

A GEARED TORQUE TOOL AND A UNITARY SUBASSEMBLY FOR THE SAME

TECHNICAL FIELD

The disclosure relates generally to portable power tools, and more particularly to subassemblies
5 for a geared torque tool.

BACKGROUND

Geared torque tools are portable power tools that comprise a transmission, e.g. defining a planetary
gearset, and a motor providing torque to the transmission. The motor typically provides low torque
at high rotational rates to the transmission, which then drives an output shaft at a relatively reduced
10 rotational rate and high torque. For example, the output shaft may define or be coupled to a head
that mates the output shaft to a threaded fastener so as to torque the fastener for fastening to a
substrate. The motor is typically an electric motor powered by a battery. A controller is connected
to the motor to control the motor to provide well-controlled or precision torque through the output
shaft. For example, electrical current received by the motor may be monitored by the controller to
15 infer a torque at the output shaft. The power supplied to the motor may be varied based on the
torque supplied to the output shaft to achieve a precise desired torque at the output shaft.

Electric motors and transmissions in geared torque tools are commonly housed and affixed or
frictionally coupled to a housing assembly. For example, frictionally coupling may involve
forming an interference fit between a part of the housing assembly and complementary portion of
20 the electric motor. The housing assembly defines an outer part of the tool (an outer shell) and will
usually form a handle for use by an operator. The housing assembly is typically constructed of
plastic due to manufacturability, e.g. via injection moulding, and cost effectiveness. In some cases,
one or more metal elements (couplers) may connect a plastic outer shell to the motor and/or
transmission.

25 For example, U.S. Patent No. 10,357,871 B2 dated 23 July 2019 discloses a precision torque
screwdriver that has a main housing defining the outside of the tool. The main housing houses a
transmission and a motor. The transmission receives torque from a motor. The transmission is

affixed to the main housing. A trigger of the torque screwdriver is fixed to the main housing via a holder thereof.

A variety of off-the-shelf electrical motors and transmissions are available and may be used together in such constructions. Using well-tested off-the-shelf components can provide cost advantages and lead to improved reliability and robustness of the overall system.

Improvements in efficiency and accuracy of applied torque are desired. It desired to achieve such improvements by maintaining reliability and avoiding costly configurations.

SUMMARY

In an aspect, the disclosure describes a geared torque tool. The geared torque tool also includes a motor defining a rotor and a stator; an exterior housing assembly securably for housing the motor by coupling to the stator; and a geartrain coupled to the rotor for torque transmission, and integrally coupled to the stator, separately from the exterior housing assembly, to support the geartrain during the torque transmission.

In an aspect, the disclosure describes a unitary subassembly for a geared torque tool. The subassembly also includes a motor defining a stator and a rotor for rotation around an axis of rotation; and a geartrain coupled to the rotor for torque transmission and directly integrally coupled to the stator axially adjacent to the motor for support and to form the unitary subassembly.

In an aspect, the disclosure describes a method of manufacturing a geared torque tool. The method of manufacturing also includes forming a subassembly by coupling a geartrain to a rotor and a stator of a motor such that torque is transmitted from the rotor to the geartrain while the geartrain is supported by the stator; and securably housing the subassembly at least partially within an exterior housing assembly.

Embodiments can include combinations of the above features.

Further details of these and other aspects of the subject matter of this application will be apparent from the detailed description included below and the drawings.

DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying drawings, in which:

FIG. 1A is a perspective view of an exemplary geared torque tool;

FIG. 1B is an exploded perspective view of the geared torque tool of **FIG. 1A**;

FIG. 2 is a side elevation view of the torque tool with a portion of the exterior housing assembly removed to expose the motor as coupled to another portion of the exterior housing assembly, in accordance with an embodiment;

- 5 **FIG. 3** is a perspective partially exploded view of the torque tool illustrating construction of the exterior housing assembly to house the motor, in accordance with an embodiment;

FIG. 4 is an exploded view of the unitary drive assembly, in accordance with an embodiment;

FIG. 5A is a side elevation view of an exemplary unitary drive assembly, in accordance with an embodiment;

- 10 **FIG. 5B** is cross-sectional view along line **5B-5B** in **FIG. 5A**;

FIG. 6A is an exploded perspective of a stator and a stator head, in accordance with an embodiment;

FIG. 6B is a front elevation view of the stator of **FIG. 6A**;

FIG. 6C is a cross-sectional view of the stator along lines **6C-6C** in **FIG. 6B**;

- 15 **FIG. 7** is a rear perspective view of the gearbox and the stator head, in accordance with an embodiment;

FIG. 8A is an exploded view of the gearbox, in accordance with an embodiment;

FIG. 8B is an enlarged view of the region **8B** in **FIG. 8A** along with the stator head, in accordance with an embodiment;

- 20 **FIG. 9** is a flowchart of an exemplary method of manufacturing a geared torque tool; and

FIG. 10 illustrates a block diagram of a computing device, in accordance with an embodiment.

