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RECIPROCATING IMPACT TOOL WITH IMPACT CONTROL

Abstract

A power tool includes a motor, a spindle defining a first end with a slot, and a crankshaft including a counterweight and a crank pin that are rotated by the motor about a crank axis so that at least one of the counterweight and the crank pin is rotated through the slot. The spindle includes a second end opposite the first end and defines a third distance taken between the first end and the second end of the spindle. The spindle further includes an anvil seat between the first end and the second end and defines a fourth distance between the anvil seat and the first end of the spindle. The power tool further includes an anvil received in the spindle, and the anvil defines a bit seat configured to receive a tool bit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation-in-part of U.S. patent application Ser. No. 19/009,836, filed on Jan. 3, 2025, which claims the benefit of U.S. Provisional Patent Application No. 63/624,954, filed on Jan. 25, 2024, and U.S. Provisional Patent Application No. 63/619,520, filed on Jan. 10, 2024, the disclosures of which are hereby incorporated by reference in its entirety.

BACKGROUND
[0002] A power tool (e.g., a chisel hammer, a rotary hammer, an air hammer, a drill, air chisel, etc.) can be used to drill or impact a workpiece with a bit (e.g., to remove material from the workpiece). An output unit of the power tool can include an impact mechanism that provides power to translate the bit in an axial (i.e., linear) direction. For example, in some applications, the impact mechanism can include a striker that translates in the axial direction to deliver an impact to a tool bit (e.g., via an anvil).
SUMMARY
[0003] According to one aspect of the present disclosure, a power tool can include a motor, a spindle defining a first end with a slot, and a crankshaft including a counterweight and a crank pin. The crankshaft can be rotated by the motor about a crank axis so that at least one of the counterweight and the crank pin is rotated through the slot.
[0004] In some examples, the counterweight can include a first distance and the crank pin can include a second distance that is greater than the first distance, with the first distance and the second distance each measured in a direction perpendicular to the crank axis.
[0005] In some examples, the spindle can have a second end opposite the first end and can define a third distance taken between the first end and the second end of the spindle. The spindle can include an anvil seat between the first end and the second end, and can define a fourth distance between the anvil seat and the first end of the spindle.
[0006] In some examples, a ratio of the fourth distance to the third distance can be between 1:1.5 and 1:2.
[0007] In some examples, the power tool can further include a fifth distance between the crank axis and the second end of the spindle, wherein a ratio of the fourth distance to the fifth distance can be between 1:1.5 and 1:2.5.
[0008] In some examples, the power tool can further include an anvil received in the spindle, the anvil defining a bit seat configured to receive a tool bit. A sixth distance can be defined between the bit seat and the crank axis when the anvil is in contact with the anvil seat.
[0009] In some examples, the sixth distance can be between 130 mm and 160 mm.
[0010] In some examples, an average impact energy imparted at the anvil can be between about 7.5 Joules and 9 Joules.
[0011] In some examples, a ratio of the sixth distance to an entire length of the power tool, as measured in a direction perpendicular to the crank axis, can be between 1:2 and 1:2.5.
[0012] In some examples, a ratio of the third distance to the sixth distance can be between 3:2 and 5:4.
[0013] In some examples, a ratio of the sixth distance to the fourth distance can be between 9:1 and 6:1.
[0014] In some examples, the power tool can further include a fifth distance between the crank axis and the second end of the spindle, wherein a ratio of the sixth distance to the fifth distance can be

between 1:1.5 and 1:1.75.

[0015] In some examples, the motor can define a motor axis and the spindle can define a spindle axis, and wherein a ratio of a seventh distance between the motor axis and the spindle axis to an inner diameter of the spindle can be between 1:2 and 3:5.

[0016] According to another aspect of the present disclosure, a power tool can include a spindle defining an anvil seat between a first end and a second end, an anvil defining a bit seat configured to receive a tool bit and engaging with the anvil seat to define a characteristic length between the bit seat and the first end of the spindle that is less than about 175 mm, and a crankshaft rotated by a motor about a crank axis to impart impacts at the anvil with an average impact energy that is between about 7.5 Joules and about 9 Joules.

[0017] In some examples, the first end of the spindle can define a slot and the crankshaft can include a counterweight that is rotated through the slot.

[0018] In some examples, a spindle chamber length defined between the anvil seat and the first end of the spindle can be between about 100 mm and about 125 mm.

[0019] In some examples, a distance from the crank axis to the first end of the spindle can be between about 200 mm and about 250 mm.

[0020] In some examples, a maximum radius of the counterweight can be between about 20 mm and about 25 mm.

[0021] In some examples, the spindle can have an inner diameter that is between about 25 mm and about 35 mm.

[0022] According to yet another aspect of the present disclosure, a power tool can include a motor, a spindle defining a first end with a slot and an anvil seat spaced from the first end, an anvil defining a bit seat configured to receive a tool bit and engaging with the anvil seat to define a characteristic length between the bit seat and the first end of the spindle that is less than about 175 mm, and a crankshaft including a counterweight and a crank pin that are rotated by the motor about a crank axis so that at least one of the counterweight and the pin is rotated through the slot.

[0023] This Summary and the Abstract are provided to introduce a selection of concepts in a simplified form that can be further described below in the Detailed Description. This Summary and the Abstract are not intended to identify key features or essential features of the claimed subject matter, nor are they intended to be used as an aid in determining the scope of the claimed subject matter.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The following drawings are provided to help illustrate various features of non-limiting examples of the disclosure and are not intended to limit the scope of the disclosure or exclude alternative implementations.

[0025] FIG. **1** is an axonometric view of a power tool in accordance with aspects of the disclosure.

[0026] FIG. **2** is a partial cross-sectional view of an output assembly the power tool of FIG. **1**, taken along line **2-2** of FIG. **1**.

[0027] FIG. **3** is a partial cross-sectional view of the output assembly of the power tool of FIG. **1**, taken along line **3-3** of FIG. **1**.

[0028] FIG. **4** is a detail view of the area taken about line **4-4** of FIG. **2**, showing details of an impact mechanism of the output assembly of the power tool of FIG. **1**.

[0029] FIG. **5** is a partial cross-sectional view of the output assembly of the power tool of FIG. **1**, taken along line **5-5** of FIG. **1**.

[0030] FIG. **6** is an exploded axonometric view of a retainer of the output assembly the power tool of FIG. **1**.

[0031] FIG. **7** is an enlarged, cross-sectional view of a drive reciprocation drive assembly of the output assembly of the power tool of FIG. **1**, taken along line **7-7** of FIG. **1**, showing details of a drive piston at a retracted position.

[0032] FIG. **8** is a cross-sectional view of the drive piston of FIG. **7** at an extended position.

[0033] FIG. **9** is an axonometric view of a transmission of the output assembly of the power tool of FIG. **1**.

[0034] FIG. **10** is a detail view taken about line **10-10** in FIG. **3**, showing details of the drive piston at a fully extended position.

[0035] FIG. **11** is a cross-sectional view of the drive piston of FIG. **10** at a first intermediate position between a fully extended position and a fully retracted position.

[0036] FIG. **12** is a cross-sectional view of the drive piston of FIG. **10** at a second intermediate position between a fully extended position and a fully retracted position.

[0037] FIG. **13** is a cross-sectional view of the drive piston of FIG. **10** at a fully retracted position.

[0038] FIG. **14** is a cross-sectional view of the drive piston of FIG. **10** at a third intermediate position between a fully extended position and a fully retracted position.

