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(54) Title: APPARATUS FOR TIGHTENING THREADED FASTENERS

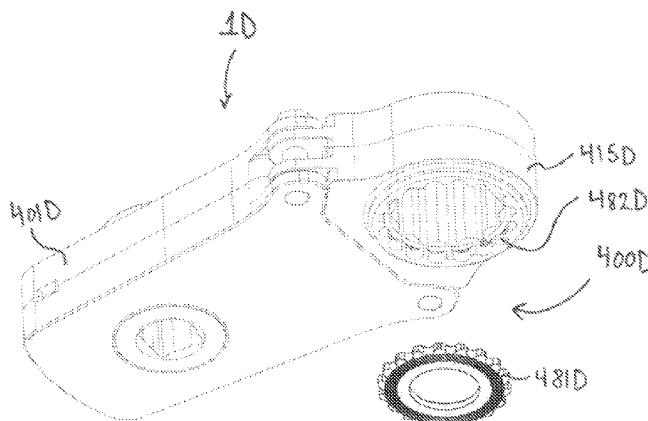


FIG. 6C

(57) Abstract: An offset drive link assembly for transmission and multiplication of torque from a power tool for tightening or loosening a threaded fastener includes: a drive force input assembly; a drive force output assembly; and a reaction force assembly. Advantageously the offset drive link assembly: allows access to previously unreachable fasteners due to, for example protruding threads, limited clearances and obstructions; makes practical previously unusable devices driven either electrically, hydraulically, manually and/or pneumatically; makes feasible previously unusable advanced materials, such as, for example aircraft-grade aluminum; creates modular components, such as, for example hex-reducing and -increasing drive bushings, male to female drive adaptors, to meet bolting application characteristics; yields accurate and customizable torque multiplication; tames drive force and reaction force application; overcomes corrosion, thread and facial deformation; avoids bolt thread galling; nullifies side load; ensures balanced bolt load for symmetrical joint compression; simplifies link and tool use; minimizes risk of operator error; and maximizes bolting safety.



Title: **APPARATUS FOR TIGHTENING THREADED FASTENERS**

Cross Reference to Related Applications

This Application is either a continuation patent application or a continuation-in-part patent application of the following commonly owned and co-pending patent applications, entire copies of which are incorporated herein by reference: U.S. Application Serial No. 61/815,428, having Filing Date of 24 April 2013, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS"; U.S. Application Serial No. 61/903,254, having Filing Date of 12 November 2013, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS"; U.S. Application Serial No. 61/916,926, having Filing Date of 17 December 2013, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS"; and U.S. Application Serial No. 61/940,919, having Filing Date of 18 February 2014, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS".

Innovations disclosed in this Application advance technology disclosed in the following commonly owned issued patents and patent applications, entire copies of which are incorporated herein by reference, including: U.S. Patent No. 5,140,874, having Issue Date of 25 August 1992, entitled "FLUID-OPERATED WRENCH"; U.S. Patent No. 7,451,672, having Issue Date of 18 November 2008, entitled "LINK ATTACHMENT TO TORQUE WRENCH"; and U.S. Patent Application Serial No. 14/241,354, having Filing Date of 26 February 2014, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS".

Background

Threaded fasteners including bolts, studs, nuts and washers are known and used in traditional bolting applications. Maintenance and repair of industrial applications begin with loosening of and end with tightening of these threaded fasteners. Often these fasteners are utterly inaccessible or unreachable with tools readily available to an operator due to, for example, protruding threads, limited clearances and bolting application obstructions. Naturally industry seeks to reduce production loss during routine, unforeseen and/or emergency maintenance and/or repair.

The present application relates to offset link attachments for torque power tools for such inaccessible and/or unreachable fasteners. Known link attachments include pawl-ratchet mechanisms or oscillating levers for tightening and loosening of such fasteners. It is believed that known link attachments can be further improved.

More generally, examples of Applicant's patent evolution is disclosed for the following product lines and drivers and tools for use therewith in the following commonly owned issued patents and patent applications, entire copies of which are incorporated herein by reference, including: traditional reaction fixtures in U.S. Patent Nos. 4,671,142, 4,706,526, 5,016,502, RE33,951, 6,152,243, D500060 and 7,765,895; the HYTORC

