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(54) **Title**: TORQUE DELIVERING POWER TOOL WITH FLY WHEEL ADAPTED TO TAKE UP REACTION FORCES

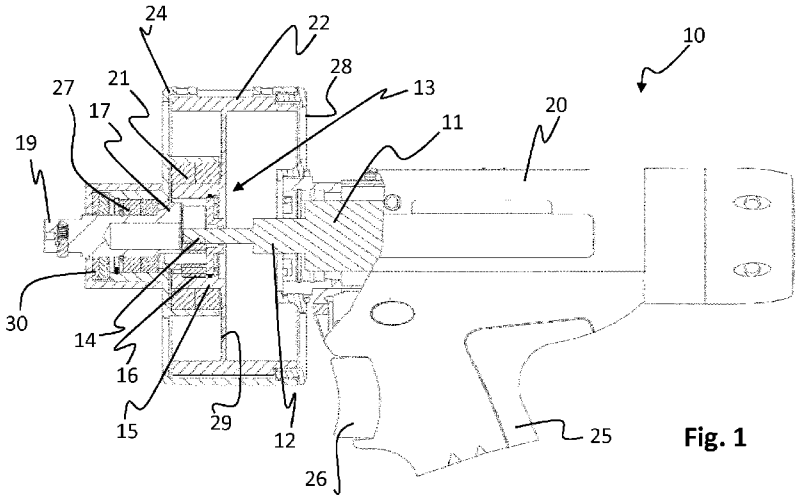

Fig. 1

(57) **Abstract**: A power tool (10) for delivering a torque in order to tighten joints, which power tool (10) comprises a output shaft (19) for connection to a screw or a nut holder and a motor (11) arranged to drive a motor shaft (12), the motor (11) being arranged inside a tool housing (20, 24, 28), wherein the motor shaft (12) is connected to the output shaft (19) via a planet gear (13) comprising a sun wheel (14), a gear rim (15) and planet wheels (16) that are interconnected by a planet carrier (17) and are arranged there between, wherein the motor shaft is connected to the sun wheel (14). The power tool comprises a flywheel (22),which is arranged to rotate with respect to the tool housing and which is arranged to receive reaction forces from the output shaft (19) via said planet gear (13).The power tool comprises a rotation lock (30), which is arranged to, when activated,lock part of the planet gear (13) from rotation,such that the motor (11) may be used to put the flywheel (22) in rotation.

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Torque delivering power tool with fly wheel adapted to take up reaction forces

The invention relates to a power tool for delivering a torque in order to tighten joints. Specifically, the invention relates to a power tool with a reduced reaction force.

Background

A hand held torque delivering power tool such as a nut runner needs to fulfil a number of criteria in order to make the power tool efficient and agreeable to use for an operator. Firstly, it should be adapted to provide a sufficiently high torque to tighten a predetermined type of joints and it should be adapted to tighten said joints to a specific desired torque and/or clamp force level.

Further, in order for the power tool to be agreeable to use for an operator it should be light and the magnitude of the reaction forces that has to be counter-acted by the operator should be kept as low as possible.

The reaction forces are produced as the screw or nut is being tightened and the clamp force in the joint is produced. A nut tightening operation generally includes two phases, a first phase during which the screw is threaded into the joint and a second phase in which the screw is tightened and the clamp force in the joint is produced. The point in time where the threading phase passes into the tightening phase is generally denoted as “snug”. It is only after snug, i.e. during the tightening phase that reaction forces will be created in the power tool. The reaction forces are created in response to the increasing torque needed to tighten the joint by rotation of the screw.

A problem that needs to be addressed in most types of hand held torque delivering power tools is to keep the counter forces as low as possible, even when a considerable torque is applied to the joint.

A solution to the above problem is presented in the patent specification US 7 311 027 B1. In the power tool described in this specification a bit holder is driven to rotate in a first direction by means of a first motor and a flywheel is driven to rotate in the opposite direction by means of a second motor. A brake is arranged to decelerate the flywheel in response to the reaction force that are transmitted from the joint to the power tool. With an increasing reaction force, an increasing deceleration of the flywheel is achieved to compensate said increasing reaction force, such that the

overall reaction force experienced by the operator will be as low as possible. A disadvantage of this arrangement is e.g. that a second motor is needed to drive the flywheel, and that energy is wasted on putting the flywheel in rotation without contributing to the tightening operation.

