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(54) POWER TOOL AND LOCKING MECHANISMS FOR MANUAL TORQUE APPLICATION

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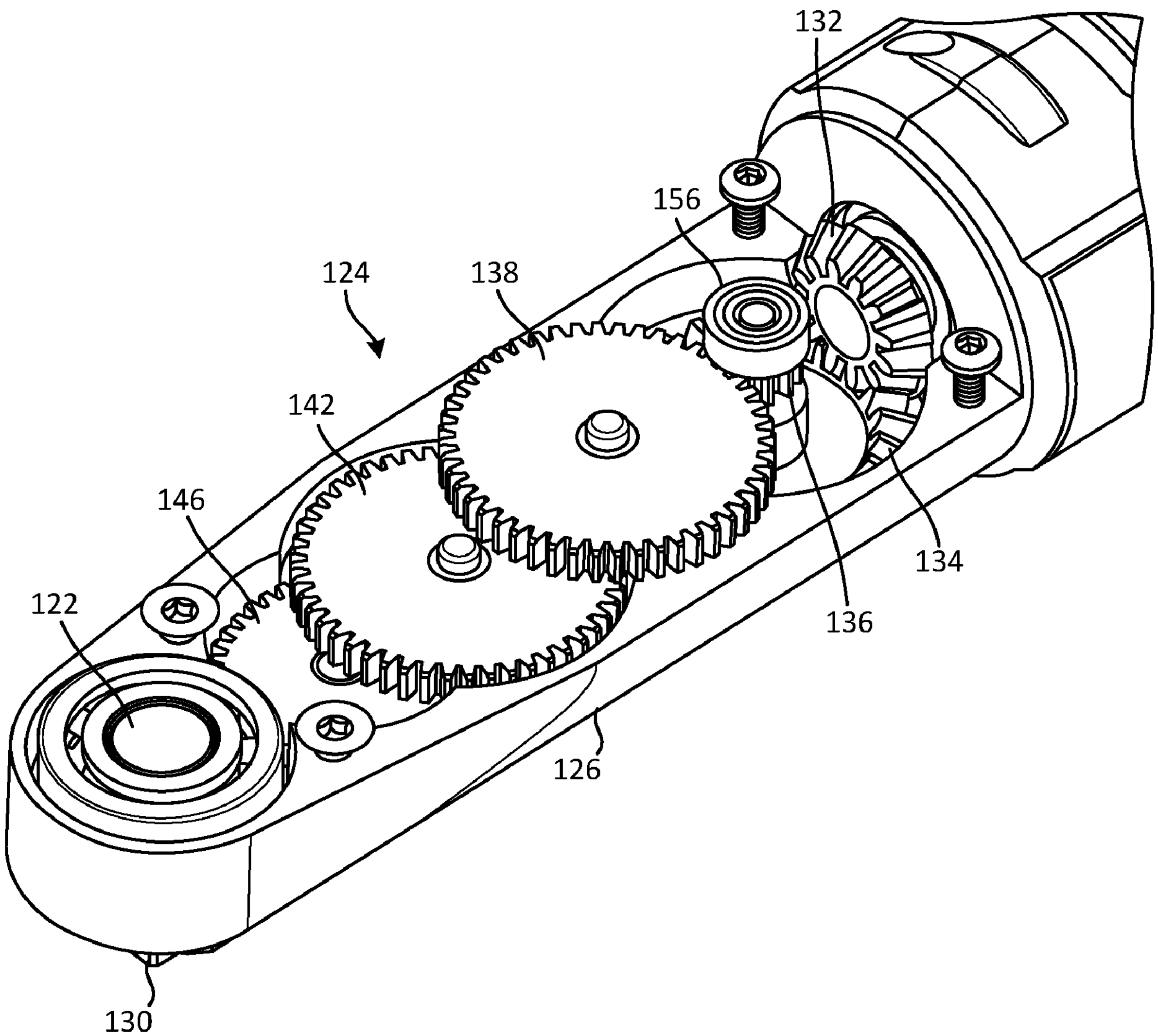
(57) ABSTRACT

A motorized tool with a direct drive mechanism and a locking mechanism that allows the tool to be used to apply a manual load or torque. The tool includes a drive lug adapted to be driven in first and second rotational directions via a gear assembly, a motor adapted to drive the gear assembly to thereby the drive lug for the application of motorized torque, and a locking mechanism that is adapted to allow application of manual torque by the drive lug.



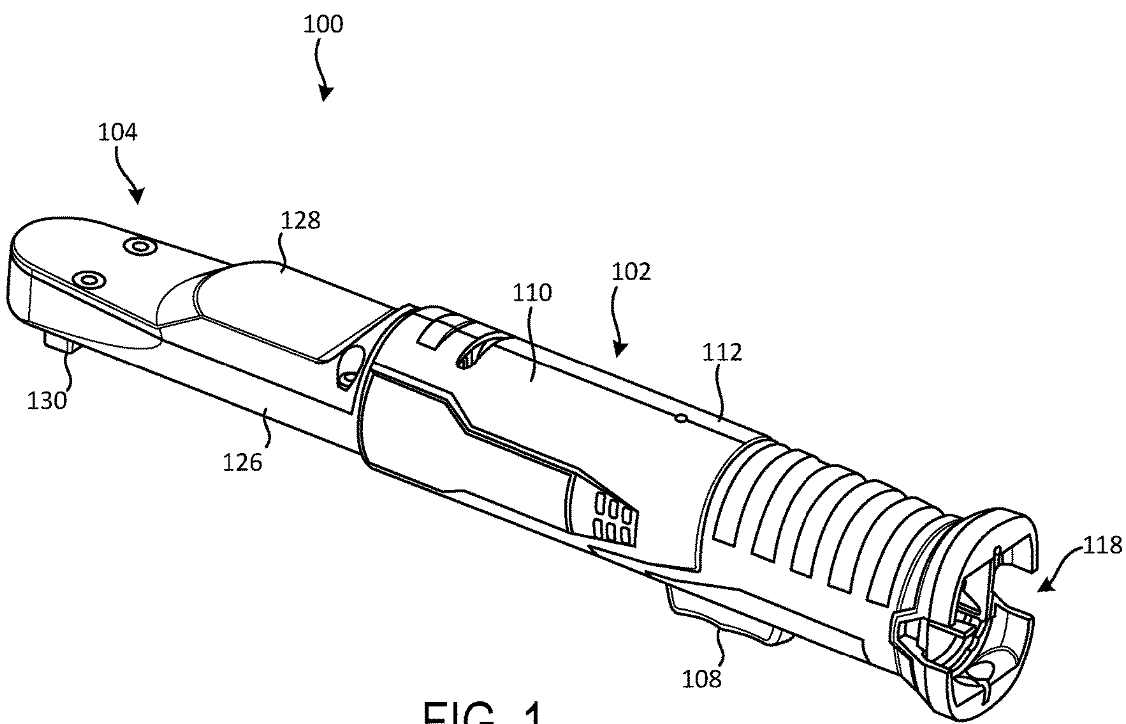

100
104
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FIG. 1

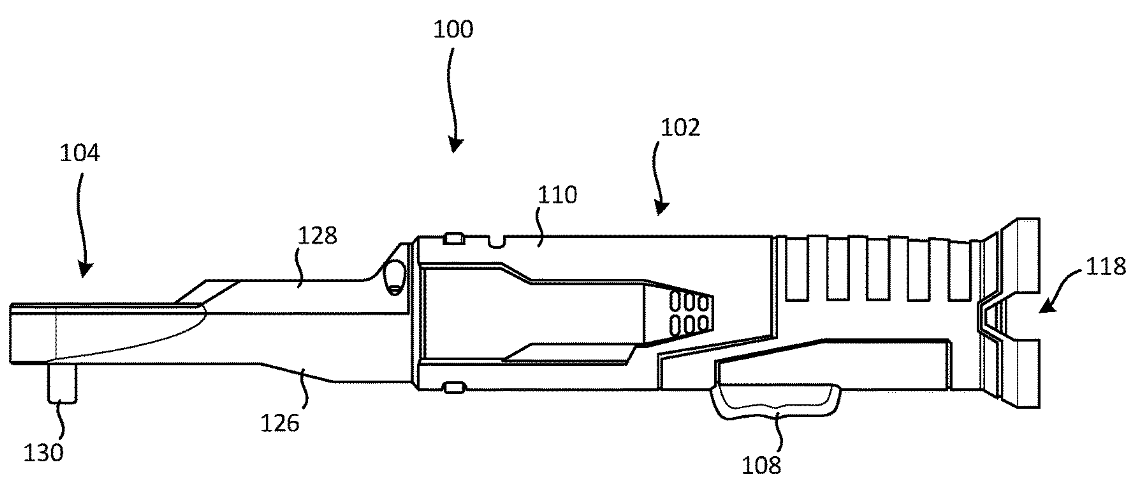
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FIG. 2