[0039] FIG. **15** is a detail view taken about line **15-15** in FIG. **7**, showing details of the transmission and a motor of the power tool of FIG. **1**.

DETAILED DESCRIPTION

[0040] The following discussion is presented to enable a person skilled in the art to make and use embodiments of the disclosed technology. Given the benefit of this disclosure, various modifications to the illustrated embodiments will be readily apparent to those skilled in the art, and the principles herein can be applied to other embodiments and applications without departing from embodiments of the disclosed technology. Thus, embodiments of the disclosed technology are not intended to be limited to embodiments shown but are to be accorded the widest scope consistent with the principles and features disclosed herein.

[0041] The following detailed description is to be read with reference to the figures, in which like elements in different figures have like reference numerals. The figures, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of embodiments of the disclosed technology. Skilled artisans will recognize the examples provided herein have many useful alternatives and fall within the scope of embodiments of the disclosed technology.

[0042] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings.

[0043] Examples of the disclosed technology can be implemented on any variety of power tools that operate with removable bits. In particular, some examples may be used with impact drivers, including chisel hammers, rotary hammers or other known implementations. In this regard, for example, FIG. **1-3** illustrate a power tool **100** in the form of a hammer tool (e.g., a chisel hammer), however the concepts described herein can also be applied to other types of power tool. The power tool **100** includes a housing **104** and an electric motor **108** disposed within the housing **104**. The power tool **100** can further include a reciprocation drive assembly **113** (shown in FIG. **2**) coupled to the motor **108** for converting torque from the motor **108** (e.g., as the motor **108** rotates about a motor axis **120**) to reciprocating motion. In some examples, the reciprocation drive assembly **113** can be coupled to the motor **108** via a transmission **112**. An impact mechanism **114** can be coupled to the reciprocation drive assembly **113** to impart repeating axial impacts on a tool bit **115** (e.g., a chisel bit or an output tool). As shown in FIG. **1**, the tool bit **115** may be slidably supported by a tool holder **130** coupled to the housing **104** so that the tool bit **115** is permitted to translate along its axis to impart the axial impacts to a work piece. In the illustrated example, the power tool **100** includes a quick-connect mechanism **138** coupled to the tool holder **130** to facilitate quick removal and replacement of different tool bits **115**. In other applications, other types of chucks can be used in place of the quick connect mechanism **138**, as may allow for tooled or toolless bit changes.

[0044] In some cases, the housing **104** includes different pieces that support different parts of the power tool **100**. For example, the housing **104** can include a pair of clamshell halves that provide an outer cover for the power tool **100**. In some cases, the housing **104** can include a gear case **200** that house one or more of the transmission **112**, the reciprocation drive assembly **113**, or the impact mechanism **114**. In the illustrated example, the gear case **200** includes an upper gear case cover **204**, a central gear case cover **206**, a lower gear case cover **208**, and a gear case cap **212**.

[0045] Continuing, in the illustrated example of the power tool **100**, the motor **108** can be configured as a direct-current (DC) motor **108** that receives power from an on-board power source (e.g., a battery pack **118**). The housing **104** can define a battery receptacle **117** that detachably receives the battery pack **118**. The battery pack **118** may include any of a number of different nominal voltages (e.g., 12V, 18V, etc.), and may be configured having a Lithium-based chemistry (e.g., Lithium, Lithium-ion, etc.) or any other suitable chemistry. Alternatively, the motor **108** may be powered by a remote power source (e.g., a household electrical outlet) through a power cord or the motor **108** can be a different type of motor, such as an alternating-current (AC) motor. The motor **108** is selectively activated by depressing a trigger which, in some cases, may activate an internal switch. The switch may be electrically connected to the motor **108** via a top-level or master controller **198** (e.g., a microcontroller), or one or more circuits, for controlling operation of the motor **108**.

[0046] With specific reference to FIGS. **2** and **3**, the gear case **200** includes a spindle case **214** that can support a spindle **160** (e.g., barrel). The spindle case **214** is covered by a boot **216**. In some cases, the boot **216** may be formed from a thermally insulating material (e.g., rubber, fiberglass, mineral wool, cellulose, polyurethane, polystyrene, etc.). In some cases, the boot **216** can include a gripping region **220** that may be gripped by the user (e.g., while operating the power tool **100**). For example, during operation of the power tool **100**, frictional forces, vibration, expansion and contraction of an air pocket within the spindle **160**, operation of the motor **108**, or other factors can generate heat which can increase a temperature of the gear case **200**. Accordingly, the boot **216** may provide an insulation layer for the user's hand from the gear case **200**. In some cases, the boot **216** can include a relatively high coefficient of friction in the gripping region **220** and prevent the power tool **100** from slipping out of the user's hand during operation.

[0047] Further, the gripping region **220** include heat dissipating elements. For example, the spindle case **214** can include a wall **224** and a plurality of ribs **228** extending from the wall **224**. In this case, the wall **224** and the ribs **228** are respectively configured as a cylindrical wall and circumferential ribs, however, other wall rib configurations are possible. The ribs **228** can protrude outwardly from the wall **224** toward the boot **216** and are spaced apart from one another in a direction parallel to a reciprocation axis **168** (e.g., an impact axis). As shown in FIGS. **2** and **3**, in the gripping region **220** of the boot **216**, the ribs **228** contact the boot **216** and minimizes a contact area between the boot **216** and the gear case **200**. Accordingly, a reduced amount of heat can be transferred directly from the gear case **200** to the boot **216** and insulate the user's hand when positioned on the gripping region **220**.

[0048] With continued reference to FIGS. **2** and **3**, a reciprocation drive assembly can be configured to convert rotational motion of a motor (e.g., via a transmission) into reciprocating linear motion of a piston. In the illustrated example, the reciprocation drive assembly **113** includes a crankshaft **132**, a reciprocating piston **156**, and a connecting rod **144**. The connecting rod **144** is connected to the crankshaft **132** at a first end **148** and a second end **152** that is opposite the first end **148**. In some cases, the connecting rod **144** can be pivotably coupled to the crankshaft **132** at each of the first end **148** and the second end **152**. The crankshaft **132** is configured to receive torque from the motor **108** and rotate about a crank axis **136** (e.g., crankshaft axis). In the illustrated example, the crankshaft **132** includes a crank pin **140** that couples to the first end **148** of the connecting rod **144**, which can be coupled to the piston **156** at the second end **152**. Correspondingly, as the crankshaft **132** rotates about the crank axis **136**, the connecting rod **144** drives the piston **156** to reciprocate along the reciprocation axis **168** and within the spindle **160** supported within the housing **104**. As shown in FIG. **3**, the connecting rod **144** includes a length L**8** (e.g., a connecting rod length) that is measured between an axis corresponding with a connection to the crank pin **140** and an axis corresponding with a connection to the piston **156**. In some cases, the length L**8** can be between 35 mm and 65 mm, or between 40 mm and 50 mm, or about 45 mm. In the illustrated example, the spindle **160** is stationary. However, in other examples, such as rotary hammers, the spindle **160** can be rotated by the motor **108** to cause rotation of a tool bit.

[0049] In some embodiments, the reciprocation drive assembly **113** can be realized by other mechanisms, including those known in the art to convert rotational motion to reciprocating motion (e.g., a scotch-yoke mechanism, a wobble drive mechanism, a swash plate mechanism, etc.). In this regard, although the various tool holders discussed below may be utilized in combination with the illustrated reciprocation drive assembly **113**, various other implementations are also possible.

