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(54) **SPINDLE BEARING ARRANGEMENT FOR A POWER TOOL**

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3,710,873 A	1/1973	Allen	
3,741,313 A	6/1973	States	
4,065,811 A *	12/1977	Pauty	366/244
4,428,438 A	1/1984	Holzer	
4,923,047 A	5/1990	Fink et al.	
4,986,369 A	1/1991	Fushiya et al.	
5,025,903 A	6/1991	Elligson	
5,080,180 A	1/1992	Hansson	
5,269,733 A *	12/1993	Anthony, III	475/331
5,447,205 A	9/1995	Thurler	
5,457,860 A	10/1995	Miranda	
5,458,206 A	10/1995	Bourner et al.	
5,474,139 A	12/1995	Odendahl et al.	
5,550,416 A *	8/1996	Fanchang et al.	310/83
5,551,927 A	9/1996	Enzmann et al.	

(Continued)

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(56) **References Cited**
U.S. PATENT DOCUMENTS

3,195,702 A	7/1965	Alexander
3,207,237 A	9/1965	Wanner
3,584,695 A	6/1971	Turnbull
3,648,784 A	3/1972	Schoeps

FOREIGN PATENT DOCUMENTS

DE	1949415 A1	10/1970
DE	1652685 A1	12/1970

(Continued)

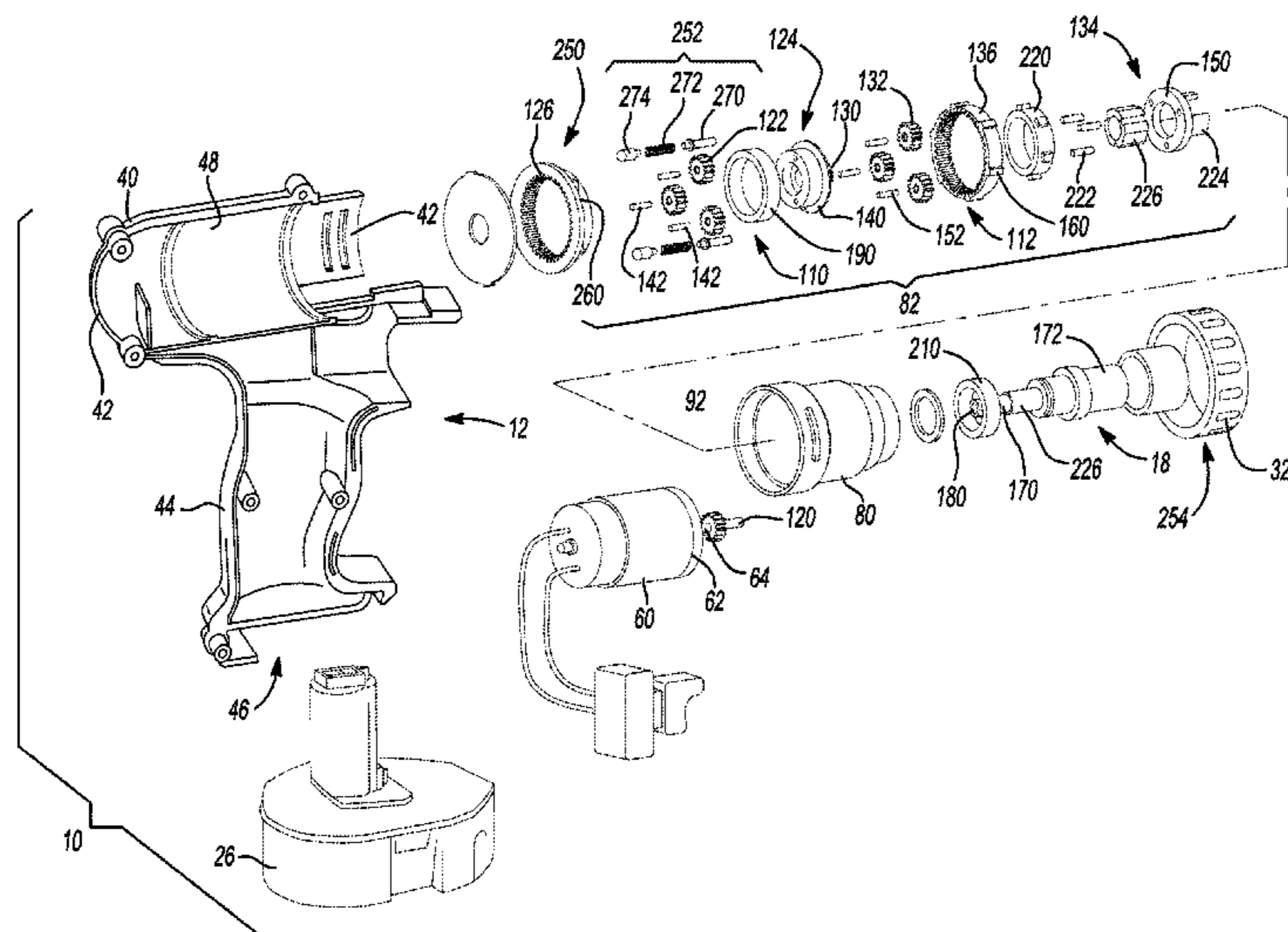
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(57) **ABSTRACT**

A power tool with a motor, a housing, a transmission, an output spindle, a front bearing and a rear bearing. The motor has an output shaft. The transmission is disposed in the housing and receives a rotary input from the output shaft. The transmission includes an input planetary stage, which has an input planet carrier, and an output planetary stage. The output spindle is driven by the transmission and has a first end, which extends at least partly through the input planetary stage, and a second end opposite the first end. The front bearing is disposed between the output spindle and the housing to support the second end of the output spindle for rotation about the spindle axis. The rear bearing indirectly supports the first end of the output spindle in the housing for rotation about the spindle axis.