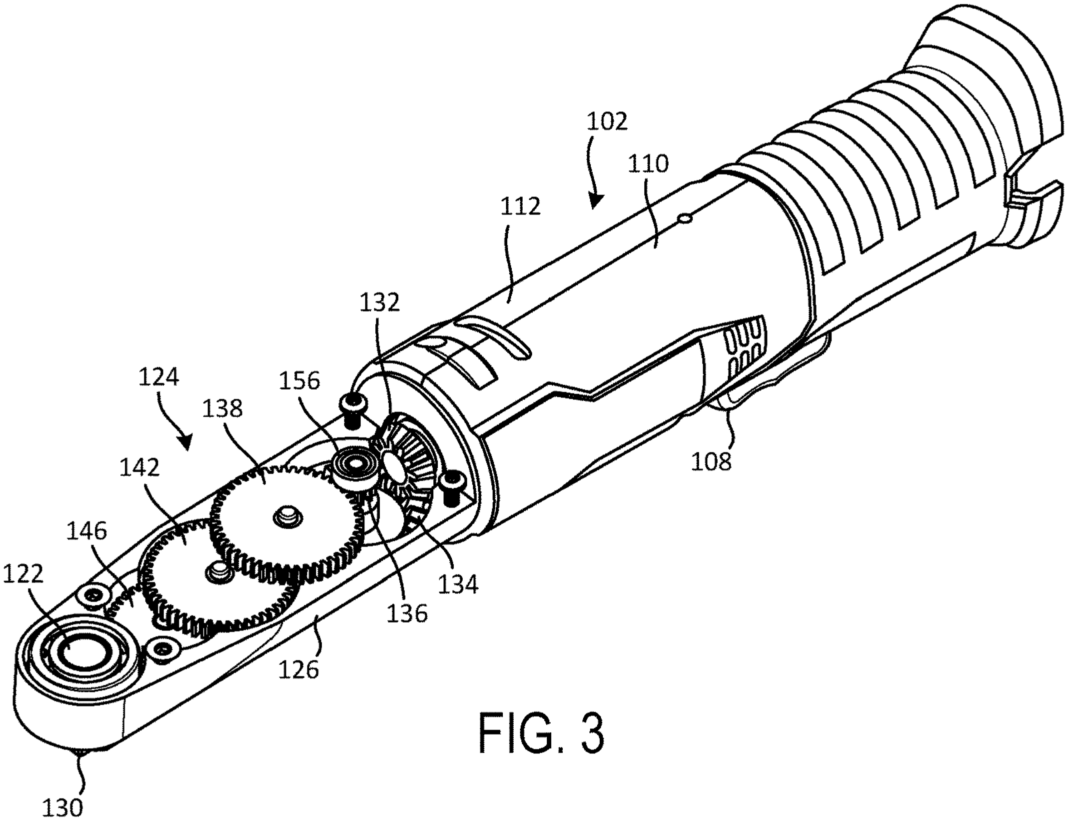
102
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FIG. 3

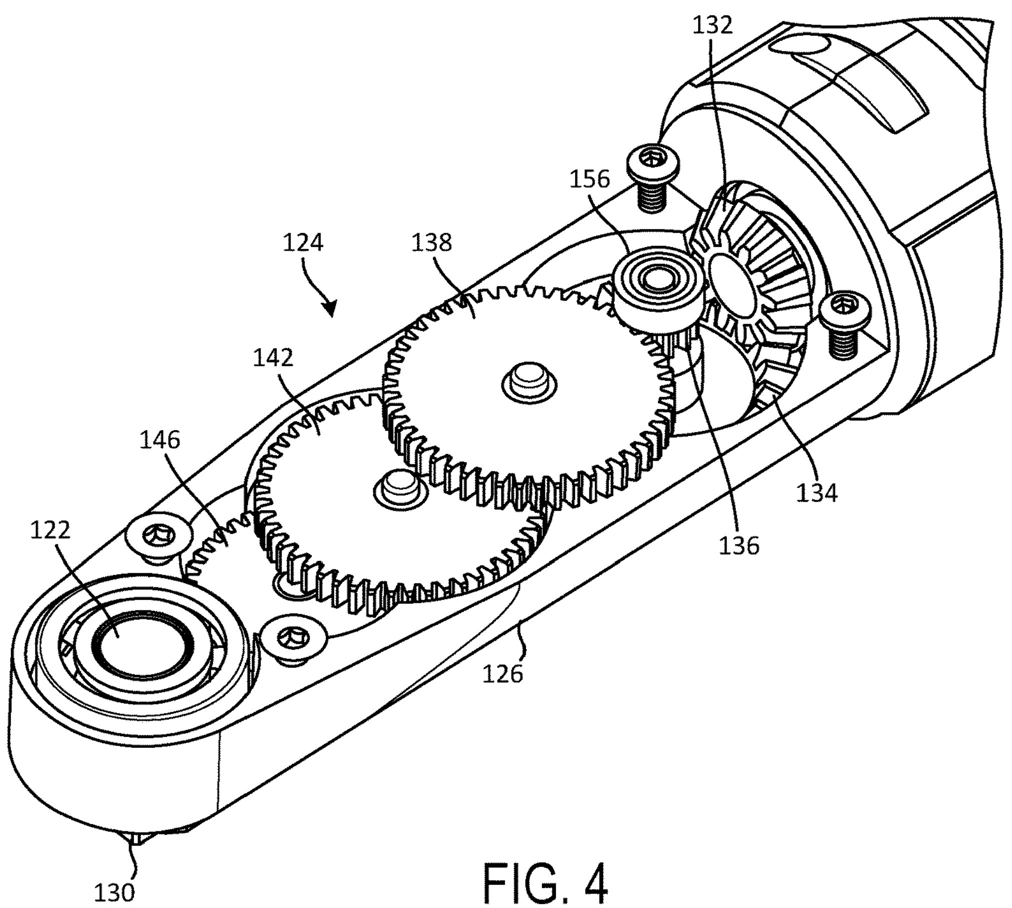
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FIG. 4

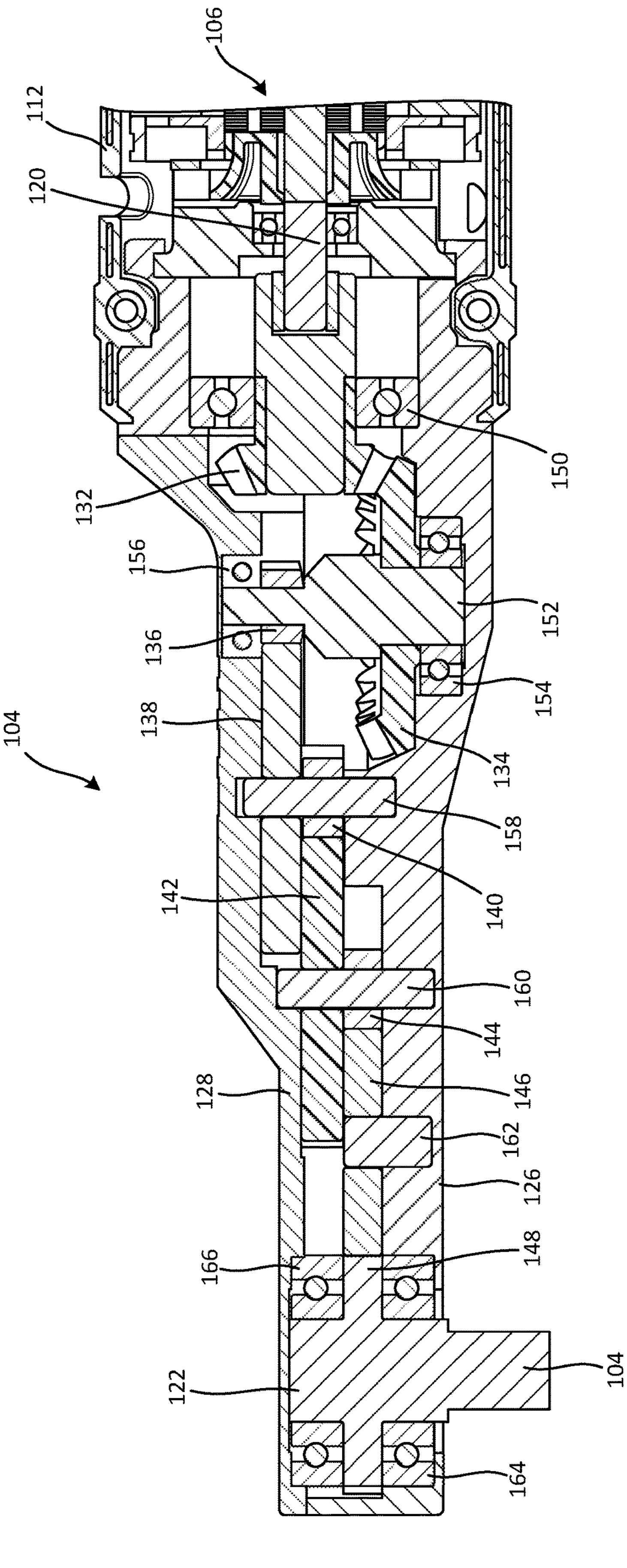
106
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FIG. 5