[0050] A reciprocation assembly moves to generate impact to a tool bit via an impact mechanism. That is, the impact mechanism moves in response to movement of the reciprocation assembly to impact a tool bit. In the illustrated example, the impact mechanism **114** includes a striker **164** and an anvil **172** that are moveably received in the spindle **160**. The striker **164** is positioned between the piston **156** and the anvil **172** and selectively reciprocates within the spindle **160** in response to reciprocation of the piston **156**. The anvil **172**, which engages the tool bit **115**, is impacted by the striker **164** when the striker **164** reciprocates toward the tool bit **115**. The impact between the striker **164** and the anvil **172** can be transferred to the tool bit **115**, causing the anvil **172** to reciprocate along with the tool bit **115** performing work on a work piece (e.g., impact a workpiece). In the illustrated example, the anvil **172** includes an inner bore **174** that receives a shank **177** of the tool bit **115**. Further, in the illustrated construction of the power tool **100**, the spindle **160** is hollow and defines an interior chamber **162** (e.g., a bore) in which the striker **164** is received. An air spring **190** (e.g., an air pocket or an air cushion) can be formed between the piston **156** and the striker **164** when the piston **156** reciprocates within the spindle **160**, whereby expansion and contraction of the air spring **190** induces reciprocation of the striker **164**. That is, as the piston **156** moves towards the striker **164**, the volume of the air spring **190** is reduced, which increases pressure within the air spring **190**. This increase in pressure can be sufficient to move the striker **164** in the same direction as piston **156** and cause the striker **164** to impact the anvil **172** to deliver an impact to a workpiece via the bit **115**. Conversely, as the piston **156** moves away from the striker **164**, the volume of the air spring **190** can increase, which reduces pressure within the air spring **190**. This reduction in pressure can be sufficient to move the striker **164** in the same direction as piston **156**, causing the striker **164** to retract and move away from the anvil **172**.

[0051] In some cases, the striker **164** or the anvil **172** can form a seal against an interior surface of the spindle **160** via one or more sealing rings (e.g., an O-ring **166**). In some examples, maintaining the seal between the striker **164** and the spindle **160** can help to maintain the air spring **190** formed within the interior chamber **162**.

[0052] In some non-limiting cases, the motor **108** can be positioned within the housing **104** (e.g., within a gearcase disposed within the housing **104**), and the spindle **160** can be coupled to the housing **104**. In some non-limiting cases, the motor **108** can be positioned within the housing **104**, the spindle **160** can be rotatable. For example, the transmission **112** between the motor **108** and the spindle **160** can transmit torque from the motor **108** to the spindle **160**, causing the spindle **160** to rotate when the motor **108** is activated. The transmission **112** can include a geartrain, although other types of transmission systems can be used, for example, belt drives, chain drives, etc.

[0053] Continuing, the power tool **100** includes retainment features that guide an axial movement of the anvil **172** along the reciprocation axis **168**. For example, as shown in FIG. **4**, a retainer **176** is provided at a distal end of the spindle **160**. The retainer **176** defines a bore **180** (e.g., a cylindrical bore) that can receive the tool bit **115**. In the illustrated example, the retainer **176** is coupled to the spindle **160** via fasteners (e.g., fasteners or retention members). The retainer **176** defines a retainer impact surface **188** that can engage with a corresponding surface of the anvil **172**. In the illustrated example, the anvil **172** defines a front anvil impact surface **184** that generally faces toward a front of the power tool **100** (e.g., toward the tool holder). When the anvil **172** moves toward the front of the power tool **100** along the reciprocation axis **168**, the retainer impact surface **188** can engage with the front anvil impact surface **184** and stop a further movement of the anvil **172** toward the front of the power tool **100**. In the illustrated example, a profile of the front anvil impact surface **184** generally corresponds to a profile of the retainer impact surface **188**. For example, each of the impact surfaces **184**, **188** can be frustoconical in shape. In other embodiments, the profiles of the front anvil impact surface **184** and the retainer impact surface **188** can be different or include different shapes (e.g., pyramidal, cylindrical, spherical, cubical, cuboidal, conical, etc.).

[0054] Further, the anvil **172** is configured to engage with the spindle **160** during the reciprocation motion of the power tool **100**. For example, as shown in FIG. **4**, the anvil **172** defines a rear anvil impact surface **268** located at a rear end of the anvil **172**, generally opposite from the front anvil impact surface **184**. The rear anvil impact surface **268** includes a first rear surface **269** that can (directly) engage with the striker **164** during the reciprocation motion and a second rear surface **270** that can engage with the spindle **160**. In some cases, the rear anvil impact surface **268** can be arranged to generally face toward a rear of the power tool **100** (e.g., toward the striker **164**). In the illustrated example, the second rear surface **270** is generally conically shaped, and the first rear surface **269** protrudes from the second rear surface **270** toward the striker **164**. Further, the second rear surface **270** engages with a corresponding surface of the spindle **160**. In particular, the spindle **160** can include a rib **272** that protrudes from a spindle wall **232** of the spindle **160** and extends circumferentially along an interior surface of the spindle wall **232**. The rib **272** can define a spindle impact surface **276** that is arranged toward the second rear surface **270** of rear anvil impact surface **268**. Accordingly, when the anvil **172** moves toward the rear of the power tool **100** along the reciprocation axis **168**, the spindle impact surface **276** can engage with the second rear surface **270** and stop a further movement of the anvil **172** toward the rear of the power tool **100**. In some cases, a profile of the spindle impact surface **276** can generally correspond to a profile of the second rear surface **270**. For example, each of the impact surfaces **270**, **276** can be frustoconical in shape. In other embodiments, the profiles of the rear anvil impact surface **268** and the spindle impact surface **276** can be different or include different shapes (e.g., pyramidal, cylindrical, spherical, cubical, cuboidal, conical, etc.).

[0055] In some configurations, the retainer **176** or the spindle **160** can absorb an impact force exerted by the striker **164** to the anvil **172** along the reciprocation axis **168** when the anvil **172** contacts the retainer **176** or the spindle **160** directly or indirectly. For example, repeated impacts by the striker **164** to the anvil **172** can cause the anvil **172** to reciprocate between the retainer **176** and the spindle **160**. When the anvil **172** impacts the retainer **176**, the impact force can be absorbed by the spindle **160** that is coupled to the anvil **172** via the retention members **192**.

[0056] In these circumstances, the retainer **176** and the spindle **160** can provide impact absorbing features that absorb at least portion of the impact force exerted by the striker **164** or the reactionary force exerted by a workpiece during operation. For example, when the anvil **172** moves back toward the spindle **160**, the rear anvil impact surface **268** can contact the spindle impact surface

276. The impact force can be transmitted to the spindle **160**, dissipating the force through the spindle **160**. When the anvil **172** moves forward toward the retainer **176**, the front anvil impact surface **184** can contact the retainer impact surface **188**. The impact force exerted by the striker **164** can be transmitted to the anvil **172**, and the transmitted impact force can be subsequently transmitted to the retainer **176** and the spindle **160** via the retention members **192**. Correspondingly, the impact force exerted by the striker **164** can be dissipated by directing the force to the spindle **160** or other parts of the power tool **100**.

