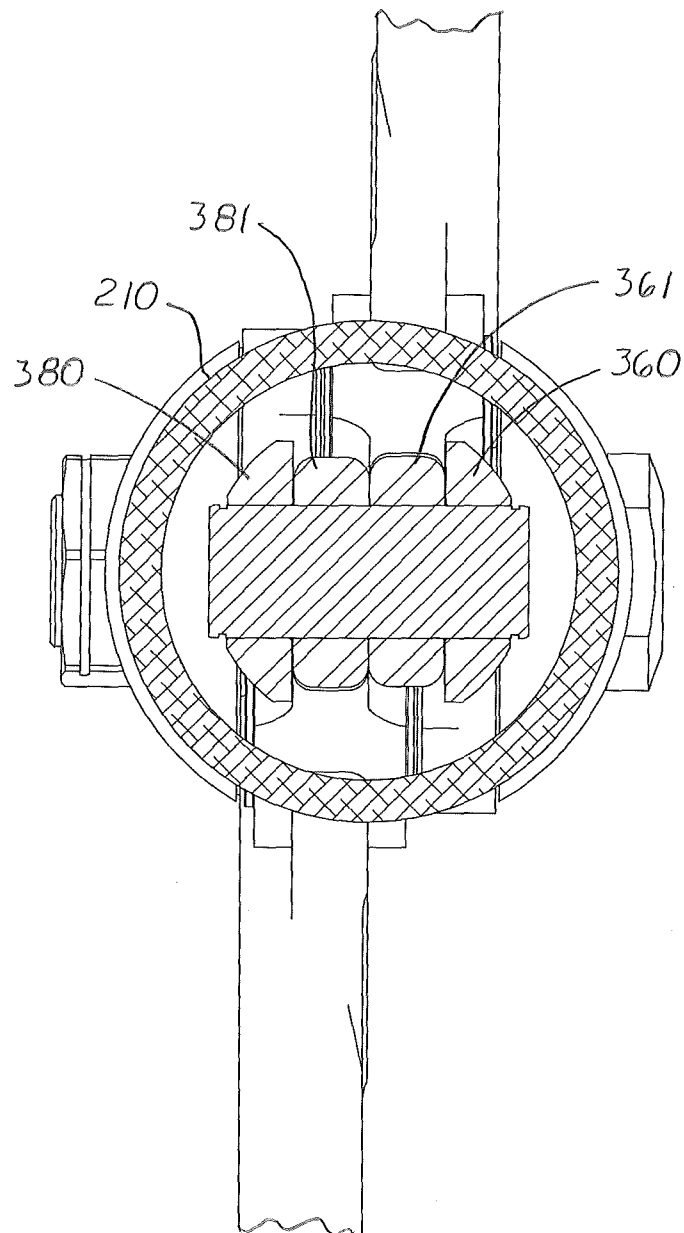


FIG. 8

**FIG. 9**

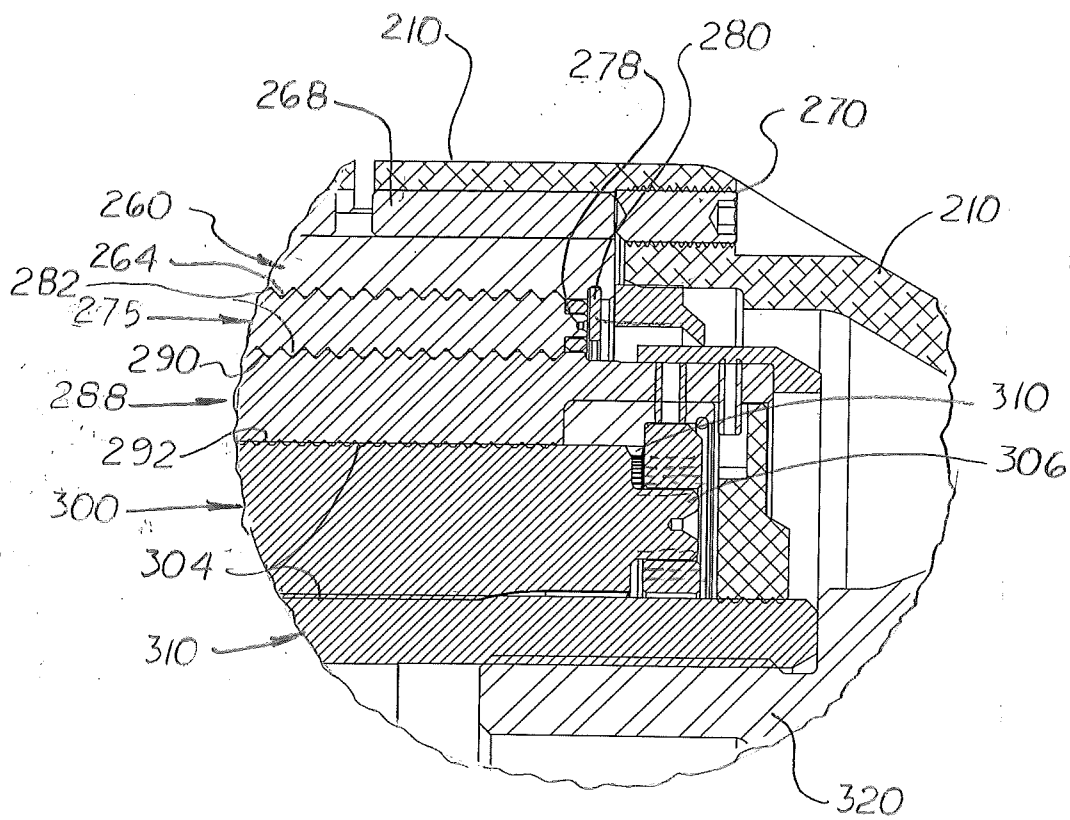


FIG. 10

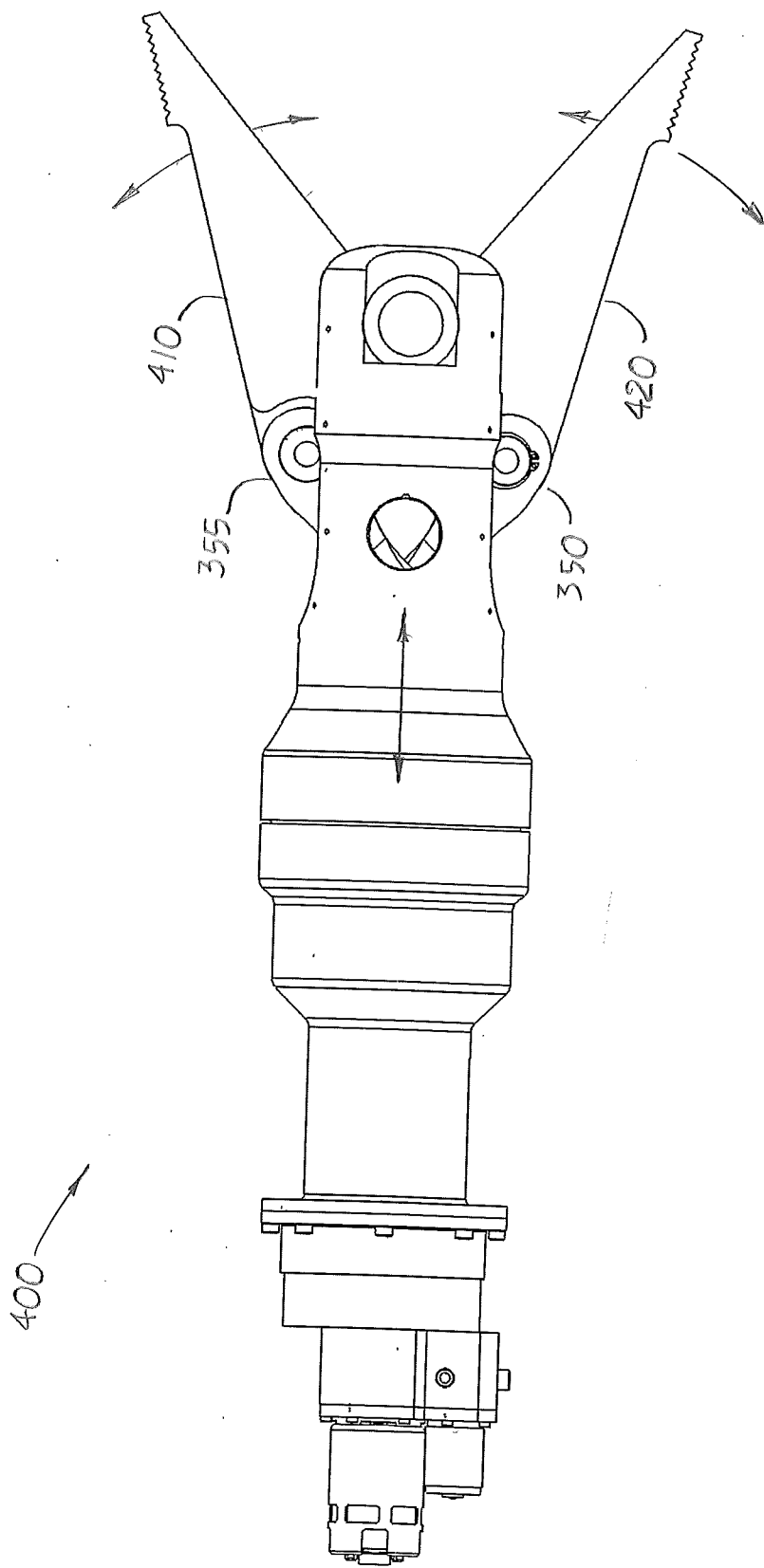


FIG. 11

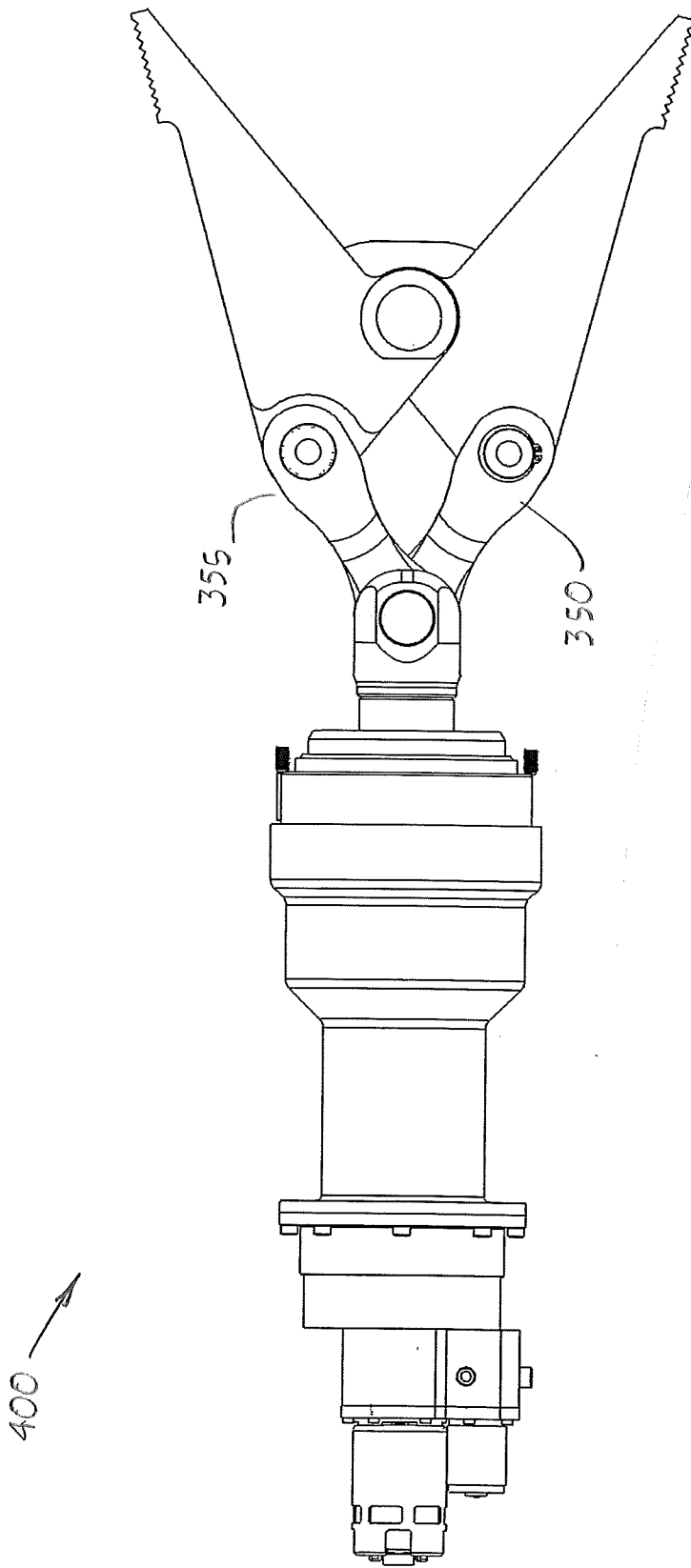


FIG. 12

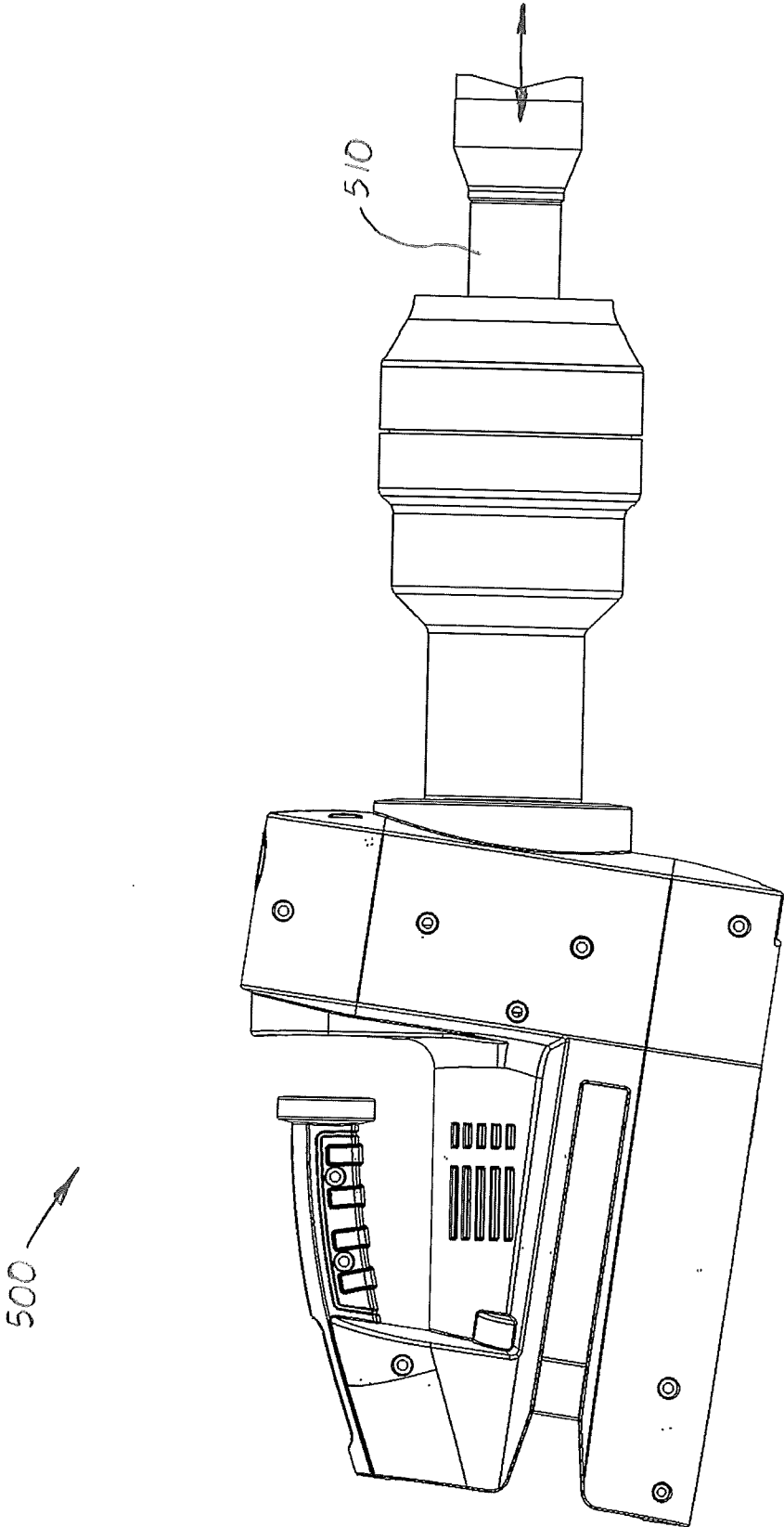


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/030843

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F16H 25/02 (2014.01)

USPC - 74/424.92; 254/100