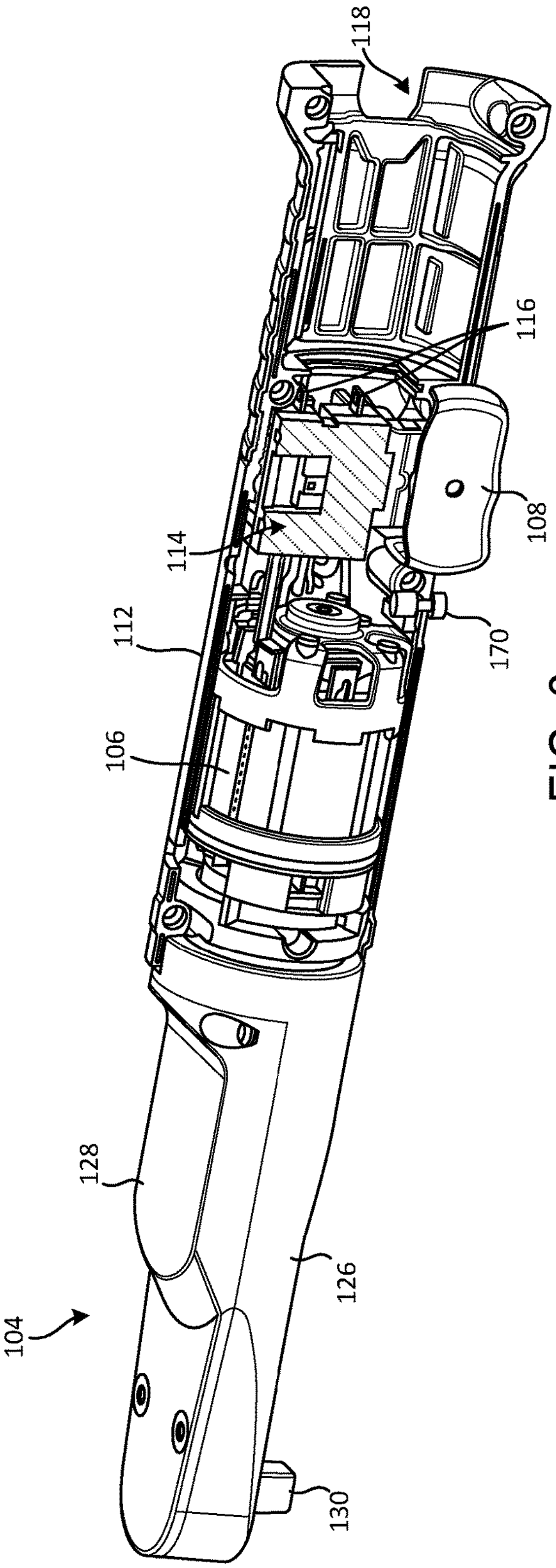

FIG. 6

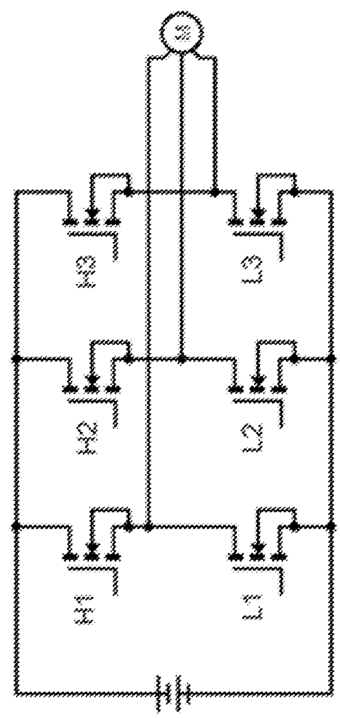

FIG. 7

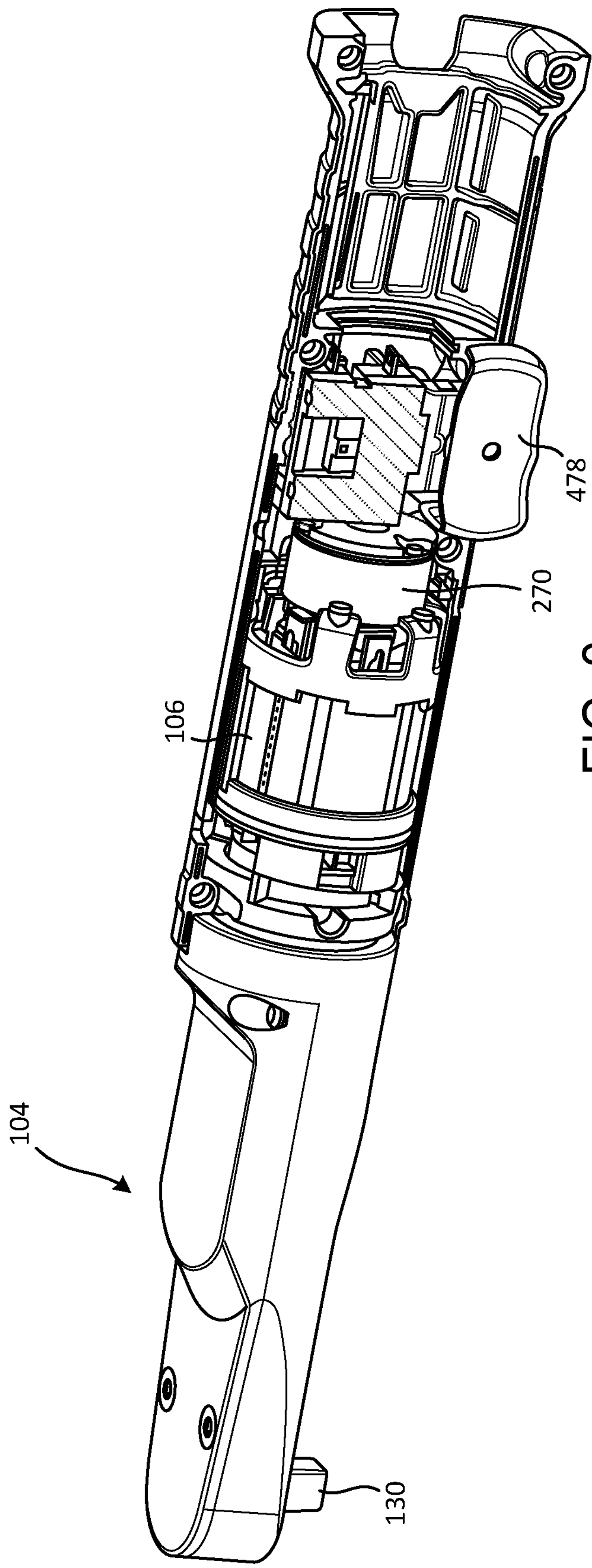

FIG. 8

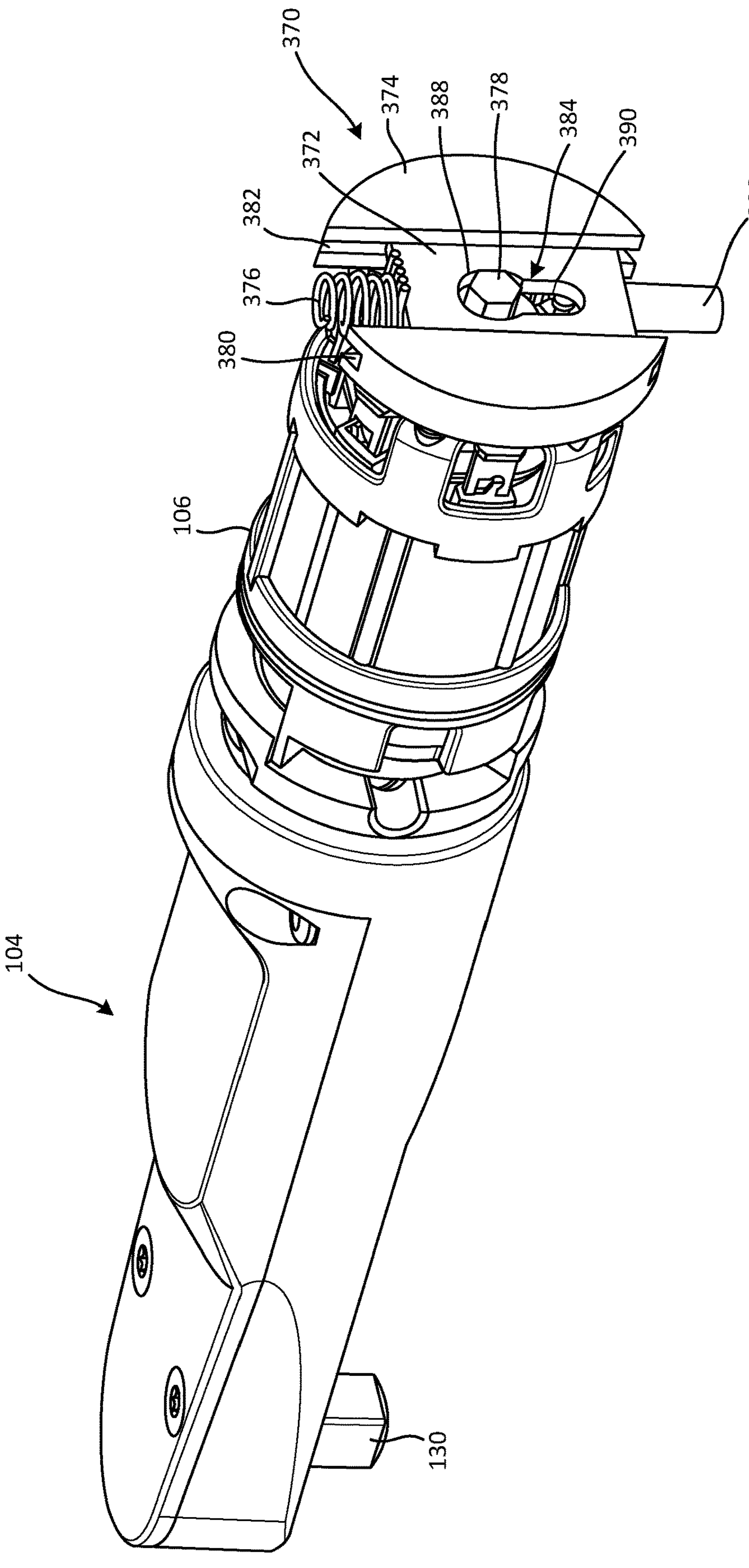

FIG. 9

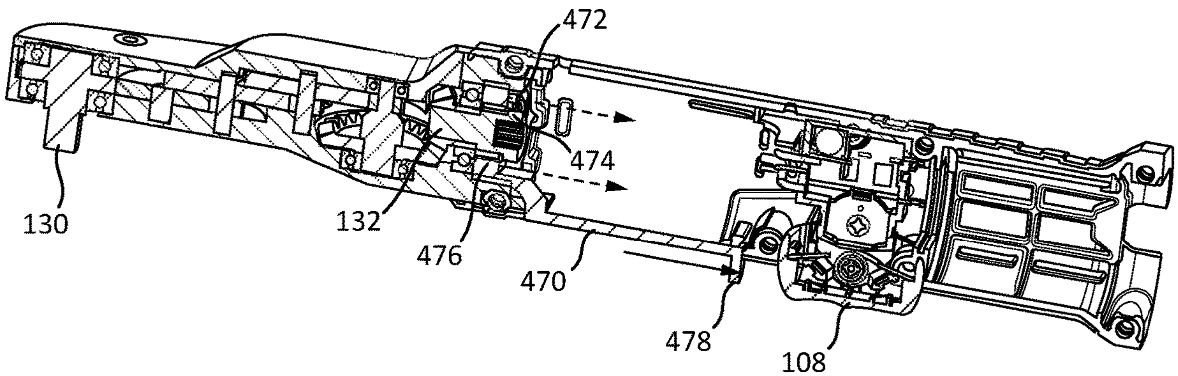

FIG. 10

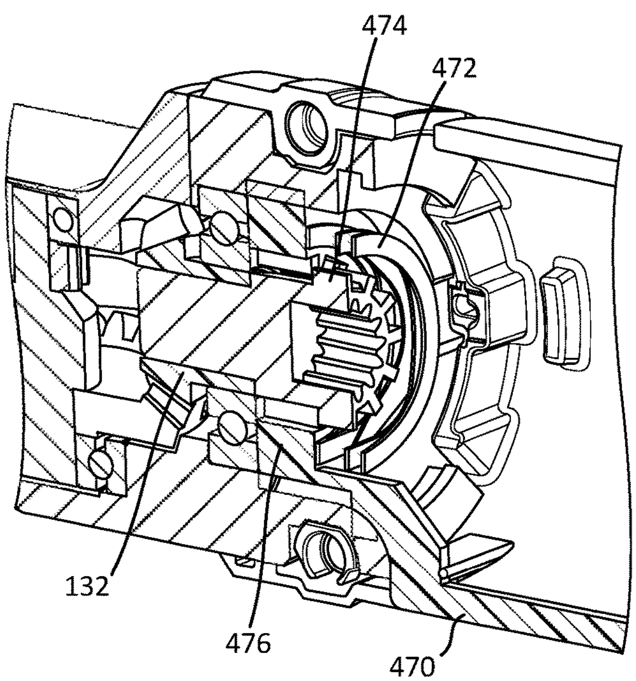

FIG. 11

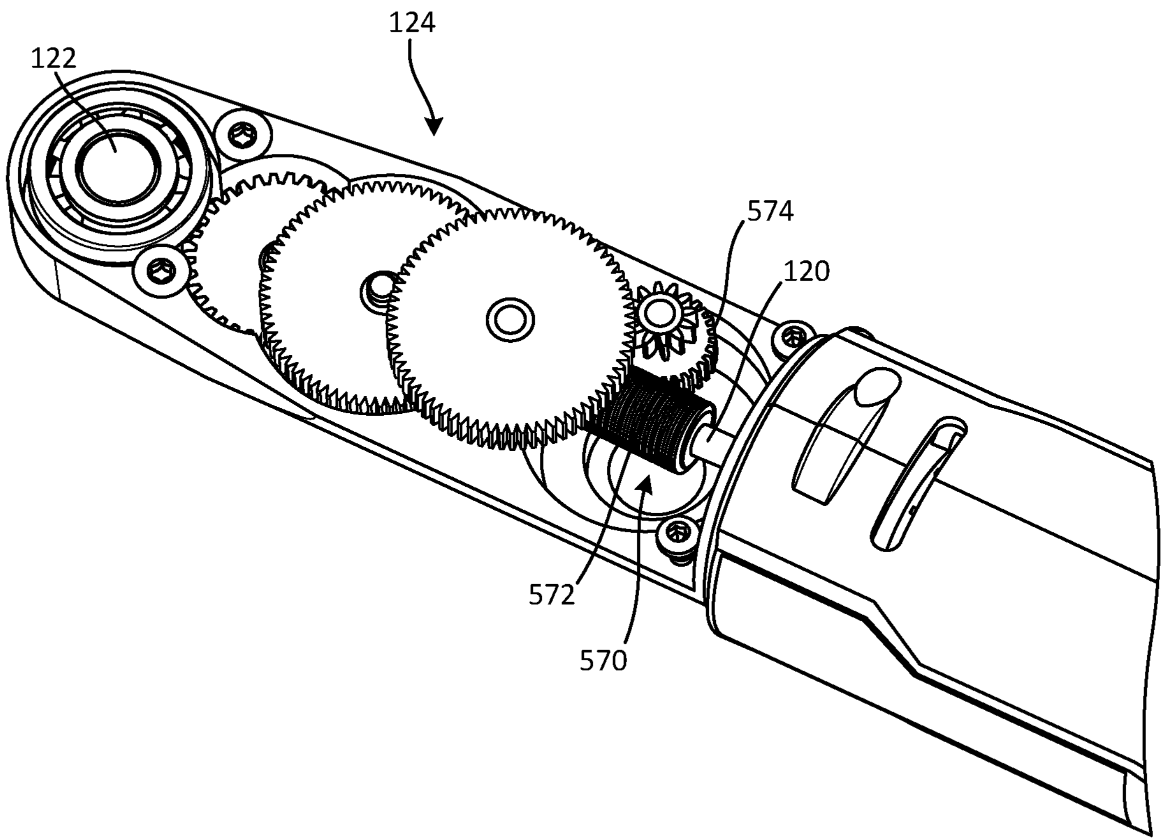

FIG. 12

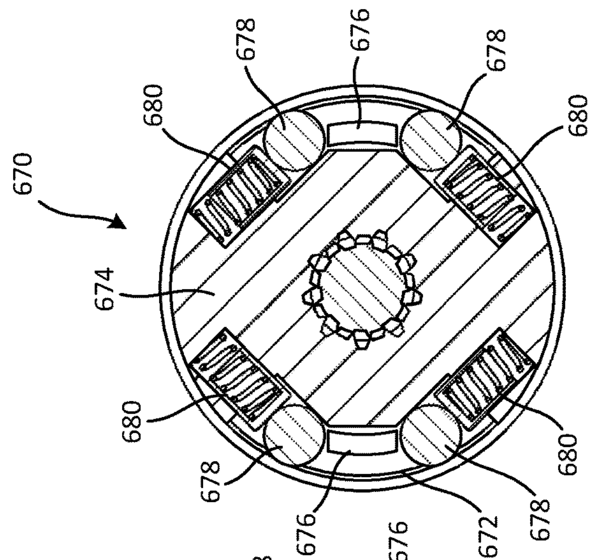

FIG. 15

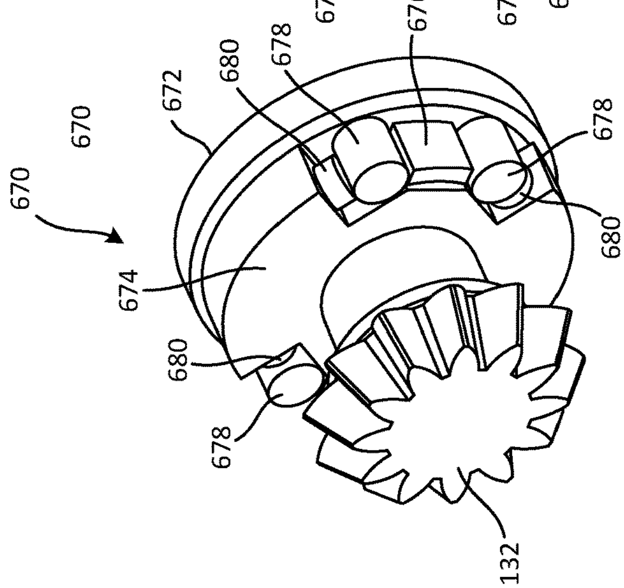

FIG. 14

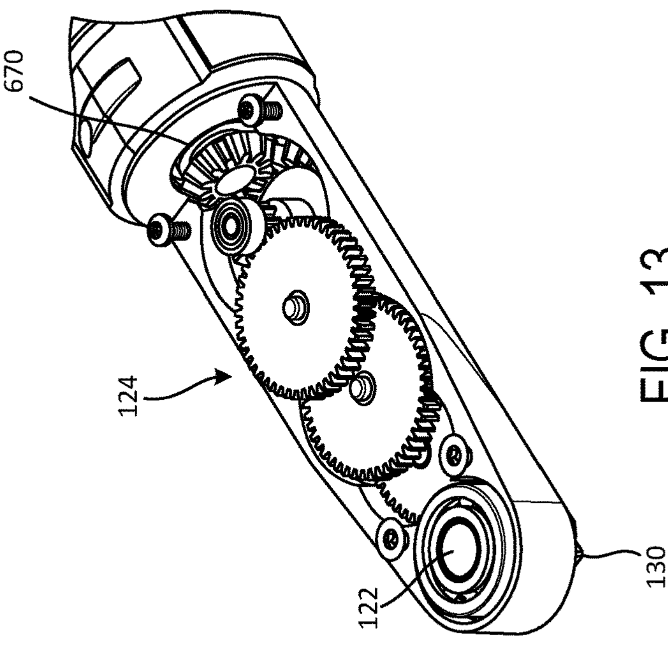

FIG. 13

POWER TOOL AND LOCKING MECHANISMS FOR MANUAL TORQUE APPLICATION

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates generally to power tools, and more particularly to locking a motorized tool to perform manual loading.

BACKGROUND OF THE INVENTION

[0002] Power hand tools, such as, for example, motorized direct drive tools, motorized ratchet wrenches, impact wrenches, and other drivers, are commonly used in automotive, industrial, and household applications to install and remove threaded fasteners, and apply a torque and/or angular displacement to a work piece, such as a threaded fastener, for example. Power hand tools generally include an output member (such as a drive lug or chuck), a trigger switch actuatable by a user, an electric motor contained in a housing, and other components, such as switches, light emitting diodes (LEDs), and batteries, for example.

[0003] Conventional motorized ratchets utilize a switch disposed on the head of the tool to select rotational direction of the tool output. As the switch is disposed on the head, it can be challenging for a user to change the direction without first removing the tool from the fastener. It is especially challenging when the tool is engaged with a fastener in a tight space and the user cannot easily access the head of the tool.

[0004] When using a motorized direct drive tool, it may be desirable to apply a manual load to the work piece while using the tool. For example, manual torque application provides the benefit of better controlling the amount of torque application. However, conventional motorized direct drive tools cannot be easily used for manual torque application, because when applying manual torque, the drive lug will freely rotate. Therefore, to provide manual torque application with a power torque application tool, the drive lug must be rotationally locked.

SUMMARY OF THE INVENTION

[0005] The present invention relates broadly to a gear system and locking mechanism for a power tool. The tool generally includes a tool housing, an output assembly (such as a direct drive type mechanism with a drive lug) adapted to provide torque to a work piece, a trigger, and a motor housed in the housing. The output assembly includes a gear assembly linking the motor to the output assembly, such as a drive lug. The gear assembly includes spur gears, bevel gears and/or a worm gear drive to create a desired gear ratio to meet speed and torque requirements required at the output assembly. In an embodiment, the gear assembly includes a plurality of spur gears, arranged to provide a power tool with a low profile. The tool may include a toggle trigger to allow for forward and reverse rotational direction control of the motor, or the tool may include a single trigger with a separate switch to change motor direction.