20 Claims, 4 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

5,573,472 A * 11/1996 Ciolli 475/301
 5,673,758 A 10/1997 Sasaki et al.
 5,690,577 A 11/1997 Enzmann et al.
 5,706,902 A 1/1998 Eisenhardt
 5,711,380 A 1/1998 Chen
 5,836,403 A 11/1998 Putney et al.
 5,842,527 A 12/1998 Arakawa et al.
 5,868,208 A 2/1999 Peisert et al.
 6,086,502 A * 7/2000 Chung 475/299
 6,135,212 A 10/2000 Georgiou
 6,142,242 A 11/2000 Okumura et al.
 6,176,321 B1 1/2001 Arakawa et al.
 6,196,330 B1 3/2001 Matthias et al.
 6,223,833 B1 5/2001 Thurler et al.
 6,311,787 B1 * 11/2001 Berry et al. 173/176
 6,401,572 B1 * 6/2002 Provost 81/57.14
 6,457,535 B1 10/2002 Tanaka
 6,457,635 B1 10/2002 Scicluna
 RE37,905 E * 11/2002 Bourner et al. 173/48
 6,500,087 B2 12/2002 Klinger et al.
 6,535,212 B1 3/2003 Goto et al.
 6,535,636 B1 3/2003 Savakis et al.
 6,550,546 B2 * 4/2003 Thurler et al. 173/48
 6,676,557 B2 * 1/2004 Milbourne et al. 475/286
 6,691,796 B1 2/2004 Wu
 6,733,414 B2 * 5/2004 Elger 475/331
 6,805,207 B2 10/2004 Hagan et al.
 6,811,509 B1 * 11/2004 Langenfeld et al. 475/83
 6,824,491 B2 * 11/2004 Chen 475/266
 6,834,730 B2 12/2004 Gass et al.
 6,857,983 B2 * 2/2005 Milbourne et al. 475/269
 6,887,176 B2 5/2005 Sasaki
 6,892,827 B2 5/2005 Toyama et al.
 6,966,391 B2 11/2005 Tang
 6,976,545 B2 12/2005 Greitmann
 7,032,683 B2 4/2006 Hetcher et al.
 7,048,075 B2 5/2006 Saito et al.
 7,073,605 B2 7/2006 Saito et al.
 7,086,483 B2 8/2006 Arimura et al.
 7,093,668 B2 8/2006 Gass et al.
 7,101,300 B2 9/2006 Milbourne et al.
 7,121,358 B2 10/2006 Gass et al.
 7,124,839 B2 10/2006 Furuta et al.
 7,131,503 B2 11/2006 Furuta et al.
 7,168,503 B1 * 1/2007 Teng 173/48
 7,201,235 B2 4/2007 Umemura et al.
 7,207,393 B2 4/2007 Clark, Jr. et al.
 7,213,659 B2 5/2007 Saito et al.
 7,216,749 B2 5/2007 Droste
 7,223,195 B2 5/2007 Milbourne et al.
 7,225,884 B2 6/2007 Aeberhard
 7,249,695 B2 * 7/2007 Shew 222/333
 7,306,049 B2 12/2007 Soika et al.
 7,308,948 B2 12/2007 Furuta
 7,314,097 B2 1/2008 Jenner et al.
 7,322,427 B2 1/2008 Shimma et al.
 7,328,752 B2 2/2008 Gass et al.
 7,331,408 B2 2/2008 Arich et al.
 7,331,496 B2 2/2008 Britz et al.
 7,455,615 B2 * 11/2008 Chen 475/300
 7,494,437 B2 * 2/2009 Chen 475/149
 7,513,845 B2 * 4/2009 Ho 475/298
 7,794,355 B2 * 9/2010 Pusateri 475/331
 7,839,035 B2 * 11/2010 Hwaung 310/76
 7,896,097 B2 * 3/2011 Teng 173/48
 7,980,324 B2 * 7/2011 Bixler et al. 173/176
 8,118,702 B2 * 2/2012 Hansson 475/338
 2003/0143042 A1 * 7/2003 Doyle et al. 408/124
 2003/0146007 A1 8/2003 Greitmann
 2004/0124727 A1 * 7/2004 Lau 310/83
 2004/0134673 A1 7/2004 Droste
 2004/0226969 A1 * 11/2004 Shew 222/333
 2004/0245005 A1 12/2004 Toyama et al.
 2005/0028997 A1 2/2005 Hagan et al.
 2005/0061521 A1 3/2005 Saito et al.

2005/0263303 A1 12/2005 Shimizu et al.
 2005/0263304 A1 12/2005 Sainomoto et al.
 2005/0263305 A1 12/2005 Shimizu et al.
 2005/0272548 A1 * 12/2005 Nagai et al. 475/91
 2006/0006614 A1 1/2006 Buchholz et al.
 2006/0021771 A1 2/2006 Milbourne et al.
 2006/0086514 A1 4/2006 Aeberhard
 2006/0090913 A1 5/2006 Furuta
 2006/0213675 A1 9/2006 Whitmire et al.
 2006/0237205 A1 10/2006 Sia et al.
 2006/0254786 A1 11/2006 Murakami et al.
 2006/0254789 A1 11/2006 Murakami et al.
 2006/0266537 A1 11/2006 Izumisawa
 2007/0034394 A1 * 2/2007 Gass et al. 173/2
 2007/0056756 A1 3/2007 Chung et al.
 2007/0065756 A1 3/2007 Lavallee et al.
 2007/0068692 A1 3/2007 Puzio
 2007/0068693 A1 3/2007 Whitmire et al.
 2007/0074883 A1 4/2007 Strasser et al.
 2007/0084614 A1 4/2007 Whitmire et al.
 2007/0174645 A1 7/2007 Lin
 2007/0181319 A1 8/2007 Whitmine et al.
 2007/0201748 A1 8/2007 Bixler et al.
 2008/0035360 A1 2/2008 Furuta
 2008/0041602 A1 2/2008 Furuta
 2009/0098971 A1 * 4/2009 Ho et al. 475/153
 2009/0101376 A1 * 4/2009 Walker et al. 173/47
 2010/0071923 A1 * 3/2010 Rudolph et al. 173/48
 2010/0163261 A1 * 7/2010 Tomayko et al. 173/47
 2011/0127059 A1 * 6/2011 Limberg et al. 173/216
 2011/0188232 A1 * 8/2011 Friedman et al. 362/119
 2011/0284591 A1 * 11/2011 Guo 222/333
 2011/0303432 A1 * 12/2011 Stauffer et al. 173/181

FOREIGN PATENT DOCUMENTS

DE 1941093 A1 4/1971
 DE 2557118 A1 6/1977
 DE 3329295 A1 2/1985
 DE 4038502 A1 6/1992
 DE 4328599 A1 3/1994
 DE 9404069 U1 6/1994
 DE 9406626 U1 6/1994
 DE 19954931 A1 6/2001
 DE 20209356 U1 10/2002
 DE 20304314 U1 7/2003
 DE 20305853 U1 9/2003
 DE 102004037072 B3 1/2006
 EP 0404035 A2 12/1990
 EP 0808695 A2 11/1997
 EP 1621290 A1 2/2006
 EP 1707322 A1 10/2006
 GB 1574652 A 9/1980
 GB 2102718 A 2/1983
 GB 2274416 A 7/1994
 GB 2328635 A 3/1999
 GB 2334909 A 9/1999
 GB 2404891 A 2/2005
 JP 62173180 A 7/1987
 JP 62297007 A 12/1987
 JP 63123678 A 5/1988
 JP 2139182 A 5/1990
 JP 2284881 A 11/1990
 JP 3043164 A 2/1991
 JP 3168363 A 7/1991
 JP 6010844 A 1/1994
 JP 6023923 A 2/1994
 JP 6182674 A 7/1994
 JP 6210507 A 8/1994
 JP 6215085 A 8/1994
 JP 07040258 A 2/1995
 JP 7080711 A 3/1995
 JP 7328955 A 12/1995
 JP 9136273 A 5/1997
 JP 9239675 A 9/1997
 JP 10291173 A 11/1998
 JP 3655481 A 8/2000
 JP 2000233306 A 8/2000
 JP 2000246659 A 9/2000

(56)

References Cited

FOREIGN PATENT DOCUMENTS

JP	2001009746 A	1/2001
JP	2001088051 A	4/2001
JP	2001088052 A	4/2001
JP	2001105214 A	4/2001
JP	2002059375 A	2/2002
JP	2002178206 A	6/2002
JP	2002224971 A	8/2002

