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(54) POWER TOOL FOR SETTING FASTENERS

(57) A power tool comprising: a motor at least partially located within the handle of the tool and having a motor output shaft extending along a first axis extending along the length of the handle; and a fastener gripping portion operatively coupled to the motor via a transmission which in use causes movement of the fastener gripping portion along a second axis, perpendicular to the first axis, between a home position and a retracted position to set a fastener engaged by the fastener gripping portion; the transmission comprising a bevel gear arrangement for redirecting torque flowing along the first axis in use which is input to the bevel gear arrangement so that torque output from the bevel gear arrangement flows along the second axis and wherein the transmission further comprises a mechanism for converting torque output from the bevel gear arrangement in use into a linear force for causing linear movement of the fastener gripping portion.

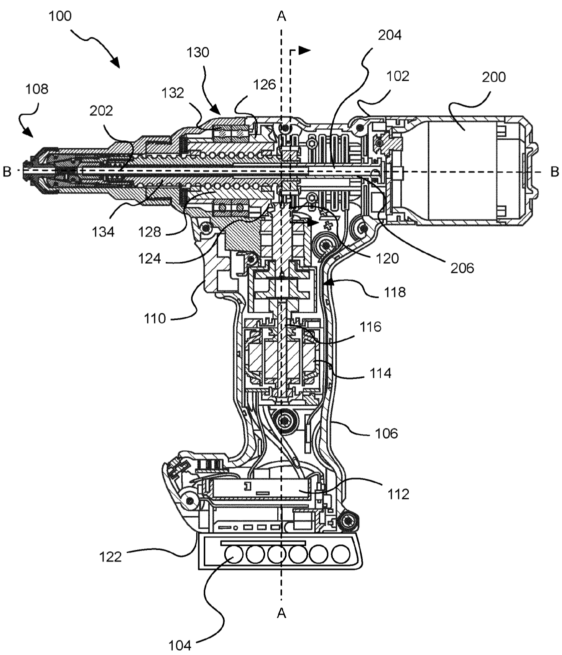

Fig. 1

EP 4 230 326 A1

Description

Field

[0001] This specification relates to a power tool for setting fasteners.

Background

[0002] Some existing blind rivet setting tools have a ball screw mechanism driven by an electric motor for causing movement of a set of jaws in order to pull the mandrel of a rivet. Such a tool is described in EP3530372A2 for example, wherein the motor is located above the handle. In order for the tool to feel balanced in a user's hand the manufacturer needs to carefully consider the arrangement of features within the housing relative to the handle. Having the motor and all transmission features above the handle makes the tool top heavy. Also due to space limitations within the housing there is some play off between arranging internal features of the tool such that the tool works vs. arranging such features so that weight distribution of the tool is optimised.

Summary

[0003] According to an aspect of the present invention there is provided a power tool comprising: a motor at least partially located within the handle of the tool and having a motor output shaft extending along a first axis extending along the length of the handle; and a fastener gripping portion operatively coupled to the motor via a transmission which in use causes movement of the fastener gripping portion along a second axis, perpendicular to the first axis, between a home position and a retracted position to set a fastener engaged by the fastener gripping portion; the transmission comprising a bevel gear arrangement for redirecting torque flowing along the first axis in use which is input to the bevel gear arrangement so that torque output from the bevel gear arrangement flows along the second axis and wherein the transmission further comprises a mechanism for converting torque output from the bevel gear arrangement in use into a linear force for causing linear movement of the fastener gripping portion.

[0004] The mechanism may be a ball screw mechanism extending along the second axis between the bevel gear arrangement and the fastener gripping portion. Alternatively the mechanism may be a roller screw mechanism extending along the second axis between the bevel gear arrangement and the fastener gripping portion.

[0005] The motor may be located entirely within the handle.

[0006] The transmission may comprise at least one planetary gear stage for transferring torque from the motor along the first axis in use.

[0007] The at least one planetary gear stage may be at least partially located within the handle, optionally entirely located within the handle.

[0008] The power tool may comprise a battery attachment portion on the handle such that a notional line extending between the battery attachment portion and the motor output shaft extends along the first axis.

[0009] The motor may be a brushless DC motor.

[0010] The fastener gripping portion may be a jaw assembly.

[0011] The power tool may be a blind rivet setting tool.