[0006] With the tool, the trigger can be actuated to cause power to be supplied to the motor to rotate the drive lug to apply torque to a work piece in a motorized torque application mode. To apply manual torque to the work piece, via a user manually rotating the tool in a manual torque application mode, the drive mechanism must be rotationally locked with respect to the tool to prevent rotational movement, otherwise manual torque application on the work piece will back drive the gears and spin the motor thus failing to transfer any torque to the work piece.

[0007] The present invention includes various embodiments that lock or otherwise prevent the drive mechanism from rotating with respect to the tool, so that the tool can be used to apply manual torque to a work piece, via a user manually rotating the tool in a manual torque application mode.

[0008] In an embodiment, the present invention includes a power tool including a drive portion and a motor with a motor shaft adapted to rotationally drive the drive portion. The power tool includes a gear assembly operably coupled to the motor shaft and the drive portion and is adapted to transfer rotational motion of the motor shaft to the drive portion. The power tool also includes a locking mechanism adapted to selectively prevent rotation of at least one of the motor shaft, gear mechanism, and drive portion to allow manual torque application by the power tool.

[0009] The locking mechanism may be any one of various types of locking mechanisms. For example, the locking mechanism may include a lock button that, when actuated, causes all high-side or low-side switching elements to be placed in a conducting state to prevent rotation of the motor shaft. The locking mechanism may include an electric brake that allows the motor shaft to rotate when power is supplied to the motor, and selectively prevents rotation of the motor shaft when power is not being supplied to the motor. The locking mechanism may include a plate that is movable between locked and unlocked positions, wherein when in the locked position, the plate prevents rotation of the motor shaft, and when in the unlocked position, the plate allows the motor shaft to rotate. The locking mechanism may include a locking bar that is movable between locked and unlocked positions, wherein when in the locked position, the locking bar prevents rotation of the motor shaft, and when in the unlocked position, the locking bar allows the motor shaft to rotate. The locking mechanism may include a sprag clutch.

[0010] In another embodiment, the present invention includes a power tool including a drive portion and a motor with a motor shaft adapted to drive the drive portion. The power tool includes a gear assembly operably coupled to the motor shaft and the drive portion and adapted to transfer rotary motion of the motor shaft to the drive portion, wherein the gear assembly includes a worm gear coupled to the motor shaft and a spur gear meshingly engaged with the worm gear, and the spur gear is unable to rotate the worm gear when a manual load is applied to the drive portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] For the purpose of facilitating an understanding of the subject matter sought to be protected, there is illustrated in the accompanying drawing embodiments thereof, from an inspection of which, when considered in connection with the following description, the subject matter sought to be protected, its construction and operation, and many of its advantages, should be readily understood and appreciated.

[0012] FIG. **1** is perspective view of an exemplar tool, incorporating an embodiment of the present invention.