Summary of the invention

An object of the invention is to provide a power tool in which the reaction forces that will be transmitted to the operator will be kept as low as possible, while at the same time providing a sufficient torque to tighten torque demanding joints. This object is achieved by the invention according to claim 1.

The invention relates to a power tool for delivering a torque to tighten joints, which power tool comprises an output shaft for connection to a screw or a nut and a motor arranged to drive a motor shaft, the motor being arranged inside a tool housing, wherein the motor shaft is connected to the output shaft via a first planet gear comprising a sun wheel, a gear rim and planet wheels that are interconnected by a planet carrier and are arranged between the sun wheel and the gear rim, wherein the motor shaft is connected to the sun wheel. The power tool further comprises a flywheel, which is arranged to rotate with respect to the tool housing and which is arranged to receive reaction forces from the output shaft via said planet gear, wherein the power tool comprises a rotation lock, which is arranged to, when activated, lock part of the planet gear from rotation, such that the motor may be used to put the flywheel in rotation.

In a first embodiment of the power tool the output shaft is connected to the planet carrier and the flywheel is connected to the gear rim, wherein the rotation lock is arranged to lock the planet carrier from rotation.

The rotation lock may comprise a solenoid or an electromagnet and an interaction surface arranged to interact with a tooth on an inner part of the planet carrier.

Further, the inner part of the planet carrier may comprise several teeth arranged along the perimeter of the circular inner part, such that the interaction surface of the rotation lock will interact with a tooth regardless of the angular position of the planet carrier.

In a different embodiment the output shaft is connected to the gear rim, the flywheel is connected to the planet carrier and the rotation lock is arranged to lock the gear rim from rotation.

In yet another embodiment the rotation lock is arranged to lock the output shaft from rotation.

In one embodiment an additional gear is arranged between the motor shaft and the output shaft, which additional gear is fixed to the tool housing such that reaction forces acting over said additional gear will be transmitted to the tool housing.

The additional gear may be a second planet gear that is arranged coaxially with the first planet gear.

In another embodiment a second planet gear is arranged between the motor shaft and the first planet gear, which second planet gear is arranged in the same gear rim as the first planet gear.

Preferred embodiments and other advantages of the invention will be apparent from the detailed description of the invention.

Short description of the drawings

In the following detailed description reference is made to the accompanying drawings, of which:

Fig. 1 shows a sectional view of a power tool according to a first embodiment of the invention;

Fig. 2 shows a sectional view of a power tool according to a second embodiment of the invention;

Detailed description of the shown embodiments of the invention

Figure 1 shows a sectional view of a power tool 10 according to a first embodiment of the invention. The power tool 10 comprises a motor 11, which is located inside a housing 20 and which in the shown embodiment consists of an electric motor. Further, the power tool 10 comprises a handle 25 and a trigger 26 for activation of the motor 11.

Upon activation, the motor 11 drives a motor shaft 12, which is connected to a sun wheel 14 of a planet gear 13. The planet gear 13 further comprises a gear rim 15 and a number of planet wheels 16 which are arranged to rotate between the sun wheel 14 and the gear rim 15. The planet wheels 16 are interconnected by means of a planet carrier 17 that is connected to an output shaft 19.

In the shown embodiment the tool housing 20 is fixedly and firmly connected to a front housing 28, which in turn is fixedly and firmly connected to a gear housing 24. The partition of the housing into several housing parts facilitates assembly and maintenance of the

power tool. In principle the power tool could be housed inside one single housing. It is important that the different housing parts are firmly connected to each other, such that they will withstand and transmit operational efforts between them. Below, the use of the general term "housing" without the use of a reference numeral refers to the joint structure of the separate housing parts.

As the power tool 10 is in operation to tighten a joint, e.g. when a screw is fastened to a nut, reaction forces that are produced in the joint during the tightening operation will be transmitted from the socket via the output shaft 19 to the planet gear 13. Conventionally, such reaction forces are transmitted from the planet wheels 16 to the gear rim and further to the power tool housing 20.

In the shown embodiment of the invention, the gear rim 15 is not fixed with respect to the housing. Instead, the gear rim 15 is mounted in bearings 21, inside the gear housing 24, such that it may rotate freely with respect to the housing. Further, a flywheel 22 is attached to the gear rim 15, such that it may rotate along with the gear rim 15. The flywheel 22 comprises a disc shaped portion 29, which connect the flywheel 22 to the gear rim 15.