DETAILED DESCRIPTION

The following disclosure relates to geared torque tools and methods of manufacturing the same.

In some embodiments, aspects disclosed herein can facilitate more accurate and efficient

- 25 application of torque.

Torque generated by geared torque tools can be very large. It is desirable to have such torque generated and applied in a predictable and efficient manner. A desired torque may be applied using feedback control of the torque tool motor based on data from sensors. It is found that undesirable

- variations and disturbances, as well as inefficiencies, during operation of a geared torque tool can arise due to structural aspects of the geared torque tool. For example, it is found that undesirable deformation of the handle(s) and the exterior housing assembly of the torque tool during operation can lead to significant disturbances and inefficiencies if the motor and geartrain are coupled to each other via the handle(s) and/or the exterior housing assembly. A unitary subassembly (a unitary drive assembly), comprising both the motor and geartrains coupled to each other as a single unit, separate from the exterior housing assembly but coupled thereto is found to cost effectively improve structural rigidity and integrity so as to reduce undesirable disturbances and inefficiencies during operation.
- 10 In various embodiments, a stator of the motor is integrally coupled to a gear of the geartrain that is suitable to remain stationary during operation of the geared torque tool. The stator of the motor may be integrally coupled to the geartrain at least partially parallel to an axis of rotation of a rotor of the stator. In some embodiments, the geartrain and the stator may be coupled to each other via one or more intervening components lying between the geartrain and the stator.
- 15 Aspects of various embodiments are described in relation to the figures.

FIG. 1A is a perspective view of an exemplary geared torque tool **100**.

FIG. 1B is an exploded perspective view of the geared torque tool **100** of **FIG. 1A**.

- The torque tool **100** comprises a motor **103** securably housed within an exterior housing assembly **102**. The motor **103** defines a rotor and stator. In **FIGS. 1A-1B**, the exterior housing assembly **102** is a handle assembly. However, it is understood that such an exterior housing assembly **102** may be free of handle(s). For example, the torque tool **100** may be remotely controlled with a pendant. In some embodiments, the exterior housing assembly **102** may be a housing of unitary construction.
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- For example, the motor **103** may be a brushless direct current (DC) electrical motor that may be powered via one or more batteries. It is understood that other types of motors may be suitable in certain applications.
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FIG. 2 is a side elevation view of the torque tool **100** with a portion of the exterior housing assembly **102** removed to expose the motor **103** as coupled to another portion of the exterior housing assembly **102**, in accordance with an embodiment.

FIG. 3 is a perspective partially exploded view of the torque tool **100** illustrating construction of the exterior housing assembly **102** to house the motor **103**, in accordance with an embodiment.

A stator of the motor **103** is coupled to the exterior housing assembly **102** to hold the exterior housing assembly in a stationary position relative to the rotor during operation. For example, as
5 shown in **FIGS. 1A-1B** and **FIGS. 2-3**, the exterior housing assembly **102** may be secured to the motor **103** via a plurality of threaded fasteners.

As shown in **FIGS. 1A-1B** and **FIGS. 2-3**, the motor **103** is coupled to a geartrain of a gearbox **104** to form a unitary drive assembly **122** terminating in an output shaft **106**. The unitary drive assembly **122** forms a subassembly of the torque tool **100** that acts as a single unit. As referred to
10 herein, a “unitary assembly” may refer to components that are coupled to each other to achieve a common purpose and that are substantially rigidly attached to each other so as to form a single unit. For example, “unitary drive assembly” may refer to a motor and a geartrain coupled to each other to achieve torque transmission and attached to each other such that the stator of the motor and carriers of the geartrain are held substantially rigidly stationary relative to each other. In
15 particular, in the unitary drive assembly **122**, the geartrain is coupled to a rotor of the motor **103** for torque transmission and integrally coupled to the stator of the motor **103** via a stator head **124** to support the geartrain during such torque transmission. The stator head **124** defines a central aperture for receiving a rotor shaft. The rotor shaft extends through the stator head **124**. The geartrain is directly coupled to the stator, separately from the exterior housing assembly **102**, so as
20 to form the unitary drive assembly **122** and for supporting the geartrain (by the stator) during torque transmission.

In some embodiments, the stator head **124** is fastened directly on to the exterior housing assembly **102**. In **FIG. 2**, the stator head **124** is shown with two apertures with one of the apertures being engaged with a fastener. During construction, a portion of the exterior housing assembly **102** is
25 integrally coupled to the stator **136** via fasteners engaging with the apertures.

In some embodiments, the motor **103** and the gearbox **104** are arranged in sequence, axially adjacent to each other (relative to a longitudinal axis **108** defining an axis of rotation of the rotor), and/or non-overlapping with (or at least partially nested within) each other. Advantageously, such a sequential arrangement may facilitate modular construction of the unitary drive assembly **122** of
30 the torque tool **100**.