JP	2002273666 A	9/2002
JP	2003071745 A	3/2003
JP	2003220569 A	8/2003
JP	2004130474 A	4/2004
JP	2005052904 A	3/2005
JP	2006123081 A	5/2006
JP	2006175562 A	7/2006
WO	WO-9521039 A1	8/1995
WO	WO-2007135107 A1	11/2007

* cited by examiner

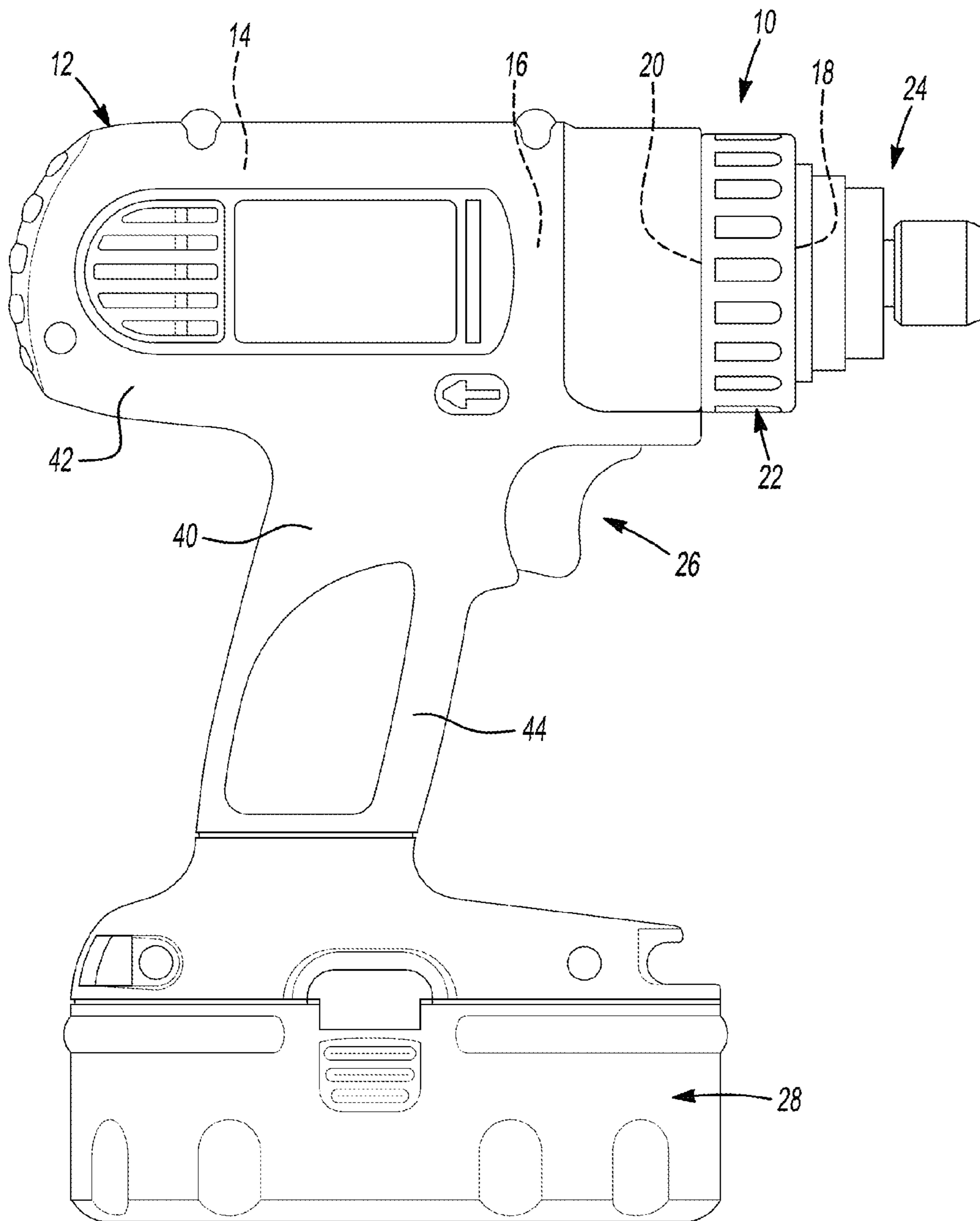


Fig-1

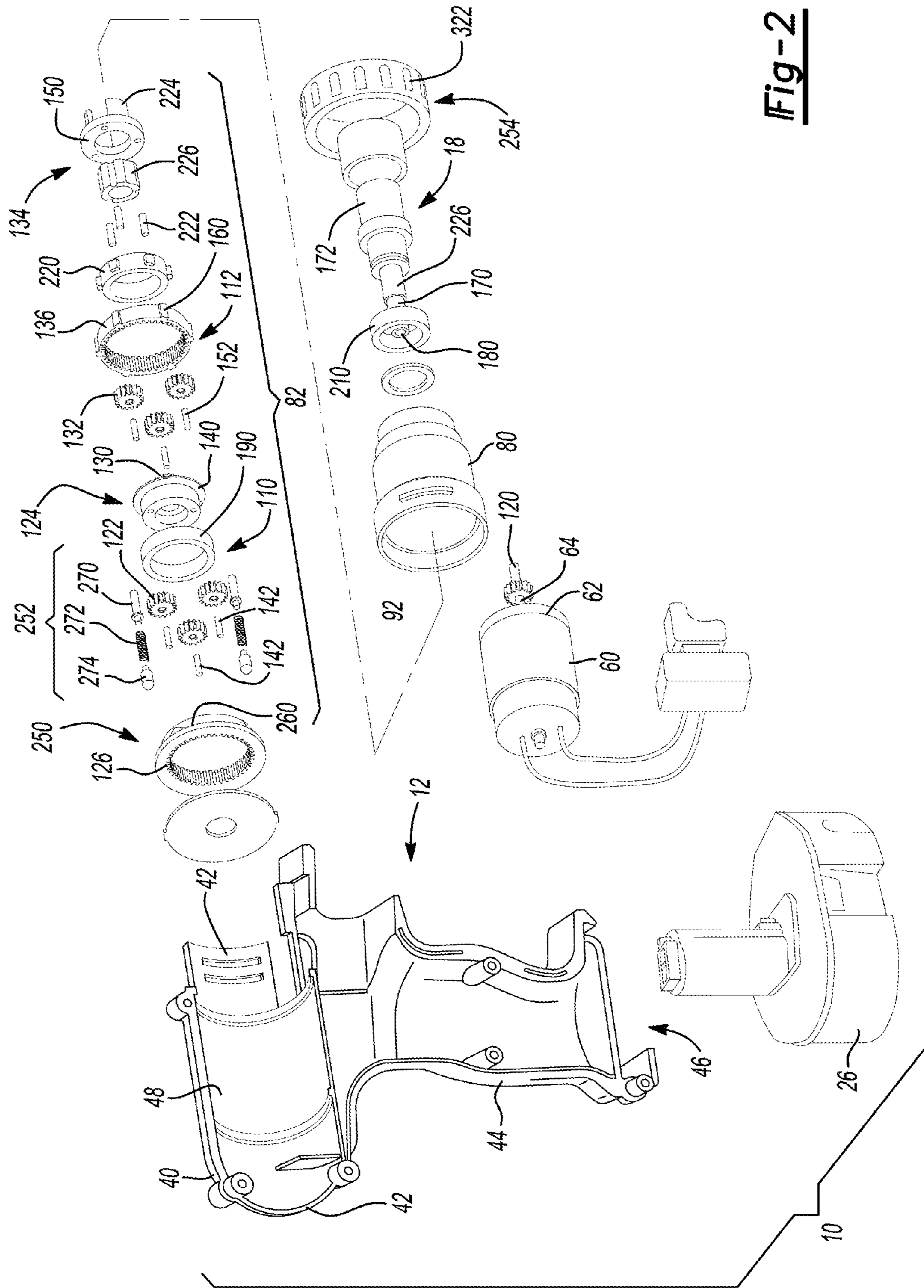


Fig-2

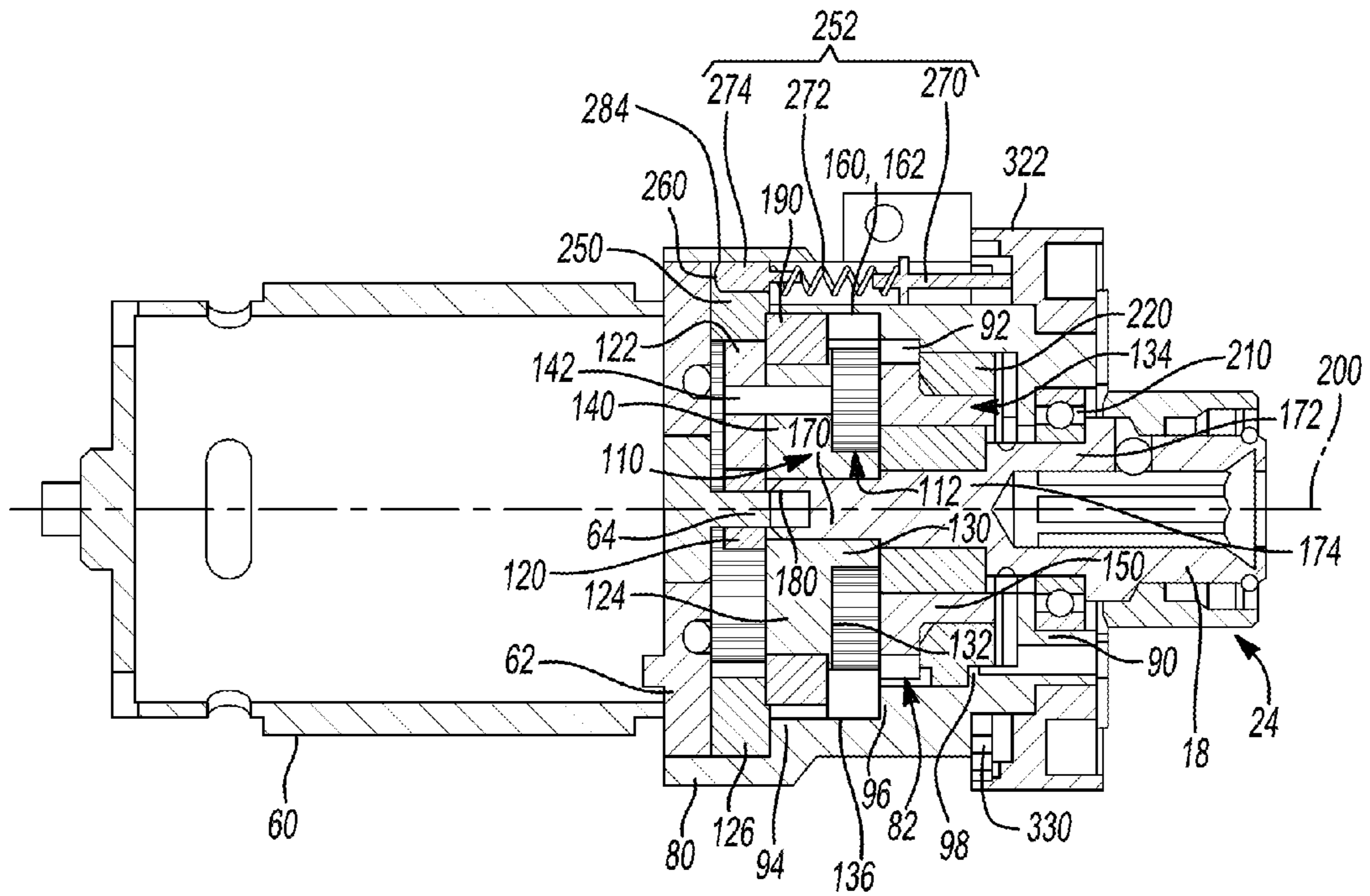


Fig-3

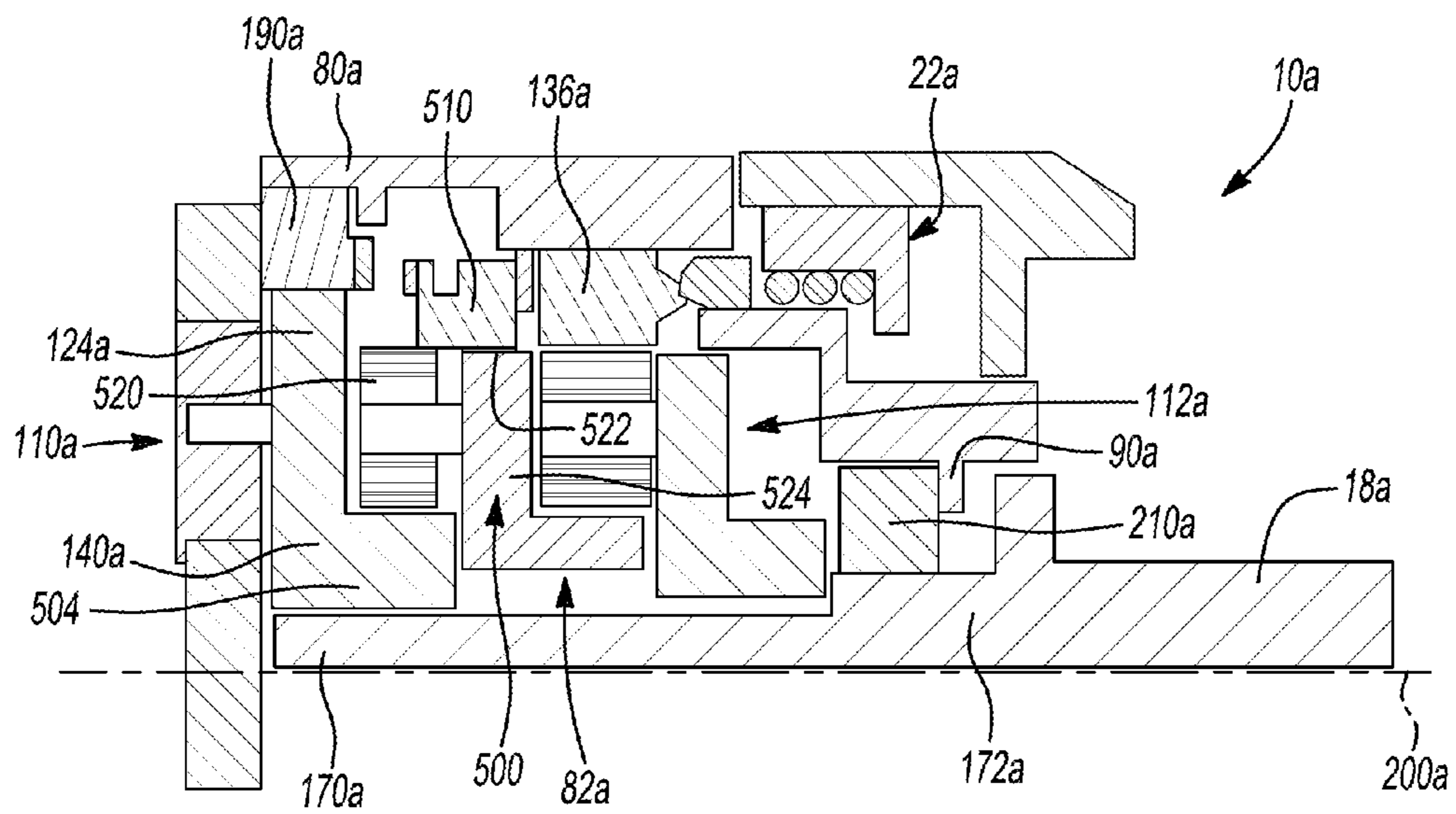


Fig-4

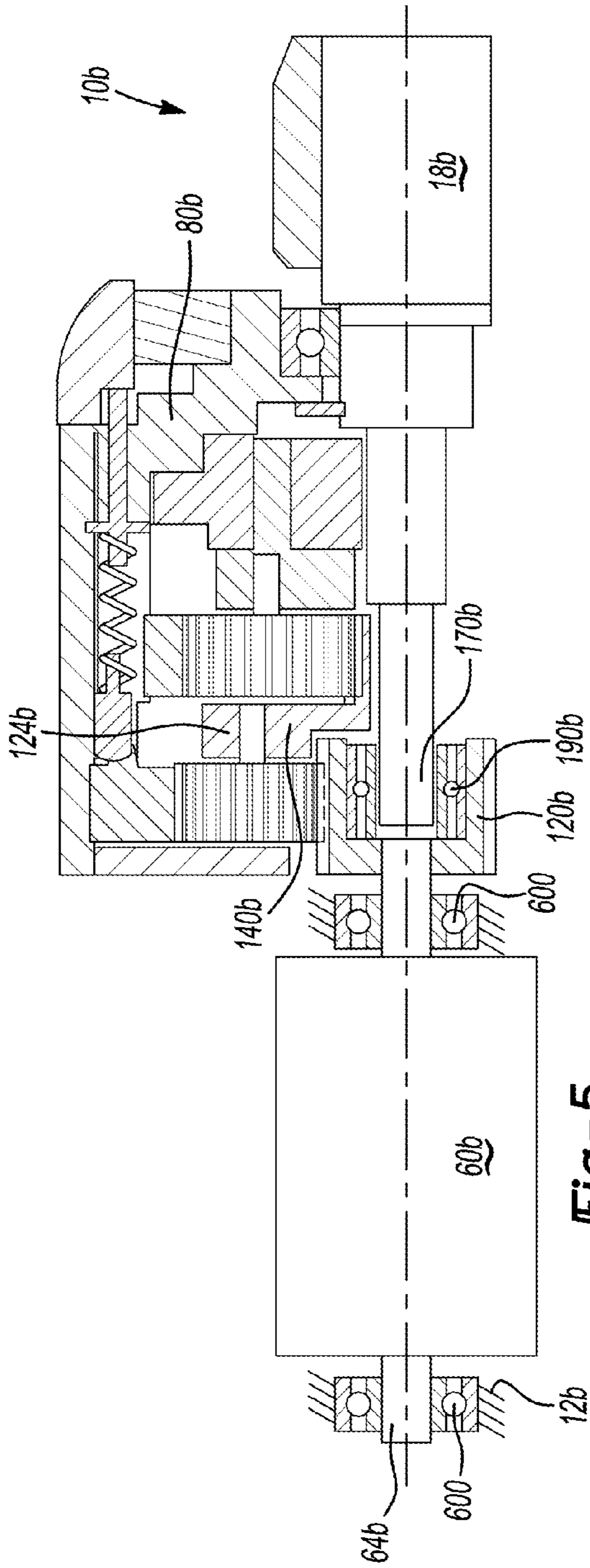


Fig-5