With this inventive arrangement, the gear rim 15 and the flywheel 22 will be set to rotate in response to the reaction forces from the output shaft 19. Hence, theoretically no reaction forces will be transmitted to the tool housing, and as a consequence, no reaction forces will be transmitted to the hand of the operator. Instead, the flywheel 22 will rotate faster and faster as the reaction forces are transmitted from the output shaft 19 via the planet gear 13 to the flywheel 22. For a joint that yields a lot of reaction forces the flywheel 22 will eventually rotate at a relatively high speed.

In a similar not shown, but equally feasible embodiment, the flywheel 22 is connected to the planet carrier 17 instead of the gear rim 15. Likewise, the output shaft 19 is connected to the gear rim 15 instead of the planet carrier 17. With such an arrangement a similar gear ratio would be achieved. A difference would however be that that the output shaft 19 would rotate in the opposite direction with respect to the sun wheel 14, and that the rotation of the flywheel would be reversed.

In the shown embodiment a rotation lock 30 is arranged on the output shaft 19. The rotation lock 30 is not arranged to brake the output shaft 19. It is arranged to keep the output shaft 19 still. The rotation lock may be a strictly mechanical lock such as a toothed interaction between the lock 30 and the peripheral surface of the output shaft 19. In such a case the rotation lock 30 could be axially translatable along the output shaft 19, between an inactive

position in which it is not in contact with the output shaft 19, and an active position in which it is in a locked engagement with the output shaft 19.

The rotation lock 30 is utilised to put the flywheel 22 in rotation before a tightening operation is performed. This is made by means of the following operation steps: Firstly, the rotation lock 30 is positioned in the active position in which it is in a locked engagement with the output shaft 19. Subsequently the motor is set to rotate counter clockwise. Due to the fact that the output shaft 19 is locked from rotation, the planet carrier 17 will also be locked from rotation such that the planet wheels 16 will only rotate around their own axis and not around the sun wheel 14. The rotation of the planet wheels 16 around their own axis, forced by the sun wheel 14 that is driven by the motor 11, will force the gear rim 15 and the interconnected flywheel 22 to rotate clockwise. With consideration taken to the inertia of the flywheel 22 and the power of the motor full rotation speed of the flywheel 22 may be achieved relatively quickly in a controlled manner where the reaction force in the housing is no higher than about 5 Nm.

Once the desired speed of the flywheel 22 have been achieved, the rotation lock 30 may be positioned in the inactive position in which it is not in contact with the output shaft 19 and the tightening operation may be commenced. The motor 11 is set to rotate clockwise in order to provide a clockwise rotation to the output shaft 19 that will tighten the joint to be tightened. During the first phase in which the nut is screwed substantially without counter action, the gear rim 15 and the flywheel 22 will be substantially unaffected, meaning that the flywheel will keep most of its rotational speed throughout this phase. Any loss of rotational speed during this phase is mainly dependent on friction, e.g. between the bolt and the nut and between the different gear parts of the planet gear 13. The rotation of the flywheel will, however, contribute to the rotation speed of the output shaft 19. Given that the flywheel 22 had reached full rotational speed, i.e. the speed that corresponds to full speed of the motor, the output shaft 19 will rotate about twice as fast compared to if the flywheel would have been static.

As snug is reached the rotational speed of the flywheel 22 will decrease as a function of the reaction forces from the joint that are transmitted via the planet gear 13 to the flywheel 22. If the sum of the reaction energy exceeds the initial kinetic energy of the flywheel 22 the flywheel 22 will eventually start to rotate counter clockwise. An advantage of this arrangement is that the effective inertia of the flywheel 22 and i.e. its capacity of taking up counter forces are used in both directions.

A second embodiment of the inventive power tool 10' is shown in figure 2. This second embodiment includes an alternative rotation lock 30'. This rotation lock 30' is arranged inside the tool housing to lock the planet carrier 17 from rotation. Since the planet carrier 17 is rotatively connected to the output shaft 19 the alternative rotation lock 30' will have the same basic effect as the rotation lock that is arranged directly on the output shaft 19. Hence, when the rotation lock 30' is activated, the planet carrier 17 and the output shaft 19 will be held still, such that the rotation provided by the motor shaft 11 will be transmitted from the sun gear 14 via the planet wheels 16, which are allowed to rotate around their own axes, to the gear rim 15 and the interconnected flywheel 22.

