United States Patent [19]

Fuchs

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[54] **POWER TOOL WITH TORQUE CONTROL**

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[52] **U.S. Cl.** ..... **173/12,** 73/136 D, 192/150

[51] **Int. Cl.** **B25b 23/14**

[58] **Field of Search** ..... 173/12; 192/150; 73/136 R, 73/136 D

[56] **References Cited**

UNITED STATES PATENTS

2,724,266	11/1955	Baker et al.	73/136 R
3,279,244	10/1966	Emmerling	73/136 R
3,613,853	10/1971	Linthicum	173/12 X
3,664,474	5/1972	Blake et al.	73/136 D

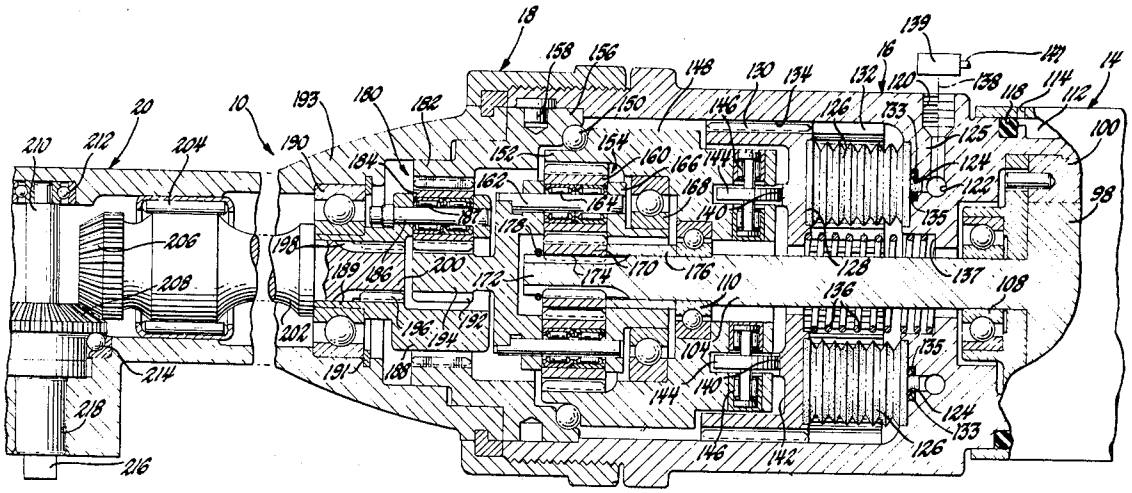
Primary Examiner—Ernest R. Purser

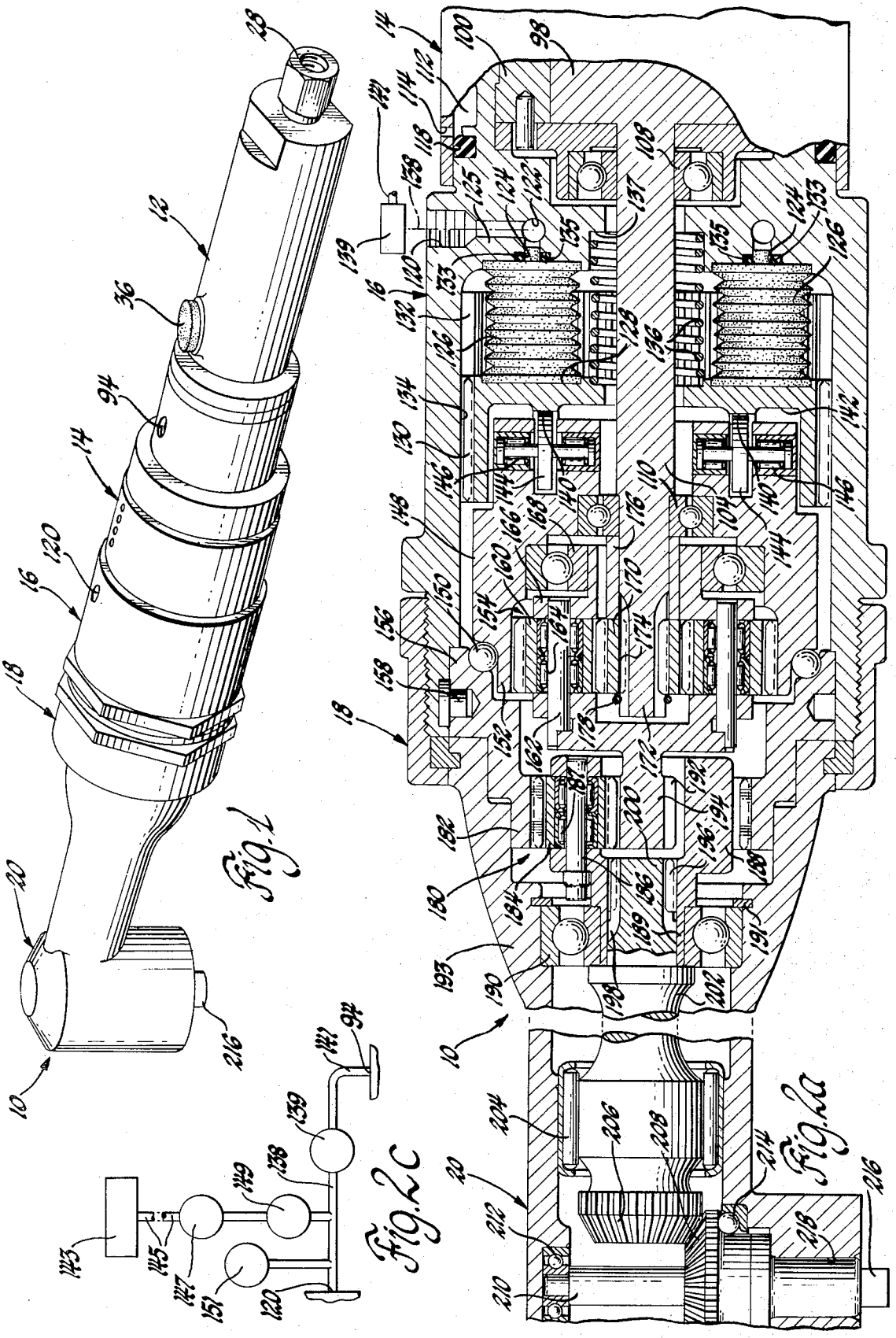
Attorney, Agent, or Firm—John P. Moran

[57] **ABSTRACT**

The drawings illustrate a power tool whose torque output may be continuously measured and controlled by the torque reaction on a rotatably mounted planetary ring gear, with transducer means associated therewith for converting the torque reaction to a fluid pressure signal to cut off the fluid flow to the motor rotor at a predetermined torque.