Brief Description of the Drawings

[0012] Various aspects and embodiments of the invention will now be described by way of nonlimiting example with reference to the accompanying drawings, in which:

Fig. 1 shows a side cross-sectional view of a blind rivet setting tool;

Fig. 2 shows a close-up of part of the blind rivet setting tool in Fig. 1; and

Figs 3a and 3b show a jaw assembly of the blind rivet setting tool in Fig. 1 in first and second configurations respectively.

Detailed Description

[0013] Fig. 1 shows a side cross-sectional view of a blind rivet setting tool 100. The tool 100 has a housing 102 of a clam shell type construction having two halves which are fastened together. A battery 104 is releasably connected to the base 122 of the handle 106 via a battery attachment feature. To use the tool 100 a user inserts the mandrel of a blind rivet into a nose 108 of the tool 100 and pulls a trigger 110. In response to a controller 112 of the tool determining that the trigger 110 has been pulled the controller 112 generates a signal to activate a motor 114, which is a DC brushless motor. The motor 114 is located in the handle 106 and has a motor output shaft 116. Torque from the motor output shaft 116 is transferred via a transmission 118 to a first bevel gear 120. The transmission 118 comprises at least one planetary gear arrangement for reducing output speed while increasing torque. The first bevel gear 120 rotates at a lower speed than the motor output shaft 116 however with an increased torque relative to the motor output shaft 116. The motor output shaft 116, transmission 118 and first bevel gear 120 are aligned along a first axis A-A which extends along a longitudinal length of the handle 106. By also locating the battery 104 on the first longitudinal axis A-A weight distribution of the tool 100 is improved.

[0014] It will be appreciated that there is some design freedom in the transmission 118 between the motor output shaft 116 and the first bevel gear 120. In particular the number of planetary gear stages, and its (or their) configuration, forming the tranmission 118 depends on the required gear ratio to be achieved between the motor output shaft 116 and the first bevel gear 120. Given that it is well known that planetary gear stages step down rotation speed while stepping up torque persons skilled in the art, based on the disclosure given herein, will be able to decide upon a suitable transmission arrangement which achives the required gear ratio for thier tool to function; wherein the appropriate gear ratio depends on multiple factors including maximum achieveble motor output torque, pitch of the ball screw arrangement 130 described below, friction between moveable featiures within the tool 100 and the maximum pull force required to set a fastener. It will be appreciated that for some tools 100 a suitable transmisison 118 may only have a single planetary gear stage, whereas for other tools a suitable transmisison 118 may have a plurality of planetary gear stages arranged in series.

[0015] Continuing with reference to Fig. 1 a second bevel gear 124 is provided on the end face of a driving sleeve 126. The driving sleeve 126 is rotationally fixed relative to an input sleeve 128 of a ball screw arrangement 130. The driving sleeve 126 and input sleeve 128 are fixed relative to each other due to a friction fit arrangement. An internal surface of the input sleeve 128 comprises a threaded surface. The outer surface of the driving sleeve 126 is supported by bearings 132 which enable rotation of the driving sleeve 126 with respect to the housing 102. A threaded rod 134 is mounted within the input sleeve 128, which extends through the input sleeve 128. A plurality of balls, such as metal ball bearings, ride in the opposing threaded surfaces of the input sleeve 128 and threaded rod 134, thereby defining a ball screw arrangement 130.

[0016] When the input sleeve 128 is rotatably driven by the driving sleeve 126 this causes axial movement of the threaded rod 134. In other words, torque from the motor 114 is transferred through the transmission 118, first and second bevel gears 120, 124 and driving sleeve 126 to the input sleeve 128, whereby rotation thereof causes axial movement of the threaded rod 134. The threaded rod 134 is configured to move along a second longitudinal axis B-B of the tool 100. The threaded rod 134 can move forwards or backwards along the axis B-B depending on the motor driving direction.

[0017] Referring to Fig. 2 a connecting sleeve 300 is attached to a first end 302 of the threaded rod 134, which is mounted to the threaded rod 134 via a screw thread. A pull-back hull 304 is threadably attached to the connecting sleeve 300. Axial movement of the threaded rod 134 along the second longitudinal axis B-B therefore also causes axial movement of the pull-back hull 304.