The rotation lock 30' of the second embodiment comprises a solenoid or an electromagnet with an interaction surface 31 arranged to interact with a tooth 32 on an inner part 33 of the planet carrier 17. This inner part 33 is preferably circular and is preferably provided with several teeth 32 arranged at close intervals along the perimeter of the circular inner part 33, such that the interaction surface 31 of the solenoid or electromagnet will interact with a tooth 32 regardless of the angular position of the planet carrier 17.

The inner part 33 of the planet carrier 17 denotes the part of the of the planet carrier 17 that faces the motor shaft 12, as opposed to a outer part that faces the output shaft 19 of the tool.

In a not shown embodiment the flywheel 22 is arranged to rotate with the planet carrier 17 and the gear rim 15 is rotatively connected to the output shaft 19. In this embodiment the rotation lock is instead arranged to lock the gear rim 15 from rotation. Hence, the rotation provided by the motor shaft 11 will be transmitted from the sun gear via the planet wheels 16, which will rotate between the sun gear 14 and the fixed gear rim 15, to the planet carrier 17 and the interconnected flywheel 22.

In a further not shown embodiment a second gear could be arranged. Such a second gear could either be arranged between the planet gear 13 and the flywheel 22 or axially to the planet gear 13. If the second gear would be arranged axially to the planet gear 13 it could be arranged either before or after the planet gear 13, i.e. either between the planet gear 13 and the output shaft 19 or between the motor shaft 11 and the planet gear 13. This second gear could be fixed with respect to the tool housing, such that the reaction forces will be transmitted to the tool housing.

An effect that is achieved by arranging two planet gears in coaxial alignment, whereof only one is arranged inside a flywheel, is that it will be possible to decide how much of the counter forces that will be transmitted to the tool housing and how much that will be transmitted to the flywheel 22. Hence in this manner it would be possible to design the power tool to a specific application or to specific conditions.

In a preferred embodiment the gearing is adapted such that less than 50% of the reaction forces are transmitted to the tool housing and more preferably less than 40 or 35% are transmitted to the tool housing. Also, the gearing is adapted such that more than 15% of the reaction forces are transmitted to the tool housing and more preferably more than 20 or 25% of the reaction forces are transmitted to the tool housing.

By means of a gear between the planet gear 13 and the flywheel 22, the flywheel 22 could be geared up so as to rotate at a higher speed than the gear rim 15. A gear ratio of 1:2 would imply that the effective kinetic energy of the flywheel 22 would be fourfold, due to the fact that the kinetic energy is proportional to the square of the rotational speed. Further, it would imply that half of the reaction forces that are transmitted from the joint during the tightening phase would be transmitted to the tool housing and half would be transmitted to the flywheel 22. Hence, by controlling the gearing between the gear rim 15 and the flywheel 22 the magnitude of forces that will have to be counter acted by the operator will also be controlled.

In yet a further embodiment two planet gears are arranged coaxially with a common gear rim, wherein the gear is interconnected to the flywheel. In this embodiment all of the reaction torque is transferred to the common flywheel.

Above, specific embodiments of the invention have been described. The scope of the invention is however not limited to either of these embodiments. Instead it is defined by the following claims.

Claims

1. A power tool (10, 10') for delivering a torque to tighten joints, which power tool (10) comprises an output shaft (19) for connection to a screw or a nut and a motor (11) arranged to drive a motor shaft (12), the motor (11) being arranged inside a tool housing (20, 24, 28), wherein the motor shaft (12) is connected to the output shaft (19) via a first planet gear (13) comprising a sun wheel (14), a gear rim (15) and planet wheels (16) that are interconnected by a planet carrier (17) and are arranged between the sun wheel (14) and the gear rim (15), wherein the motor shaft is connected to the sun wheel (14), **characterised in** that the power tool comprises a flywheel (22), which is arranged to rotate with respect to the tool housing and which is arranged to receive reaction forces from the output shaft (19) via said planet gear (13), wherein the power tool comprises a rotation lock (30, 30'), which is arranged to, when activated, lock part of the planet gear (13) from rotation, such that the motor (11) may be used to put the flywheel (22) in rotation.

2. The power tool (10') according to claim 1, wherein the output shaft (19) is connected to the planet carrier (17), the flywheel (22) is connected to the gear rim (15), and the rotation lock (30') is arranged to lock the planet carrier (17) from rotation.