11 Claims, 13 Drawing Figures




Fig. 1
Fig. 2
Fig. 2A
Fig. 2C

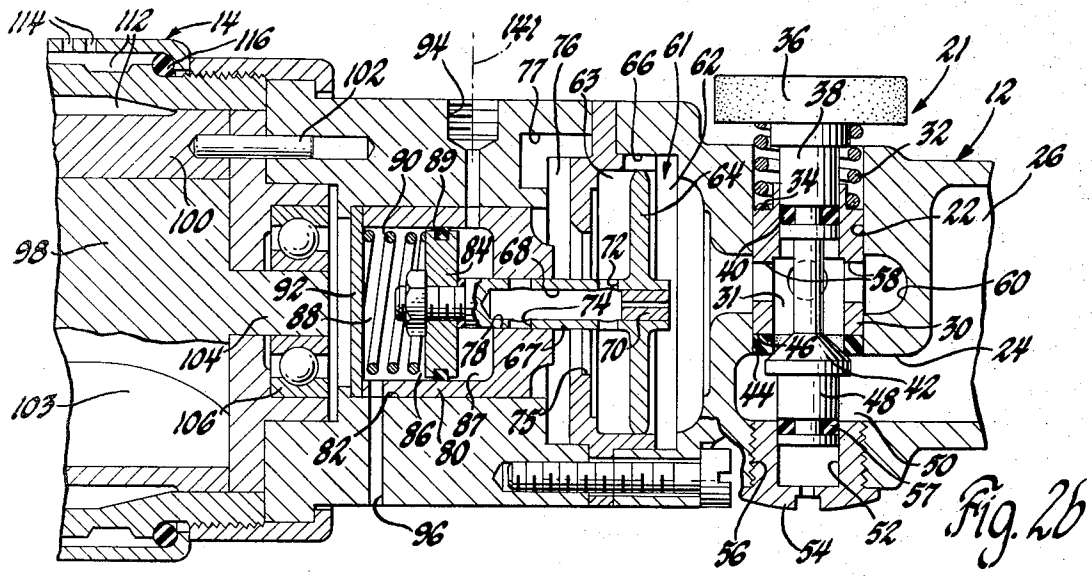


Fig. 2b

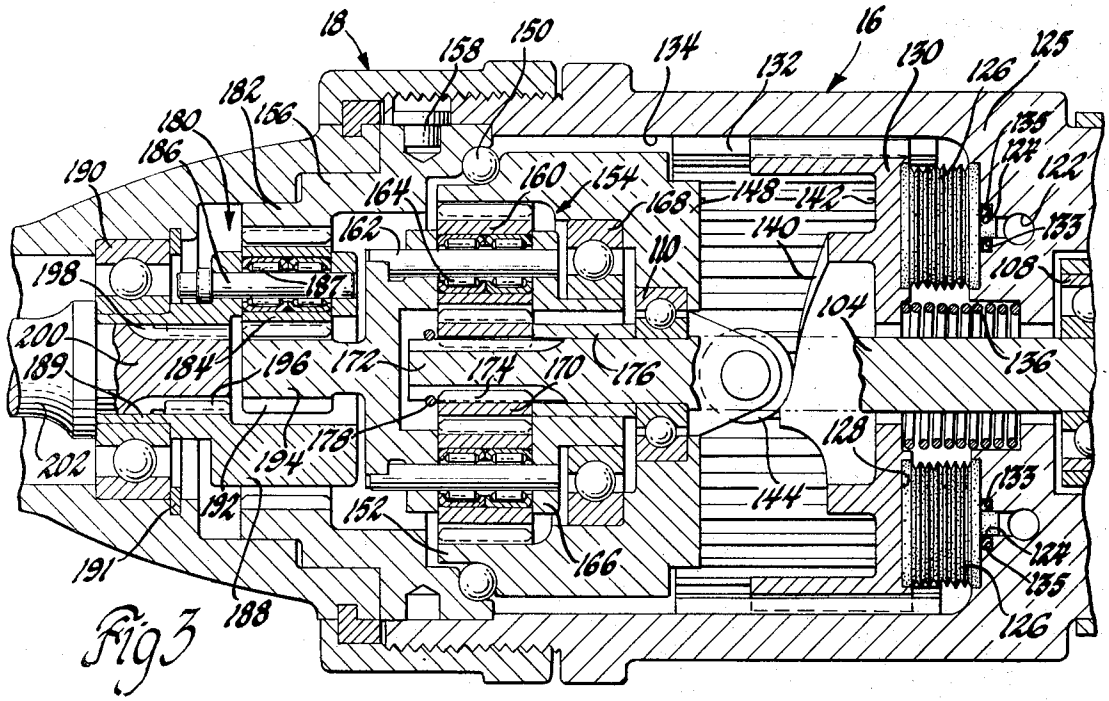


Fig 3

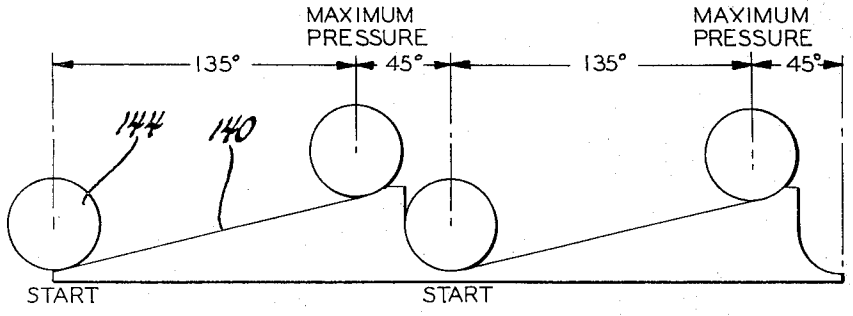


Fig. 4

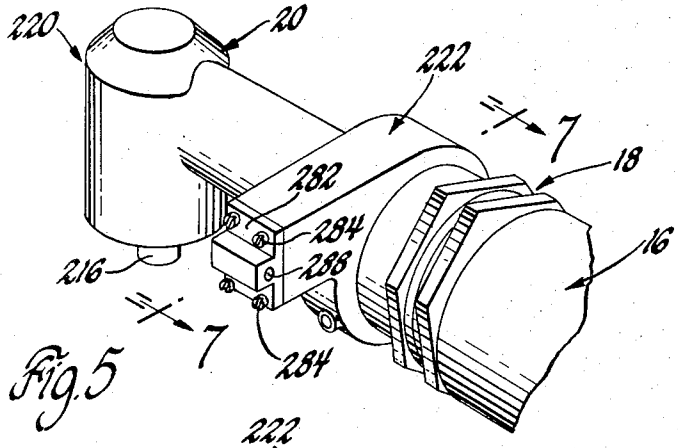


Fig. 5

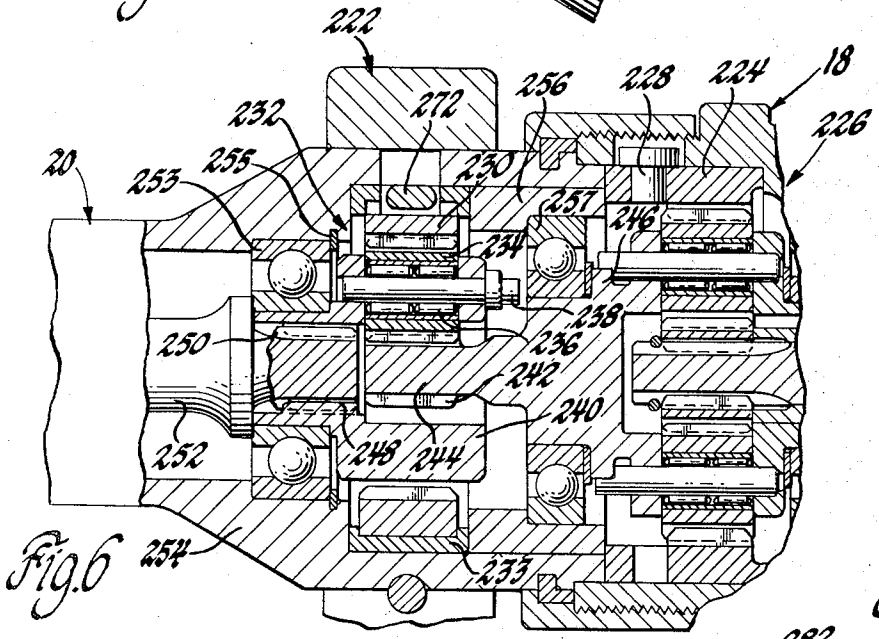


Fig. 6

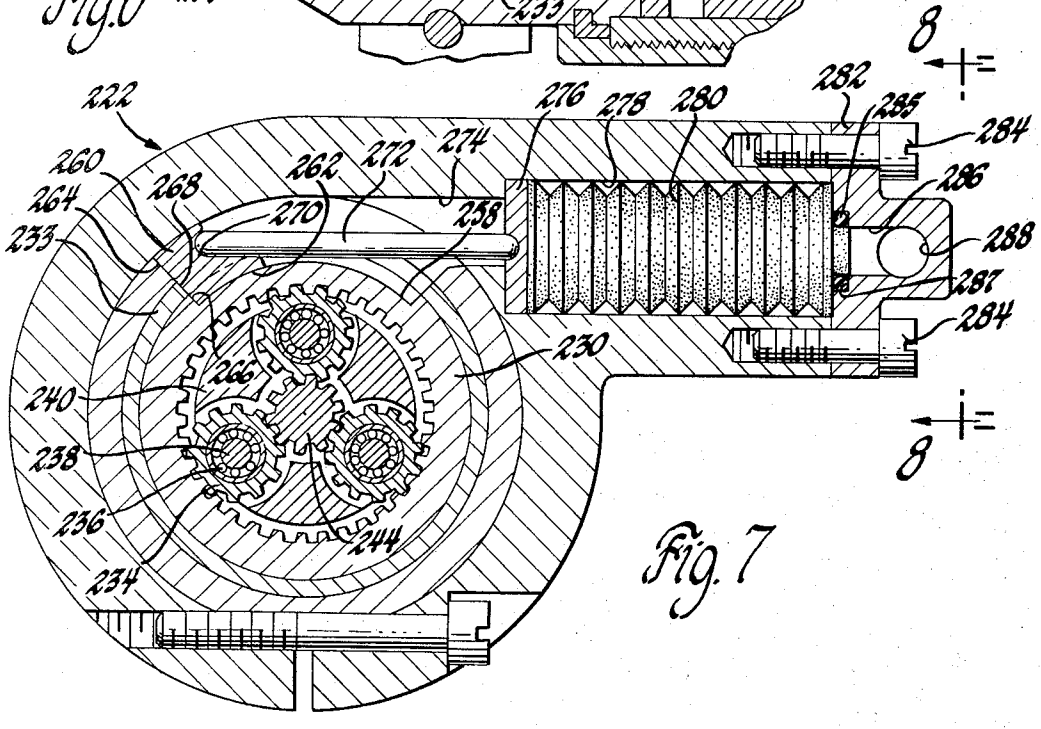


Fig. 7

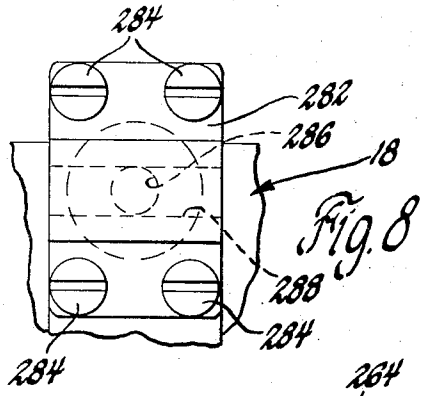


Fig. 8

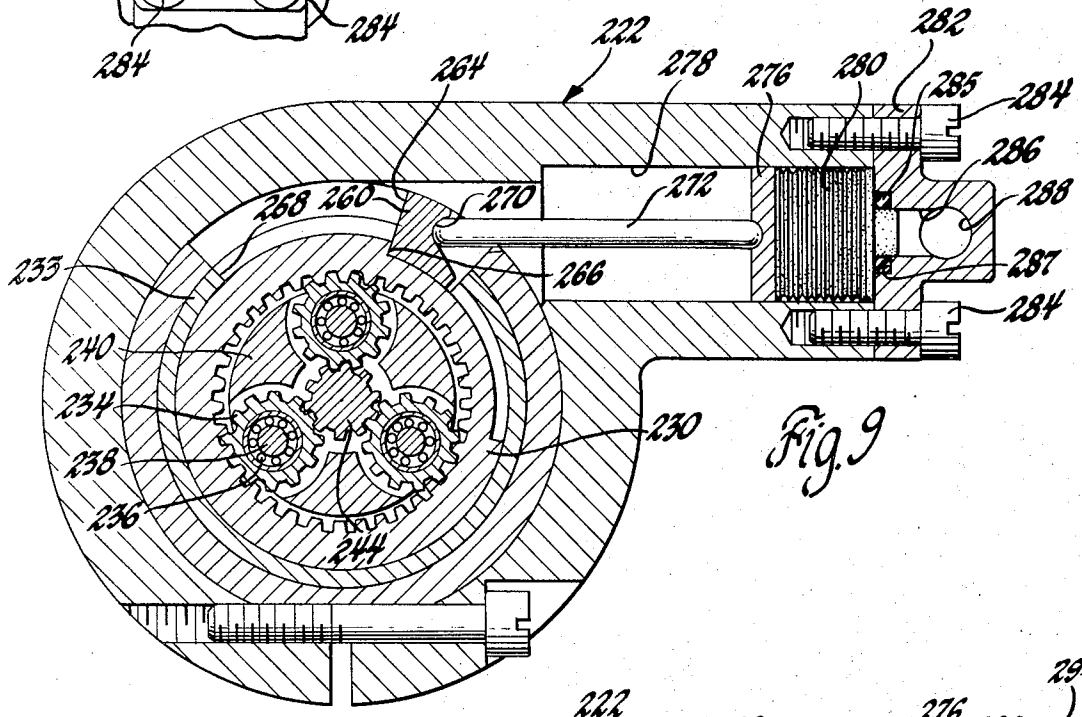


Fig. 9

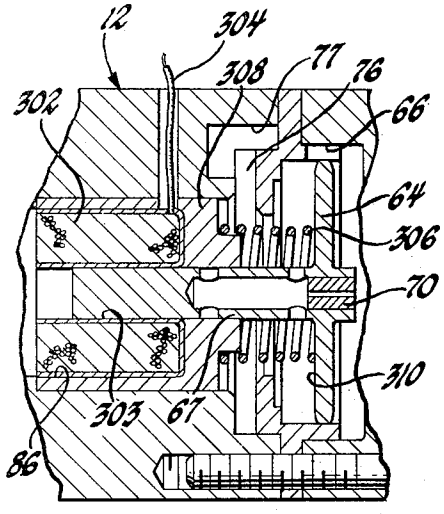


Fig. 11

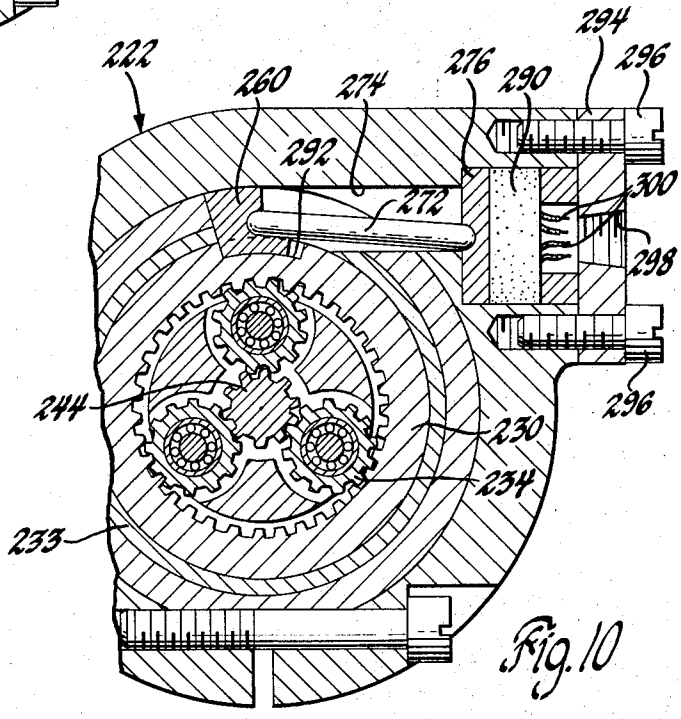


Fig. 10

POWER TOOL WITH TORQUE CONTROL

This invention relates generally to power tools and, more particularly, to torque-controlled tools.

At the present time torque-controlled power tools are known to include valving actuated in response to torque output which serves to block the exhaust and stall the motor. Other arrangements include back pressure-sensing devices which upset a delicately balanced poppet, in response to torque output, to cut off incoming air. Still other present day arrangements include mechanical linkage for controlling an incoming air-poppet valve in response to torque output. Additional designs include spring-loaded clutches which become disengaged at a predetermined spring tension in response to output torque.