[0018] A jaw assembly 500 is located within the pull-back hull 304. The jaw assembly (shown in Fig. 3a) has a plurality of circumferentially arranged jaws 306 each of which has a ramped outer surface 308 for cooperating with a conical inner surface 310 of the pull-back hull 304. A separator sleeve 312 is forced by a spring 314 against the jaws 306; more specifically a ramped front surface 316 of the separator sleeve 312 is forced against ramped rear surfaces 318 of the jaws 306. A nosepiece 320 is releasably attached at the opening to the nose 108 of the tool 100 which has an annular ramped surface 402. Each of the jaws 306 have a front ramped surface 400 for cooperating with the annular ramped surface 402 of the nose piece 320. Cooperation between the ramped outer surfaces 308 of the jaws 306 and the conical inner surface 310 of the pull-back hull 304, between the ramped rear surfaces 318 of the jaws 306 and the ramped front surface 316 of the separator sleeve 312 and between the front ramped surfaces 400 of the jaws and the annular ramped surface 402 of the nose piece 320 enables the tool 100 to set blind rivets in use.

[0019] To set a blind rivet, while the jaw assembly 500 is in a home position a mandrel of the blind rivet is inserted through the nose piece 320 such that the mandrel extends between the jaws 306, thereby urging the jaws 306 radially apart (see Fig. 3b). Upon pulling the trigger 110 of the tool 100 the controller 112 receives output from a trigger sensor and in response activates the motor 114 for causing the threaded rod 134, and thus the pull-back hull 304, to move along the second longitudinal axis B-B to the right in Figs. 1 and 2. As the pull-back hull 304 is retracted its conical inner surface 310 is forced against the outer surfaces 308 of the jaws 306, whereby a component of force draws the jaws 306 backwards with the pull-back hull 304 away from the home position whereas another component of force urges the jaws 306 radially inwards thereby clamping the mandrel of the blind rivet being set between the jaws 306.

[0020] In other words pulling the pull-back hull 304 to the right in Figs. 1 and 2 causes the jaws 306 to grip and pull the mandrel of a rivet being set. The blind rivet thus is pulled against the nose piece 320 for deforming the blind rivet and when the mandrel of the blind rivet is pulled far enough for setting the blind rivet the mandrel snaps.

[0021] Designers are free to select a suitable way for the controller 112 to control operation of the motor 114 in use to implement a fastening operation. In other words designers are free to select a suitable way for the controller 112 to determine when the jaw assembly 500 has been retracted far enough during a fastener setting stage of operation at which point in time retraction of the jaw assembly 500 is ceased. For example a mechanical switch may be provided within the tool 100 and in response to the controller 112 determining that the trigger 110 has been pulled by a user the controller 112 causes the pull-back hull 304 (and thus the jaw assembly 500) to be retracted until a feature of the pull-back hull 304 actuates the mechanical swich thereby generating output indicative that the jaw assembly 500 has been pulled back sufficiently far to set a blind rivet. Alternatively an optical sensor may be provided within the tool 100 which generates output based on the presence or absence of a feature on the pull-back hull 304 wherein based on output from the optical sensor the controller 112 can determine that the pull-back hull 304 (and thus the jaw assembly 500) has reached a predetermined retracted position for setting a blind rivet. Alternatively the controller

112 may be configured to monitor the magnitude of current drawn from the battery 104 during a fastening operation and when the current draw drops by at least a predetermined extent during a fastening stage of operation the controller 112 can determine that the mandrel of the blind rivet being fastened has snapped and thus that the jaw assembly 500 has been pulled back sufficiently far.

[0022] Subsequently to the fastening stage of operation the tool 100 is required to perform a reset operation to dispose of the broken mandrel and to accept a fresh blind rivet for setting. During a reset operation of the tool 100 the controller 112 causes the motor 114 to reverse its direction for moving the threaded rod 134, and thus the pull-back hull 304, in the other direction along the second longitudinal axis B-B to the left in Figs. 1 and 2. When the pull-back hull 304 has been moved sufficiently far to the left the spring 314 via the separator sleeve 312 will urge the front ramped surfaces 400 of the jaws 306 against the annular ramped surface 402 of the nose piece 320. Further movement of the threaded rod 134 to the left in Figs. 1 and 2 will increase the pressure of the spring 314 against the separator sleeve 312 and thus cause the front ramped surfaces 400 of the jaws 306 to ride along the annular ramped surface 402 of the nose piece 320 while the ramped rear surfaces 318 of the jaws 306 ride along the ramped front surface 316 of the separator sleeve 312. This causes the jaws 306 to move radially outwards and release the grip on the snapped mandrel, whereby with reference to Fig. 1 the released snapped mandrel can be caused to fall under gravity along an internal path 204 in the direction of a collection chamber 200. For example, after a rivet setting operation, when the jaw assembly 500 has been returned to the home position, the user tilts the tool 100 such that the snapped mandrel moves into the collection chamber 200. The internal path 204 is defined by aligned openings extending through components between the jaws 306 and the collection chamber 200, including a first channel 202 extending through the threaded rod 134 along the second longitudinal axis B-B and a second channel 204 through a guidance sleeve 206.