[0013] FIG. **2** is a side plan view of the exemplar tool of FIG. **1**.

[0014] FIG. **3** is a perspective view of the exemplar tool of FIGS. **1** and **2**, showing internal components of a head portion of the tool, according to an embodiment of the present invention.

[0015] FIG. **4** is an enlarged perspective view showing internal components of a head portion of the tool of the tool of FIG. **3**.

[0016] FIG. **5** is a cross-sectional side view of the head portion of the exemplar tool of FIGS. **1** and **2**.

[0017] FIG. **6** is a perspective view of the exemplar tool of FIGS. **1** and **2**, showing internal components of the tool, according to an embodiment of the present invention.

[0018] FIG. **7** is a diagram showing the high and low side switches for controlling a brushless DC motor, according to an embodiment of the present invention.

[0019] FIG. **8** is a perspective view of an exemplar tool, showing an internal portion of the tool, according to another embodiment of the present invention.

[0020] FIG. **9** is a perspective view of a head portion and motor of an exemplar tool, according to another embodiment of the present invention.

[0021] FIG. **10** is a cross-sectional view of an exemplar tool, according to another embodiment of the present invention.

[0022] FIG. **11** is a cross-sectional view of a head portion of the exemplar tool of FIG. **10**.

[0023] FIG. **12** is a perspective view of internal components of a head portion of an exemplar tool, according to another embodiment of the present invention.

[0024] FIG. **13** is a perspective view of internal components of a head portion of an exemplar tool, according to another embodiment of the present invention.

[0025] FIG. **14** is an enlarged view of a sprag clutch of the exemplar tool of FIG. **13**, according to an embodiment of the present invention.

[0026] FIG. **15** is a cross-sectional view of the sprag clutch of FIG. **14**, according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0027] While the present invention is susceptible of embodiments in many different forms, there is shown in the drawings, and will herein be described in detail, a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to embodiments illustrated. As used herein, the term "present invention" is not intended to limit the scope of the claimed invention and is instead a term used to discuss exemplary embodiments of the invention for explanatory purposes only.

[0028] The present invention relates broadly to a gear system and locking mechanism for a power tool. The tool generally includes a tool housing, an output assembly (such as a direct drive type mechanism with a drive lug) adapted to provide torque to a work piece, a trigger, and a motor housed in the housing. The output assembly includes a gear assembly linking the motor to the output assembly, such as a drive lug. The drive lug may be engageable with tool extensions, such as sockets, which are engageable with work pieces. The gear assembly includes spur gears, bevel gears and/or a worm gear drive to create a desired gear ratio to meet speed and torque requirements required at the output assembly. In an embodiment, the gear assembly includes a plurality of spur gears, arranged to provide a power tool with a low or slim profile. The tool may include a toggle trigger to selectively reverse the rotational direction of the motor, or the tool may include a single trigger with a separate switch to change the motor direction.