[0057] With conventional power tool designs, impacts may occur even when a tool bit is not in contact with a workpiece, causing dry-firing. To prevent impacts from being created when a power tool is not contacting a workpiece with a tool bit, as can reduce operator fatigue and tool wear, conventional designs for impacting tools provide a parking feature in which a striker is prevented from reciprocating within a spindle. For example, O-rings are included to restrain anvil movement and prevent contact between the striker and anvil. However, such parking features add complexity to the manufacturing process and increase the overall size of the tool. According to aspects of the present disclosure, providing a retainer for an anvil and a protruded wall in a spindle can reduce or eliminate the need for a parking feature (e.g., to prevent dry firing), which can typically increase a length of the power tools. For example, by arranging an anvil between a retainer (e.g., the retainer **176**) and a protruded wall (e.g., the rib **272**), a travel length of the anvil can be limited or reduced between the retainer and the protruded wall and improve efficiency of the power tool.

[0058] In particular, with continued reference to FIG. **4**, a travel distance Dr can be defined as a difference between a stop surface distance D.sub.S and an anvil impact surface distance D.sub.A (i.e., D.sub.T=D.sub.S−D.sub.A), wherein each of the respective distances is taken along the same line extending in the axial direction (e.g., approximately parallel with the axis **168**). For example, the stop surface distance D.sub.S is measured between the retainer impact surface **188** and the spindle impact surface **276**, and the anvil impact surface distance D.sub.A is measured between the front anvil impact surface **184** and the rear anvil impact surface **268**. In some cases, the travel distance Dr can be the distance that the anvil **172** can travel along the reciprocation axis **168** between the retainer **176** or the spindle **160**, or being limited by other components of the power tool **100**. In the illustrated embodiment, the stop surface distance D.sub.S can be greater than the anvil impact surface distance D.sub.A by a small distance. Correspondingly, the travel distance D.sub.T of the anvil **172** can be less than the stop surface distance D.sub.S. For example, in some embodiments, the travel distance Dr can be less than or equal to 50% of the stop surface distance D.sub.S. In other embodiments, the travel distance D.sub.T can be less than or equal to 25% of the stop surface distance D.sub.S. In the illustrated embodiment, the travel distance Dr can be less than or equal to 20% of the stop surface distance D.sub.S. In further embodiments, the travel distance D.sub.T can be less than or equal to 10% of the stop surface distance D.sub.S. By dissipating the impact forces generated during operation of the power tool **100** into the retainer **176**, the retention members **192** and the spindle **160**, the need for a parking feature can be reduced or eliminated, and the travel distance D.sub.T can be reduced relative to the stop surface distance D.sub.S, which advantageously allows an overall length of the power tool **100** to be reduced as compared to traditional chisel hammers.

[0059] FIGS. **5** and **6** illustrate details of the retainer **176** and surrounding features. In particular, the spindle **160** can include the spindle wall **232** that defines a bore **236** within which the drive piston **156**, the striker **164**, and the anvil **172** reciprocate. The spindle **160** includes a proximal end **240** (e.g., shown in FIGS. **2** and **3**) located proximate the motor **108** and a crank axis **136** that a gear **128** rotates about, and a distal end **244** located distant from the motor **108** and toward the front of the power tool **100**. The retainer **176** can include a retainer wall **248**. A portion of the retainer wall **248** can be received into the bore **236** at the distal end **244** of the spindle **160**, in close fit with the spindle wall **232** (e.g., nominal slip fit).

[0060] The retainer **176** can include features and elements for coupling with the spindle **160**. For example, the retainer wall **248** can define a plurality of recesses **252** that are circumferentially spaced apart from one another and aligned axially with respect to the reciprocation axis **168**. In some cases, the recesses **252** can be sized and shaped to receive the retention members **192**. In the illustrated embodiment, the retention members **192** are cylindrically shaped and recesses **252** are correspondingly cylindrically shaped to receive respective portions of the retention members **192**. In other embodiments, the retention members **192** may instead include different shapes (e.g., ovoid, spherical, frustoconical, prismatic, arc-shaped, etc.), and the recesses **252** can be correspondingly shaped to (tightly) receive the retention members.

[0061] Similarly, the spindle **160** can include features and elements for coupling with the retainer **176**. For example, the spindle wall **232** can define a plurality of apertures **256** extending therethrough, so that the bore **236** can be accessed through the plurality of apertures **256**. The apertures **256** can be circumferentially spaced apart from one another and aligned axially with respect to the reciprocation axis **168**. The apertures **256** can be sized and shaped to receive respective portions of the retention members **192**. In the illustrated embodiment, the retention members **192** are cylindrically shaped and apertures **256** are correspondingly cylindrically shaped to tightly receive respective portions of the retention members **192**. In other embodiments, the apertures **256** can include different shapes to (tightly) receive correspondingly shaped retention members which may not be cylindrically shaped.

[0062] With continued reference to FIGS. **5** and **6**, the recesses **252** of the retainer **176** can be aligned with the apertures **256** of the spindle **160**. The retention members **192** can be provided through the recesses **252** and the apertures **256**. In particular, a first portion of each retention member **192** can be arranged in a respective recess **252** and a second portion (e.g., remaining portion) of each retention member **192** can be arranged in the corresponding aligned aperture **256**. Therefore, the retention members **192** can provide a coupling mechanism to couple the retainer **176** to the spindle **160**.

[0063] In some cases, the gear case cap **212** can be provided at the distal end **244** of the spindle **160** and retain the retention members **192** within the recesses **252** and the apertures **256**. The gear case cap **212** can include a flange **260** and a cap wall **264** that extends axially away from the flange **260**. In some cases, the cap wall **264** can be cylindrically shaped, although other shapes are possible. The cap wall **264** be fitted over the distal end **244** adjacent the retention members **192** and retain the retention members **192** in place within the recesses **252** and the apertures **256**. In some cases, the flange **260** can be secured to the gear case **200** (e.g., via fasteners such as screws or adhesives).

[0064] In some cases, the retention members **192** can be formed from a first material that includes a first Young's modulus. The spindle **160** can be formed from a second material that includes a second Young's modulus. The retainer **176** can be formed from a third material that includes a third Young's modulus. In some cases, the first, second, and third materials can each include a hard and rigid material (e.g., metals, hardened steel, etc.). In other embodiments, different types of materials with different rigidities can be provided, including elastomer, rubber, wood, plastic, concrete, glass, high permeability materials, low permeability materials, ferrous material, etc. In some embodiments, the first Young's modulus can be equal to or greater than the second Young's modulus and equal to or greater than the third Young's modulus. In some cases, two or more of the first, second, and third materials can be the same or different.

[0065] Further, in the illustrated embodiment, the power tool **100** includes eight retention members **192** and eight corresponding recesses **252** and apertures **256**, which are spaced at equal intervals circumferentially about the spindle **160**. In other embodiments, the power tool **100** may include fewer number of retention members, corresponding recesses, and corresponding apertures (e.g., one, two, three, four, five, six, or seven). In some embodiments, the power tool **100** can include a greater number of retention members, corresponding recesses, and corresponding apertures (e.g., greater than eight).