[0023] Designers are free to select a suitable way for the controller 112 to control operation of the motor 114 in use to implement a reset operation. In other words designers are free to select a suitable way for the controller 112 to determine when the jaw assembly 500 has returned to the home position at which point in time reverse movement of the jaw assembly 500 is ceased. For example a mechanical switch may be provided within the tool 100 and in response to the controller 112 determining that the trigger 110 has been released by a user the controller 112 causes the pull-back hull 304 (and thus the jaw assembly 500) to be moved in the reverse direction until a feature of the pull-back hull 304 actuates the mechanical swich thereby generating output indicative that the jaw assembly 500 has returned to the home position. Alternatively an optical sensor may be provided within the tool 100 which generates output based on the presence or absence of a feature on the pull-back hull 304 wherein based on output from the optical sensor the controller 112 can determine that the pull-back hull 304 (and thus the jaw assembly 500) has reached the home position. Alternatively a magnet is provided on the pull-back hull 304 and a Hall sensor is provided in a fixed location within the tool, wherein such features can be arranged such that upon the Hall sensor generating a suitable output based on interacting with the magnet on the pull-back hull 304 the controller 112 can determine that the pull-back hull 304 (and thus the jaw assembly 500) has reached the home position.

[0024] Turning to Figs 3a and 3b the jaw assembly 500 will now be discussed in more detail. Fig. 3a shows a perspective view of the jaw assembly 500 in a first configuration in which the jaws 306 are located radially as close to each other as possible. Fig. 3b shows a perspective view of the jaw assembly 500 in a second configuration in which the jaws 306 are urged radially apart from each other such as by a mandrel of a blind rivet being inserted through the space between the jaws 306 or the jaws 306 being forced against the annular ramped surface 402 of the nose piece 320. The jaw assembly 500 comprises three identical jaws 306 circumferentially arranged about a jaw assembly axis G-G. When the jaw assembly 500 is mounted in the tool 100, the jaw assembly axis G-G is coaxial with the second longitudinal axis B-B of the tool 100. The three jaws 306 can move radially with respect to the jaw assembly axis G-G.

[0025] There are situations during which the jaw assembly 500 is removed from the tool, in particular during routine maintenance of the tool 100 during which it is disassembled and then reassembled after being cleaned. Alternatively the jaw assembly 500 may be swapped with a new jaw assembly because the jaws 306 of the original jaw assembly have worn. Further alternatively the jaw assembly 500 may be swapped with a new jaw assembly because the different jaw assemblies are configured for use with different sized mandrels. Referring again to Figs. 3a and 3b the jaw assembly has a flexible o-ring 502 for holding the jaws 306 of the jaw assembly 500 together when it is not located within the tool 100. Each of the jaws 306 defines part of an annual groove 504 when the jaws 306 are in the configuration shown in Fig. 3a wherein the o-ring 502 is located in the annular groove 504 and biases the jaws 306 together. The o-ring 502 can be made from an elastic material such as rubber.

[0026] In view of the foregoing it will be appreciated that by locating the motor 114, the transmission 118 and the battery 104 on the same axis A-A extending along the length of the handle 106 improves weight distribution of internal features of the tool 100. Also by providing the motor 114 within the handle 106 leaves more space available within the tool housing above the handle, whereby there is more freedom to position features of the tool in positions which improve weight distribution of internal features of the tool.

[0027] By providing the motor 114 only partially within the handle 106 achieves the abovementioned advantages to a lesser extent. By providing the motor 114 and also at least part of the transmission 118 within the handle 106 achieves the abovementioned advantages to a greater extent.