The output shaft **106** extends axially outwardly from the gearbox **104** distal from the motor **103**. The output shaft **106** is operable by the motor via the gearbox **104** so as to cause the output shaft **106** to rotate about the longitudinal axis **108**. The output shaft **106** may define, or be suitable to couple with a tool head defining, a mating adapter or spindle for mating with a workpiece, e.g. a threaded fastener, to allow rotation thereof by the torque tool **100**.

As shown in **FIG. 3**, the exterior housing assembly **102** comprises a first portion **102A** and a second portion **102B** complementary to the first portion **102A**. The first and second portions **102A, 102B** are securably fastened to respective first and second sides of the motor **103** (sides of the stator thereof) that are opposite to each other. In such a manner, the exterior housing assembly **102** at least partially covers the motor, and a stator thereof, and forms a handle **110** of the exterior housing assembly **102** to allow an operator to grasp the torque tool **100**. In various embodiments, the first and second portions **102A, 102B** may be handle portions.

In some embodiments, the first exterior housing portion may be securably fastened to a first side of the gearbox **104**, including its geartrain, and the second portion may be securably fastened to a second side of the gearbox **104**, including its geartrain, that is opposite to the first side so as to cover the gearbox **104**. The first and/or second portions may be directly fastened to the first and second sides of the gearbox **104**.

In various embodiments, a trigger **112** may be mounted on the handle **110** or proximal thereto so as to allow the operator to operate the torque tool **100**. In various embodiments, the exterior housing assembly **102** may further comprise a trigger guard **114** for preventing accidental engagement of the trigger **112**.

A controller **117** may be housed at least partially within or between the two portions **102A, 102B** of the exterior housing assembly **102**. In various embodiments, the controller **117** may be housed at an end of the handle **110** distal from the motor **103**. The controller **117** may be securably sandwiched between the first and second portions **102A, 102B** of the exterior housing assembly **102**. The controller **117** may be disposed in a pocket formed between the first and second portions **102A, 102B**. In various embodiments, the controller **117** may be fastened to the portions **102A, 102B** and thereby held securely between the two portions **102A, 102B**. Advantageously, in some embodiments, a portion of the controller **117** (e.g. a housing thereof) may form a lower terminal end of the exterior housing assembly **102**.

A battery pack **118** may be engaged with the exterior housing assembly **102**. In various embodiments, the battery pack **118** may directly engage with the controller **117** and may be wholly disposed adjacent thereto. One or more batteries of the battery pack **118** may be connected to the motor **103** for powering the motor **103**. For example, a dual battery pack may include two batteries acting cooperatively to power the motor **103**.

In various embodiments, the exterior housing assembly **102** may at least partially be formed of plastic or other cost effective material, e.g. the portions **102A**, **102B** may be injection molded plastic parts. Such materials may easily deform and fail under repeated and/or excessive loading, but may provide cost advantages and improved manufacturability. For example, in some embodiments, ergonomic or textured handling surfaces may be cost-effectively achieved.

The motor may provide a high rotational speed, low torque input to the gearbox **104**. In turn, the gearbox **104** may generate low rotational speed, high torque output via the output shaft **106**. Advantageously, this may allow application of high torque by the use of relatively small motors.

The motor **103** may be fastened to the gearbox **104** at a low torque end of a geartrain of the gearbox **104**. Advantageously, this may enhance structural integrity of the unitary drive assembly **122** as a unit, e.g. by mitigating application of high torque on to fastening or joining portions between the motor **103** and the gearbox **104**.

The torque tool **100** may comprise a controller operably coupled to the motor. The torque tool **100** may comprise one or more sensors, e.g. an encoder for measuring a shaft rotation. The controller may be configured to control the motor based on data generated by the sensors so as to achieve controlled torque at the output shaft **106**. Controlled torque may include a predetermined torque level or a predetermined torque curve.

The unitary drive assembly **122** of the torque tool **100** may adapted to rigidly couple to an end of an external reaction arm **107**, e.g. by frictional engagement or fastening engagement of a ring **116** of the gearbox **104** with a slot on the reaction arm **107** that is complementary to the ring **116**. For example, the reaction arm **107** may be a metal bar or other rigid component. Another end of the reaction arm **107** may be rigidly coupled to or attached to a non-moving structure to allow rotation of the output shaft **106**, a gearset of the gearbox **104** that is engaged for rotation with the output shaft **106**, and a rotor of the motor that is operably engaged with the gearset to power the shaft **106**, without rotation of a stator of the motor **103**, the exterior housing assembly **102**, and a carrier of the gearset in the gearbox **104**. Such an arrangement may be structurally advantageous, since

the unitary drive assembly **122** may be held in place without putting the typically structurally weak exterior housing assembly **102** under excessive loading. It is understood that a reaction arm **107** may not be provided in some embodiments.