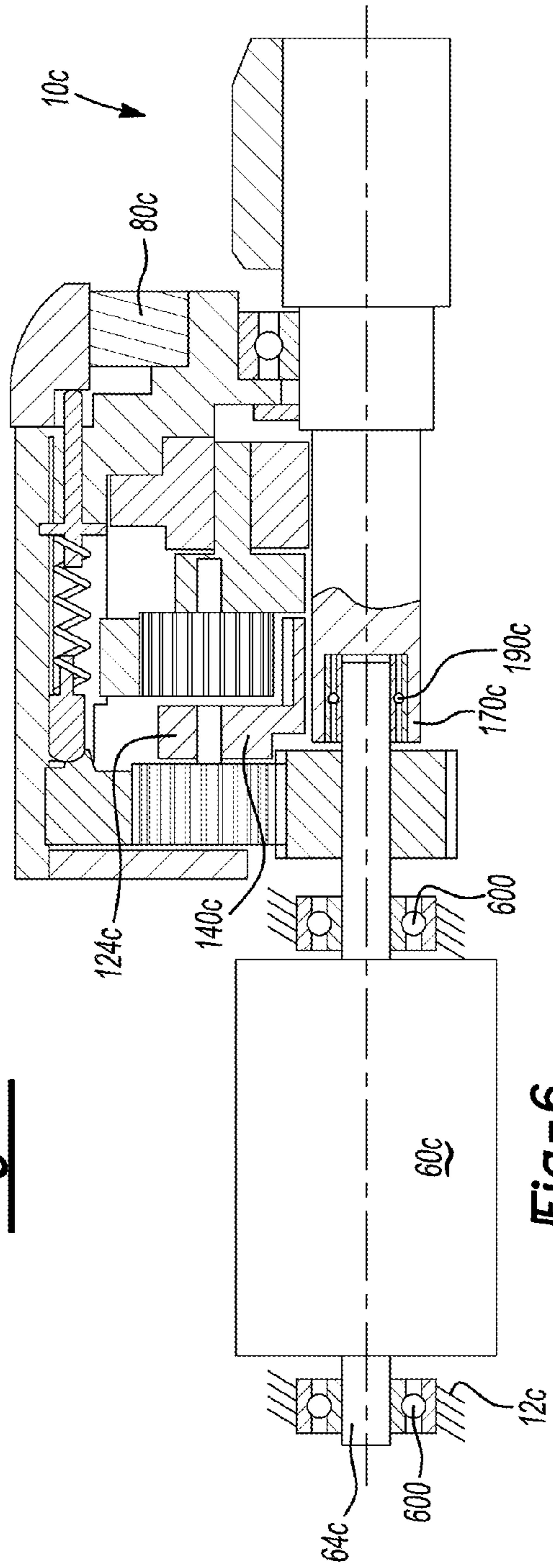


Fig-6

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SPINDLE BEARING ARRANGEMENT FOR A POWER TOOL

FIELD

The present disclosure relates to a spindle bearing arrangement for a power tool.