It should also be noted that the prior art torque-controlled tools which include planetary gearing for reducing a fast motor speed to a practical output speed for most applications, generally include a planetary ring gear which is secured to the outer shell of the tool.

An object of the invention is to provide an improved rotary power tool whose output torque may be continuously controlled and/or measured by resistance to the reactive torque of a ring gear of a planetary drive unit thereof which ring gear is arranged to rotate through a predetermined arc in response to output torque.

Another object of the invention is to provide an improved torque-controlled power tool, wherein the ring gear of one of the planetary drive units thereof is rotatably mounted, with transducer means associated therewith for responding to the rotary reaction of the planetary ring gear to output torque to provide a fluid pressure signal, upon attainment of a predetermined torque, to cut off the air supply to the motor.

A further object of the invention is to provide a torque-controlled power tool including a rotatably mounted planetary ring responsive to output torque, and transducer means responsive to such rotary movement of the ring gear to cut off the air supply to the motor section rotor, with the transducer being encased within the power tool housing.

Still another object of the invention is to provide a torque-controlled power tool including a rotatably mounted planetary ring gear responsive to output torque and which is formed integrally on a cam follower member having rollers associated therewith and riding on camming ramps formed on a cam spline member which is moved axially when the rollers move along the ramps, with the axial movement thereof compressing a plurality of adjacent bellows, for providing a fluid pressure signal indicative of output torque to cut off the air supply to the motor section of the power tool upon the attainment of a predetermined output torque.

A still further object of the invention is to provide a torque-controlled power tool including a rotatably mounted planetary ring gear responsive to output torque and having a shoe and linkage member rotatable with the ring gear to tangentially compresa a bellows or a pressure-sensing load cell, for example, providing a fluid pressure signal to cut off the air supply to the motor upon the attainment of a predetermined output torque.