[0066] FIGS. **7-9** illustrate the motor **108**, the transmission **112**, and the reciprocation drive assembly **113** in greater detail. In particular, the crankshaft **132** includes a counterweight **280** and a crank **284** that includes the crank pin **140**. The counterweight **280** can be defined by a distance L**1** (e.g., a radial distance, a first distance) that is measured along a direction of the reciprocation axis **168** between the crank axis **136** and a first distal edge of the counterweight **280**. The crank **284** can further be defined by a distance L**2** (e.g., a radial distance, a second distance) that is measured along the direction of the reciprocation axis **168** between the crank axis **136** and a second distal edge of the counterweight **280**, on a side that includes the crank **284**. In the illustrated example, the distance L**1** of the counterweight **280** is shorter than the distance L**2** of the crank **284**. In some cases, the shorter distance L**1** can permit the counterweight **280** to avoid contact with the drive piston **156** when the drive piston **156** is at a fully retracted position (e.g., at a bottom dead center position, as shown in FIG. **7**). In some cases, the larger distance L**2** of the crank **284** can increase a crank radius R**1** of the crank pin **140**. In particular, as shown in FIG. **7**, the crank radius R**1** is a distance between the crank axis **136** and an axis of the crank pin **140**. However, the illustrated example provides an arrangement of the crank **284**, such that the crank **284** can be arranged closer to the transmission **112**, or be rotated away from the drive piston **156** at the bottom dead center position without an interference with the drive piston **156**, the spindle **160**, or other parts of the transmission **112**. In some cases, the crank radius R**1** (e.g., as shown in FIG. **7**) can be between 10 mm and 25 mm, or between 15 mm and 20 mm, or about 17 mm. The distance L**1** can be between 13 mm and 23 mm, or between 15 mm and 20 mm, or about 18 mm. The distance L**2** can be between 15 mm and 30 mm, or between 20 mm and 25 mm, or about 23 mm. In some examples, the distance L**2** can be configured as a maximum radius of the counterweight **280**.

[0067] In particular, as best shown in FIG. **9**, the proximal end **240** of the spindle **160** can include a plurality of cutouts or slots **292** located at each respective lateral side of the spindle **160**. In some cases, each of the slots **292** can be defined between an upper rim **296** of the spindle **160** and a lower rim **300** of the spindle **160**. In the illustrated example, the spindle **160** is arranged below the gear **128**, and the crank **284** can at least partially overlap with the upper rim **296** and the lower rim **300** in a direction parallel to the crank axis **136** when the drive piston **156** is at a fully extended position (e.g., at a top dead center position, as shown in FIGS. **8-10**). Put differently, When the drive piston **156** is approaching or returning from the fully extended position, at least a portion of the crank **284** of the crankshaft **132** can pass between the upper and lower rims **296**, **300** of the spindle **160**. Accordingly, the slots **292** can permit the crank **284** to rotate about the crank axis **136** and provide translating movement to the drive piston **156** without interfering the spindle **160** (e.g., which remains stationary in chisel hammers) or the drive piston **156**. In the illustrated example, the piston **156** can maintain a skirt engagement with the spindle **160** by contacting the upper rim **296** and the lower rim **300** and can be prevented from twisting within the spindle **160** during operation. In some examples, maintaining the skirt engagement between the piston **156** and the spindle **160** can be helpful for preserving tool life by reducing excess side loading on interior wall of the spindle **160** and maintaining piston alignment within the bore of the spindle **160**.

[0068] In some cases, the illustrated configuration of the spindle **160** can allow for a compact arrangement of the reciprocation drive assembly **113** or the transmission **112** within the gear case **200** and a shorter overall length of the power tool **100**. For example, the slots **292** or other types of slotted geometry of the spindle **160** can allow for the distance L**2** that is greater than the distance L**1** and achieve a desired level of performance of the power tool **100** (e.g., an average impact energy of about 7.5 Joules to about 9 Joules). Further, the slots **292** or other types of slotted geometry of the spindle **160** can allow for a shorter geometry of the connecting rod **144**. In some examples, the configurations of the reciprocation drive assembly **113** can provide a desired length L**7** (e.g., an impact position length, as shown in FIG. **2**) between the crank axis **136** and a rear surface **165** of the striker **164**. In some examples, the length L**7** can be between 50 mm and 150 mm, or between 75 mm and 125 mm, or about 106 mm. In some examples, a ratio of the length L**7** to the crank radius R**1** can be less than 6.75, or less than 6.50, or less than 6.25. In the illustrated example, the ratio of the length L7 to the crank radius R1 is about 6.18. In some examples, a ratio of the length L7 to the length L8 of the connecting rod **144** can be greater than 1.80, or greater than 1.90, or greater than 2.00. In the illustrated example, the ratio of the length L7 to the length L8 of the connecting rod **144** is about 2.35. In some examples, a ratio of the crank radius R1 to the length L8 can be greater than 0.24, or greater than 0.30. In the illustrated example, the ratio of the crank radius R1 to the length L8 is 0.38. In some cases, a higher ratio of the crank radius R1 to the length L8 can be associated with a smaller angle (e.g., the angle A1 or the angle A2) between the crank **284** and the connecting rod **144**. In further examples, a ratio of the impact energy of the power tool **100** to the length L8 can be greater than 0.13, or greater than 0.17, or greater than about 0.20.

[0069] Further, while the illustrated embodiment of the reciprocation drive assembly **113** includes a crank mechanism, the reciprocation drive assembly **113** can include other types of mechanisms, including a wobble bearing mechanism, a scotch yoke mechanism, a rack and pinion mechanism, a cam shaft mechanism, a swash plate mechanism, etc. For example, in the reciprocation drive assembly **113** including a wobble bearing mechanism, the crank radius R1 (e.g., a throw distance) can be equivalent to a length of a piston throw of the wobble bearing mechanism.

[0070] FIGS. **10-14** illustrate operational views of the transmission **112** and the reciprocation drive assembly **113** at different positions. As generally described above, the spindle **160** can include features that permit a rotational movement of the crank **284** without interference between a fully extended position and a fully retracted position of the drive piston **156**.

[0071] FIG. **10** illustrates the drive piston **156** at a fully extended position (e.g., at the top dead center position). In the illustrated example, the connecting rod **144** is aligned along the reciprocation axis **168**. A portion of the crank **284** and the crank pin **140** are at least partially arranged within the spindle **160** at the proximal end **240**. For example, the crank **284** and the crank pin **140** at least partially overlap with the upper rim **296** (e.g., shown in FIGS. **7-9**) and the lower rim **300**. The counterweight **280** is arranged toward a rear end of the power tool **100** (e.g., toward the motor **108**).

[0072] FIG. **11** illustrates the drive piston **156** at a partially retracted (e.g., or partially extended), first intermediate position between the fully extended position (e.g., shown in FIG. **10**) and the full retracted position (e.g., shown in FIG. **13**). In the illustrated example, the crankshaft **132** is rotated to a 45-degree position in a counterclockwise direction from the fully about the crank axis **136**, and the connecting rod **144** is arranged at an oblique angle relative to the reciprocation axis **168**. In some cases, at least a portion of the connecting rod **144** can be arranged in one of the slots **292** arranged between the upper rim **296** (e.g., shown in FIGS. **7-9**) and the lower rim **300**. At this position, the crank **284** and the crank pin **140** are arranged outside of the spindle **160**. The counterweight **280** can be rotated about the crank axis **136** by 45 degrees.