In various embodiments, the exterior housing assembly **102** may comprise openings **120**, e.g., vents, that expose a portion of the motor to ambient air so as to allow cooling of the motor during operation. Advantageously, such portion of the motor may be a stationary (relative to the exterior housing assembly **102**) portion and may comprise fins or other features to enhance heat rejection away from the motor. For example, enhanced heat rejection of a stator portion may be achieved. The exterior housing assembly **102** may additionally comprise textured surfaces for facilitating handling by an operator. For example, textured surfaces may be provided at a rear and/or side portion of the handle **110**.

FIG. 4 is an exploded view of the unitary drive assembly **122**, in accordance with an embodiment.

FIG. 5A is a side elevation view of an exemplary unitary drive assembly **122**, in accordance with an embodiment.

FIG. 5B is cross-sectional view along line **5B-5B** in **FIG. 5A**.

The unitary drive assembly **122** may be suitable to couple with the exterior housing assembly **102** as a subassembly of the torque tool **100**. The unitary drive assembly **122** may be secured to the exterior housing assembly **102**. The unitary drive assembly **122** may be partially or wholly housed in the exterior housing assembly **102**. The unitary drive assembly **122** may integrally couple to a reaction arm **107** so as to hold the unitary drive assembly **122** stationary. As such, positioning and support of the motor **103** and gearbox **104** of the torque tool **100** during operation may be achieved without the exterior housing assembly **102**. Advantageously, in various embodiments, ease of operation and improved rigidity may be achieved in a cost effective manner.

As shown in **FIG. 4** and **FIGS. 5A-5B**, a rotor **130** of the motor **103** is coupled to the geartrain of the gearbox **104** for torque transmission. The geartrain is defined by a plurality of sequentially-arranged planetary gearsets **134A**, **134B**, **134C**, **134D**, **134E** supported in a plurality of carriers **132A**, **132B**, **132C** and connecting components, such as adapter plate **142**. In various embodiments, the adapter plate **142** may be annulus. Each of the carriers **132A**, **132B**, **132C** may be an annulus surrounding one or more planetary gearsets for supporting the planetary gearsets **134A**, **134B**, **134C**, **134D**, **134E** for torque transmission. For example, each of the carriers **132A**,

132B, **132C** may define a corresponding annular or ring gear engaging with one or more planet gears of the planetary gearsets **134A**, **134B**, **134C**, **134D**, **134E**.

As shown in **FIG. 5B**, the stator **136** may be an annular stator comprising a core **128** and a sleeve **126** attached to the core **128**. Fins and other heat exchange surfaces may be formed on the sleeve **126** to facilitate heat transfer, e.g. through the openings **120**. The stator **136** is integrally coupled to the gearbox **104** via the stator head **124**. A plurality of fasteners **138** are sequentially received in apertures in the stator **136** and the stator head **124** to form a plurality of fastening connections. The plurality of fastening connections are distributed around a flange of the sleeve **126** to couple the geartrain to the sleeve **126**.

The rotor **130** may be contained within the core **128** of the stator **136**. The stator **136** may circumferentially surround the rotor **130**.

As shown in **FIG. 5B**, a shaft of the rotor **130** engages with a sun gear of the planetary gearset **134A**. The planet gears of the planetary gearset **134A** are engaged with an annular gear surrounding the planet gears and defined by the carrier **132A**. During operation, the planet and sun gears rotate within, and supported by, the stationary carrier **132A** to transmit shaft power (torque) to the planetary gearset **134B**. In an analogous manner, shaft power is transmitted from the planetary gearset **134B** to the planetary gearset **134C**, from the planetary gearset **134C** to the planetary gearset **134D**, and from the planetary gearset **134D** to the planetary gearset **134E**. During operation, the planet and sun gears of the planetary gearsets **134B**, **134C** rotate within, and are supported by, the stationary carrier **132B**, and the planet and sun gears of the planetary gearsets **134D**, **134E** rotate within, and are supported by, the stationary carrier **132C**. The output shaft **106** is engaged with the planetary gearset **134E** to provide output shaft power.

The planetary gearsets **134A**, **134B**, **134C**, **134D**, **134E** serve to increase torque from a low torque at a low torque end of the geartrain that is proximal to the motor **103** relative to the output shaft **106** to a high torque at a high torque end of the geartrain that is proximal to the output shaft **106** relative to the motor **103**. The stator **136** may be integrally coupled to a low torque end of the geartrain. Advantageously, this may facilitate maintaining fastening connections between the stator **136** and the geartrain.

The carrier **132A** may be engaged within the stator head **124**. Keyways or slots in the carrier **132A** may be engaged with protrusions **140** formed in the stator head **124** so as to integrally couple the carrier **132A** to the stator **136**.