[0029] With the tool, the trigger can be actuated to cause power to be supplied to the motor to rotate the drive lug to apply torque to a work piece in a motorized torque application mode. To apply a manual torque to the work piece, via a user manually rotating the tool in a manual torque application mode, the drive mechanism must be rotationally locked in place with respect to the tool, otherwise the manual torque application will back drive the gears and spin the motor, thus preventing manual torque application to a work piece. The present invention includes various alternate embodiments that can selectively or automatically rotationally lock the drive mechanism, so that a manual torque application may be applied. Therefore, the present invention provides the ability to use a power tool, such as the tool disclosed herein, selectively in either a motorized or powered torque application, where torque is applied to a work piece via the motor, or a manual torque application, where torque is applied to a work piece via manual rotation of the tool by a user. This is beneficial, for example, where more manual control over torque application is desired. Manual torque application has the benefit of better controlling torque application.

[0030] Referring to FIGS. **1-7**, a tool **100**, such as a motorized direct drive type tool, is illustrated. The tool **100** includes a tool housing **102**, an output assembly **104** (such as a direct drive type head assembly) operably coupled to the tool housing **102**, a motor **106** disposed in the tool housing **102** and operably coupled to the output assembly **104**, and a trigger **108** operably coupled to the motor **106** and actuatable to operate the motor **106** and thereby the output assembly **104**. In an example, the tool housing **102** may include first and second housing portions **110**, **112** (respectively forming first and second sides of the housing **102**) that are coupled together in a clamshell type manner and coupled to the output assembly **104**. In another example, the tool housing **102** (including the first and second housing portions **110**, **112**) may be a single integrated or monolithic piece.

[0031] The tool housing **102** may enclose or house internal components of the tool **100**, such as the motor **106**, a switch assembly **114** (shown in FIG. **6**), motor control electronics and/or controller (which may be incorporated into the switch assembly **114** or separate), and power source components, such as terminals **116** adapted to operably couple to a battery, such as a rechargeable type battery) that may be received in a battery receiving portion **118** of the tool housing **102**. The tool may also include other components, such as a display for configuring and setting the tool, one or more indicators such as light emitting diodes, and other components for operation of the tool, for example. The tool housing **102** may also include a textured or knurled grip to improve a user's grasp of the tool **100** during use.

[0032] The motor **106** is disposed in and supported in the tool housing **102** and operably coupled to the trigger **108** via the switch assembly **114**. The motor **106** includes a motor shaft **120** (as shown in FIG. **5**) that is operably coupled to the output assembly **104**, as described in further detail below. Thus, actuation of the trigger **108** by a user causes the motor **106** to operate and rotate the output assembly **104** in a desired rotational direction.

[0033] The motor **106** may be a brushless or brushed type motor, or any other suitable motor. A power source can be associated with the tool **100** to provide electric or other forms of power to the tool **100**, such as, for example, electric, hydraulic, or pneumatic, to operate the motor **106**. In an embodiment, the power source (not shown) can be housed in the battery receiving portion **118** of the tool housing **102**, opposite the output assembly **104**, a midsection of the tool **100**, or any other portion of the tool **100**/tool housing **102**. The power source may also be an external component that is not housed by the tool **100**, but that is operatively coupled to the tool **100** through, for example, hoses, wires or wireless means. In an embodiment, the power source is a removable and rechargeable battery that is adapted to be disposed in the battery receiving portion **116** of the tool housing **102** and electrically coupled to corresponding terminals **116** of the tool **100**.

[0034] The output assembly **104** includes an output assembly housing adapted to house components of a direct drive mechanism, including a drive portion **122** and a gear assembly **124** operably coupled to and adapted to drive the drive portion **122**. In an embodiment, the output assembly housing includes first and second output assembly housing portions **126**, **128**. The components of the drive portion **122** and a gear assembly **124** may be assembled into the first output assembly housing portion **126**, and the second output assembly housing portion **128** may act as a cover and be coupled to the first output assembly housing portion **126** to house the components.

[0035] The drive portion **122** may include a drive lug **130**, for example. The drive lug **130** is adapted to apply torque to a work piece, such as a fastener, via an adapter, bit, or socket coupled to the drive lug **130**, such as a bi-directional ratchet square or hexagonal drive. As illustrated, the drive lug **130** is oriented at about a 90 degree angle with respect to a longitudinal axis of the tool **100** and/or tool housing **102**, and is a square “male” connector designed to fit into or matingly engage a female counterpart, such as, for example, a socket. However, the drive lug **130** may be oriented at other angles with respect to the longitudinal axis. The drive portion **122** may alternatively include a “female” connector designed to matingly engage a male counterpart. The drive portion **122** may also be structured to directly engage a work piece without requiring coupling to an adapter, bit, or socket.

[0036] The gear assembly **124** operably couples the drive portion **122** to the motor shaft **120** and is adapted to transfer rotational motion of the motor shaft **120** to the drive portion **122**. Referring to FIGS. **3**-**6**, the gear assembly **124** includes a first bevel gear **132** coupled to the motor shaft **120**, a second bevel gear **134** meshingly engaged with the first bevel gear **132**, and a plurality of spur gears adapted to transfer rotational motion of the motor shaft **120**, and first and second bevel gears **132**, **134**, to the drive portion **122**. In an example, the gear assembly **124** includes first through sixth spur gears **136**-**146**. However, it will be appreciated that more or less spur gears may be used based on the application.

[0037] As shown in FIG. **5**, the first bevel gear **132** is disposed on and rotatable with the motor shaft **120**. The first bevel gear **132** is also supported in the first output assembly housing portion **126** by a bearing **150** with an inner diameter of the bearing **150** engaged (such as via interference or press-fit engagement) with an outer surface of a shaft portion of the first bevel gear **132**, and an outer diameter of the bearing **150** engaged (such as via clearance-fit, interference fit, or press-fit engagement) with an inner bearing surface of the first output assembly housing portion **126**. The first bevel gear **132** also include gear teeth meshingly engaged with gear teeth of the second bevel gear **134**.

[0038] The second bevel gear **134** and first spur gear **136** are coupled to and rotatable with a first gear shaft **152**. The second bevel gear **134** is coupled to and disposed proximal to a first end of the first gear shaft **152** that is supported in the first output assembly housing portion **126** by a bearing **154**. The first spur gear **136** is coupled to and disposed proximal to a second end of the first gear shaft **152** that is supported in the second output assembly housing portion **128** by a bearing **156**.

[0039] The second spur gear **138** and third spur gear **140** are coupled to and rotatable with a second gear shaft **158**. The second spur gear **138** is coupled to and disposed proximal to a first end of the second gear shaft **158** that is supported in the second output assembly housing portion **128**, and the third spur gear **140** is coupled to and disposed proximal to a middle or a second end of the second gear shaft **158** that is supported in the first output assembly housing portion **126**. The second spur gear **138** is also aligned with and includes gear teeth meshingly engaged with gear teeth of the first spur gear **136**.

[0040] The fourth spur gear **142** and fifth spur gear **144** are coupled to and rotatable with a third gear shaft **160**. The fourth spur gear **142** is coupled to and disposed proximal to a first end of the third gear shaft **160** that is supported in the second output assembly housing portion **128**, and the fifth spur gear **144** is coupled to and disposed proximal to a middle or a second end of the third gear shaft **160** that is supported in the first output assembly housing portion **126**. The fourth spur gear **142** is also aligned with and includes gear teeth meshingly engaged with gear teeth of the third spur gear **140**.

[0041] The sixth spur gear **146** is coupled to and rotatable with a fourth gear shaft **162** that is supported in the first output assembly housing portion **126**. The sixth spur gear **146** is also aligned with and includes gear teeth that are meshingly engaged with gear teeth of the fifth spur gear **144** and meshingly engaged with gear teeth of an output gear portion **148** of the drive portion **122**. As shown in FIG. **5**, the drive portion **122** is supported in the first and second output assembly housing portions **126**, **128** by bearings **164**, **166**, respectively, disposed on opposite sides of the output gear portion **148**, with the drive lug **130** extending out of the first output assembly housing portion **126**.

[0042] The trigger **108**, which can be actuated by a user to selectively cause power to be supplied from a power source, is operable to cause the motor **106** to provide torque to the output assembly **104** to cause the drive portion **122**/drive lug **130** to rotate in a desired rotational direction. The trigger **108** may also be operably coupled to the switch assembly **114** that is adapted to cause power to be supplied from the power source to the motor **106** when the trigger **108** is actuated.

[0043] In an example, the trigger **108** is a toggle trigger capable of rotating or pivoting in first and second toggle directions to cause the motor **106** to rotate the motor shaft **120**, where the first toggle direction drives the motor shaft **120** in a first motor direction (or first rotational direction), and the second toggle direction drives the motor shaft **120** in a second motor direction (or second rotational direction). The rotational direction of the drive portion **122**/drive lug

130 may correspond to the motor direction, and thus can be selected by actuation of the trigger **108** in the desired first or second toggle direction. Additionally, the trigger **108** and/or switch assembly **114** may also include a variable speed type mechanism. In this regard, actuation of the trigger **108** causes the motor to operate at a faster speed the further the trigger **108** is actuated.