These and other objects and advantages of the invention will be apparent when reference is made to the following description and accompanying drawings, wherein:

FIG. **1** is a perspective view of a rotary power tool embodying the invention;

FIGS. **2***a* and **2***b* are cross-sectional views of the FIG. **1** structure;

FIG. **2***c* is a schematic view of a fluidal circuit which may be used with the FIGS. **2***a* and **2***b* structures;

FIG. **3** is a fragmentary cross-sectional view of a portion of the FIG. **2***a* structure illustrating an operational position thereof;

FIG. **4** is a schematic view of selected operational conditions;

FIG. **5** is a fragmentary perspective view of an alternate embodiment of the FIG. **1** structure;

FIG. **6** is a fragmentary cross-sectional view of a portion of the FIG. **5** structure;

FIG. **7** is a cross-sectional view taken along the plane of line **7**—**7** of FIG. **5**, and looking in the direction of the arrows;

FIG. **8** is an end view taken along the plane of line **8**—**8** of FIG. **7**, and looking in the direction of the arrows;

FIG. **9** is a cross-sectional view similar to FIG. **7**, illustrating an operational position thereof;

FIG. **10** is a fragmentary cross-sectional view illustrating an alternate embodiment of the FIG. **7** arrangement; and

FIG. **11** is a fragmentary cross-sectional view illustrating an alternate embodiment of a portion of the FIG. **2***b* structure.

FIGURES 1–4 EMBODIMENT

Referring now to the drawings in greater detail, FIG. **1** illustrates a power tool assembly **10**, including generally a handle section **12**, a motor section **14**, a transducer section **16**, a planetary section **18**, and a head section **20**.

More specifically, as may be noted in FIG. **2***b*, the handle section **12** includes a valve assembly **21** mounted in a transverse opening **22** formed through a wall portion **24** in the handle section **12** adjacent an air inlet chamber **26** to which air is communicated via an air inlet fitting **28** (FIG. **1**) mounted in the end of the handle section **12**. The valve assembly **21** includes a sleeve member **30** secured in the opening **22** and having a central chamber **31**. A spring **32** is mounted between the outer end face **34** of the sleeve member **30** and a manual button **36**. The button **36** is secured to a valve stem **38** having an O-ring seal **40** mounted thereabout and slidably mounted within the sleeve member **30**. A frusto-conical valve **42** is formed on the inner end of the valve stem **38** for cooperation with a valve seat member **44** formed on the inner end **46** of the sleeve member **30**. An extension shaft **48** formed on the valve **42** extends across a passage **50** adjacent the chamber **26** and is slidably mounted in an opening **52** which may be formed in a plug member **54** threadedly mounted in a threaded opening **56** formed in the handle section axially aligned with the opening **22**. An O-ring seal **57** is mounted around the extension shaft **48** in the opening **52**.

A plurality of ports **58** are formed in the fixed sleeve member **30** for communication with a passage **60** which, in turn, communicates with a chamber **61** which is divided into two variable chambers **62** and **63** by a poppet valve **64** slidably mounted therein. A passage **66** communicates between the chambers **62** and **63** radially outwardly of the poppet valve **64**. A stem **67** is

formed on the poppet valve **64**, extending away from the sleeve member **30**. An axial passage **68** is formed part-way through the stem **67**, including a bleed plug **70** secured in the right end (FIG. **2***b*) of the axial passage **68**. Radial ports **72** and **74** are formed in the stem **67** a predetermined distance apart, the ports **72** communicating between the axial passage **68** and the chamber **62** to the left of the poppet valve **64**. An opening **75** communicates between the left chamber **62** and a chamber **76** and, thence, with a supply passage **77**.

The stem **67** is slidably mounted in and extends through an axial opening **78** formed in a piston housing **80** secured in a central opening or chamber **82** formed in the handle section **12**. A piston **84** is secured to the end of the stem **67** opposite the poppet valve **64** and is slidably mounted in a chamber **86** of the piston housing **80**, dividing the chamber **86** into two variable chambers **87** and **88**. A suitable seal **89** is mounted around the outer periphery of the piston **84** within the chamber **86**. A spring **90** is mounted between the piston **84** and an end wall **92** of the chamber **86**. A signal inlet port **94** is formed in the handle section **12** communicating with the chamber **86** to the right (FIG. **2***b*) of the piston **84**, while a bleed port **96** formed in the handle section **12** communicates the chamber **86** to the left (FIG. **2***b*) of the piston **84** to the atmosphere.

The motor section **14** includes a motor rotor **98** mounted within a sleeve member **100** secured by pins **102** to the handle section **12**. An outer vane portion **103** of the motor rotor **98** receives air under pressure in a conventional manner from the supply passage **77** via suitable conduitry (not shown). A motor shaft **104** is formed on the motor rotor **98** and rotatably mounted in bearings **106** (FIG. **2***b*), **108** (FIG. **2***a*), and **110** mounted in the handle section **12**, the motor section **14** and the planetary section **18**, respectively. An annular chamber **112** is formed around the sleeve member **100**, with exhaust ports **114** communicating with the atmosphere. Suitable seals **116** and **118** are mounted adjacent the respective ends of the annular chamber **112**.

An outlet port **120** is formed in the transducer section **16**, communicating internally with an annular passage **112** which, in turn, communicates with a pair of ports **124** formed in a fixed wall **125** of the motor section **14**, and leading, respectively, to a pair of bellows **126** located radially outwardly of an intermediate portion of the motor shaft **104**. The bellows **126** are mounted between the fixed wall **125** and an end face **128** of a cam spline member **130**, the latter being slidably mounted on splines **132** formed in a chamber **134** within the transducer section **16**, and the open end of the bellows **126** being sealed by an O-ring seal **133** mounted in a groove **135** formed in the wall **125**. A spring **136** is mounted around the motor shaft **104** between the end face **128** and an annular groove **137** formed in the wall **125**. A line **138** communicates between the outlet port **120** (FIG. **2***a*) and a suitable adjustable valve means, represented by **139**. A line **141** communicates a fluid pressure signal from the valve means **139** to the signal inlet port **94** and, thence, to the chamber **87** once the pressure within the bellows **126** reaches a predetermined level. As illustrated in FIG. **2***c*, air is supplied from any suitable high pressure source, represented at **143**, through a line **145** including a pressure regulator **147** and a check valve **149**, the latter providing a predetermined amount of preloading of the bellows **126**. Pressure within the line **138** may be measured on a suitable gage **151** operatively connected thereto.

Ramps or cam surfaces **140** (FIG. **3**) are formed on the opposite face **142** of the cam spline member **130**, and are contacted by cam rollers **144** rotatably mounted in suitable bearings **146** mounted in a cam follower or roller carrier **148** within the planetary section **18**. While two rollers and ramps are illustrated, one or more than two roller-ramp combinations could be utilized.