3. The power tool (10') according to claim 2, wherein the rotation lock (30') comprises a solenoid and an interaction surface (31) arranged to interact with a tooth (32) on an inner part (33) of the planet carrier (17) when the solenoid is activated.

4. The power tool (10') according to claim 2, wherein the rotation lock (30') comprises an electromagnet and an interaction surface (31) arranged to interact with a tooth (32) on an inner part (33) of the planet carrier (17) when the electromagnet is activated.

5. The power tool (10') according to either of claims 3 or 4, wherein the inner part (33) of the planet carrier (17) comprises several teeth (32) arranged along the perimeter of the circular inner part (33), such that the interaction surface (31) of the rotation lock (30') will interact with a tooth (32) regardless of the angular position of the planet carrier (17).

6. The power tool according to of claim 1, wherein the output shaft (19) is connected to the gear rim (15), the flywheel (22) is connected to the planet carrier (17) and the rotation lock is arranged to lock the gear rim (15) from rotation.

7. The power tool (10) according to claim 1, wherein the rotation lock (30) is arranged to lock the output shaft (19) from rotation.

8. The power tool according to anyone of the preceding claims, wherein an additional gear is arranged between the motor shaft (11) and the output shaft (19), which additional gear is fixed to the tool housing such that reaction forces acting over said additional gear will be transmitted to the tool housing.

9. The power tool according to claim 8, wherein the additional gear is a second planet gear that is arranged coaxially with the first planet gear (13).

10. The power tool according to anyone of the claims 2-5 or 7, wherein a second planet gear is arranged between the motor shaft (11) and the first planet gear (13), which second planet gear is arranged in the same gear rim (15) as the first planet gear (13).

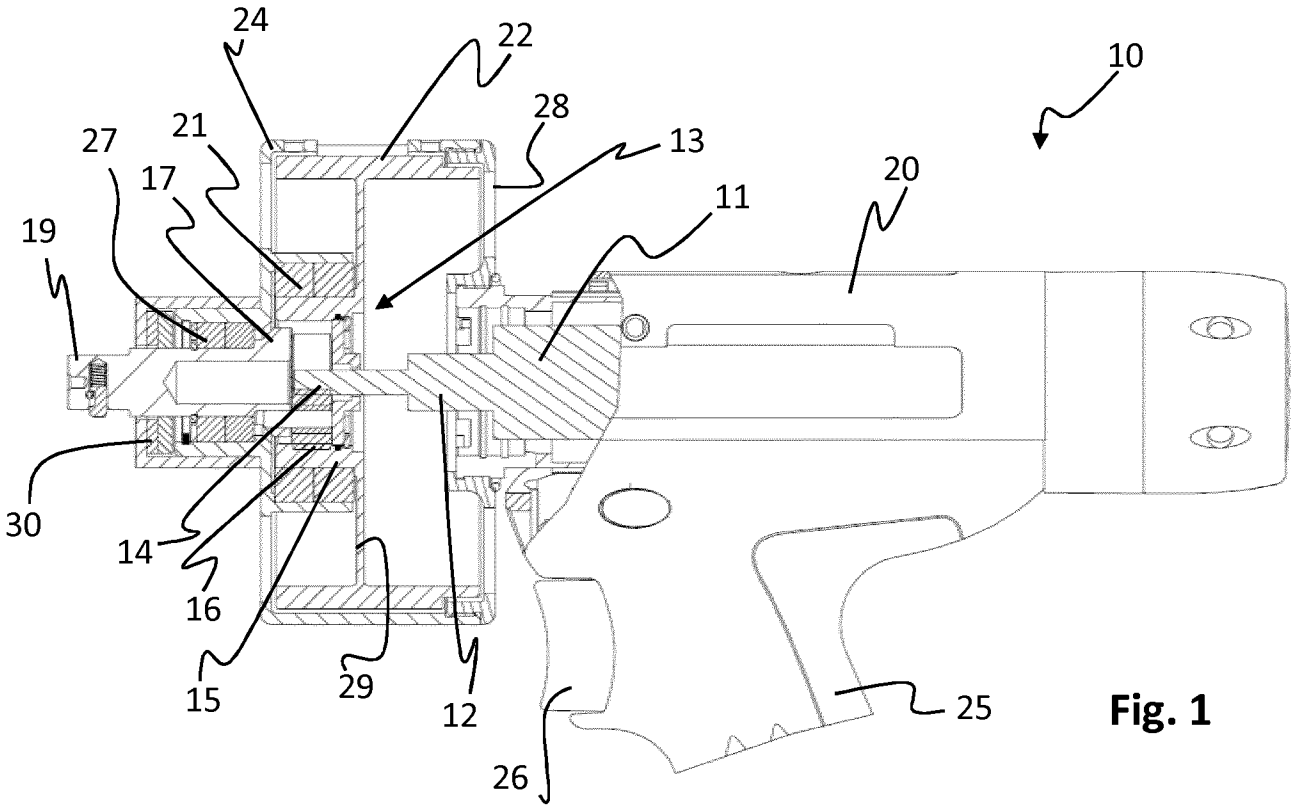
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Fig. 1