[0073] FIG. **12** illustrates the drive piston **156** at another partially retracted, second intermediate position, which includes the drive piston **156** translated further toward a motor-side of the power tool **100**. In the illustrated example, the crankshaft **132** is rotated to a 90-degree position in a counterclockwise direction from the 45-degree position about the crank axis **136**. The connecting rod **144** is arranged at an oblique angle relative to the reciprocation axis **168**. In particular, an angle A1 between the connecting rod **144** and the crank **284** can be between 60° and 80°, or between 65° and 75°, or about 68°. At this position, at least a portion of the connecting rod **144** can be arranged in the slot **292**. The crank **284** and the crank pin **140** are arranged outside of the spindle **160**, and a portion of the counterweight **280** is arranged within the spindle **160** between the upper rim **296** (e.g., shown in FIGS. **7-9**) and the lower rim **300**. In particular, the counterweight **280** can slid into the slot **292** when the crankshaft **132** is rotated from the 45-degree position to the 90-degree position. Accordingly, the crankshaft **132** can rotate without interfering with the spindle **160** or the piston **156**, and the piston **156** can continue to translate within the spindle **160** along the reciprocation axis **168**.

[0074] FIG. **13** illustrates the drive piston **156** at a fully retracted position. In the illustrated example, the crankshaft **132** is rotated to a 180-degree position in a counterclockwise direction from the 90-degree position about the crank axis **136**. At this position, the drive piston **156** can be located at the bottom dead center position. A portion of the drive piston **156** can axially overlap with the slots **292** and be positioned between the upper rim**296** and the lower rim **300**. In some cases, the upper and lower rims **296**, **300** can protrude beyond the drive piston **156**, i.e., closer to the crank axis **136**, in this position. Further, the counterweight **280** can be proximate the proximal end **240** of the spindle **160** and arranged outside the spindle **160**. The connecting rod **144** can axially overlap with the counterweight **280** above the counterweight **280**, and the connecting rod **144** can extend along the reciprocation axis **168**.

[0075] FIG. **14** illustrates the drive piston **156** at a partially retracted, third intermediate position between the fully extended position and the fully retracted position of the drive piston **156**. In the illustrated example, crankshaft **132** is rotated to a 270-degree position in a counterclockwise direction from the 180-degree position about the crank axis **136**. The connecting rod **144** is arranged at an oblique angle relative to the reciprocation axis **168**. In particular, an angle A**2** between the connecting rod **144** and the crank **284** can be between 60° and 80°, or between 65° and 75°, or about 68°. At this position, a portion of the connecting rod **144** can be arranged in one of the slots **292**, and a portion of the counterweight **280** can be arranged in the other one of the slots **292**.

[0076] In some cases, the drive piston **156** can continue to extend from the 270-degree position as shown in FIG. **14** to complete one stroke of the drive piston **156**. In some cases, the crankshaft **132** can rotate in a clockwise direction, in a reverse direction than as described above. By allowing portions of the crankshaft **132** to slide through the slots **292** as the crankshaft **132** rotates about the crank axis **136**, the drive piston **156** can continue its reciprocating motion while without an interference and while maintaining a compact arrangement of the components within the power tool **100**.

[0077] Referring to FIG. **15**, examples of the present disclosure can provide an arrangement of the transmission **112** that can reduce or eliminate shifting a rotor of the motor **108** along the motor axis **120** during operation of the power tool **100**. For example, the transmission **112** includes a central gear case cover **206** arranged adjacent the motor **108** and defines a bearing pocket **310**. In some cases, a bearing **314** that includes an outer race **316** can be arranged within the bearing pocket **310**. A bearing retainer **312** can be secured to the central gear case cover **206** (e.g., via fasteners such as screws) and can abut the outer race **316** to secure the outer race **316** within the bearing pocket **310**. An inner race **318** of the bearing **314** can engage with the pinion **124** when the pinion **124** rotates relative to the outer race **316** and the central gear case cover **206**. In some cases, the pinion **124** can be connected to an end of the motor shaft **116** and include a flange **322** that abuts an axial end face of the inner race **318**. A retainer **320** (e.g., circlip, e-clip, etc.) can be provided within a groove **126** formed in the pinion **124**. The retainer **320** can engage with an opposite axial end face of the inner race **318**. Accordingly, a translational movement of the pinion **124** can be limited by placing the bearing **314** between a head portion of the pinion **124** and the retainer **320**. In some cases, an axial position of the inner race **318** can be determined by the axial position of the outer race **316**. In some cases, the axial position of the outer race **316** can be determined by the central gear case cover **206** and the bearing retainer **312**. Accordingly, the arrangement of the central gear case cover **206** can determine the axial position of the pinion **124**.

[0078] Further, the motor **108** can include a stator assembly **330** and a rotor assembly **332** that is rotatably supported on the motor shaft **116** relative to the stator assembly **330**. The rotor assembly **332** can include a rotor core **334** (e.g., such as a lamination stack) that is arranged on the motor shaft **116** (e.g., via press fit or nominal interference fit). The rotor core **334** can define a first axial end surface **336** that contacts a corresponding second axial end surface **338** defined on the pinion **124**. Thus, the pinion **124** fixes the rotor core **334** against translation in a forward direction (i.e., toward the central gear case cover **206**).

[0079] During operation of the power tool **100**, the rotor core **334** may have a tendency to slip on

the motor shaft **116**. In some cases, the rotor core **334** can translate axially toward the central gear case cover **206** due to the repeated reciprocating forces and impact forces acting on one or more of the drive piston **156**, the striker **164**, the anvil **172**, or the tool bit **115**. In some cases, the contact between the pinion **124** and the rotor core **334** can prevent the rotor core **334** from slipping and translating toward the central gear case cover **206** during operation of the power tool **100**.
[0080] Returning to FIG. **2**, one or more components of the power tool **100** can include various dimensions that characterize dimensional relationships between relative positions of different components of the power tool **100**. In some cases, characterizing various dimensional relationships can be useful for varying an overall size of the power tool **100** (e.g., to provide a compact power tool vertically or horizontally). For example, the power tool **100** can include a distance D**1** (e.g., a characteristic length, a sixth distance) measured between the crank axis **136** and a first longitudinal axis **350** that extends through a seat **175** of the anvil **172** that receives the tool bit **115**. The distance D**1** is measured in a direction parallel to the reciprocation axis **168**. Because the anvil **172** is moveable within the spindle **160**, the distance D**1** is measured when the anvil **172** is fully retracted to be in contact with the rib **272** (e.g., an anvil seat) defined in the spindle **160** to limit movement of the anvil **172** toward the striker **164** (e.g., toward the crankshaft **132**). In some cases, the fully retracted position of the anvil **172** can be associated with a working or impacting position of the power tool **100**. Thus, the distance D**1** corresponds with the shortest overall length of the power tool **100** when the tool bit **115** is inserted.
[0081] In some cases, the distance D**1** can be between 100 mm and 200 mm, or between 120 mm and 180 mm, or between 130 mm and 160 mm, or about 142 mm. In some cases, the distance D**1** can be less than 200 mm, less than 175 mm, or less than 156 mm. In some cases, a ratio of the distance D**1** to an entire length L**4** of the power tool **100** (e.g., without the tool bit installed or a rear housing of the full assembly) can be between 3:10 and 3:5, or between 2:5 and 1:2, or about 9:20. In particular, the entire length L**4** can be measured between a second longitudinal axis **352** that extends through the distal end **178** of the retainer **176** and a third longitudinal axis **354** that extends through an end of the motor **108**, as measured in a direction parallel to the reciprocation axis **168**. In some cases, the entire length LA can be between 200 mm and 400 mm, or between 250 mm and 350 mm, or between 275 mm and 325 mm, or about 297 mm.
[0082] In some cases, the distance D**1** can be varied to adjust the length L**4** of the power tool **100** measured in the direction parallel to the reciprocation axis **168**. For example, decreasing the distance D**1** can shorten an overall length of the power tool **100**, whereas increasing the distance D**1** can lengthen the overall length of the power tool **100**. In some examples, various dimensions of the spindle **160** can be adjusted to vary the distance D**1**. For example, the inner chamber **162** of the spindle **160** includes a length L**3** (e.g., a fourth distance) as measured in a direction parallel to the reciprocation axis **168**, and the spindle **160** can include an inner diameter ID as measured in a direction parallel to the crank axis **136**. For example, the inner diameter ID can be between 15 mm and 40 mm, or between 25 mm and 35 mm, or about 32.5 mm. Further, the length L**3** can be between 75 mm and 150 mm, or between 100 mm and 125 mm, or about 112 mm. In some cases, the length L**3** can be decreased to shorten the distance D**1** or increased to lengthen the distance D**1**. In some examples, the distance D**1** is greater than 100% of the length L**3**, or greater than 120% of the length L**3**, or greater than 150% of the length L**3**, etc. In some cases, the inner diameter ID can correspondingly be increased or decreased to maintain the same volume of the interior chamber **162** (e.g., to maintain a desired impact energy via the air spring **190**). In some examples, the inner diameter ID can be varied to achieve a desired amount of impact energy without lengthening or shortening the entire length L**4**. In some cases, the inner diameter ID can be substantially increased to receive the striker **164** having a greater volume or a greater mass, for example, to achieve a greater impact energy of the power tool **100**. In some cases, a mass of the striker **164** can be between 70 grams and 160 grams, or between 100 grams and 130 grams, or about 123 grams.
[0083] Further, in some examples, the slots **292** of the spindle **160** can include a length L**5**, as