NUT™ in U.S. Patent Nos. 5,318,397, 5,341,560, 5,499,9558, 5,538,379, 5,539,970, 5,640,749, 5,946,789, 6,152,243, 6,230,589, 6,254,323 and 6,461,093; the HYTORC WASHER™ in U.S. Patent Nos. 6,490,952, 6,609,868, 6,883,401, 6,929,439, 6,986,298, 7,003,862, 7,066,053, 7,125,213, 7,188,552, 7,207,760 and 7,735,397; the HYTORC® XXI® in U.S. Patent No. 6,298,752; the HYTORC jGUN®, FLIP-Gun®, THRILL® Gun and Z™ Gun in U.S. Patent Nos. and U.S. Application Nos. 6,490,952, 6,609,868, 6,883,401, 6,929,439, 6,986,298, 7,003,862, 7,066,053, 7,125,213, 7,188,552; 7,207,760, 7,641,579, 7,735,397, 7,798,038, 7,832,310, 7,950,309, 8,042,434, D608,614, 13/577,995 and 61/916,926.

Description of the Preferred Embodiments

An offset drive link assembly for transmission and multiplication of torque from a power tool for tightening or loosening a threaded fastener includes: a drive force input assembly; a drive force output assembly; and a reaction force assembly.

Advantageously the offset drive link assembly: allows access to previously unreachable fasteners due to, for example protruding threads, limited clearances and obstructions; makes practical previously unusable devices driven either electrically, hydraulically, manually and/or pneumatically; makes feasible previously unusable advanced materials, such as, for example aircraft-grade aluminum; creates modular components, such as, for example hex-reducing and -increasing drive bushings, male to female drive adaptors, to meet bolting application characteristics; yields accurate and customized torque multiplication; tames drive force and reaction force application; overcomes corrosion, thread and facial deformation; avoids bolt thread galling; nullifies side load; ensures balanced bolt load for symmetrical joint compression; simplifies link and tool use; minimizes risk of operator error; and maximizes bolting safety.

The invention may be described by way of example only with reference to the accompanying drawings, of which:

Figure 1 is an exploded perspective view of an embodiment of the present invention in the form of an apparatus 1;

Figure 2 is a perspective view of an embodiment of the present invention in the form of apparatus 1;

Figure 3 is a perspective view of an embodiment of the present invention in the form of an apparatus 1A;

Figure 4 is a perspective view of an embodiment of the present invention in the form of an apparatus 1B;

Figure 5 is a perspective view of an embodiment of the present invention in the form of an apparatus 1C;

Figure 6A is an exploded and separated perspective view of portions of an embodiment of the present invention in the form of an apparatus 1D;

Figure 6B is an exploded and separated perspective view of portions of an embodiment of the present invention in the form of an apparatus 1D;

Figure 6C is a perspective view of an embodiment of the present invention in the form of apparatus 1D;

Figure 7 is a perspective view of portions of an embodiment of the present invention in the form of apparatus 1 with an hydraulic torque tool;

Figure 8 is a perspective view of portions of an embodiment of the present invention in the form of apparatus 1D with a pneumatic torque tool;

Figure 9 is an exploded perspective view of portions of an embodiment of the present invention in the form of apparatus 1D with three modular drive force output gears of various sizes; and

Figure 10 is a perspective view of an embodiment of the present invention in the form of an apparatus 1E with two modular drive force input engagements;

Referring to FIGs. 1A and 1B by way of example, these show perspective views of embodiments of the present invention as a reaction arm-free apparatus 1A and 1B for gall-minimized tightening and loosening of an industrial threaded fastener 20 of the kind having a nut 21, a washer 22 and a stud 23. Apparatus 1A and 1B include: drive input and output assembly 100; turning force multiplication assembly 200; vibration force assembly 300; mode shifting assembly 400; and dual drive output and reaction socket assembly 500.

Referring to FIG. 1, by way of example, it shows an exploded perspective view of an embodiment of the present invention in the form of apparatus 1, or offset drive link assembly 1, for transmission and multiplication of torque from a device (not shown) for tightening or loosening a threaded fastener (not shown). Apparatus 1 includes: a drive force input assembly 100; a drive force output assembly 200; and a reaction force assembly 400. Apparatus 1 further includes a drive force idler assembly 300, but note that it's not required. Referring to FIG. 2, by way of example, it shows a perspective view of apparatus 1.

Drive force input assembly 100 includes a drive force input gear 101, or drive force input engagement 101, formed between a first and a second reaction force assembly housing 401 and 405. A first drive force input gear sleeve 102 is formed between first reaction force assembly housing 401 and drive force input gear 101. A second drive force input gear sleeve 103 is formed between second reaction force assembly housing 405 and drive force input gear 101.