BACKGROUND

U.S. Pat. No. 6,431,289 and U.S. patent application Ser. No. 12/610,762 disclose various rotary power tools having an output spindle, which is driven by a planetary-type transmission, and a torque limiting clutch for selectively limiting an output torque of the rotary power tool. While such rotary power tools are satisfactory for their intended purposes, such rotary power tools are nonetheless susceptible to improvement.

SUMMARY

This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

In one form, the teachings of the present disclosure provide a power tool having a motor, a housing, a transmission, an output spindle, a first bearing and a second bearing. The motor has an output shaft. The transmission is at least partly disposed in the housing and receives a rotary input from the output shaft. The transmission includes a planet carrier. The output spindle is driven by the transmission and includes a first end, which is supported for rotation about a spindle axis by the planet carrier, and a second end opposite the first end. The first bearing is disposed between the housing and the planet carrier and supports the planet carrier for rotation about the spindle axis. The second bearing is disposed between the housing and the output spindle and is configured to support the output spindle for rotation about the spindle axis at a location proximate the second end.

In another form, the teachings of the present disclosure provide a power tool with a motor, a housing, a transmission, an output spindle, a front bearing and a rear bearing. The motor has an output shaft. The transmission is disposed in the housing and receives a rotary input from the output shaft. The transmission includes an input planetary stage, which has an input planet carrier, and an output planetary stage. The output spindle is driven by the transmission and has a first end, which extends at least partly through the input planetary stage, and a second end opposite the first end. The front bearing is disposed between the output spindle and the housing to support the second end of the output spindle for rotation about the spindle axis. The rear bearing indirectly supports the first end of the output spindle in the housing for rotation about the spindle axis.

In still another form, the present disclosure provides a power tool that includes a motor, a housing, a transmission, an output spindle, a spindle lock and front and rear bearings. The motor has an output shaft. The transmission is disposed in the housing and receives a rotary input from the output shaft. The transmission includes an input planetary stage, which has an input planet carrier, and an output planetary stage. The output spindle is driven by the transmission and is received through the output planetary stage such that the first end extends at least partly through the input planetary stage. The spindle lock is mounted on the output spindle between the first and second ends. The front and rear bearings, which are disposed

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on opposite sides of the spindle lock, support the output spindle relative to the housing for rotation about a spindle axis.

Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

FIG. 1 is a side elevation view of an exemplary tool constructed in accordance with the teachings of the present disclosure;

FIG. 2 is an exploded perspective view of the tool of FIG. 1;

FIG. 3 is a longitudinal section view of a portion of the tool of FIG. 1; and

FIGS. 4 through 6 are section views of portions of five other tools constructed in accordance with the teachings of the present disclosure.

Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

With reference to FIGS. 1 and 2 of the drawings, a power tool constructed in accordance with the teachings of the present disclosure is generally indicated by reference numeral 10. As those skilled in the art will appreciate, the power tool 10 may be either a corded (e.g., AC powered) or cordless (e.g., DC battery operated) device, such as a portable screwdriver, impact driver, drill/driver or hammer drill/driver. In the particular embodiment illustrated, the power tool 10 is a cordless screwdriver having a housing 12, a motor assembly 14, a transmission assembly 16, an output spindle 18, a spindle lock 20, a clutch mechanism 22, a chuck 24, a trigger assembly 26 and a battery pack 28. Those skilled in the art will understand that several of the components of power tool 10, such as the chuck 24, the trigger assembly 26 and the battery pack 28, are conventional in nature and need not be described in significant detail in this application. Reference may be made to a variety of publications for a more complete understanding of the operation of the conventional features of power tool 10. One example of such publications is commonly assigned U.S. Pat. No. 5,897,454 issued Apr. 27, 1999, the disclosure of which is hereby incorporated by reference as if fully set forth herein.

The housing 12 can include a pair of clam shell housing halves 40 (only one shown in FIG. 2) that can cooperate to define a body 42, a handle 44 and a battery interface 46 that can be configured to receive the battery pack 28. The handle 44 can house the trigger assembly 26 in a conventional manner, while the body 42 can define a motor cavity 48 into which the motor assembly 14 can be received. The housing 12 can be configured with an exterior gear case housing (not shown) that can be coupled to a front side of the body 42 and configured to shroud or cover all or portions of the transmission assembly 16 and clutch mechanism 22. In the particular example provided, however, the clam shell housing halves 40 are configured to shroud or cover the transmission assembly 16 and the clutch mechanism 22.

With reference to FIGS. 2 and 3, the motor assembly 14 can comprise a motor 60 and an adapter plate 62. The motor 60 can be any type of motor, such as a DC electric motor, and can include an output shaft 64. The motor 60 can be received in the motor cavity 48 and can be electrically coupled to the trigger assembly 26 and the battery pack 28. The adapter plate 62 can be fixedly coupled to an end of the motor 60.

The transmission assembly 16 can comprise a transmission housing 80 and a transmission 82. The transmission housing 80 can be a hollow, generally tubular structure that is configured to house the transmission 82 and portions of the clutch mechanism 22. The transmission housing 80 can be received into the motor cavity 48 and can engage the clam shell housing halves 40 such that the transmission housing 80 is axially fixed and non-rotatably engaged to the housing 12. The transmission housing 80 can define a front bearing mount 90 and a central cavity 92 having a first shoulder 94, a second shoulder 96 and a third shoulder 98.

The transmission 82 can be a planetary-type transmission having an input planetary stage 110 and an output planetary stage 112 that can be received in the central cavity 92 of the transmission housing 80. It will be appreciated that although the particular transmission depicted and described herein is a two-stage, single speed transmission, the teachings of the present disclosure have application to other types of transmissions, including those that are operable in more than one speed ratio and/or those that comprise fewer or more than two planetary stages (i.e., a single stage planetary transmission or a transmission having at least one planetary stage disposed between the input and output planetary stages 110 and 112). The input planetary stage 110 can comprise an input sun gear 120, a plurality of input planet gears 122, an input planet carrier 124 and an input ring gear 126, while the output planetary stage 112 can comprise an output sun gear 130, a plurality of output planet gears 132, an output planet carrier 134 and an output ring gear 136.

The input sun gear 120 can be mounted on the output shaft 64 of the motor 60 for rotation therewith. The input planet gears 122 can be meshingly engaged with the input sun gear 120 and the input ring gear 126. The input planet carrier 124 can comprise a carrier body 140 and a plurality of pins 142 that can be mounted to the carrier body 140. Each of the input planet gears 122 can be rotatably mounted on a respective one of the pins 142. The input ring gear 126 can be abutted against the first shoulder 94. The adapter plate 62 can be received in the central cavity 92 and non-rotatably coupled to the transmission housing 80 to thereby limit rearward axial movement of the input ring gear 126 relative to the transmission housing 80, as well as to inhibit rotation of the motor 60 relative to the transmission housing 80.