[0028] It will be appreciated that whilst various aspects and embodiments have heretofore been described the scope of the present invention is not limited thereto and instead extends to encompass all arrangements, and modifications and alterations thereto, which fall within the spirit and scope of the appended claims.

[0029] In some embodiments the motor 114 is only partially received within the handle 114.

[0030] In some embodiments at least one planetary gear stage of the transmission 118 is received in the handle 106.

[0031] In some embodiments the motor 114 and the transmission 118 are received in the handle 106.

[0032] In some examples the battery 104 is removable from the tool 100 or alternatively the battery 104 is integral to the tool 100. Alternatively or additionally the tool 100 may comprise other power sources e.g. it may be configured to receive power from a mains power supply.

[0033] As shown in Fig. 1, the driving sleeve 126 and input sleeve 128 are fixed to each other due to a friction fit arrangement. Alternatively the driving sleeve 126 and input sleeve 128 can be fixed via an interlocking arrangement such as a spline fit arrangement or other male and female interlocking-type arrangement.

[0034] As shown in Fig. 3a, the o-ring 502 is seated in a groove 504. In some alternative examples the o-ring 502 may be replaced with any suitable means to keep the jaws 306 together such as a c-clip, a circlip, an e clip, a snap ring, or another spring fastener.

[0035] The o-ring 502 is made from an elastic material such as rubber. In other examples, the o-ring 502 is optionally made from polyurethane, PTFE, ethylene propylene rubber, neoprene, nitrile, or silicone.

[0036] As shown in Fig. 3a the jaw assembly 500 comprises three jaws 306. However, in alternative examples, the jaw assembly 500 can comprise any number of jaws 306 more than two.

[0037] In some examples the jaws 306 do not interlock with each other for maintaining jaw alignment.

[0038] In some embodiments the tool 100 can be configured to detect the occurrence of a mandrel snapping by monitoring motor speed. During a pull back stage of operation as the jaw assembly 500 pulls the mandrel of a rivet more tightly the speed of the motor 114 will decrease and then suddenly increase when the mandrel snaps. The controller 112 can monitor for such a sudden increase in motor speed and in response to detecting such occurrence determine that the mandrel of the rivet being set has snapped and in response cease retracting the jaw assembly 500. Subsequently the controller 112 initiates the reset stage of operation either automatically or in response to release of the trigger 110.

[0039] The motor 114 has been described as being a brushless motor and the controller 112 cooperates with the brushless motor (in particular with its control electronics) in order to control the brushless motor. In other embodiments however the motor 114 may be a brushed motor having a motor output shaft driven by a stator and having at least one magnet on the motor output shaft. It is here mentioned that in battery operated embodiments the motor 114 is configured to operate using DC current, whereas in mains operated embodiments the motor is configured to operate using AC current.

[0040] In some embodiments the tool 100 may have a roller screw mechanism instead of a ball screw arrangement 300 for transferring rotational motion into linear motion. A person skilled in the art will appreciate that this can be achieved by rotationally fixing the driving sleeve 126 to an input sleeve of the roller screw mechanism; wherein a set of rollers are provided between the internal surface of the input sleeve and an external surface of the threaded rod 134. When the driving sleeve 126 is caused to rotate it drives rotation of the input sleeve of the roller screw mechanism and thus via the rollers causes linear movement of the threaded rod 134 and thus the jaw assembly.

[0041] Finally the heretofore described functionality need not necessarily be used exclusively in blind rivet setting tools but may be used in other power tools having a fastener gripping portion which moves backwards from a home position in order to set a fastener and which is then returned to the home position. For example the heretofore described functionality can be implemented in other tools such as rivet setting tools (not necessarily blind rivet fastening tools), swage fastener tools and lockbolt fastener tools wherein the fastener gripping portion of such tools is configured to grip the type of fastener which the tool is used to set e.g. the fastener gripping portion of a swage fastener tool is configured to grip a swage fastener.

Claims

1. A power tool comprising:

   a motor at least partially located within the handle of the tool and having a motor output shaft extending along a first axis extending along the length of the handle; and

   a fastener gripping portion operatively coupled to the motor via a transmission which in use causes movement of the fastener gripping portion along a second axis, perpendicular to the first axis, between a home position and a retracted position to set a fastener engaged by the fastener gripping portion;

   the transmission comprising a bevel gear arrangement for redirecting torque flowing along the first axis in use which is input to the bevel gear arrangement so that torque output from the bevel gear arrangement flows along the second axis and wherein the transmission further comprises a mechanism for converting torque output from the bevel gear arrangement in use into a linear force for causing linear movement of the fastener gripping portion.