The roller carrier **148** is mounted inwardly on the bearing **110** and outwardly on a bearing **150** mounted around an internally toothed ring gear **152** of a first planetary unit **154**, the ring gear **152** being integrally formed on the roller carrier **148** for rotation therewith. The bearing **150** is mounted within a stepped sleeve member **156** mounted within the planetary section **18** and restrained from movement therein by a fixed radial pin **158**.

A plurality of pinion gears **160** are rotatably mounted on a shaft or pin **162** by needle bearings **164**. The shaft **164** is secured to a pinion gear carrier **166** mounted at one end thereof within the cam follower **148** on bearings **168**. The pinion gears **160** mesh with the ring gear **152** and with a sun gear **170** mounted on the end portion **172** of the motor shaft **104** by splines **174**. A cylindrical spacer **176** is mounted around the motor shaft **104** between oppositely disposed end faces of the sun gear **170** and the bearing **110**, with the sun gear **170** being retained against the spacer **176** by a retainer ring **178** secured to the shaft end portion **172**.

A second planetary unit **180** includes an internally toothed ring gear **182** formed integrally on the forward end portion of the stepped sleeve member **156**, a plurality of pinion gears **184** rotatably mounted on shafts or pins **186** by needle bearings **187** and by a carrier **188** having a reduced forward end portion **189** rotatably mounted on bearings **190** retained axially by a retainer ring **191** within the outer shell **193** of the head section **20**. The pinion gears **184** mesh with the ring gear **182** and with a splined sun gear **192** formed on an end **194** of the carrier **166** of the first planetary unit **154**.

A plurality of splines **196** are formed on the inner surface of the carrier **188**, radially inwardly of the bearings **190**. The splines **196** mesh with splines **198** formed on an end **200** of a shaft **202** extending into the head section **20**, being rotatably supported therein on a plurality of needle bearings **204**.

A first bevel gear **206** is formed on the forward end of the shaft **202** for meshing with a second bevel gear **208** formed on a transverse shaft **210** rotatably mounted on bearings **212** and **214** in the head section **20**. A square drive tool connector **216** is formed on the shaft **202**, extending through an opening **218** formed in the head section **20**, at right angles to the axis of the aligned planetary, transducer, motor, and handle sections **18**, **16**, **14**, and **12**, respectively. Any suitable tool fastener device (not shown) may be connected to the square drive tool connector **216**.

OPERATION

High pressure air enters the air inlet chamber **26** and the adjacent passage **50** via the fitting **28** from any suitable source (not shown). Once the valve button **36** is manually depressed, the high pressure air is communicated from the passage **50** past the valve seat member **44** into the chamber **31**, through the ports **58** into the

passage **60** and the chamber **62**, and, thence, through the passage **66**, the chamber **63**, the opening **75**, and the chamber **76**, to the adjacent supply passage **77** which communicates with the outer vane portion **103** of the motor rotor **98** to rotate the motor rotor **98** and its shaft **104**. The air is exhausted to the atmosphere via the annular chamber **112** and the exhaust ports **114**.

Rotation of the motor shaft **104** rotates the sun gear **170** of the first planetary unit **154** therewith, for example, in a clockwise direction as viewed from the right in FIG. **2***a*. Such rotation of the sun gear **170** causes the pinion gears **160** to each rotate in a counterclockwise direction about its respective shaft **162**, while meshing with the ring gear **152**, with the carrier **166** being caused to rotate in a counterclockwise direction about the axis of the motor shaft **104**. The ring gear **152** is initially restrained from rotating by virtue of the rollers **144** on the cam follower **148** being positioned at the low point or "start" position (FIG. **4**) of the fixed ramps **140**.

Rotation of the carrier **166** at its end portion **194** causes the sun gear **192** of the second planetary unit **180** to also rotate in the counterclockwise direction, thereby rotating the pinion gears **184**, which are meshing with the fixed ring gear **182**, in a clockwise direction about their respective shafts **186**, and the carrier **188** in a clockwise direction about the axis of the carrier end portion **194**. Such clockwise rotation of the carrier **188** directly rotates the shaft **202** via the splines **196** and **198**, thereby rotating the bevel gears **206** and **208** and the tool drive connector **216**.

As indicated above, the ring gear **152** of the first planetary unit **154** is initially restrained by virtue of being formed on the cam follower **148** whose rollers **144** are initially seated against the low portions of the respective ramps **140** of the fixed cam spline member **132**, the latter being urged leftwardly in FIGS. **2***a* and **3** by the spring **136**. However, as torque at the output end of the tool drive connector **216** increases under load conditions, the reaction sensed by the ring gear **152** overcomes the force of the spring **136**, causing the ring gear **152** to move in the clockwise direction, as urged by the pinion gears **160**, thus rotating the cam follower **148** and the rollers **144**. Such rotation of the rollers **144** moves the latter along the ramps **104** toward the "maximum pressure" position (FIG. **4**), forcing the cam spline member **130** to slide axially along the splines **132**, compressing the pair of bellows **126** to build up the pressure therein to a predetermined point.

As illustrated in FIG. **4**, the maximum pressure or stop position of each roller **144** is at some predetermined point adjacent the elevated end of the respective ramps **140**, say, for example, **135** degrees away from the low end or start position. Any point between the start position and the maximum pressure position may be selected as the release point for the transmission of the fluid pressure signal and is determined by the adjustment of the valve means **139**. At this point, the pressure within the bellows **126**, transmitted via the line **138** to the valve means **139**, will be relayed as a fluid pressure signal through the line **141** to the signal inlet port **94**. This fluid pressure signal is communicated from the inlet port **94** to the chamber **87**, moving the piston **84** to the left in FIG. **2***b*, against the force of the spring **90**, and pulling the poppet valve **64** to the left, seating the valve **64** adjacent the opening **75**, thereby closing off the passage **66** and its communication via the chamber **63** with the chamber **76** and the supply passage **77**. Hence, the air supply to the motor rotor **98** is cut off and the rotation of the tool drive connector **216** is stopped. The valve **64** is held in seated position by high pressure in the chamber **61**, and the high pressure in the chamber **87** is reduced by air escaping through the motor **98** and the exhaust outlet **114**, which allows the valve means **139** to close and the bellows **126** to return to starting preload position. After the motor rotor **98** is stopped by the seating of the valve **64**, the valve button **36** is released. High pressure air in the chamber **61** is released through the bleed plug **70** and the radial ports **72** into the chamber **77**, then through the motor rotor **98** and the exhaust outlet **114**, allowing the spring **88** to return the valve **64** to its original position. It should be noted that preloading, although not essential to the operation of the control and monitoring circuit, provides a conveniently variable means of regulating the rotational movement of the roller carrier **148** and the ring gear **152** (FIGS. **2***a* and **3**) by limiting the displacement of the bellows **126**. The mechanical force exerted against the bellows **126** is balanced by the air pressure within the bellows **126** at the time the maximum torque output, as preset by the adjustable valve means **139**, is reached. A pressure-monitoring means, such as the gage **151**, may be provided to allow observation and/or recording of both the preload pressure and the output torque pressure developed within the control circuit. This output torque pressure will be an accurate measure of the torque produced at the square drive tool connector **216**.