The output sun gear 130 can be coupled to the carrier body 140 of the input planet carrier 124 for rotation therewith. The output planet gears 132 can be meshingly engaged with the output sun gear 130 and the output ring gear 136. The output planet carrier 134 can comprise a carrier body 150 and a plurality of pins 152 that can be mounted to the carrier body 150. Each of the output planet gears 132 can be rotatably mounted on a respective one of the pins 152 of the output carrier 134. The output ring gear 136 can be abutted against the second shoulder 96 and non-rotatably engaged to the transmission housing 80. In the particular example provided, the output ring gear 136 includes a plurality of external teeth 160 that are engaged to internal teeth 162 formed on the interior of the transmission housing 80 proximate the second shoulder 96.

The output spindle 18 can be a unitarily formed shaft structure that can be received at least partially through the

transmission 82. The output spindle 18 can comprise a rear end 170, a front end 172 and an anvil mount 174 that can be disposed between the rear and front ends 170 and 172. The rear end 170 can be generally cylindrically shaped and can extend fully or partly through the input planetary stage 110 where it can be supported for rotation by an element of the transmission 82. For example, the rear end 170 can extend through or into at least one of the output sun gear 130 and the carrier body 140 of the input planet carrier 124 such that the input planet carrier 124 supports the rear end 170 of the output spindle 18. The output shaft 64 of the motor 60 can be received in an appropriately sized aperture 180 in the rear end 170 of the output spindle 18.

A suitable rear bearing 190, such as a journal bearing or bushing, can be disposed between the transmission housing 80 and the carrier body 140 of the input planet carrier 124 to support the input planet carrier 124 for rotation about a spindle axis 200. It will be appreciated that the rear bearing 190, which can be disposed axially between the input ring gear 126 and the output ring gear 136, can indirectly support the rear end 170 of the output spindle 18 about the spindle axis 200.

A suitable front bearing 210, such as a ball bearing, can be disposed in the front bearing mount 90 between the transmission housing 80 and the front end 172 of the output spindle 18. The front end 172 can be configured to transmit rearwardly-directed thrust loads into the front bearing 210 so that they may be transmitted into the transmission housing 80. One or more snap rings or other retaining devices can be employed to limit axial movement of the front bearing 210 on the front end 172 of the output spindle 18.

The spindle lock 20 can comprise an outer collar 220, a plurality of lock pins 222, a plurality of projections 224, which can be integrally formed with the carrier body 150 of the output planet carrier 134, and an anvil 226. The outer collar 220 can be an annular structure that can be received against the third shoulder 98 in the central cavity 92 and non-rotatably engaged to the transmission housing 80. The lock pins 222 can extend longitudinally parallel to the spindle axis 200 between the projections 224 and an interior surface of the outer collar 220. The anvil 226 can be mounted on the anvil mount 174 on the output spindle 18 such that the anvil 226 is coupled to the output spindle 18 for rotation therewith. The spindle lock 20 is configured to permit the output spindle 18 to rotatably driven by the transmission 82, but to lock the output spindle 18 to the transmission housing 80 (to thereby inhibit rotation of the output spindle 18) when the output spindle 18 is rotated manually.

The clutch mechanism 22 can include a clutch member 250, one or more engagement assemblies 252 and an adjustment mechanism 254. The clutch member 250 can be an annular structure that can be fixedly coupled to the input ring gear 126. In the particular example provided, the clutch member 250 includes an arcuate clutch face 260 that is formed into an axially forward facing side of the input ring gear 126. The outer diameter of the clutch member 250 is sized to rotate within the portion of the central cavity 92 that is proximate the first shoulder 94 in the transmission housing 80. While the input ring gear 126 and the clutch member 250 have been illustrated as a one piece (i.e., unitarily formed) construction, those skilled in the art will understand that they may be constructed otherwise.

In the particular embodiment illustrated, the engagement assemblies 252 are disposed 180° apart from one another (only one is shown in FIG. 3 for clarity) and each engagement assembly 252 includes a pin member 270, a follower spring 272 and a follower 274. The pin member 270 includes a

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cylindrical body portion **280** having an outer diameter that is sized to slip-fit within an actuator aperture **284** that is formed through the transmission housing **80**. A first end of the pin member **270** can have an end that can be defined by a spherical radius and can be configured to engage the adjustment mechanism **254**.

The follower spring **272** can be a compression spring whose outside diameter is sized to slip fit within the actuator aperture **284**. The forward end of the follower spring **272** can contact the pin member **270**, while the opposite end of the follower spring **272** can contact the follower **274**. An end portion of the follower **274** can be cylindrical in shape and sized to slip fit within the inside diameter of the follower spring **272**. In this regard, the end portion of the follower **274** can act as a spring follower to prevent the follower spring **272** from bending over when it is compressed. The follower **274** can also include a cylindrically shaped body portion, which can be sized to slip fit within the actuator aperture **284**, and a tip portion that is configured to extend axially through the first shoulder **94** and engage the clutch face **260**. In the particular example illustrated, the tip portion is defined by a spherical radius.

The adjustment mechanism **254** can include a setting collar **322** can be shaped in the form of a generally hollow cylinder that is sized to fit and cover a front end of the housing **12**. The setting collar **322** can include an annular face into which an adjustment profile **330** is formed. The adjustment profile **330** can be tapered or stepped such that rotation of the setting collar **322** will cause corresponding axial movement of the pin member **270**, which operates to change the torque setting of the clutch mechanism **22** as a result of corresponding compression or extension of the follower spring **272**.

The setting collar **322** can include a contoured outer surface that can permit the user of the tool **10** to comfortably rotate both the setting collar **322** to set the adjustment profile **330** at a position corresponding to a desired torque setting of the clutch mechanism **22**.

During the operation of the tool **10**, an initial drive torque is transmitted by the output shaft **64** of the motor **60** to the input planetary stage **110**, causing the input planet gears **122** to rotate. Rotation of the input planet gears **122** creates a first intermediate torque that is applied against the input ring gear **126**. A clutch torque applied by the clutch mechanism **22** resists the first intermediate torque to thereby prevent the input ring gear **126** from rotating within the transmission housing **80** such that the first intermediate torque is applied to the input planet carrier **124** and the remainder of the transmission **82** so as to multiply the first intermediate torque in a predetermined manner according to the reduction ratio of the transmission **82**.

A portion of another power tool **10a** constructed in accordance with the teachings of the present disclosure is schematically illustrated in FIG. 4. In the example provided, the transmission **82a** includes an input planetary stage **110a**, an intermediate planetary stage **500**, and an output planetary stage **112a**. The output spindle **18a** extends through the transmission **82a** such that the rear end **170a** of the output spindle **18a** is received through or into at least one of an intermediate sun gear **504** (which is associated with the intermediate planetary stage **500**) and the carrier body **140a** of the input planet carrier **124a** such that the input planet carrier **124a** supports the rear end **170a** of the output spindle **18a**. The rear bearing **190a** can be disposed between the transmission housing **80a** and an element of the transmission **82a** located rearwardly of the final or output stage of the transmission **82a** (i.e., rearwardly of the output planetary stage **112a**). In the particular example provided, the rear bearing **190a** is disposed between

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the transmission housing **80a** and the carrier body **140a** of the input planet carrier **124a** to support the input planet carrier **124a** for rotation about the spindle axis **200a**. As with the previous example, the front bearing **210a** is received in a front bearing mount **90a** formed in a transmission housing **80a** and cooperates to align front end **172a** of the output spindle **18a** to the spindle axis **200a**.