During operation, the carriers **132A**, **132B**, **132C** may be held stationary by a reaction arm **107** integrally coupled to the geartrain and to the stator **136** (via the geartrain). The reaction arm **107** reacts against a stationary structure so as to support the torque tool **100** during operation.

As shown in **FIG. 5B**, the planets and sun gears of each planetary gearset may be arranged in a corresponding bracket. Retaining pins and/or other fasteners may be used to couple the bracket to the planet and sun gears.

A face of the geartrain is fastened to a face of the stator **136** that is non-parallel to the longitudinal axis **108**. In some embodiments, these faces may be perpendicular to the longitudinal axis **108**.

The fasteners **138** may couple integrally couple the stator **136** to the geartrain via the adapter plate **142**. The adapter plate **142** of the geartrain may be securably fastened to the sleeve **126** of the stator **136**. The adapter plate **142** may be coupled to the carrier **132B** via one or more detent assemblies, i.e. ball detent assemblies **144**. In various embodiments, detent assemblies may include wave-spring assemblies. The adapter plate **142** allows coupling of the stator **136** to the annular gear (annulus) defined by the carrier **132B**. In some embodiments, the stator **136** may be directly coupled to the adapter plate **142** or the annular gear defined by the carrier **132B**. As referred to herein, "annulus" may refer to an annular gear.

A collar **146** surrounds the geartrain at a low torque end thereof. The collar **146** is coupled to the adapter plate **142** via slots and keys that engage with the slots.

FIG. 6A is an exploded perspective of a stator **136** and a stator head **124**, in accordance with an embodiment.

FIG. 6B is a front elevation view of the stator of **FIG. 6A**.

FIG. 6C is a cross-sectional view of the stator along lines **6C-6C** in **FIG. 6B**.

In various embodiments, the sleeve **126** of the stator **136** is adhesively coupled to the core **128**, which may be hollow to receive the rotor **130** therethrough. In various embodiments, a thermally conductive adhesive couples the sleeve **126** to the core **128** of the stator **136** to allow heat dissipation. For example, the adhesive may be a heatsink glue or other type of adhesive configured for high thermal conductivity, e.g. a thermal conductivity of 1.4 W/m·K at 25 °C. In some embodiments, the adhesive may be an epoxy adhesive, e.g. a two-part adhesive. The adhesive may be configured to operate at up 150 °C or higher. The adhesive may be configured to bond metal to metal. In various embodiments, the adhesive may form a hard, durable material upon curing with

a hardness of 77 D so as to rigidly couple the sleeve **126** to the core **128**. Advantageously, the adhesive may be electrically insulating, e.g. a resistivity of the adhesive may be $9 \times 10^{12} \Omega \cdot \text{cm}$ or greater.

In some embodiments, the sleeve **126** is constructed of a metal or metal alloy. In some
5 embodiments, such a metal may be Aluminum, e.g. 6061 – T6 Aluminum. In various
embodiments, the sleeve **126** may be constructed of copper, titanium, or magnesium, or alloys
thereof.

The sleeve **126** may comprise a plurality of apertures for receiving fasteners for fastening the
handling assembly **102** to the stator **136**. For example, such apertures may allow fastening via
10 threaded fasteners.

FIG. 7 is a rear perspective view of the gearbox **104** and the stator head **124**, in accordance with
an embodiment.

FIG. 8A is an exploded view of the gearbox **104**, in accordance with an embodiment.

FIG. 8B is an enlarged view of the region **8B** in **FIG. 8A** along with the stator head **124**, in
15 accordance with an embodiment.

The collar **146** comprises keys distributed around an internal circumference of the collar **146**. The
keys are protrusions that extend radially inwardly from the internal circumference. The protrusions
are complementary to slots distributed around an outer circumference of the adapter plate **142** to
allow engagement of the protrusions with the slots to hold the collar **146** in-place relative to the
20 adapter plate **142**. The adapter plate **142** is rigidly fastened to the stator head **124** via fasteners **138**.
The adapter plate **142** is also rigidly coupled to a plate **148** via a plurality of fasteners.

The carrier **132A** is held stationary relative to the stator **136** by engagement of slots on an outer
circumference of the carrier **132A** with protrusions **140** formed in the stator head **124** to allow
rotation of the planetary gearset **134A** relative to the carrier **132A**.

25 The carrier **132B** is coupled to the adapter plate **142**, and components attached thereto, via the ball
detent assembly **144**. In particular, the carrier **132B** allows releasable fastening of the carrier **132B**
(an annular gear defined thereby) to the stator **136**. As shown in **FIG. 5B**, the adapter plate **142**
and the plate **148**, once fastened to each other, define an annular space therebetween for receiving
a rim of the carrier **132B**. The rim of the carrier **132B** includes slots or pockets for retaining therein
30 a spring and ball of the ball detent assembly **144**. A plurality of depressions, complementary to an

end of the ball of the ball detent assembly **144**, are formed on a rearward lip of the plate **148** that faces the rim of the carrier **132B** so as to receive the end of the ball of the ball detent assembly **144** to engage therewith. The plurality of depressions may be distributed circumferentially around the lip. The plurality of depressions represent pre-set angular positions of the carrier **132B**.