measured in a direction parallel to the reciprocation axis **168**. The length L**5** can be adjusted to vary the length L**3** or the distance D**1**. For example, the length L**5** can be between 5 mm and 10 mm, or about 8 mm. In some cases, a distance D**3** between an end of the spindle **160** and the crank axis **136**, as measured in a direction parallel to the reciprocation axis **168**, can be adjusted to vary the length D**1**. For example, the distance D**3** can be between 15 mm and 25 mm, or between 17 mm and 23 mm, or about 21 mm. In some cases, a ratio of the distance D**1** to the distance D**3** can be between 10:1 and 5:1, or between 9:1 and 6:1, or about 27:4.

[0084] In some cases, the distance D**1** can be determined based on a desired impact energy of the power tool **100**. For example, the distance D**1** of about 142 mm can be associated with an impact energy of the power tool **100** between 5 Joules (J) and 10 J, or between 8 J and 9 J. In some cases, the distance D**1** can be characterized by between about 10 mm per 1 J and about 20 mm per 1 J, or between 15.8 mm per 1 J and 17.6 mm per 1 J. In some cases, the power tool **100** including a desired length of L**3** can produce an average impact energy of between about 8 J and about 9 J per stroke. In some cases, the power tool **100** can maintain the predetermined amount of desired impact energy regardless of varying the distance D**1**. For example, based on the distance D**1**, one or more of a power rating of the motor **108**, a driving mode of the power tool **100**, or an operating speed of the motor **108** can be determined. In some cases, the power tool **100** can define a ratio of the impact energy to a bare weight of the power tool **100** (e.g., weight of the power tool **100** without a bit and the battery back **118**) that is above 0.50 J/kg, or above 0.75 J/kg, or above 1.00 J/kg, or about 1.25 J/kg.

[0085] Further, the power tool **100** can be defined by a distance D**2** (e.g., a fifth distance) between the crank axis **136** and the second longitudinal axis **352**. The distance D**2** is measured in a direction parallel to the reciprocation axis **168**. In some cases, the distance D**2** can be between 200 mm and 250 mm, or between 210 mm and 240 mm, or between 220 mm and 230 mm, or about 224 mm. In some cases, the distance D**2** can be at least 100% of the distance D**1**, or at least 125% of the distance D**1**, or at least 150% of the distance D**1**, or about 160% of the distance D**1**. Put differently, a ratio between the distance D**1** and the distance D**2** can be between 1:1.3 and 1:2, or between 1:1.5 and 1:1.75, or about 1:1.6. In some cases, a ratio of the distance D**2** and the entire length L**4** of the power tool **100** can be between 1:2 and 1:1, or between 3:5 and 9:10, or between 7:10 and 4:5, or about 3:4. In some examples, a ratio of the length L**3** to the distance D**2** can be between 1:4 and 1:1, between 1:3.5 and 1:2.5, or about 1:2.

[0086] In some cases, the distance D**2** can be varied to adjust an overall length of the power tool **100** measured in a direction parallel to the reciprocation axis **168**. In some examples, dimensions of different components of the power tool **100** (e.g., the spindle **160**, the tool holder **130**, the retainer **176**, the spindle case **214**, etc.) can be adjusted to reduce the distance D**1** or the distance D**2**. For example, the spindle **160** can include a length L**6** (e.g., a third distance) as measured in a direction parallel to the reciprocation axis **168**. In some cases, the length L**6** can be between 150 mm and 250 mm, or between 175 mm and 225 mm, or about 201 mm. In some cases, a ratio of the length L**3** to the length L**6** can be less than 1:1, less than 1:1.5, less than 1:2, less than 1:2.5, between 1:1 and 1:2.5, between 1:1.5 and 1:2, or about 1:1.8. In some cases, a ratio of the length L**6** to the distance D**1** can be between 2:1 and 1:1, or between 3:2 and 5:4, or about 1.4:1.

[0087] In some cases, the length L**6** can be adjusted to vary one or more of the distance D**1**, the distance D**2**, or the length L**4**. In some cases, one or more of the distance D**1**, the distance D**2**, the distance D**3**, the length L**3**, and the length L**5**, and the length L**6** can be adjusted to provide an overall reduced or increased length L**4** of the power tool **100**. In some cases, reducing the length L**3** can reduce the distance D**1** or the distance D**2**. In some cases, reducing the length L**6** can reduce the distance D**1** or the distance D**2**. In some cases, reducing the length L**5** or the distance D**3** can reduce the distance D**1** or the distance D**2**. In some cases, reducing the distance D**1** can reduce the distance D**2**. Accordingly, dimensions of the power tool **100** can provide a horizontally compact power tool in a direction parallel to the reciprocation axis **168**.

[0088] In some examples, dimension of the power tool **100** can further provide a vertically compact power tool **100** in a direction parallel to the crank axis **136**. With continued reference to FIG. **2**, a distance D**4** (e.g., a seventh distance) between the motor axis **120** and the reciprocation axis **168** is shown. The distance D**4** is measured in a direction parallel to the crank axis **136**. In particular, the distance D**4** can be between 10 mm and 30 mm, or between 15 mm and 25 mm, or about 18 mm. In some cases, a ratio of the distance D**4** and the inner diameter ID can be between 2:5 and 7:10, or between 1:2 and 3:5, or about 11:20. In some cases, the distance D**4** can be adjusted to increase or decrease an overall height of the power tool **100** as measured in a direction parallel to the crank axis **136**. For example, the gear **128** can be connected to the crankshaft **132** at a height closer to the reciprocation axis **168**, and the motor **108** can engage with the gear **128** at a height closer to the reciprocation axis **168**. Accordingly, the distance D**4** can be decreased, and the overall height of the power tool **100** can be decreased. Therefore, adjusting the distance D**4** can provide a vertically compact power tool **100**.