Drive force output assembly 200 includes a drive force output gear 201, or drive force output engagement 201, formed between third and fourth reaction force assembly housing 410 and 415. A first drive force output gear sleeve 202 is formed between third reaction force assembly housing 410 and drive force output gear 201. A second drive force output gear sleeve 203 is formed between fourth reaction force assembly housing 415 and drive force output gear 201.

Tool drive idler assembly 300 includes a drive force idler gear 301 formed about a tool drive idler pin 302. A tool drive idler bushing 303 is formed between idler gear 301 and idler pin 302. Tool drive idler assembly 300 is formed within offset drive link assembly 1 and between drive force input gear 101 and drive force output gear 201.

Reaction force assembly 400 includes: first and second reaction force assembly housing 401 and 405, formed as a top and a bottom, respectively, near drive force input assembly 100; and third and fourth reaction force assembly housing 410 and 415, formed as a top and a bottom, respectively, near drive force output assembly 200. A reaction arm 450 is: integral with offset drive link assembly 1; formed adjacent assembled reaction force assembly housings 401, 405, 410 and 415; and held in place by a first reaction force assembly link pin 421. Reaction arm 450 may be formed on the other side of offset drive link assembly 1 and held in place by a second reaction force assembly link pin 422.

Fastenings 420 draw together components of offset drive link assembly 1 and include: first and second reaction force assembly link pins 421 and 422; a first, a second, a third and a fourth reaction assembly socket head cap screw 423, 424, 425 and 426; and various dowel pins. Once secured, fastenings 420 assemble drive force input assembly 100, drive force output assembly 200, drive force idler assembly 300, and reaction force assembly 400.

Drive force input gear 101 includes a drive force input square drive 111, or drive force input polygonal adaptor 111, to receive a first turning force 120, or a drive force 120, acting in a first direction 122. First reaction force assembly housing 401 includes a reaction force input spline 431, or reaction force input polygonal adaptor 431, to receive a second turning force 121, or a reaction force 121, acting in a second direction 123. Drive force 120 and reaction force 121 are substantially equal to and in opposite direction of each other.

Drive force input gear 101 transfers drive force 120 to drive force idler gear 301, which transfers drive force 120 to drive force output gear 201. First reaction force assembly housing 401 substantially transfers reaction force 121 to reaction arm 400, which then substantially transfers reaction force 121 to a stationary object.

Drive force output gear 201 may be formed in any suitable size or geometry, such as hexagonal or 12 point. Drive force output gear 201 may be formed in any size and/or any shape to accommodate any size and/or any shape threaded fastener for use with inaccessible or unreachable bolting applications.

FIG. 3 is a perspective view of another embodiment of the present invention in the form of apparatus 1A having a reaction force assembly 400A. Reaction force assembly 400A includes: a reaction arm 450A; and a reaction pin assembly 460A. Reaction pin assembly 460A includes: a first and a second reaction hole 461A and 462A; a reaction pin 463A; and a cotter pin 465A. Reaction force assembly 400A may be used with or without reaction arm 450A to transfer the reaction force to a stationary object. Note the change in shape of reaction force assembly housings 401A and 405A.

FIG. 4 is a perspective view of another embodiment of the present invention in the form of apparatus 1B having a reaction force assembly 400B. Reaction force assembly 400B includes: a reaction arm 450B; and a reaction pin assembly 460B. Reaction pin assembly 460B includes: a first and a second reaction hole 461B and 462B; and a reaction pin 463B. Reaction force assembly 400B may be used with or without reaction arm 450B to transfer the reaction force to a stationary object. Note the modifications in reaction arm 450B, which extends the length of and is held in place against, by reaction pin 463B, modified reaction force assembly housings 401B and 405B.

FIG. 5 is a perspective view of another embodiment of the present invention in the form of apparatus 1C having a reaction force assembly 400C. Reaction assembly 400C includes a reaction arm 450C. Reaction arm 450C extends the length of modified reaction force assembly housings 401C and 405C. Reaction inlets 471C and 472C hold reaction arm 450C in place. Note the slight modification to reaction arm 450C.

Referring to FIGs. 6A and 6B, by way of example, these show an exploded and separated perspective view of an embodiment of the present invention in the form of an apparatus 1D. Figure 6C is a perspective view of an embodiment of the present invention in the form of apparatus 1D. Similar to apparatus 1A, 1B and 1C, apparatus 1D varies only in its reaction force assembly 400D. Reaction force assembly 400D utilizes Applicant's ZTM washer, gun, driver and offset link technologies disclosed in the following commonly owned and co-pending patent applications, entire copies of which are incorporated herein by reference: U.S. Application Serial No. 61/916,926, having Filing Date of 17 December 2013, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS"; and U.S. Application Serial No. 61/940,919, having Filing Date of 18 February 2014, entitled "APPARATUS FOR TIGHTENING THREADED FASTENERS".

International bolting standards call for a hardened washer to be placed under every threaded fastener. ZTM Washers are hardened washers proprietary to the Applicant, HYTORC[®], that become the reaction point for torquing tools right under the nut or bolt head. They eliminate any possible pinch points for operators' appendages. Operators need not searching for satisfactory stationary objects. Straight, co-axial tensioning all but eliminates bending and/or side-loading of the stud. They provide a smooth, consistent, low-friction surface on which turns the nut or bolt head. The top has a polished surface against which the nut or bolt head will turn, while the bottom, which goes next to the flange face, is knurled to prevent rotation as the nut is tightened.

ZTM Washers protect flange surfaces from damage or embedment and evenly distribute bolt load around the joint due to larger surface area. They can be made in a full range of inch and metric sizes from a full range of materials options for every application. They comply with all ASME, ASTM and API requirements for dimensions, hardness, and thickness. They work with pneumatic, hydraulic, electric and manual torque tools. And with the addition of a companion friction washer, it eliminates the need for a backup wrench to prevent the opposite nut from turning along with the bolt.

ZTM Washer benefits are achievable with dual action and reaction sockets proprietary to HYTORC[®], which hold on to the washer and turn the nut against it.

The second method, as claimed herein and shown fully in FIGs. 6A, 6B and 6C and partially in FIGs. 7 and 8, utilizes HYTORC[®]'s proprietary dual drive offset link, such as, for example, apparatus 1D. Link 1D is powered by HYTORC[®]'s proprietary coaxial action and reaction torque tools, such as, for example, the HYTORC[®] ICE[®] 700 hydraulic torque tool or the HYTORC[®] ZTM Gun 800 pneumatic torque multiplier. Other such tools include HYTORC[®]'s proprietary jGUN[®] Single Speed, jGUN[®] Dual Speed Plus, AVANTI[®] and/or STEALTH[®].

Generally during a tightening operation, a bottom knurled face 481D of ZTM Washer 480D rests on a joint to be closed while a bottom face of a nut or bolt head to be tightened rests on a top smooth face 482D of ZTM Washer 480D. Polygonal edges 483D of ZTM Washer 480D nonrotatably engage with and react in a recess 485D of an outer socket 415D of reaction force assembly 400D. Meanwhile an outer socket 201D of drive force output assembly 200 tightens the nut or bolt head over ZTM Washer 480D.

Referring to FIG. 9, by way of example, this shows is an exploded perspective view of portions of an embodiment of the present invention in the form of apparatus 1D with three modular drive force output gears 291D, 292D and 293D of various sizes.

Referring to FIG. 10, by way of example, this shows a perspective view of an embodiment of the present invention in the form of an apparatus 1E with two modular drive force input engagements 191E and 192E. To combine a HYTORC[®] proprietary coaxial action and reaction torque tool with a HYTORC[®] proprietary offset link begin by choosing the correct size and geometry of ratcheting socket for the nut to be tightened and for the correct size and geometry of the square drive in tool. The links are easily exchanged by removing the two retaining bolts.

The direction, whether to tighten or loosen is determined by the direction of the tightening wrench. The word "tighten" or "loosen" is stamped into the side of the tool and can be read once the drive of the tool has been inserted into the drive receptacle.

Each offset link is marked with a "factor" which indicates how to compensate for any gear-ratio effects through the link. Each unique socket insert is marked with its "factor". The desired torque to be applied to the nut is multiplied by this factor to determine the input torque value on the appropriate torque to pressure conversion chart for the tool being used. Note that other methods exist.

Offset drive link assemblies of the present application are flexibly adjustable to any bolting application environment due to interchangeable tool drive input assemblies, tool drive output assemblies and tool drive reaction assemblies. Such interchangeability allows for adjustment to varied fastener sizes and/or shapes. Operators no longer need several offset links of varying size for varied worksite applications, nor do operators need to completely disassemble and reassemble the links. The reaction force is passed on the housing of the offset link, which will abut against a stationary object. To ensure that the reaction force does not destroy the housing and to ensure a solid abutment, the link contains a reaction member or a Z™ Washer engagement, which can be switched from one side to another of the link housing for tightening and loosening. Rather than having to turn the link over, as is the case with links on other limited clearance hydraulic tools, links of the present application remain in position. The reaction arm is merely changed from one side to the other. If hydraulic the tool is flipped over; if pneumatic the turning motion is merely reversed with a switch.