- 5 The carrier **132B** may serve as an indexing rotor of the geartrain to allow indexing (repositioning to a pre-set angular position) of the carrier **132B** relative to the stator head **124** (and adapter plate **142**). Selective engagement of one or more ball detent assemblies **144**, i.e. balls thereof with depressions on the rearward lip of the plate **148**, allows rotation of the carrier **132B** relative to the stator head **124**. In particular, the ball detent assembly **144** may be selectively disengageable by
- 10 torque applied to the carrier **132B** (the index rotor), e.g. by causing (a non-depressed portion) to push the ball to depress the spring to release the carrier **132B** for rotation relative to the plate **148** and the adapter plate **142**. In this case, rotation of the carrier **132B** may rotate planetary gearsets to rotate the output shaft **106**. This may allow repositioning of the handle **110** by rotation of the exterior housing assembly **102** relative to the output shaft **106**.
- 15 The one or more ball detent assemblies **144** may be distributed around the carrier **132B** at a low torque end of the geartrain so as to ensure fastening. In various embodiments, the size and number of the ball detent assemblies **144** may be adapted to withstand applied torque and prevent slippage.

FIG. 9 is a flowchart of an exemplary method **900** of manufacturing a geared torque tool.

- Step **902** of the method **900** includes forming a subassembly by coupling a geartrain to a rotor and a stator of a motor such that torque is transmitted from the rotor to the geartrain while the geartrain is supported by the stator. The geartrain may be supported rigidly by the stator.
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Step **904** of the method **900** includes securably housing the subassembly at least partially within an exterior housing assembly.

- Some embodiments of the method **900** include fastening the geartrain to the stator to integrally couple the stator to the geartrain.
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Some embodiments of the method **900** include securably fastening a first exterior housing portion to a first side of the stator and a second exterior housing portion to a second side of the stator opposite the first side so as to at least partially cover the stator and form a handle of the exterior housing assembly.

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Some embodiments of the method **900** include securably fastening the first exterior housing portion to a first side of the geartrain and the second exterior housing portion to a second side of the geartrain opposite the first side so as to at least partially cover the geartrain.

In some embodiments of the method **900**, the stator is an annular stator circumferentially surrounding the rotor and integrally coupled to an annulus of the geartrain.

In some embodiments of the method **900**, the annulus of the geartrain is securably fastened to a sleeve of the stator that is adhesively coupled to a core of the stator.

In some embodiments of the method **900**, a thermally conductive adhesive couples the sleeve to the core of the stator to allow heat dissipation.

In some embodiments of the method **900**, the annulus of the geartrain is coupled to a flange of the sleeve via a plurality of fastening connections distributed around the flange of the sleeve.

In some embodiments of the method **900**, the annulus of the geartrain is an annular gear engaged with, and surrounding, a planetary gearset coupled to the rotor for torque transmission.

In some embodiments of the method **900**, the geartrain comprises an indexing rotor of the geartrain that is selectively engageable to allow rotation of the exterior housing assembly relative to an output shaft of the geared torque tool.

In some embodiments of the method **900**, the indexing rotor defines an annular gear releasably fastened to the stator and engaged with a planetary gearset coupled to the rotor for torque transmission.

In some embodiments of the method **900**, the indexing rotor is releasably fastened to the stator via one or more ball detent assemblies distributed around the indexing rotor at a low torque end of the geartrain, the ball detent assemblies being selectively disengageable by torque applied to the index rotor.

Some embodiments of the method **900** include coupling integrally a reaction arm to the stator via the geartrain.

In some embodiments of the method **900**, the stator is integrally coupled to a low torque end of the geartrain.

FIG. 10 illustrates a block diagram of a computing device **1000**, in accordance with an embodiment.

As an example, the previously described controller to control output torque of the geared torque tool may be implemented using the example computing device **1000** of **FIG. 10**.

The computing device **1000** includes at least one processor **1002**, memory **1004**, and at least one I/O interface **1006**. At least one network communication interface **1008** may be provided.

- 5 The processor **1002** may be a microprocessor or microcontroller, a digital signal processing (DSP) processor, an integrated circuit, a field programmable gate array (FPGA), a reconfigurable processor, a programmable read-only memory (PROM), or combinations thereof.

The memory **1004** may include a computer memory that is located either internally or externally such as, for example, random-access memory (RAM), read-only memory (ROM), compact disc
10 read-only memory (CDROM), electro-optical memory, magneto-optical memory, erasable programmable read-only memory (EPROM), and electrically-erasable programmable read-only memory (EEPROM), Ferroelectric RAM (FRAM).