[0044] In another example, the trigger **108** can be a linearly depressible type trigger, where a user can depress the trigger **108** inwardly to selectively cause power to be supplied from a power source and cause the motor **106** to provide torque to the output assembly **104** and cause the drive portion **122**/drive lug **130** to rotate in a desired rotational direction. The trigger **108** may again be operably coupled to the switch assembly **114** that is adapted to cause power to be supplied from the power source to the motor **106** when the trigger **108** is actuated. The trigger **108** may also be outwardly biased, relative to the tool housing **102**, such that the trigger **108** is inwardly depressible by a user to cause the tool **100** to operate, and a release of the trigger **108** causes the trigger **108** to biasedly move outwardly, relative to the tool housing **102**, to cease operation of the tool **100** via the biased nature of the trigger **108**. The trigger **108** and switch assembly **114** may also be a variable speed type mechanism. In this regard, actuation or depression of the trigger **108** causes the motor to operate at a faster speed the further the trigger **108** is depressed. However, any suitable trigger **108** or switch can be implemented without departing from the spirit and scope of the present invention.

[0045] In an example, the motor **106** is a brushless DC (BLDC) motor, and the tool **100** includes motor control electronics and/or controller(s) (which may be incorporated into the switch assembly **114** or separate) operably coupled to and adapted to control the motor **106**. For example, referring to FIG. **7**, the motor control electronics may include a printed circuit board (PCB) including one or more switching elements disposed thereon. The switching elements may be field effect transistors (FETs), such as, for example, metal-oxide semiconductor field-effect transistors (MOSFETs). In an embodiment, the switching elements may include three high-side switching elements, H**1**, H**2**, and H**3**, and three low-side switching elements, L**1**, L**2**, and L**3**, each being operable in either one of a first or conducting state and a second or non-conducting state. The switching elements are controlled by the PCB to selectively apply power from a power source (e.g., a battery pack) to the motor **106** to achieve desired commutation. By selectively activating particular high-side and low-side switching elements, the motor **106** is operated by having the motor control electronics or controller send a current signal through coils located on a stationary part of the motor **106** called a stator. The coils cause a magnetic force to be applied to a rotating part of the motor **106**, called a rotor, when current runs through the coils. The rotor contains permanent magnets that interact with the magnetic forces caused by the windings of the stator. By selectively activating successive combinations of high and low-side switching elements in a particular order, thereby sending a particular order of current signals through the windings of the stator, the stator creates a rotating magnetic field which interacts with the rotor causing it to rotate, which rotates the motor shaft **120** in a desired direction and at a desired speed, in a well-known manner.

[0046] Thus, when the tool **100** is used in a motorized torque application mode, the trigger **108** is actuated and the motor control electronics and/or controller(s) cause the motor shaft **120** to rotate, depending on actuation of the trigger **108**, and thereby cause the first bevel gear **132** to rotate. The first bevel gear **132** causes the second bevel gear **134** and first spur gear **136** to rotate. The first spur gear **136** causes the second spur gear **138** and third spur gear **140** to rotate. The third spur gear **140** causes the fourth spur gear **142** and fifth spur gear **144** to rotate. The fifth spur gear **144** causes the sixth spur gear **146** to rotate, and the sixth spur gear **146** causes the drive portion **122**/drive lug **130** to rotate and apply motorized torque to a work piece.

[0047] However, it may be desirable for a user to apply a manual load or torque to a work piece, by rotating the tool **100** by hand, in a manual torque application mode. In this situation, the tool **100** includes a locking mechanism that locks rotation of the drive mechanism (i.e., the drive portion **122** and/or gear assembly **124**) with respect to the tool **100** to prevent the drive portion **122** and/or gear assembly **124** from back driving and spinning the motor shaft **120**.

[0048] Referring to FIG. **6**, in an embodiment, the tool **100** includes a locking mechanism in the form of a lock button **170** that is operably coupled to the motor control electronics and/or controller(s). When the lock button **170** is selectively depressed or otherwise actuated by a user, the motor control electronics and/or controller(s) activates (i.e., places in a conducting state) all high-side switching elements (H**1**, H**2**, and H**3**). This causes the motor **106** to rotationally hold or lock a position of the rotor and/or motor shaft **120** and allows for the tool **100** to be used in a manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand. During manual loading or torquing, the high-side switching elements (H**1**, H**2**, and H**3**) prevent the drive portion **122** and/or gear assembly **124** from being back driven.

[0049] Alternately, when the lock button **170** is depressed or otherwise actuated by a user, the motor control electronics and/or controller(s) activates (i.e., places in a conducting state) all low-side switching elements (L**1**, L**2**, and L**3**). This causes the motor **106** to rotationally hold or lock a position of the rotor and/or motor shaft **120** and allows for the tool **100** to be used in the manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand. During manual loading or torquing, the low-side switching elements (L**1**, L**2**, and L**3**) prevent the drive portion **122** and/or gear assembly **124** from being back driven.

[0050] Referring to FIG. **8**, in another embodiment, the tool **100** includes a locking mechanism in the form of an electrically off brake **270**. The electrically off brake **270** may be operably coupled to a rear end of the motor shaft **120** and/or rotor of the motor **106** behind the motor **106**, between the motor **106** and the switching assembly **114**. Alternately, the electrically off brake **270** may be operably coupled to a front end of the motor shaft **120** between the motor **106** and the gear assembly **124**. The electrically off brake **270** is also operably coupled to the trigger **108**, switch assembly **114**, motor control electronics and/or controller. The electrically off brake **270** is normally in a locked position when the trigger **108** is not actuated (i.e., the motor is not being supplied with power) and automatically locks a rotational position of the motor shaft **120** and thereby rotation of the drive portion **122** and/or gear assembly **124** with respect to the tool **100**. The electrically off brake **270** may mechanically clamp, by means of a spring clamping a friction material against the motor shaft **120** and/or rotor of the motor **106** to rotationally hold and prevent the motor shaft **120** and/or rotor from rotating to allow for the tool **100** to be used in the manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand. During manual loading or torquing, the electrically off brake **270** prevents the drive portion **122** and/or gear assembly **124** from being back driven.

[0051] Once the trigger **108** is actuated, the tool **100** operates in the motorized torque application mode to apply motorized torque to a work piece, and electric power is applied to the electrically off brake **270** causing the electrically off brake **270** to release (i.e., be in an unlocked position), for example, by means of a solenoid, When the electrically off brake **270** is released, the motor shaft **120** and/or rotor of the motor **106** are allowed to rotate to apply motorized torque to a work piece. When trigger **108** is released, the electrically off brake **270** will return to its normal locked position automatically locking the motor shaft **120** and/or rotor from rotating, and the tool **100** can again be used in the manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand.

[0052] Referring to FIG. **9**, in another embodiment, the tool **100** includes a locking mechanism in the form of a mechanical lock mechanism **370**. The mechanical lock mechanism **370** includes a plate **372**, a plate guide **374**, and bias member **376**, and a hex portion **378** coupled to or formed on a rear end of the motor shaft **120**. The plate guide **374** may be a separate piece disposed in and coupled to the tool housing **102** behind the motor **106** or formed directly in the tool housing **102**. The plate guide **374** includes first and second plate slots **380**, **382** adapted to respectively receive first and second sides of the plate **372** and allow the plate **372** to slide within the first and second plate slots **380**, **382**.

[0053] The plate **372** is slidably disposed in the first and second plate slots **380**, **382** and includes a keyhole **384** and a lock button **386** extending from an end of the plate **372**, and the lock button **386** is adapted to extend out of the tool housing **102** when the mechanical lock mechanism **370** is assembled into the tool housing **102**. The keyhole **384** includes a first hole portion **388** that receives and is larger than the hex portion **378**, and a second hole portion **390** that that is adapted to engage opposing sides of the hex portion **378** when the hex portion **378** is disposed in the second hole portion **390**.

[0054] The bias member **376** may be in the form of a spring or other type of bias member. The bias member **376** applies a bias force to an end of the plate **372** opposite the lock button **386** to bias the plate **372** in a first direction to cause the hex portion **378** to be disposed in the first hole portion **388**. When the hex portion **378** is disposed in the first hole portion **388**, the mechanical lock mechanism **370** is in an unlocked position. In the unlocked position, the tool **100** can be used in the motorized torque application mode to apply motorized torque to a work piece.

[0055] However, when a user selectively depresses the lock button **386** against the force of the bias member **376**, the plate **372** is slid or moved along the first and second slots in a second direction to cause the hex portion **378** to be disposed in the second hole portion **390**. When the hex portion **378** is disposed in the second hole portion **390**, edges of the plate **372** surrounding the second hole portion **390** engage opposing sides of the hex portion **378** and prevent the motor shaft **120** and/or rotor of the motor **106** from rotating, and the mechanical lock mechanism **370** is a locked position. In the locked position, the motor shaft **120** is prevented from rotating to allow for the tool **100** to be used in the manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand.

[0056] When the lock button **386** is released, the bias member **376** biases the plate **372** in the first direction to cause the hex portion **378** to be disposed in the first hole portion **388** to dispose the mechanical lock mechanism **370** in the unlocked position.

[0057] Referring to FIGS. **10** and **11**, in another embodiment, the tool **100** includes a locking mechanism in the form of a locking bar **470** and bias member **472**. In this embodiment, the first bevel gear **132** is modified to include gear teeth **474** on an end of the shaft portion proximal to the motor **106**. The mechanical locking bar **470** includes locking teeth **476** that engage the gear teeth **474** when the locking bar **470** is disposed in a locked position to prevent the gear assembly **124** and/or motor shaft **120** from rotating to allow for the tool **100** to be used in the manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand.