FIGURES 5–9 EMBODIMENT

The alternate embodiment of a power tool assembly **220** shown in FIGS. **5–9** includes a transducer section **222** in lieu of the bellows **126**, the cam spline member **130**, the ramps **140**, the rollers **144**, and the cam follower **148**. In this arrangement, the ring gear **224** (FIG. **6**) of the first planetary unit **226** is secured to a wall of the planetary section **18** by a fixed pin member **228**. The ring gear **230** of a second planetary unit **232** is rotatably mounted within a cylindrical bearing member **233** secured in the transducer section **222**, meshing with pinion gears **234** on bearings **236** around pinion shafts **238** supported by a carrier **240**. The pinion gears **234** also mesh with a sun gear splines **242** formed on an extended end **244** of the carrier **246** of the first planetary unit **226**. Splines **248** are formed on an inner surface of the carrier **240** to drivingly connect with splines **250** formed on the output shaft **252**. The carrier **240** is supported in bearings **253** retained in the outer shell **254** of the head section **20** by a retainer ring **255**.

A cylindrical spacer member **256** supports bearings **257** for the first planetary carrier **246** and is mounted within the outer shell **254** of the head section **20** between oppositely disposed end faces of the bearing member **233** and the first ring member **224**.

An arcuate pocket **258** (FIG. **7**) is formed in part on the outer periphery of the second ring gear **230**, and in part in the adjacent cylindrical ring gear bearing member **233** secured within the transducer section **222**. A shoe **260**, having an arcuate seating surface **262** formed thereon, is slidably mounted in the arcuate pocket **258**. A flat side or end face **264** is formed on the shoe **260** for at times abutting against both respective edges **266** and **268** (FIG. **7**) of the ring gear **230** and the fixed bearing member **233**. A transverse groove or slot **270**

is formed on the side of the shoe **260** opposite the flat side **264**, suitable for the seating thereagainst of an end of a torque link member **272**. The torque link member **272** extends through a tangentially extending opening **274** formed in the transducer section **222**, abutting against a disc **276** slidably mounted in a chamber **278**. A bellows **280** is mounted in the chamber **278** intermediate the disc **276** and an end cover **282**, the latter being secured to the transducer section **222** by bolts **284**, and the open end of the bellows **280** being sealed by an O-ring seal **285** mounted in a groove **287** formed in the end cover **282**. A port **286** formed in the end cover **282** communicates between the interior of the bellows **280** and an outlet passage **288** formed in the end cover **282**.

In operation, as torque builds up under load at the tool drive connector **216**, the second ring gear **230** is caused to rotate against the force of the bellows **280**, moving the shoe **260**, the torque link member **272** and disc **276** to the right as illustrated in FIG. **9**, compressing the bellows **280** and providng a pressure change in the outlet passage **288** which may be transmitted to any suitable pressure-actuated means, such as the valve means **139** of FIG. **2***a*, to cut off the supply of air to the motor rotor **98** as explained above.

The inherent springiness of the bellows **280** will return the disc **276**, the torque link member **272** and the shoe **260** to the respective positions illustrated in FIG. **7** once the rotation of the tool drive connector **216** is stopped.

FIGURE 10 EMBODIMENT

FIG. **10** illustrates an alternate embodiment of the transducer section **222** including a pressure-sensing load cell **290** adjacent the disc **276**, in lieu of the bellows of the FIG. **7** structure. It should be noted that an arcuate pocket **292** is included which is substantially shorter than the arcuate pocket **258** of FIG. **7**. An end cover **294**, secured to the transducer section **222** by bolts **296**, has an outlet opening **298** formed therein suitable for the extension therethrough of a plurality of electrical conductors **300**. This arrangement provides a signal-generating means involving a minimum of movement of the ring gear **230**, the shoe **260**, the torque link member **272**, and the disc **276**.

FIGURE 11 EMBODIMENT

FIG. **11** illustrates an alternate embodiment of the valving portion of the handle section **12** which may be used in conjunction with the load cell arrangement of FIG. **10**. In this structure, a solenoid **302** is mounted in the chamber **86** and has an axial passage **303** formed therein for the slidable mounting therein of the poppet valve stem **67** in lieu of the piston **84** illustrated in FIG. **2***b*, and the signal is communicated thereto via leads **304** rather than by the fluid pressure inlet **94** and the chamber **87** associated with the piston **84**. A spring **306** is mounted intermediate a fixed wall **308** and the adjacent face **310** of the poppet valve **64**. Once the torque build-up signal is transmitted via the leads **304** through suitable amplification and electrical interface means to the solenoid **302**, the latter is energized and pulls the valve stem **67** farther into the axial passage **303**, against the force of the spring **306**, thereby pulling the poppet valve **64** past the passage **66** to thus cut off the air supply to the motor supply passage **77**.

It should be apparent that the invention provides an improved torque-controlled rotary power tool wherein a rotatable planetary ring gear and an adjacent transducer section combine to efficiently control and/or provide a means of continuously measuring output torque in proportion to the pressure developed on the transducer by rotation of the ring gear as it reacts to operational output torque.

While several embodiments of the invention have been shown and described, other modifications thereof are possible.

I claim:

1. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, passage means communicating between said source of fluid and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of said fluid therethrough, a motor shaft extending from said motor rotor, at least one planetary unit including a ring gear rotatably mounted in said housing, a sun gear operatively connected to and driven by said motor shaft, a carrier member, a plurality of pinion gears rotatably mounted on said carrier member and meshing with said sun and ring gears, rotary output means operatively connected to said carrier member, a bellows unit operatively connected between said ring gear and a fixed wall of said housing and having a predetermined initial internal pressure, said ring gear rotatably reacting to increasing output torque on said rotary output means to increase said internal pressure of said bellows unit, and signal means responsive to said increased pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

2. The rotary power tool described in claim **1**, and an indicating means operatively connected to said bellows unit, said internal pressure of said bellows unit being continuously monitored by said indicating means.

3. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, passage means communicating between said source of fluid and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of said fluid therethrough, a motor shaft extending from said motor rotor, at least one planetary unit including a ring gear rotatably mounted in said housing, a sun gear formed on said motor shaft, a carrier member, a plurality of pinion gears rotatably mounted on said carrier member and meshing with said sun and ring gears, rotary output means operatively connected to said carrier member, ramp means splined to said housing, roller means mounted on said ramp means and operatively connected to said ring gear so as to be caused to roll along said ramp means in response to rotary motion of said ring gear, pressure-reacting means mounted intermediate said ramp means and a fixed wall of said housing, said ring gear rotatably reacting to increasing output torque on said rotary output means to axially actuate said ramp means through said roller means to increase the pressure of said pressure-reacting means, and signal means responsive to said increased pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

4. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, passage means communicating between said source of fluid and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of said fluid therethrough, a motor shaft extending from said motor rotor, at least one planetary unit including a ring gear rotatably mounted in said housing, a sun gear formed on said motor shaft, a carrier member, a plurality of pinion gears rotatably mounted on said carrier member and meshing with said sun and ring gears, rotary output means operatively connected to said carrier member, an arcuate pocket formed in said ring gear, a shoe having a seat formed in a face thereof, a torque-link member abutted against said seat and extending therefrom for converting the rotary motion of said ring gear to tangential motion, pressure-reacting means mounted intermediate said torque-link member and a fixed wall of said housing, said ring gear rotatably reacting to increasing output torque on said rotary output means to actuate said torque-link member via said pocket and shoe to increase the pressure of said pressure-reacting means, and signal means responsive to said increased pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

5. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, passage means communicating between said source of fluid and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of fluid therethrough, a motor shaft extending from said motor rotor, cam means operatively mounted in said housing, a plurality of bellows mounted intermediate said cam means and a fixed wall of said housing, at least one planetary unit including a ring gear formed on said cam means, a sun gear formed on said motor shaft, a carrier member, a plurality of pinion gears rotatably mounted on said carrier member and meshing with said sun and ring gears, rotary output means operatively connected to said carrier member, said ring gear rotatably reacting to the output torque on said rotary output means to cause said cam means to compress said bellows and increase said pressure thereof, and signal means responsive to said pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

6. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, an inlet port for receiving fluid from said source of fluid under pressure, passage means communicating between said inlet port and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of said fluid therethrough, a motor shaft extending from said motor rotor, a cam follower rotatably mounted in said housing around said motor shaft, a cam spline member slidably mounted in said housing around said motor shaft, a plurality of bellows mounted intermediate said cam spline member and a fixed wall of said housing and having a predetermined initial internal pressure, at least one arcuate ramp formed on said cam spline member, at least one roller rotatably mounted on said cam follower and positioned on said at least one arcuate ramp, a first planetary ring gear formed on said cam follower, a first sun gear formed on said motor shaft, a first carrier member, a first plurality of pinion gears rotatably mounted on said first carrier member and meshing with said first sun and ring gears, a second sun gear formed on said first carrier member, a second ring gear secured to said housing, a second carrier member, a second plurality of pinion gears rotatably mounted on said second carrier member and meshing with said second sun and ring gears, rotary output means operatively connected to said second carrier member, said first ring gear rotatably reacting to increasing output torque on said rotary output means to rotate said cam follower and said at least one roller to roll said roller toward the high point of said at least one ramp and thereby force said cam spline member to move axially to compress said bellows and increase said internal pressure thereof, and signal means responsive to said internal pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

7. The rotary power tool described in claim 6, wherein said signal means includes second valve means for providing a fluid signal to close said first-mentioned valve means.

8. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, an inlet port for receiving fluid from said source of fluid under pressure, passage means communicating between said inlet port and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of said fluid therethrough, a motor shaft extending from said motor rotor, a first planetary unit including a first ring gear secured to said housing, a first sun gear formed on said motor shaft, a first carrier member, and a first plurality of pinion gears rotatably mounted on said first carrier member and meshing with said first sun and ring gears, a second planetary unit including a second sun gear formed on said first carrier member, a second ring gear rotatably mounted in said housing, a second carrier member, and a second plurality of pinion gears rotatably mounted on said second carrier member and meshing with said second sun and ring gears, rotary output means operatively connected to said second carrier member, linkage means operatively connected for tangential movement with said second ring gear, and a bellows unit mounted intermediate said linkage means and a fixed wall of said housing and having a predetermined initial internal pressure, said first ring gear rotatably reacting to increasing output torque on said rotary output means to tangentially move said linkage means to compress said bellows and increase said internal pressure thereof, and signal means responsive to said internal pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

9. The rotary power tool described in claim 8, wherein said signal means includes second valve means for providing a fluid signal to close said first-mentioned valve means.

10. A rotary power tool for use with a source of fluid under pressure, said rotary power tool comprising a housing including a fluid-actuated motor rotor, an inlet port for receiving fluid from said source of fluid under pressure, passage means communicating between said

inlet port and said motor rotor, valve means operatively mounted in said passage means for controlling the flow of said fluid therethrough, a motor shaft extending from said motor rotor, a first planetary unit including a first ring gear secured to said housing, a first sun gear formed on said motor shaft, a first carrier member, and a first plurality of pinion gears rotatably mounted on said first carrier member and meshing with said first sun and ring gears, a second planetary unit including a second sun gear formed on said first carrier member, a second ring gear rotatably mounted in said housing, a second carrier member, and a second plurality of pinion gears rotatably mounted on said second carrier member and meshing with said second sun and ring gears, rotary output means operatively connected for tangential movement with said second ring gear, and a pressure-sensing load cell mounted intermediate said linkage means and a fixed wall of said housing, said first ring gear rotatably reacting to increasing output torque on said rotary output means to tangentially move said linkage means to apply pressure to said pressure-sensing load cell, and signal means responsive to said pressure to cause said valve means to cut off said fluid flow through said passage means upon the attainment of a predetermined output torque.

11. The rotary power tool described in claim **10**, wherein said signal means includes a solenoid and means for providing an electrical signal to cause said solenoid to close said valve means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,834,467 Dated September 10, 1974

Inventor(s) John R. Fuchs

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 37, after "ring" insert -- gear --;
line 58, change "compresa" to -- compress --.

Column 3, line 43, change "112" to -- 122 --.

Column 4, line 22, change "164" to -- 162 --.

Column 5, line 45, change "104" to -- 140 --.

Column 7, line 21, change "providng" to -- providing --.

Signed and sealed this 3rd day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents