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(54) Title: LOW REACTION POWER WRENCH

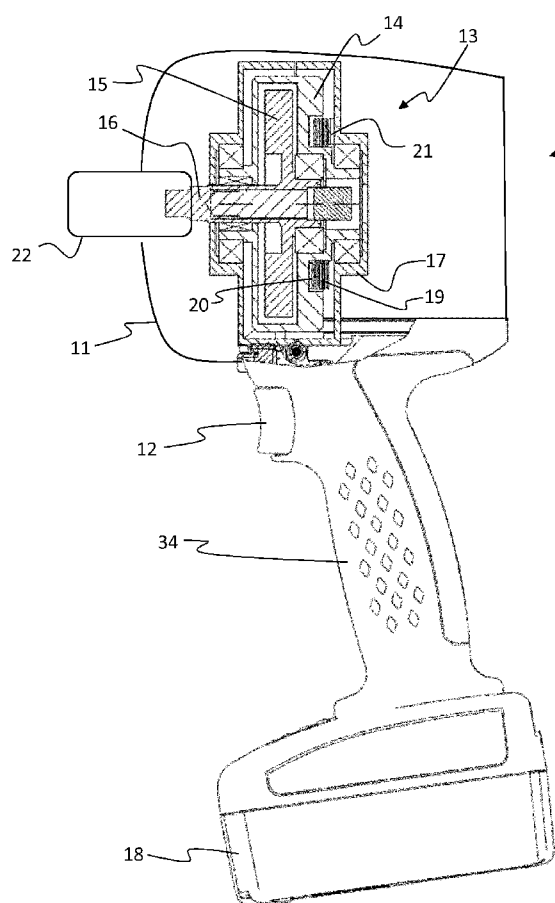


Fig. 1

(57) Abstract: A power wrench (10) including an electric motor (13) comprising a stator (14) and a rotor (15), a torque delivering output shaft (16) that is drivingly connected to the rotor (15), and a housing (11,17) in which the stator (14) is arranged. The stator (14) is rotatively arranged with respect to the housing (11,17). A spring (19) may be arranged to urge the stator (14) towards an initial position.



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Low reaction power wrench

The invention relates to a power wrench that is adapted to yield a low reaction torque. According to a first aspect the invention relates to a handheld power wrench in which the reaction forces experienced by an operator holding the tool during a tightening operation are reduced. According to a second aspect the invention relates to a fixed power wrench in which the reaction forces in the fixture of the tool during a tightening operation are reduced.

10 Background

Power wrenches are industrially used to tighten joints, such as bolts screws and nuts. A general desire for all types of power wrenches, especially handheld power wrenches is to keep the reaction forces that are produced during a tightening operation as low as possible. It is however also relevant to keep reaction forces low for tools that are fixed in a structure such as robot arms or the like. Low reaction forces will reduce the stress in such structures and will hence reduce the mechanical demands on them, since they will merely need to be constructed to carry the weight of the power wrench and to withstand a limited reaction torque. Reduced stress demands will imply a monumental saving with respect to tolerances of the construction holding the tool.

Different techniques are known for keeping the reaction forces low. One manner of reducing reaction forces is to use a pulsating motion or to build up inertia in the power wrench, wherein the produced inertia may be delivered to the joint without the creation of any reaction forces.

These conventional methods have both advantages and drawbacks. Hence, there is room for improvements in the field of power wrenches with a low reaction force.

Summary of the invention

An object of the invention is to provide new kind of power wrench with a low reaction force.

This object is achieved by the invention, which relates to a power wrench including:

- an electric motor comprising a stator and a rotor,
- a torque delivering output shaft that is drivingly connected to the rotor, and
- a housing in which the stator is arranged, the rotor being arranged to rotate with respect to the housing around a motor rotation axis, wherein the stator is arranged such that it may rotate with respect to the housing around a motor rotation axis and is resiliently arranged with respect to the housing, and wherein at least one spring is arranged to urge the stator towards an initial position.

The invention provides a power wrench in which the reaction forces experienced by an operator holding the tool during a tightening operation are reduced in that the stator is allowed to rotate around the motor rotation axis inside the housing of the power wrench.

In one specific embodiment the at least one spring acts in both rotational directions around the motor rotation axis and has a proportional spring force that is proportional to its angular displacement from the initial position.

In another specific embodiment the at least one spring acts in only one rotational direction, whereas the stator is prevented from rotation in the opposite direction around the motor rotation axis.

Preferably the stator in such an embodiment is arranged to only rotate in the counter clockwise direction, i.e. in the opposite direction of the tightening direction of a normal threaded joint, such that it may recoil in response to a delivered torque during a tightening operation.

In yet another specific embodiment the at least one spring acts in both rotational directions around the motor rotation axis and has a spring force that increases in a non-linear manner with its angular displacement from the initial position. The spring force may either
5 increase progressively with its extension or in a decreasingly manner.

In yet another specific embodiment at least one end stop is arranged to limit the rotation of the stator around the motor rotation axis.

In one specific embodiment the rotor is rigidly connected to the output shaft.

10 In another embodiment the rotor is instead connected to the output shaft via a reduction gearing.

The reduction gearing may be a planet gear comprising a rim gear, a sun gear and planet wheels there between, and wherein the rotor is connected to the sun gear, the output shaft is connected to the planet
15 wheels via a planet carrier, and wherein the rim gear is rotatively connected to the stator of the motor via a bridge, the output shaft being coaxial with the rotor and arranged to rotate around the motor rotation axis.

An angle meter may be arranged to monitor the rotation of the stator
20 around the motor rotation axis. Further, a second angle meter may be arranged to monitor the rotation of the rotor around the motor rotation axis. This may be useful for many reasons. For instance it is useful to know the mutual position of the rotor and stator in order to optimise the drive of the motor so as to powerize the correct section
25 of the stator to drive the rotor in an optimal manner.

The stator and the rotor may be disc-shaped and arranged opposite to each other.

Other features and advantages of the invention will be apparent from the figures and from the detailed description of the shown embodiment.

Short description of the drawings

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

- Fig. 1** shows a schematic view of a power wrench according to a first specific embodiment of the invention;
- Fig. 2** shows a front view of a motor house according to the first embodiment of the invention;
- Fig. 3** shows a cut along the line III-III of the motor house shown in fig. 2;
- Fig. 4** shows a perspective view of the motor house shown in fig. 2;
- Fig. 5** shows a perspective cut view of the motor house shown in fig. 4;
- Fig. 6** shows a front view of a motor house according to a second embodiment of the invention;
- Fig. 7** shows a cut along the line VII-VII of the motor house shown in fig. 6;
- Fig. 8** shows a perspective cut view of the motor shown in fig. 6; and
- Fig. 9** shows a schematic view of a power wrench according to a second aspect of the invention.

Detailed description of the shown embodiment of the invention

- In fig. 1 a power wrench 10 according to a first embodiment of the invention is shown. The power wrench comprises a housing 11 that houses an electric motor 13. A lower part of the housing is formed as a handle 34 with a trigger 12 for driving the electric motor 13. The motor 13 includes a stator 14 and a rotor 15. A power source 18, such as a rechargeable battery an electric cable or a combination thereof, is arranged below the handle 34 to power the motor 13. Typically, the

power wrench further includes a control unit for controlling the motor, and a communication unit for communicating with a distant control station.

5 An output shaft 16 is arranged for delivering a torque to a joint that is to be tightened or loosened. The rotor is arranged to rotate around a rotational axis X. The output shaft is 16 drivingly connected to the rotor 15, such that the rotation of the rotor 15 is transferred to the output shaft 16, directly or via a gearing. Typically, the rotor 15 and the output shaft 16 are arranged to rotate around a common axis,
10 the rotational axis X. In the shown embodiment the motor 13 is arranged inside a motor house 17, which is rigidly connected to the main housing 11. The motor may however just as well be directly supported by the housing 11, such that the motor house could be dispensed with. In the shown embodiment the motor house 17 tightly
15 encloses and supports the rotor 15 and the stator 14 of the motor 13. As is indicated in fig. 1 the stator 14 is rotatively arranged with respect to the motor house 17, such that it may rotate around the same rotational axis X as the rotor 15.

In the first embodiment, shown in figures 1-5, the rotor 14 is rigidly
20 connected to the output shaft 16, which in turn is connectable to a screw, bolt or nut for tightening or loosening a joint including said screw, bolt or nut. In the embodiment shown in figure 1 a socket 22 for connection to a bolt or a nut is arranged on the output shaft 16.

The stator 14 is resiliently arranged with respect to the housing 11
25 and the motor house 17. A spring 19 is arranged to keep the stator 14 in an initial position, in which the spring is in equilibrium. In the shown embodiment the spring 19 is a torsional spring with a first end 20 fixed to the stator 14 and a second end 21 arranged to the motor house 17.

30 The stator 14 will rotate within predetermined limits as a result of reaction forces created during a tightening operation. The torque created by the motor will drive the output shaft and when the

resistance in the joint increases will be transmitted as reaction forces to the stator. A normal tightening operation typically comprises a first threadening phase in which the bolt, screw or nut of the joint is rotated with only a substantially low torque applied by the motor and a second phase in which a clamp force is build up in the joint such that the torque increases continuously. In the first phase the stator 14 will remain substantially still, but during the second phase the stator 14 will rotate in the opposite direction with respect to the rotational direction of the rotor 15. The spring 19 may have a spring force that is proportional to its offset from the initial position. There may be also be two or more springs. Further, the spring or springs may be non-linear such that the torque acting on the stator increases non-linearly with an increasing angular displacement of the stator, either exponentially or converging towards a maximum value.

In addition to the spring or springs end stops (not shown) may be arranged to limit the rotation of the stator around the motor rotation axis X. Typically, one single end stop may be arranged to physically hinder the stator to rotate more than 360° or 180° in either direction. Two end stops may however be arranged to allow the stator 14 to rotate less than any specific angle in either direction, and to different degrees in the different directions.

Figure 3 and figure 5 shows a sectional view and a cut perspective view, respectively. As is visible in these figures the stator 14 is journaled with respect to the motor house 17 by means of a front bearing 23 and a rear bearing 24. The rotor 15 is arranged opposite to the stator 14. In the shown embodiment the rotor 15 and stator 14 are disc-shaped. They may however also be cylindrical, one arranged coaxially inside the other.

An advantage with a disc-shaped stator and rotor is that it may imply an increased inertia in the stator, which increases the reaction torque that may be compensated by the rotation of the stator.

A second embodiment is shown in figures 6-8, in which the rotor is connected to the output shaft 16 via a reduction gearing. In the shown embodiment the reduction gearing is a planetary gear with a typical reduction ratio of about 1:4, the output shaft 16 being co-axial to the rotor 15 and arranged to rotate around the same rotational axis X as the rotor 15. Specifically, the rotor 15 is rigidly connected to a sun wheel 28 of the planetary gear. A planet carrier 30 carries a number of planet wheels 29 that rotate around separate planet gear shafts 32. In the shown embodiment three planet wheels 29 are arranged. There may however also be 1, 2, 4 or more planet wheels. The planet carrier 30 is rigidly connected to the output shaft 16. A rim gear 31 is arranged to enclose the planet wheels 29 which will rotate around the sun wheel 28 and their own shafts 32 as a function of the rotation of the sun wheel 28, which in turn is implied by the rotation of the rotor 15.

The reaction forces that are created during a tightening operation are provided to the rim gear 31. In the prior art a rim gear is normally rigidly arranged inside the housing so as to transmit the reaction forces to the housing of the power wrench. In the inventive second embodiment these reaction forces are instead transferred to the stator 14. Namely, the rim gear 31 is connected to the stator 14 via a bridge 33. The bridge 33 is journalled with respect to the motor house 17 in the front stator bearing 23, and the rotor is journalled with respect to the stator 14 in the front rotor bearing 25.

The inventive stator arrangement is intended to be controlled by means of a control unit so as to deliver a controlled and well defined torque to a joint. In addition to the torque transducer 27 arranged inside the rotor shaft an angle encoder may be arranged to monitor the rotation of the output shaft 16 and a meter may be arranged to monitor the rotation of the stator 14. As the spring action of the spring 19 increases according to a known formula with respect to the angular displacement of the stator 14, and as the reaction forces will be transmitted to the stator the angular displacement of the stator 14

around the rotational axis X will be an indirect indication of the reaction forces produced during a tightening operation. Hence, a torque meter, an angle meter or both may be used to monitor the angular displacement of the stator 14. A torque meter could be
5 arranged at the second end 21 of the spring 19 to register the force with which the spring acts on the motor house 17.

The control unit may further be configured to control the motor in response to the angular displacement of the stator 14 around the rotational axis X. For instance, the control unit may be configured to
10 limit the angular displacement of the stator 14 such that the experienced reaction torque will remain below a predetermined threshold. Further, a gyro (not shown) may be arranged to monitor the rotation of the housing 11 around the motor rotation axis of the output shaft, which is common to the rotational axis X of the rotor
15 15. At a specific angular rotation of the housing the motor may be slowed down or turned off as a safety arrangement. Depending on the magnitude of the angular displacement of the housing the tightening operation may either be concluded a moment later or interrupted to be concluded at another time.

20 The control unit may be configured to control a tightening operation actively during a tightening operation, e.g. in order to reach a set target torque with as little reaction force as possible. The control unit may also be configured to deliver torque pulses and to optimise these pulses in response to the movement of the stator 14. Such
25 optimisation may be dependent on many different parameters and may be readily tested by a person skilled in the art.

A second aspect of the invention is schematically shown in figure 9. In this embodiment the power wrench 10 is arranged in the form of a fixed power wrench. Specifically a power wrench held by an articulated
30 robot arm comprised of three arm-parts 41,42,43 interconnected by articulated joints 44,45. A third articulated joint 46 may be arranged

in order to allow a proximal arm-part 41 to articulate with respect to a base structure 47.

As is apparent from the schematic illustration in figure 9 the arm-parts 41,42,43 and articulated joints 44,45,46 may be of a relatively
5 light construction, not adapted to withstand great torques but well adapted to carry a power wrench in accordance with the invention and to withstand the relatively low reaction torques that are produced by the present inventive power wrench.

Above, the invention has been described with reference to two specific
10 embodiments. The invention is however not limited to these embodiments. It is obvious to a person skilled in the art that the invention maybe varied within its scope of protection, which is defined by the following claims.

Claims

1. A power wrench (10) including:

- an electric motor (13) comprising a stator (14) and a rotor (15),
- a torque delivering output shaft (16) that is drivingly connected

5 to the rotor (15), and

- a housing (11,17) in which the stator (14) is arranged, the rotor (15) being arranged to rotate with respect to the housing around a motor rotation axis (X), **characterised in** that the stator (14) is arranged such that it may rotate with respect to the housing around

10 the motor rotation axis (X) and is resiliently arranged with respect to the housing (11,17), wherein at least one spring (19) is arranged to urge the stator (14) towards an initial position.

2. The power wrench (10) according to claim 1, wherein the at least one spring acts in both rotational directions around the motor

15 rotation axis (X) and has a proportional spring force that is proportional to its angular displacement from the initial position.

3. The power wrench (10) according to claim 1, wherein the at least one spring acts in both rotational directions about the motor rotation axis (X) and has a spring force that increases in a non-linear manner

20 with its angular displacement from the initial position.

4. The power wrench (10) according to anyone of the preceding claims, wherein at least one end stop is arranged to limit the rotation of the stator (14) around the motor rotation axis.

5. The power wrench (10) according to anyone of the preceding

25 claims, wherein the rotor (15) is rigidly connected to the output shaft (16) such that the output shaft (16) is coaxial with the rotor (15) and arranged to rotate around the motor rotation axis (X).

6. The power wrench (10) according to anyone of the claims 1-4, wherein the rotor (15) is connected to the output shaft (16) via a

30 reduction gearing.

7. The power wrench (10) according to claim 6, wherein the reduction gearing is a planet gear comprising a rim gear (31), a sun gear (18) and planet wheels (29) there between, and wherein the rotor (15) is connected to the sun gear (18), the output shaft is connected to the planet wheels (29) via a planet carrier (30), and wherein the rim gear (31) is rotatively connected to the stator (14) of the motor (13) via a bridge (33), the output shaft (16) being coaxial with the rotor (15) and arranged to rotate around the motor rotation axis (X).

8. The power wrench (10) according to anyone of the preceding claims, wherein an angle meter is arranged to monitor the rotation of the stator (14) around the motor rotation axis (X).

9. The power wrench (10) according to anyone of the preceding claims, wherein the stator (14) and the rotor (15) are disc-shaped and arranged opposite to each other.

10. The power wrench (10) according to anyone of the preceding claims, further comprising a handle (34) adapted to be held by an operator.

11. The power wrench (10) according to anyone of the claims 1-9, further comprising an attachment portion adapted to be fixed to a robot arm.