2. The power tool of claim 1 wherein the mechanism is a ball screw mechanism extending along the second axis between the bevel gear arrangement and the fastener gripping portion.

3. The power tool of claim 1 wherein the mechanism is a roller screw mechanism extending along the second axis between the bevel gear arrangement and the fastener gripping portion.

4. The power tool of any preceding claim wherein the motor is located entirely within the handle.

5. The power tool of any preceding claim wherein the transmission comprises at least one planetary gear stage for transferring torque from the motor along the first axis in use.

6. The power tool of claim 5 wherein the at least one planetary gear stage is at least partially located within the handle.

7. The power tool of claim 6 wherein the at least one planetary gear stage is entirely located within the handle.

8. The power tool of any preceding claim further comprising a battery attachment portion on the handle such that a notional line extending between the battery attachment portion and the motor output shaft extends along the first axis.

9. The power tool of any preceding claim wherein the motor is a brushless DC motor.

10. The power tool of any preceding claim wherein the fastener gripping portion is a jaw assembly.

11. The power tool of any preceding claim wherein the power tool is a blind rivet setting tool.

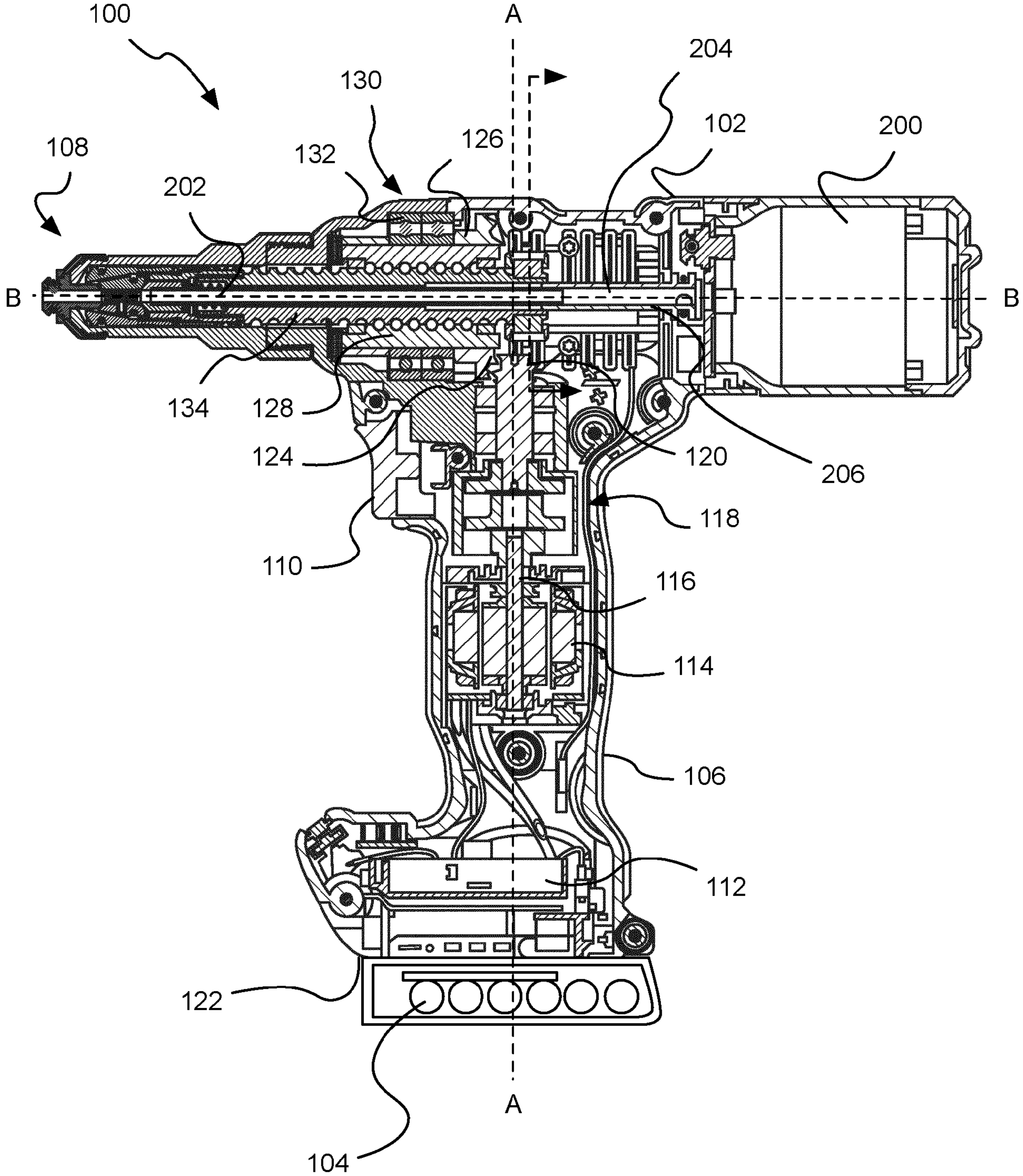
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Fig. 1