[0089] In some implementations, devices or systems disclosed herein can be utilized, manufactured, or installed using methods embodying aspects of the invention. Correspondingly, any description herein of particular features, capabilities, or intended purposes of a device or system is generally intended to include disclosure of a method of using such devices for the intended purposes, a method of otherwise implementing such capabilities, a method of manufacturing relevant components of such a device or system (or the device or system as a whole), and a method of installing disclosed (or otherwise known) components to support such purposes or capabilities. Similarly, unless otherwise indicated or limited, discussion herein of any method of manufacturing or using for a particular device or system, including installing the device or system, is intended to inherently include disclosure, as embodiments of the invention, of the utilized features and implemented capabilities of such device or system.

[0090] Also as used herein, unless otherwise limited or defined, “or” indicates a non-exclusive list of components or operations that can be present in any variety of combinations, rather than an exclusive list of components that can be present only as alternatives to each other. For example, a list of “A, B, or C” indicates options of: A; B; C; A and B; A and C; B and C; and A, B, and C. Correspondingly, the term “or” as used herein is intended to indicate exclusive alternatives only when preceded by terms of exclusivity, such as “either,” “one of,” “only one of,” or “exactly one of.” For example, a list of “one of A, B, or C” indicates options of: A, but not B and C; B, but not A and C; and C, but not A and B. A list preceded by “one or more” (and variations thereon) and including “or” to separate listed elements indicates options of one or more of any or all of the listed elements. For example, the phrases “one or more of A, B, or C” and “at least one of A, B, or C” indicate options of: one or more A; one or more B; one or more C; one or more A and one or more B; one or more B and one or more C; one or more A and one or more C; and one or more of A, one or more of B, and one or more of C. Similarly, a list preceded by “a plurality of” (and variations thereon) and including “or” to separate listed elements indicates options of multiple instances of any or all of the listed elements. For example, the phrases “a plurality of A, B, or C” and “two or more of A, B, or C” indicate options of: A and B; B and C; A and C; and A, B, and C.

[0091] Also as used herein, unless otherwise defined or limited, directional terms are used for convenience of reference for discussion of particular figures or examples or to indicate spatial relationships relative to particular other components or context, but are not intended to indicate absolute orientation. For example, references to downward, forward, or other directions, or to top, rear, or other positions (or features) may be used to discuss aspects of a particular example or figure, but do not necessarily require similar orientation or geometry in all installations or configurations.

[0092] Also as used herein, unless otherwise limited or defined, “substantially parallel” indicates a direction that is within ±12 degrees of a reference direction (e.g., within ±6 degrees or ±3 degrees), inclusive. Similarly, unless otherwise limited or defined, “substantially perpendicular” similarly

indicates a direction that is within ±12 degrees of perpendicular a reference direction (e.g., within ±6 degrees or ±3 degrees), inclusive. Correspondingly, “substantially vertical” indicates a direction that is substantially parallel to the vertical direction, as defined relative to the reference system (e.g., a local direction of gravity, by default), with a similarly derived meaning for “substantially horizontal” (relative to the horizontal direction). Discussion of directions “transverse” to a reference direction indicate directions that are not substantially parallel to the reference direction. Correspondingly, some transverse directions may be perpendicular or substantially perpendicular to the relevant reference direction.
[0093] Unless otherwise specifically indicated, ordinal numbers are used herein for convenience of reference, based generally on the order in which particular components are presented in the relevant part of the disclosure. In this regard, for example, designations such as “first,” “second,” etc., generally indicate only the order in which a thus-labeled component is introduced for discussion and generally do not indicate or require a particular spatial, functional, temporal, or structural primacy or order.
[0094] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the invention. Given the benefit of this disclosure, various modifications to these embodiments will be readily apparent to those skilled in the art, and the principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

Claims

1. A power tool comprising: a motor; a spindle defining a first end with a slot; and a crankshaft including a counterweight and a crank pin that are rotated by the motor about a crank axis so that at least one of the counterweight and the crank pin is rotated through the slot.
2. The power tool of claim 1, wherein the counterweight includes a first distance and the crank pin includes a second distance that is greater than the first distance, the first distance and the second distance each measured in a direction perpendicular to the crank axis.
3. The power tool of claim 1, wherein the spindle has a second end opposite the first end and defines a third distance taken between the first end and the second end of the spindle; and wherein the spindle includes an anvil seat between the first end and the second end, and defines a fourth distance between the anvil seat and the first end of the spindle.
4. The power tool of claim 3, wherein a ratio of the fourth distance to the third distance is between 1:1.5 and 1:2.
5. The power tool of claim 3 further comprising a fifth distance between the crank axis and the second end of the spindle, wherein a ratio of the fourth distance to the fifth distance is between 1:1.5 and 1:2.5.
6. The power tool of claim 3 further comprising an anvil received in the spindle, the anvil defining a bit seat configured to receive a tool bit, wherein a sixth distance is defined between the bit seat and the crank axis when the anvil is in contact with the anvil seat.
7. The power tool of claim 6, wherein the sixth distance is between 130 mm and 160 mm.
8. The power tool of claim 7, wherein an average impact energy imparted at the anvil is between about 7.5 Joules and 9 Joules.
9. The power tool of claim 6, wherein a ratio of the sixth distance to an entire length of the power tool, as measured in a direction perpendicular to the crank axis, is between 1:2 and 1:2.5.
10. The power tool of claim 6, wherein a ratio of the third distance to the sixth distance is between 3:2 and 5:4.
11. The power tool of claim 6, wherein a ratio of the sixth distance to the fourth distance is between

9:1 and 6:1.

12. The power tool of claim 6 further comprising a fifth distance between the crank axis and the second end of the spindle, wherein a ratio of the sixth distance to the fifth distance is between 1:1.5 and 1:1.75.

13. The power tool of claim 1, wherein the motor defines a motor axis and the spindle defines a spindle axis, and wherein a ratio of a seventh distance between the motor axis and the spindle axis to an inner diameter of the spindle is between 1:2 and 3:5.

14. A power tool comprising: a spindle defining an anvil seat between a first end and a second end; an anvil defining a bit seat configured to receive a tool bit and engaging with the anvil seat to define a characteristic length between the bit seat and the first end of the spindle that is less than about 175 mm; and a crankshaft rotated by a motor about a crank axis to impart impacts at the anvil with an average impact energy that is between about 7.5 Joules and about 9 Joules.

15. The power tool of claim 14, wherein the first end of the spindle defines a slot and the crankshaft includes a counterweight that is rotated through the slot.

16. The power tool of claim 14, wherein spindle chamber length defined between the anvil seat and the first end of the spindle is between about 100 mm and about 125 mm.

17. The power tool of claim 14, wherein a distance from the crank axis to the first end of the spindle is between about 200 mm and about 250 mm.

18. The power tool of claim 15, wherein a maximum radius of the counterweight is between about 20 mm and about 25 mm.

19. The power tool of claim 14, wherein the spindle has an inner diameter that is between about 25 mm and about 35 mm.

20. A power tool comprising: a motor; a spindle defining a first end with a slot and an anvil seat spaced from the first end; an anvil defining a bit seat configured to receive a tool bit and engaging with the anvil seat to define a characteristic length between the bit seat and the first end of the spindle that is less than about 175 mm; and a crankshaft including a counterweight and a crank pin that are rotated by the motor about a crank axis so that at least one of the counterweight and the crank pin is rotated through the slot.