[0058] The bias member **472** may be in the form of a spring or other type of bias member. The bias member **472** applies a bias force to the locking bar **470** in a direction away from the trigger to cause the locking teeth **476** to be disengaged from the gear teeth **474**. This causes the locking bar **470** to be disposed in an unlocked position. In the unlocked position, the tool **100** can be used in the motorized torque application mode to apply motorized torque to a work piece.

[0059] The locking bar **470** may include a tab **478** that is selectively movable by a user in a direction towards the trigger **108** to cause the locking bar **470** to move in a direction towards the trigger **108** and the locking teeth **476** to engage the gear teeth **474**. When the locking teeth **476** are engaged with the gear teeth **474**, the locking bar **470** is disposed in the locked position and prevents the gear assembly **124** and/or motor shaft **120** from rotating to allow for the tool **100** to be used in the manual torque application mode, in which a user can apply manual torque to a work piece by rotating the tool **100** by hand.

[0060] When the tab **478** is released, the bias member **472** biases the locking bar **470** in a direction away from the trigger to cause the locking teeth **476** to be disengaged from the gear teeth **474**, and the locking bar **470** to be disposed in the unlocked position.

[0061] Referring to FIG. **12**, in another embodiment, the tool **100** includes a locking mechanism in the form of a modified gear assembly that includes a worm drive **570**. The worm drive **570** includes a worm gear **572** coupled to the motor shaft **120**, instead of the first bevel gear **132** described above, and a spur gear **574**, instead of the second bevel gear **134** described above, that meshingly engages the worm gear **572**. In this embodiment, in the motorized torque application mode, the worm gear **572** transmits power through the gear assembly including a plurality of spur gears (such as the first through sixth spur gears **136-146** described above) adapted to transfer rotary motion of the motor shaft **120**, and worm gear **572** and spur gear **574** to the drive portion **122**.

[0062] In this embodiment, the worm gear **572** provides an increased gear ratio in a small area compared to the bevel gears described above. The worm gear **572** may also automatically prevent the motor shaft **120** from rotating during manual loading. The spur gear **574** is disposed about 90 degrees relative to the worm gear **572**, and the spur gear **574** is unable to rotate the worm gear **572** during manual loading because the spur gear **574** does not provide enough rotational force to overcome the frictional force between the spur gear **574** and the worm gear **572**. Thus, the worm drive **570** allows motorized torque to be applied to a work piece via the tool **100**, but also prevents the gear assembly and/or motor shaft **120** from being back driven to allow for manual torque to be applied to a work piece via a user rotating the tool **100** by hand.

[0063] Referring to FIGS. **13-15**, in another embodiment, the tool **100** includes a locking mechanism in the form of a two-way sprag clutch **670**. The two-way sprag clutch **670** may be disposed between the motor shaft **120** and the first bevel gear **132**. The two-way sprag clutch **670** includes an input plate **672** and a driven plate **674**. The input plate **672** includes two lugs **676**, that in either direction respectively push on pairs of rollers **678** that prevent the sprag clutch **670** from locking and allow for the transmission of power to the drive portion **122** when the tool is used in the motorized torque application mode to apply motorized torque to a work piece. However, when power is not being supplied to the motor **106**, the sprag clutch **670** automatically locks the gear assembly **124** from rotation. For example, when the tool is used in the manual torque application mode to apply manual torque to a work piece via a user rotating the tool **100** by hand, a manual load is applied to the sprag clutch **670** in either direction, and plungers or springs **680** respectively push the rollers **678**, wedging the rollers **678** against the tool housing **102** or an inner bearing surface of the first output assembly housing portion **126**. The rollers **678** lock the gear assembly **124** from rotation during manual application of torque, and the sprag clutch **670** remains locked until the tool **100** is driven via the motor or a manual load is applied in an opposite direction.

[0064] Thus, the tool **100** can be used to apply torque to a work piece in a motorized torque application mode via actuation of the trigger **108**, which causes power to be supplied to the motor **106** to rotate the drive lug **130**. The tool **100** can also be used to apply torque to a work piece in a manual torque application mode via a user manually rotating the tool **100**. As described herein various locking mechanism can be used to selectively rotationally lock the drive mechanism, so that a manual torque application may be applied to a work piece. Therefore, the present invention provides the ability to use a power tool, such as the tool **100**, selectively in either a motorized or powered torque application.

[0065] As used herein, the term "coupled" and its functional equivalents are not intended to necessarily be limited to direct, mechanical coupling of two or more components. Instead, the term "coupled" and its functional equivalents are intended to mean any direct or indirect mechanical, electrical, or chemical connection between two or more objects, features, work pieces, and/or environmental matter. "Coupled" is also intended to mean, in some examples, one object being integral with another object. As used herein, the term "a" or "one" may include one or more items unless specifically stated otherwise.

[0066] The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only and not as a limitation. While particular embodiments have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made without departing from the broader aspects of the inventors' contribution. The actual scope of the protection sought is intended to be defined in the following claims when viewed in their proper perspective based on the prior art.

1. A power tool including a drive portion and a motor with a motor shaft adapted to drive the drive portion that is adapted to engage a work piece, the power tool comprising:
- a gear assembly operably coupled to the motor shaft and the drive portion and adapted to transfer rotational motion of the motor shaft to the drive portion; and
- a locking mechanism adapted to prevent rotation of at least one of the motor shaft, gear mechanism, and drive portion to allow for manual torque application to the work piece with the power tool.

2. The power tool of claim **1**, wherein the motor is a brushless motor, and the locking mechanism includes a lock button, wherein when the lock button is actuated, all high-side switching elements or all low-side switching elements are placed in a conducting state to prevent rotation of the motor shaft to allow for manual torque application.

3. The power tool of claim **1**, wherein the locking mechanism includes an electrically off brake.

4. The power tool of claim **3**, wherein the electrically off brake is operably coupled to the motor shaft, wherein when power is supplied to the motor, the electrically off brake allows the motor shaft to rotate, and when power is not supplied to the motor, the electrically off brake prevents rotation of the motor shaft to allow for manual torque application.

5. The power tool of claim **4**, wherein the electrically off brake mechanically clamps the motor shaft when power is not supplied to the motor to prevent rotation of the motor shaft to allow for manual torque application.

6. The power tool of claim **1**, wherein the locking mechanism includes a plate that is movable between locked and unlocked positions, wherein when the plate is in the locked position, the plate prevents rotation of the motor shaft to allow for manual torque application, and when the plate is in the unlocked position, the plate allows the motor shaft to rotate.

7. The power tool of claim **6**, wherein the locking mechanism includes a bias member adapted to bias the plate into the unlocked position.

8. The power tool of claim **6**, wherein the plate includes first and second hole portions, and when the plate is in the unlocked position, a hex portion of the motor shaft is disposed in the first hole portion and the plate allows the motor shaft to rotate, and when the plate is in the locked position, the hex portion of the motor shaft is disposed in the second hole portion and the plate prevents rotation of the motor shaft to allow for manual torque application.

9. The power tool of claim **1**, wherein the locking mechanism includes a locking bar that is movable between locked and unlocked positions, wherein when the locking bar is in the locked position, the locking bar prevents rotation of the motor shaft to allow for manual torque application, and when the locking bar is in the unlocked position, the locking bar allows the motor shaft to rotate.

10. The power tool of claim **1**, wherein the locking mechanism includes a sprag clutch.

11. The power tool of claim **1**, further comprising a trigger that when actuated, causes power to be supplied to the motor to rotate the motor shaft.

12. The power tool of claim **11**, wherein the trigger is a toggle trigger actuatable in first and second toggle directions.

13. The power tool of claim **12**, wherein when the toggle trigger is actuated in the first toggle direction, the motor causes the motor shaft to rotate in a first rotational direction, and when the toggle trigger is actuated in the second toggle direction, the motor causes the motor shaft to rotate in a second rotational direction.

14. The power tool of claim **10**, wherein the sprag clutch is disposed between the motor shaft and the gear assembly.

15. A power tool including a drive portion and a motor with a motor shaft adapted to drive the drive portion, the power tool comprising:

a gear assembly operably coupled to the motor shaft and the drive portion and adapted to transfer rotational motion of the motor shaft to the drive portion, wherein the gear assembly includes a worm gear coupled to the motor shaft and a spur gear meshingly engaged with the worm gear, and the spur gear is unable to rotate the worm gear when a manual torque application is applied by the drive portion.

16. The power tool of claim **15**, further comprising a trigger that, when actuated, causes power to be supplied to the motor to cause the motor shaft to rotate to cause the drive portion to rotate.

17. The power tool of claim **16**, wherein the trigger is a toggle trigger selectively actuatable in first and second toggle directions.

18. The power tool of claim **17**, wherein when the toggle trigger is actuated in the first toggle direction, the motor causes the motor shaft to rotate in a first rotational direction, and when the toggle trigger is actuated in the second toggle direction, the motor causes the motor shaft to rotate in a second rotational direction.

19. The power tool of claim **16**, wherein the motor is a brushless motor.

20. The power tool of claim **19**, further comprising motor control electronics operably coupled to the motor and the trigger and adapted to control operation of the motor.

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