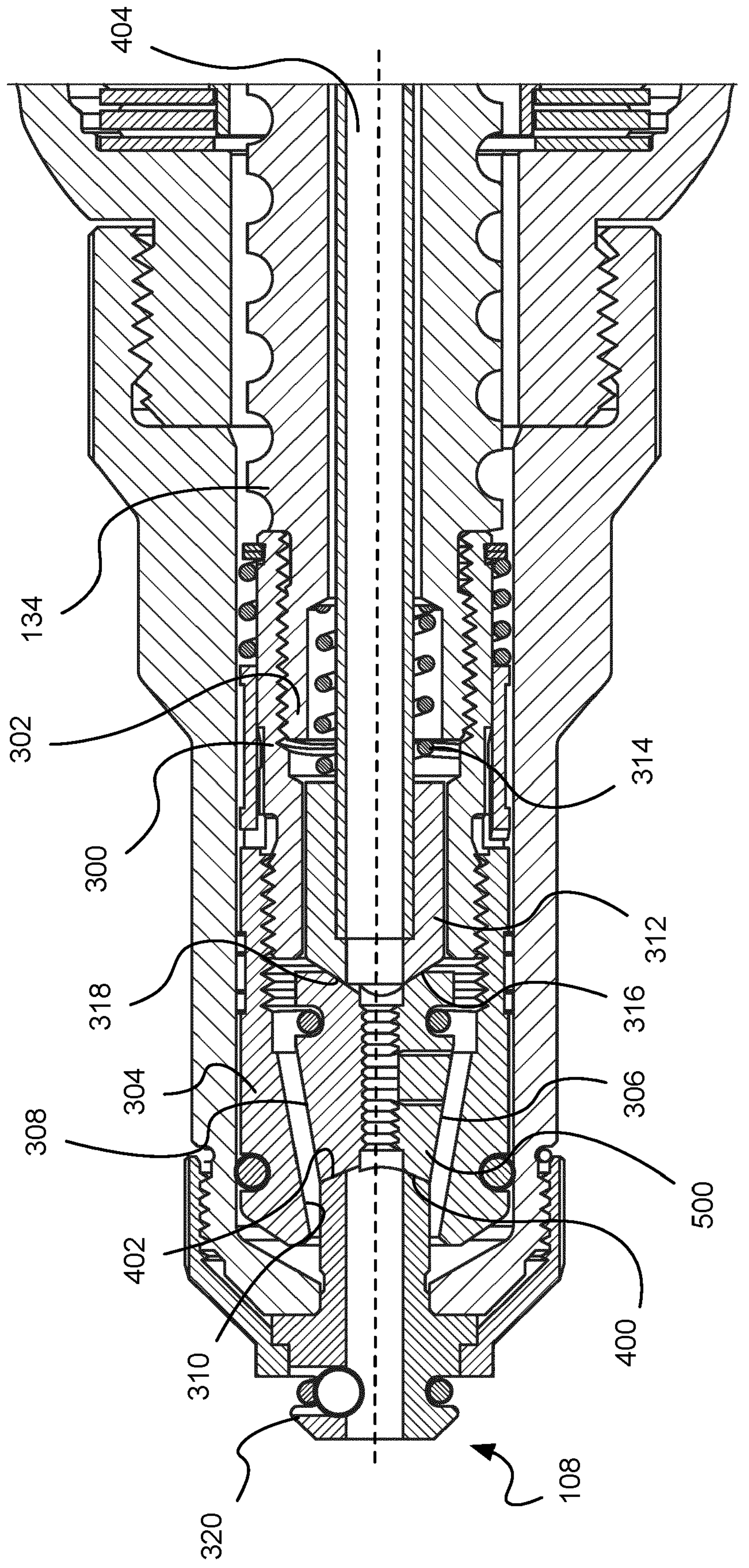
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Fig. 2