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A01G 3/033, 3/037; A62B 3/00, 99/00; B21D 1/12; B23D 17/00, 17/02, 17/04, 28/00, 29/00; B25B 27/00; B25F 5/00; B26B 15/00, 17/00; B66F 3/00, 3/12; F01B 3/00; F16H 55/00, 55/14, 55/18 (2014.01)

USPC - 30/228; 72/308, 392, 705; 74/424.81, 424.92; 192/20; 254/1, 98, 100, 103, 151, 231; 269/246; 475/334; D29/124

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - A62B 3/005; B26B 15/00; F16H 25/22, 25/2204, 25/2252, 25/2266 (2014.07)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Patent, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/011230 A1 (LORINI) 24 January 2013 (24.01.2013) entire document	1-3
Y	US 5,520,064 A (HICKERSON et al) 28 May 1996 (28.05.1996) entire document	1-3
A	US 5,297,780 A (HICKERSON et al) 29 May 1994 (29.05.1994) entire document	1-8
A	DE 198 23 154 C1 (BECK et al) 25 November 1999 (25.11.1999) see machine translation	1-8
A	US 4,896,862 A (GANLEY) 30 January 1990 (30.01.1990) entire document	1-8

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Date of the actual completion of the international search

25 July 2014

Date of mailing of the international search report

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