The I/O interface **1006** may enable the computing device **1000** to interconnect with one or more sensors and/or input devices. A sensor may include an encoder, temperature sensor, and a current
15 sensor. An input device may include a keyboard, mouse, camera, touch screen and a microphone, or with one or more output devices such as a display screen and a speaker.

The networking interface **1008** may be configured to receive and transmit data and/or data sets to a target data storage or data structures. The target data storage or data structure may, in some embodiments, reside on a computing device or system.

- 20 As can be understood, the examples described above and illustrated are intended to be exemplary only.

In some embodiments, the motor may comprise an annular rotor surrounding a stator located within the annular rotor. In such embodiments, carriers gears of planetary gearset may be allowed to rotate while the sun gear is kept fixed. Nevertheless, it is found advantageous for the stator to
25 be annular and contain the rotor. For example, improved structural rigidity may be achieved.

The embodiments described in this document provide non-limiting examples of possible implementations of the present technology. Upon review of the present disclosure, a person of ordinary skill in the art will recognize that changes may be made to the embodiments described herein without departing from the scope of the present technology. For example, the motor may
30 be a gearmotor, the indexing rotor may be replaced with a freely sliding connection of the exterior

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housing assembly that allows rotation of the exterior housing assembly relative to the unitary drive assembly, the ball detent assembly may be aligned normal to the longitudinal axis, and the indexing rotor may be absent with the stator being directly fastened to a carrier. Yet further modifications could be implemented by a person of ordinary skill in the art in view of the present disclosure,

5 which modifications would be within the scope of the present technology.

WHAT IS CLAIMED IS:

1. A geared torque tool, comprising:
a motor defining a rotor and a stator;
an exterior housing assembly for securably housing the motor by coupling to the stator;
5 and
a geartrain coupled to the rotor for torque transmission, and integrally coupled to the stator, separately from the exterior housing assembly, to support the geartrain during the torque transmission.
2. The geared torque tool of claim 1, wherein the stator is an annular stator circumferentially
10 surrounding the rotor and integrally coupled to an annulus of the geartrain.
3. The geared torque tool of claim 2, wherein the annulus of the geartrain is securably fastened to a sleeve of the stator that is adhesively coupled to a core of the stator.
4. The geared torque tool of claim 3, wherein a thermally conductive adhesive couples the sleeve to the core of the stator to allow heat dissipation.
- 15 5. The geared torque tool of claim 3, wherein the annulus of the geartrain is coupled to a flange of the sleeve via a plurality of fastening connections distributed around the flange of the sleeve.
6. The geared torque tool of claim 2, wherein the annulus of the geartrain is an annular gear engaged with, and surrounding, a planetary gearset coupled to the rotor for torque transmission.
- 20 7. The geared torque tool of claim 1, wherein the geartrain comprises an indexing rotor of the geartrain that is selectively engageable to allow rotation of the exterior housing assembly relative to an output shaft of the geared torque tool.
8. The geared torque tool of claim 7, wherein the indexing rotor defines an annular gear releasably fastened to the stator and engaged with a planetary gearset coupled to the rotor for
25 torque transmission.

9. The geared torque tool of claim 8, wherein the indexing rotor is releasably fastened to the stator via one or more ball detent assemblies distributed around the indexing rotor at a low torque end of the geartrain, the ball detent assemblies being selectively disengageable by torque applied to the index rotor.
- 5 10. The geared torque tool of claim 1, further comprising:
a reaction arm integrally coupled to the stator via the geartrain.
11. The geared torque tool of claim 1, wherein the stator is integrally coupled to a low torque end of the geartrain.
- 10 12. The geared torque tool of claim 1, wherein the exterior housing assembly comprises a first portion and a second portion complementary to the first portion, the first portion being securably fastened to a first side of the stator and a second portion being securably fastened to a second side of the stator opposite to the first side of the stator so as to at least partially cover the stator and form a handle of the exterior housing assembly.
- 15 13. The geared torque tool of claim 12, wherein the first portion is securably fastened to a first side of the geartrain and the second portion is securably fastened to a second side of the geartrain opposite the first side so as to cover the geartrain.
14. The geared torque tool of claim 1, wherein the geartrain and the stator are axially adjacent to each other relative to an axis of rotation of the rotor and non-overlapping.
- 20 15. The geared torque tool of claim 1, wherein a face of the geartrain is fastened to a face of the stator that is non-parallel to an axis of rotation of the rotor, the face of the geartrain and the face of the stator being axially adjacent to one another.
16. A unitary subassembly for a geared torque tool, comprising:
a motor defining a stator and a rotor for rotation around an axis of rotation; and
a geartrain coupled to the rotor for torque transmission and directly integrally coupled to
25 the stator axially adjacent to the motor for support and to form the unitary subassembly.