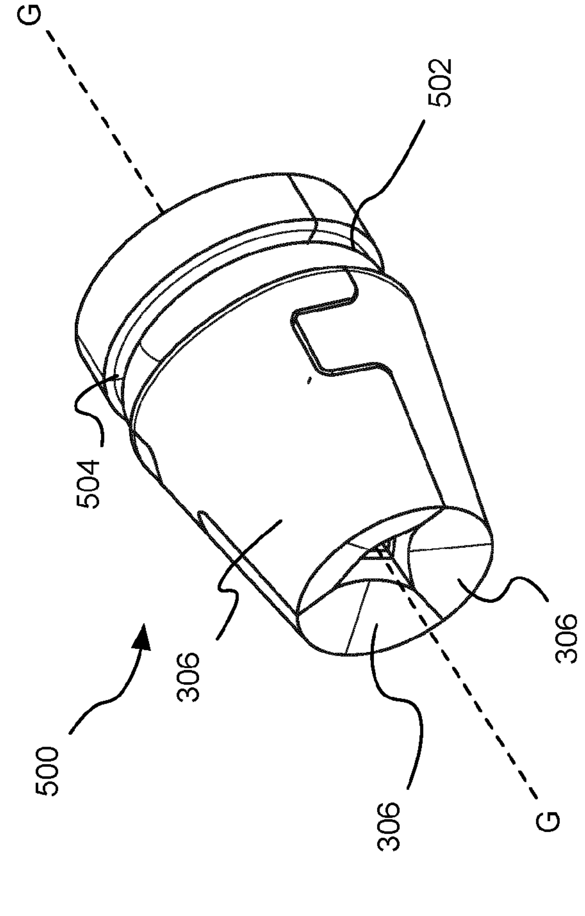

Fig. 3a

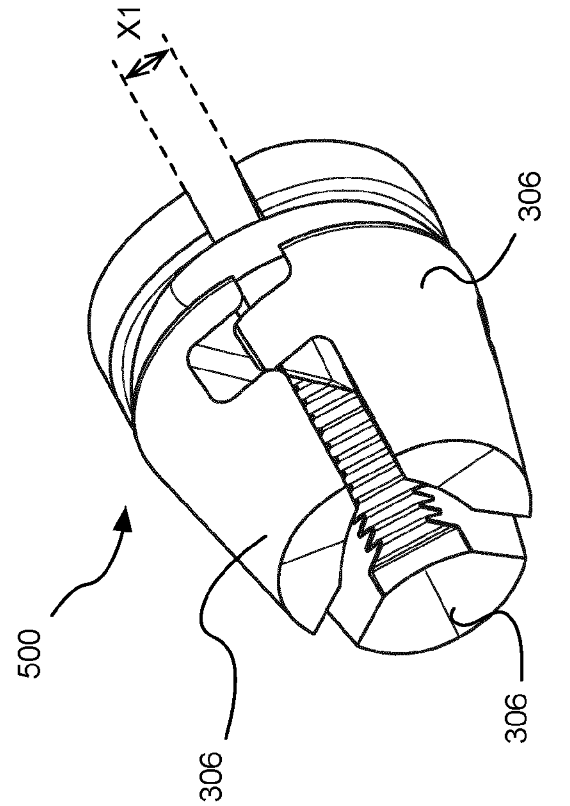

Fig. 3b

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 1315

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2019/247913 A1 (LIAN YI FENG [CN] ET AL) 15 August 2019 (2019-08-15) * figures * -----	1-11	INV. B21J15/04 B21J15/10 B21J15/26
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A	JP 2021 041417 A (MAKITA CORP) 18 March 2021 (2021-03-18) * figures * -----	1-11	
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TECHNICAL FIELDS SEARCHED (IPC)
B21J

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	20 June 2023	Charvet, Pierre

CATEGORY OF CITED DOCUMENTS

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