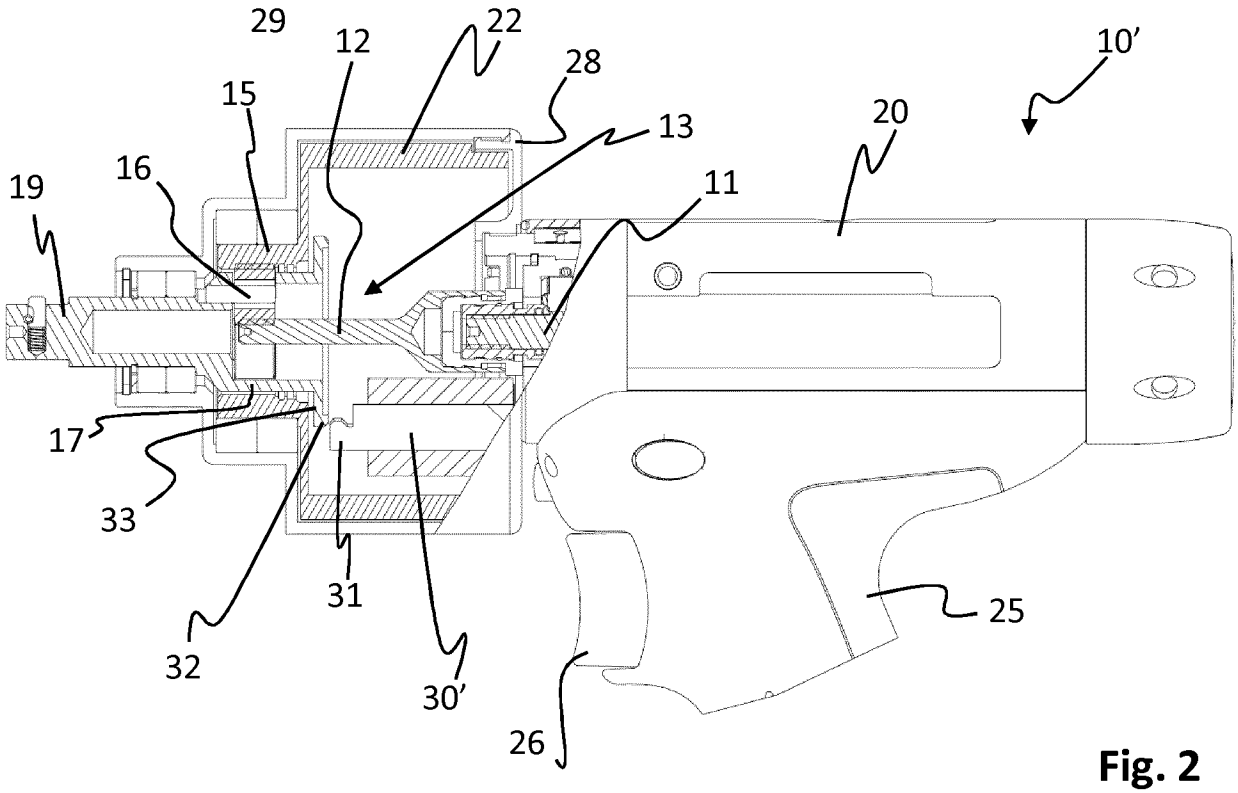
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Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/055568

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25B21/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7 311 027 B1 (TATSUNO KOJI [JP]) 25 December 2007 (2007-12-25) cited in the application the whole document	1
A	DE 37 35 007 A1 (KVERNELAND AS [NO]) 3 May 1989 (1989-05-03) the whole document	1
A	US 2004/149470 A1 (CHAN IN FONG [HK]) 5 August 2004 (2004-08-05) the whole document	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 June 2013	05/07/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kühn, Thomas

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/055568

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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