In the particular example provided, the transmission **82a** is a two-speed, three-stage planetary-type transmission in which a ring gear **510** associated with the intermediate planetary stage **500** is movable between a first position (shown), in which the ring gear **510** is meshingly engaged to the planet gears **520** and a toothed exterior surface **522** of the planet carrier **524** of the intermediate planetary stage **500**, and a second position in which the ring gear **510** is translated axially rearwardly so as to non-rotatably engage the rear bearing **190a** and disengage the toothed exterior surface **522** of the planet carrier **524** of the intermediate planetary stage **500**. Moreover, the clutch mechanism **22a** is configured to resist rotation of the output ring gear **136a**.

A portion of another power tool **10b** constructed in accordance with the teachings of the present disclosure is schematically illustrated in FIG. 5. This example is generally similar to that of FIGS. 1-3, except that a pair of motor bearings **600** support the output shaft **64b** (relative to the housing **12b**) on opposite sides of the motor **60b**, the output spindle **18b** extends into the input sun gear **120b**, the output shaft **64b** of the motor **60b** does not extend into the rear end **170b** of the output spindle **18b**, and the rear bearing **190b** is received between the input sun gear **120b** and the rear end **170b** of the output spindle **18b** (rather than between the carrier body **140b** of the input planet carrier **124b** and the transmission housing **80b**).

A portion of another power tool **10c** constructed in accordance with the teachings of the present disclosure is schematically illustrated in FIG. 6. This example is generally similar to that of FIGS. 1-3, except that a pair of motor bearings **600** support the output shaft **64c** (relative to the housing **12c**) on opposite sides of the motor **60c** and the rear bearing **190c** is received between the output shaft **64c** of the motor **60c** and the rear end **170c** of the output spindle **18c** (rather than between the carrier body **140c** of the input planet carrier **124c** and the transmission housing **80c**).

The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the invention, and all such modifications are intended to be included within the scope of the invention.

What is claimed is:

1. A power tool comprising:
 - a motor having an output shaft;
 - a housing;
 - a transmission in the housing and receiving a rotary input from the output shaft, the transmission comprising a planet carrier;
 - an output spindle driven by the transmission, the output spindle comprising a first end, which is supported for rotation about the spindle longitudinal axis by the planet carrier, and a second end opposite the first end, the

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second end extending from the housing and being adapted to drive a chuck into which a tool bit is removably received;

a first bearing engaging the housing and the planet carrier, the first bearing supporting the planet carrier for rotation about the spindle axis; and

a second bearing engaging the housing and the output spindle, the second bearing being configured to support the output spindle for rotation about the spindle longitudinal axis at a location nearer to the second end than the first end of the output spindle.

2. The power tool of claim 1, wherein the output shaft is received in the first end of the output spindle.

3. The power tool of claim 1, wherein a diameter of the first end is smaller than a diameter of a portion of the output shaft engaged by the first bearing.

4. The power tool of claim 1, further comprising a torque clutch that can cooperate with the transmission to limit an output torque of the power tool.

5. The power tool of claim 4, wherein the transmission further comprises a ring gear and wherein the torque clutch comprises a follower member that is biased into engagement with the ring gear to resist rotation of the ring gear relative to the housing.

6. The power tool of claim 4, wherein the torque clutch is disposed between the first and second ends of the output spindle.

7. The power tool of claim 1, wherein a spindle lock is mounted to the output spindle between the first and second ends.

8. The power tool of claim 7, wherein the spindle lock is mounted to a portion of the output spindle having a diameter that is different than a diameter of the first end and a diameter of the second end.

9. The power tool of claim 1, wherein the transmission comprises an output planetary stage and another planetary stage that is disposed between the motor and the output planetary stage, the planet carrier being associated with the another planetary stage.

10. The power tool of claim 1, wherein the transmission is a single speed transmission.

11. The power tool of claim 1, wherein the transmission includes a member that is movable between a first position and a second position, wherein the transmission operates in a first speed ratio to transmit rotary power when the member is in the first position, and wherein the transmission operates in a second, different speed ratio to transmit rotary power when the member is in the second position.

12. The power tool of claim 11, wherein the member is movable along a longitudinal axis of the transmission.

13. The power tool of claim 12, wherein the member is non-rotatably engaged to the first bearing when the member is in the first position.

14. The power tool of claim 13, wherein the member is a ring gear.

15. A power tool comprising:

a motor having an output shaft;

a housing;

a transmission in the housing and receiving a rotary input from the output shaft, the transmission comprising a planet carrier;

a chuck;

an output spindle driven by the transmission, the output spindle comprising a first end, which is supported for

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rotation about the spindle longitudinal axis by the planet carrier, and a second end opposite the first end, the second end being mounted to the chuck;

a first bearing engaging the housing and the planet carrier, the first bearing supporting the planet carrier for rotation about the spindle axis; and

a second bearing engaging the housing and the output spindle, the second bearing being configured to support the output spindle for rotation about the spindle longitudinal axis at a location nearer to the second end than the first end of the output spindle;

wherein the transmission includes a member that is movable between a first position and a second position, wherein the transmission operates in a first speed ratio to transmit rotary power when the member is in the first position, and wherein the transmission operates in a second, different speed ratio to transmit rotary power when the member is in the second position;

wherein the member is movable along a longitudinal axis of the transmission;

wherein the member is non-rotatably engaged to the first bearing when the member is in the first position; and

wherein the first bearing comprises a first set of teeth and wherein the member comprises a second set of teeth that are engageable to the first set of teeth.

16. The power tool of claim 12, wherein the movable member is disposed between the first and second ends of the output spindle.

17. A power tool comprising:

a motor having an output shaft;

a housing;

a transmission in the housing and receiving a rotary input from the output shaft, the transmission comprising an input stage and a planet carrier;

a chuck;

an output spindle driven by the transmission, the output spindle having a first end, which extends at least partly through the input stage, and a second end opposite the first end, the second end directly driving the chuck, the output spindle consisting of a single, continuous shaft member that extends between and includes the first and second ends;

a front bearing that engages the output spindle and the housing to support the second end of the output spindle for rotation about the spindle longitudinal axis; and

a rear bearing received in the housing and supporting an element of the transmission for rotation in the housing, the element of the transmission receiving the first end of the output spindle therein such that the rear bearing indirectly supports the first end of the output spindle in the housing for rotation about the spindle longitudinal axis.

18. The power tool of claim 17, wherein the first end of the output spindle is journally received into an element of the transmission.

19. The power tool of claim 17, wherein the element of the transmission comprises at least one of the planet carrier and a sun gear.

20. The power tool of claim 17, wherein a spindle lock is mounted to the output spindle between the first and second ends.

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