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17. The unitary subassembly of claim 16, wherein the geared torque tool defines an exterior housing assembly, and the unitary subassembly is securably housable at least partially within the exterior housing assembly to form the geared torque tool.
18. The unitary subassembly of claim 16, wherein the stator is an annular stator
5 circumferentially surrounding the rotor and integrally coupled to an annulus of the geartrain.
19. The unitary subassembly of claim 18, wherein the annulus of the geartrain is securably fastened to a sleeve of the stator that is adhesively coupled to a core of the stator.
20. The unitary subassembly of claim 19, wherein a thermally conductive adhesive couples the sleeve to the core of the stator to allow heat dissipation.
- 10 21. The unitary subassembly of claim 19, wherein the annulus of the geartrain is coupled to a flange of the sleeve via a plurality of fastening connections distributed around the flange of the sleeve.
22. The unitary subassembly of claim 18, wherein the annulus of the geartrain is an annular gear engaged with, and surrounding, a planetary gearset coupled to the rotor for torque
15 transmission.
23. The unitary subassembly of claim 16, wherein the geartrain comprises an indexing rotor of the geartrain that is selectively engageable to allow rotation of the stator relative to an output shaft of the geartrain.
24. The unitary subassembly of claim 23, wherein the indexing rotor defines an annular gear
20 releasably fastened to the stator and engaged with a planetary gearset coupled to the rotor for torque transmission.
25. The unitary subassembly of claim 24, wherein the indexing rotor is releasably fastened to the stator via one or more ball detent assemblies distributed around the indexing rotor at a low torque end of the geartrain, the ball detent assemblies being selectively disengageable by torque
25 applied to the index rotor.
26. The unitary subassembly of claim 16, further comprising:
a reaction arm integrally coupled to the stator via the geartrain.

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27. The unitary subassembly of claim 16, wherein the geartrain and the stator are axially non-overlapping.
28. The unitary subassembly of claim 16, wherein a face of the geartrain is fastened to a face of the stator that is non-parallel to an axis of rotation of the rotor, the face of the geartrain and the
5 face of the stator being axially adjacent to one another.
29. The unitary subassembly of claim 16, wherein the stator is integrally coupled to a low torque end of the geartrain.
30. A torque tool comprising the unitary subassembly of any one of claims 16 to 29.
31. A method of manufacturing a geared torque tool, comprising:
10 forming a subassembly by coupling a geartrain to a rotor and a stator of a motor such that torque is transmitted from the rotor to the geartrain while the geartrain is supported by the stator; and
securably housing the subassembly at least partially within an exterior housing assembly.
32. The method of claim 31, wherein the forming the subassembly includes
15 fastening the geartrain to the stator to integrally couple the stator to the geartrain.
33. The method of claim 31, further comprising:
securably fastening a first exterior housing portion to a first side of the stator and a second exterior housing portion to a second side of the stator opposite the first side so as to at least partially cover the stator and form a handle of the exterior housing assembly.
- 20 34. The method of claim 33, further comprising:
securably fastening the first exterior housing portion to a first side of the geartrain and the second exterior housing portion to a second side of the geartrain opposite the first side so as to at least partially cover the geartrain.
35. The method of claim 31, wherein the stator is an annular stator circumferentially
25 surrounding the rotor and integrally coupled to an annulus of the geartrain.

36. The method of claim 35, wherein the annulus of the geartrain is securably fastened to a sleeve of the stator that is adhesively coupled to a core of the stator.
37. The method of claim 36, wherein a thermally conductive adhesive couples the sleeve to the core of the stator to allow heat dissipation.
- 5 38. The method of claim 36, wherein the annulus of the geartrain is coupled to a flange of the sleeve via a plurality of fastening connections distributed around the flange of the sleeve.
39. The method of claim 36, wherein the annulus of the geartrain is an annular gear engaged with, and surrounding, a planetary gearset coupled to the rotor for torque transmission.
40. The method of claim 31, wherein the geartrain comprises an indexing rotor of the geartrain
10 that is selectively engageable to allow rotation of the exterior housing assembly relative to an output shaft of the geared torque tool.
41. The method of claim 40, wherein the indexing rotor defines an annular gear releasably fastened to the stator and engaged with a planetary gearset coupled to the rotor for torque transmission.
- 15 42. The method of claim 41, wherein the indexing rotor is releasably fastened to the stator via one or more ball detent assemblies distributed around the indexing rotor at a low torque end of the geartrain, the ball detent assemblies being selectively disengageable by torque applied to the index rotor.
43. The method of claim 31, further comprising:
20 coupling integrally a reaction arm to the stator via the geartrain.
44. The method of claim 31, wherein the stator is integrally coupled to a low torque end of the geartrain.