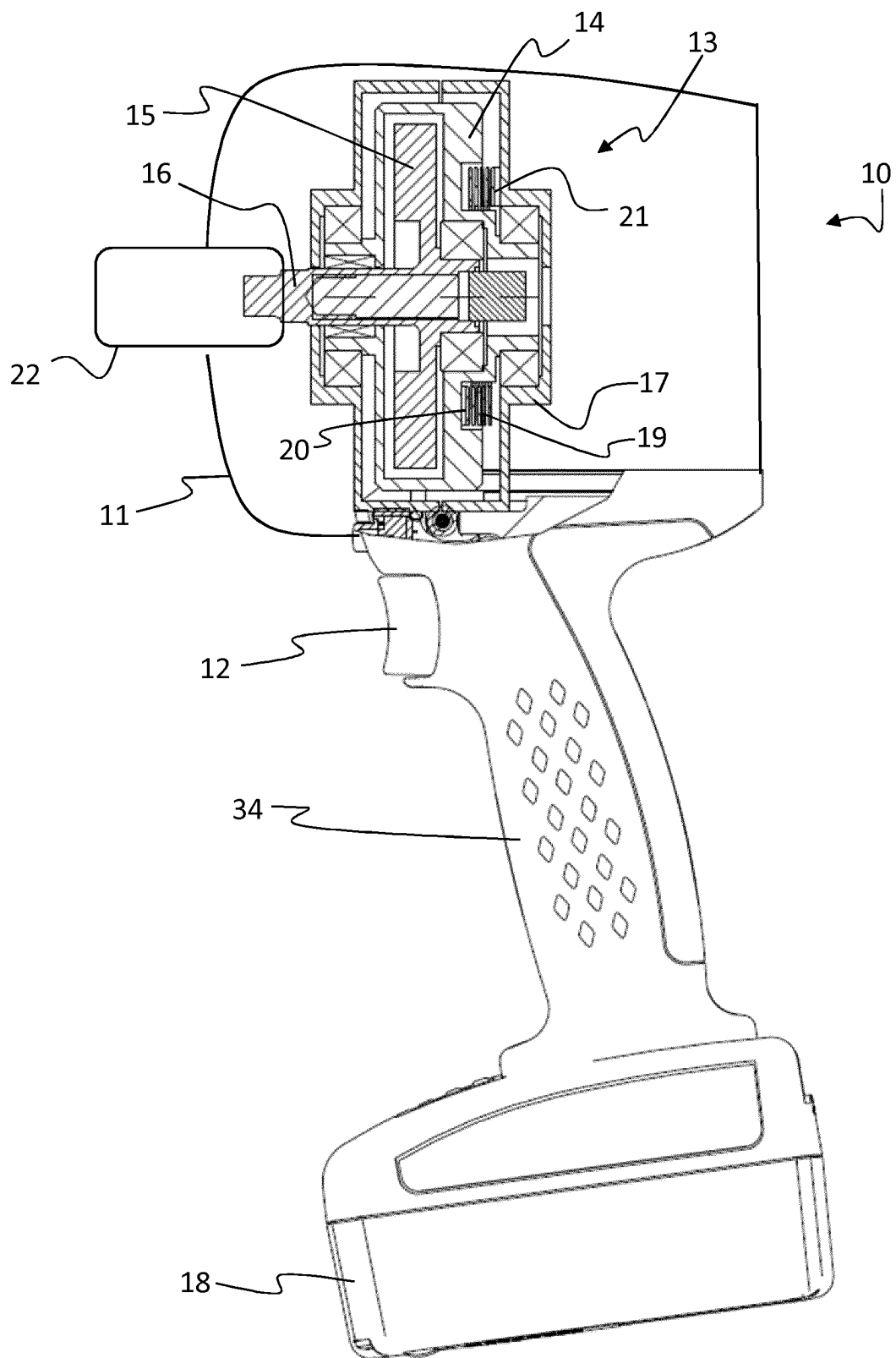


Fig. 1

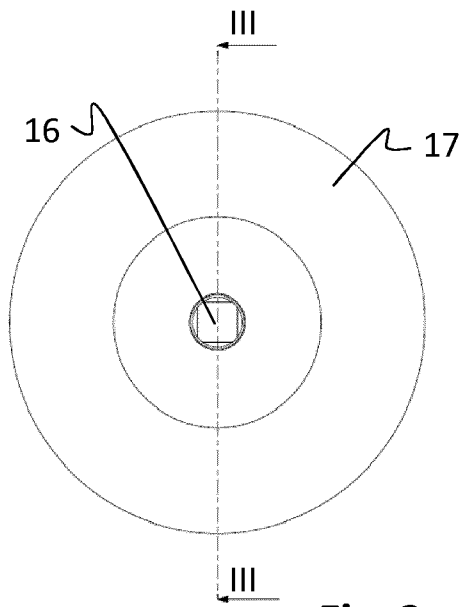


Fig. 2

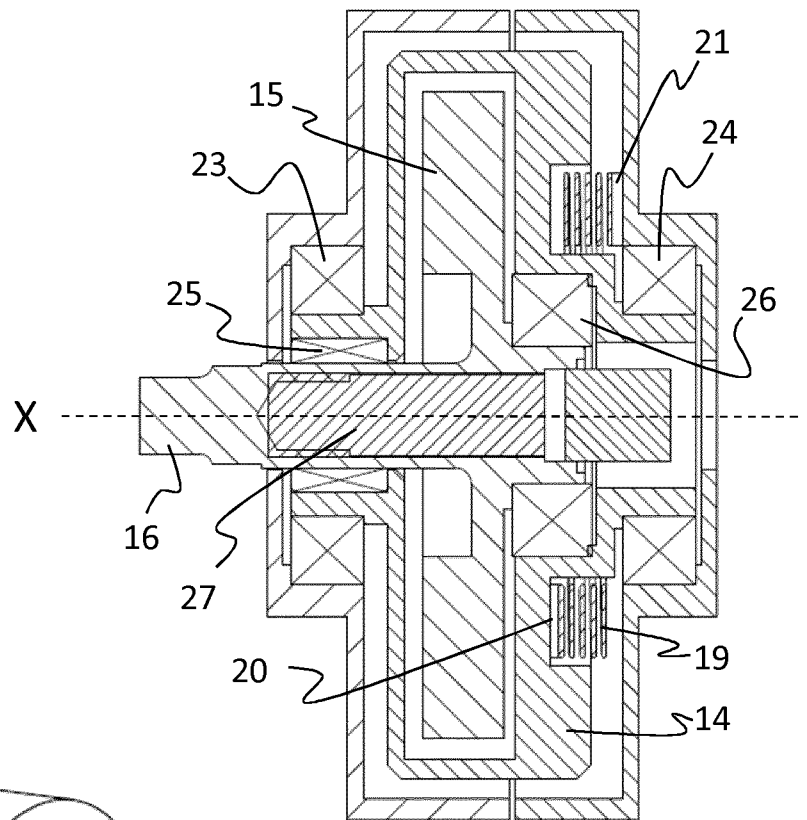


Fig. 3

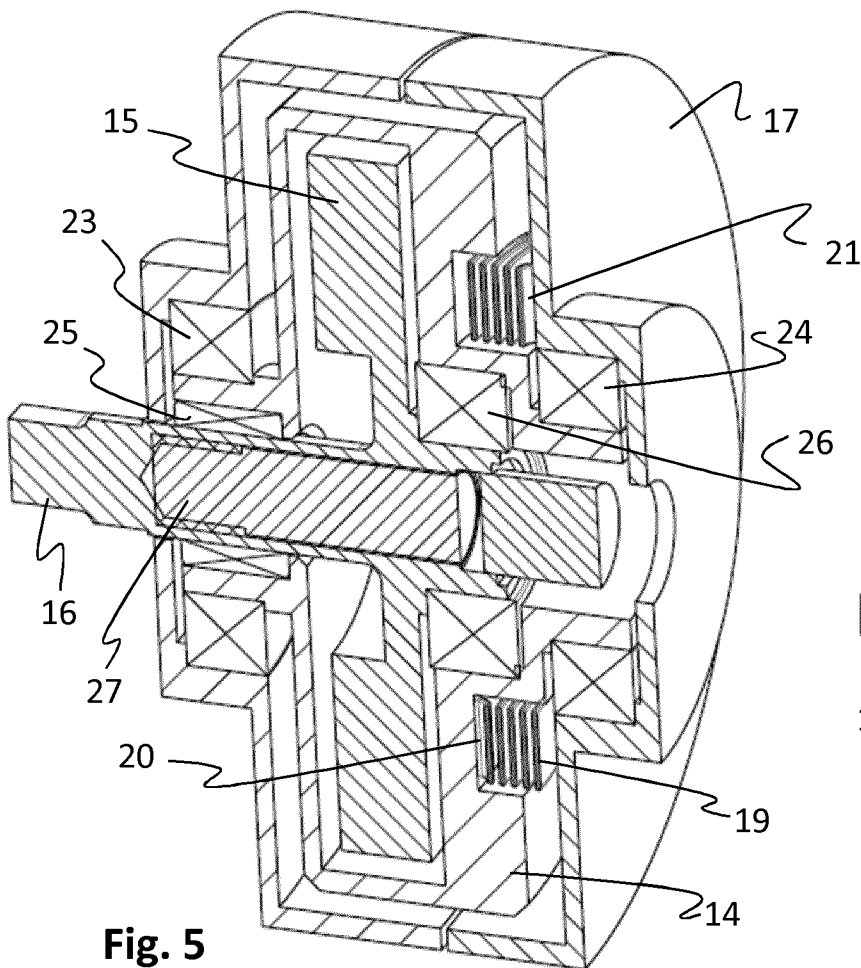


Fig. 5

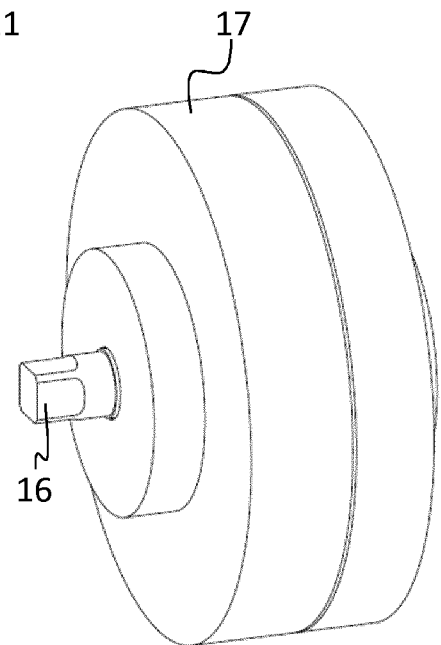


Fig. 4

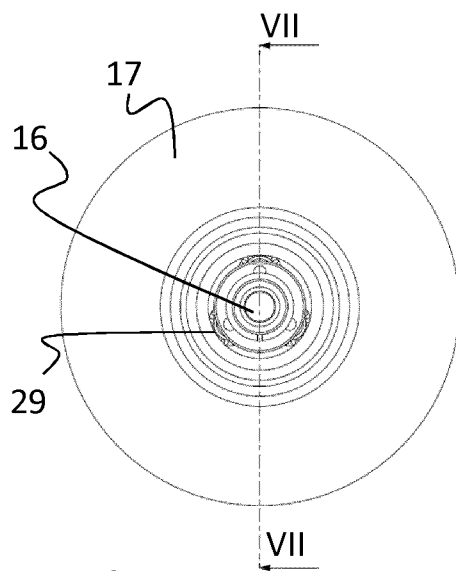


Fig. 6

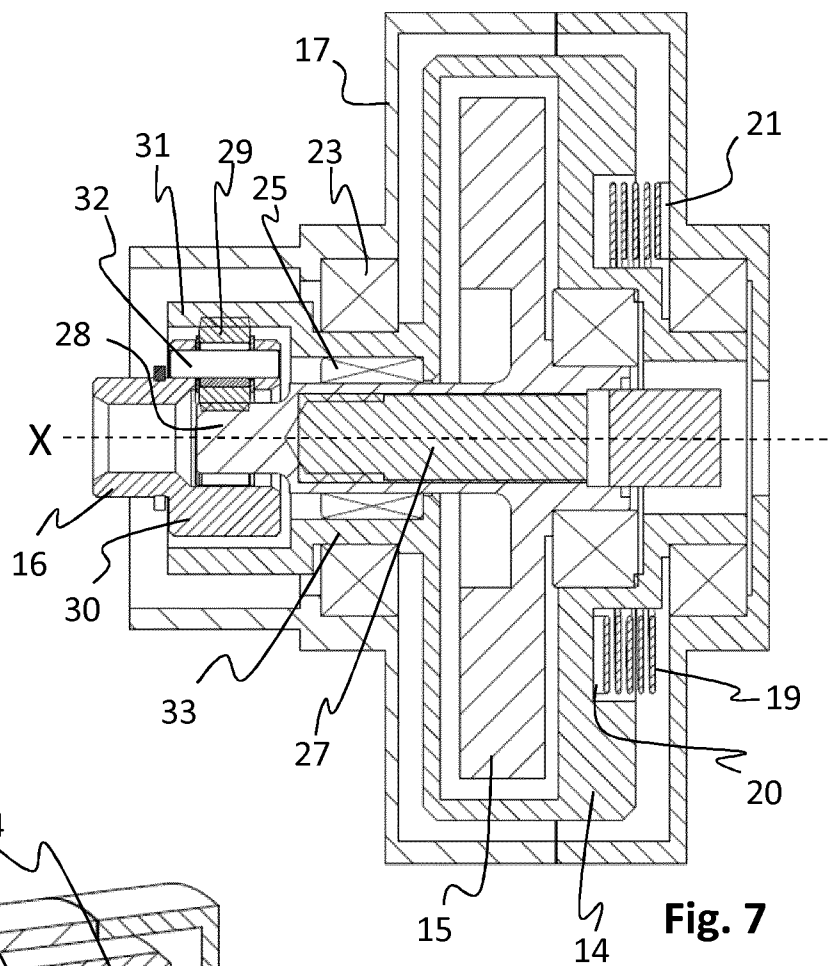


Fig. 7

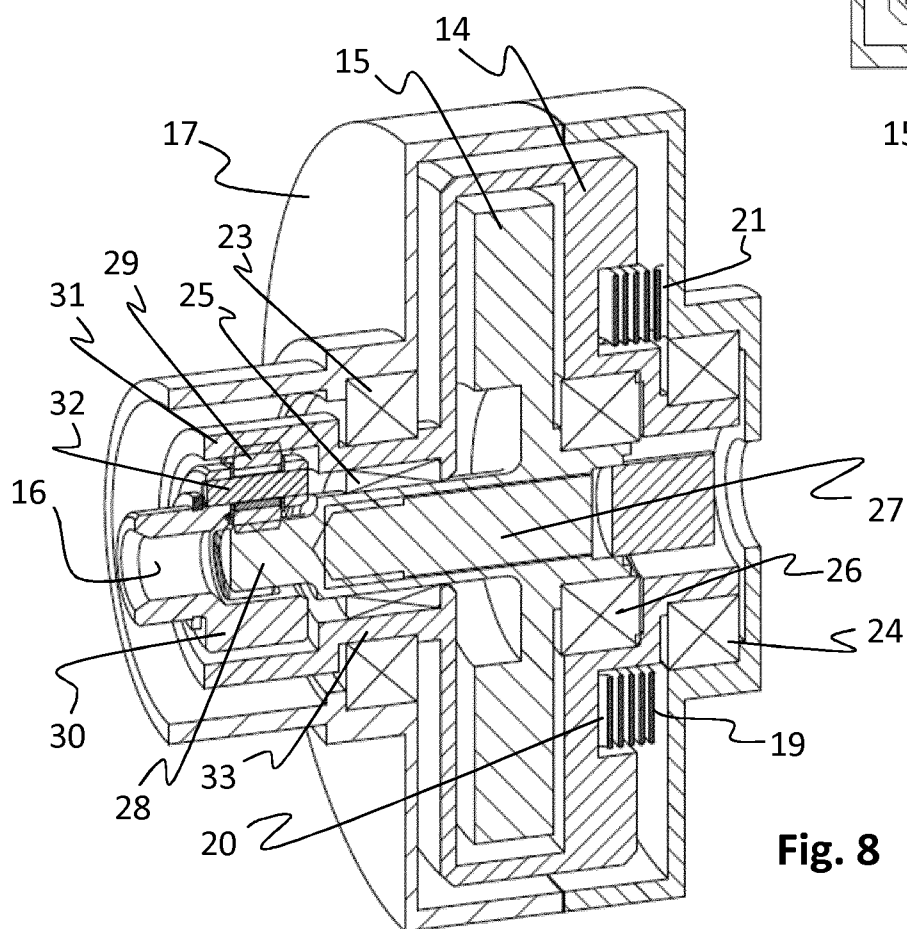
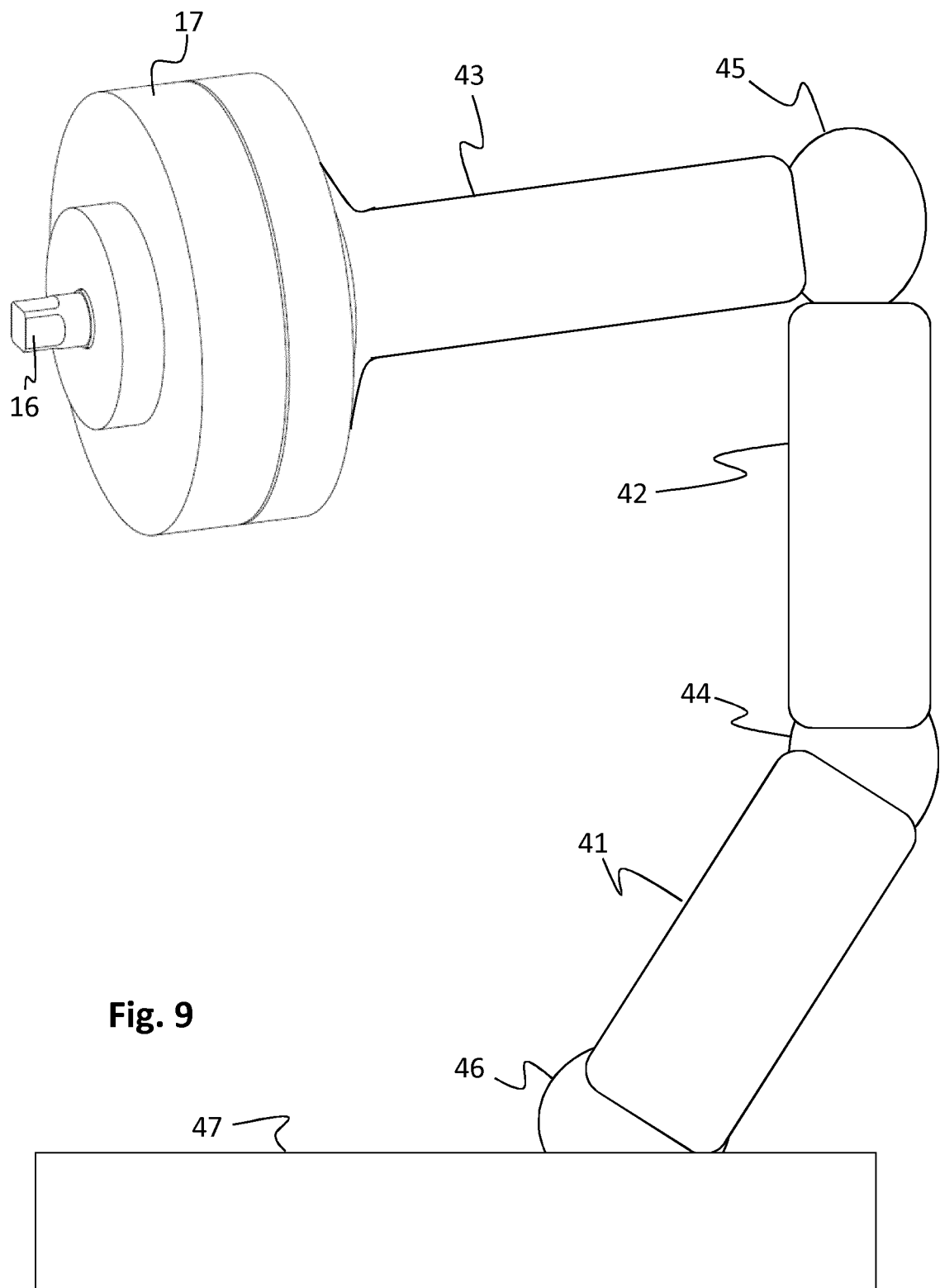


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/058319

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	DE 10 2011 105345 A1 (FISW STEUERUNGSTECHNIK GMBH [DE]) 27 December 2012 (2012-12-27) paragraphs [0032], [0033], [0034], [0040], [0041]; figures 5,6,7	1-11
A	DE 10 2004 022774 A1 (KOENIG & BAUER AG [DE]) 22 December 2005 (2005-12-22) the whole document	1
A	DE 10 2009 020092 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 11 November 2010 (2010-11-11) the whole document	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

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08/07/2016

Name and mailing address of the ISA/

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Pastramas, Nikolaos

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/058319

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