Offset links of the present application have reaction fixture connections to accommodate any reaction configuration to meet any industrial requirement. Note that the transmission housing does not react but it passes the reaction force applied by the tool to it on to the link, which does react. The reaction force is absorbed by both the housing, which might tilt it relative to the link, and the link to maintain alignment on the nut to ensure extended product life.

Furthermore such offset drive link assemblies maximize operator safety and portability and minimize tool twisting forces, overall tool size, tool and fastener side loads, fastener bending forces, fastener thread galling and other fastener damage.

An offset drive link assembly for transmission and multiplication of torque from a power tool for tightening or loosening a threaded fastener includes: a drive force input assembly; a drive force output assembly; and a reaction force assembly.

Advantageously the offset drive link assembly: allows access to previously unreachable fasteners due to, for example protruding threads, limited clearances and obstructions; makes practical previously unusable devices driven either electrically, hydraulically, manually and/or pneumatically; makes feasible previously unusable advanced materials, such as, for example aircraft-grade aluminum; creates modular components, such as, for example hex-reducing and -increasing drive bushings, male to female drive adaptors, to meet bolting application characteristics; yields accurate and customizable torque multiplication; tames drive force and reaction force application; overcomes corrosion, thread and facial deformation; avoids bolt thread galling; nullifies side load; ensures balanced bolt load for symmetrical joint compression; simplifies link and tool use; minimizes risk of operator error; and maximizes bolting safety.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above. The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in

terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilized for realizing the invention in diverse forms thereof. Note that there may be slight differences in descriptions of numbered components in the specification.

While the invention has been illustrated and described as embodied in a fluid operated tool, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

When used in this specification and claims, the terms “comprising”, “including”, “having” and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

What is claimed is:

Claims

1. An apparatus for transmission and multiplication of torque from a device for tightening or loosening a threaded fastener including:
 - a drive force input assembly;
 - a drive force output assembly; and
 - a reaction force assembly.
2. An apparatus for transmission and multiplication of torque including:
 - a device for tightening or loosening a threaded fastener;
 - a drive force input assembly;
 - a drive force output assembly; and
 - a reaction force assembly.
3. An apparatus according to claim 1 or 2 including:
 - the drive force input assembly having a drive force input engagement to receive a first turning force from the device acting in a first direction;
 - the drive force output assembly, operatively engageable with the drive force input engagement, having a drive force output engagement to transfer the first turning force to the fastener; and
 - the reaction force assembly having a reaction force input engagement to receive a second turning force from the device in a second direction and a reaction force output engagement to transfer the second turning force to a stationary object.
4. An apparatus according to claim 3 wherein the stationary object is a washer under the fastener.
5. An apparatus according to claim 3 wherein the drive force input engagement includes an input gear with an input polygonal adaptor and wherein the drive force output engagement includes an output gear with an output polygonal adaptor.
6. An apparatus according to claim 3 wherein the drive force input engagement includes an input gear with a square drive and wherein the drive force output engagement includes an output gear with either a hex drive or a 12 point drive.
7. An apparatus according to claim 3 wherein the reaction force assembly includes a reaction force assembly housing formed between the reaction force input engagement and the reaction force output engagement.
8. An apparatus according to claim 7 wherein the reaction force input engagement includes a first polygonal adaptor and the reaction force output engagement includes either a reaction force transfer fixture or a second polygonal adaptor.
9. An apparatus according to claim 7 wherein the reaction force input engagement includes a first polygonal adaptor and the reaction force output engagement includes a reaction arm.

10. An apparatus according to claim 7 wherein the reaction force input engagement includes a spline adaptor and the reaction force output engagement includes a recess for a reaction surface.
11. An apparatus according to claim 10 wherein the reaction surface is a washer under the threaded fastener nonrotatably engageable with the recess, the washer acting as the stationary object.
12. An apparatus according to claim 3 wherein the reaction force assembly includes:
a first, a second, a third and a fourth reaction housing portion;
the reaction force input engagement formed adjacent the first reaction housing portion; and
the reaction force output engagement formed adjacent to either the first, the second, the third and the fourth reaction housing portions or the fourth reaction housing portion.
13. An apparatus according to claim 12 wherein the reaction force input engagement includes a first polygonal adaptor and the reaction force output engagement includes either a reaction force transfer fixture or a second polygonal adaptor.
14. An apparatus according to claim 12 wherein the reaction force input engagement includes a first polygonal adaptor and the reaction force output engagement includes a reaction arm formed adjacent to the first, the second, the third and the fourth reaction housing portions.
15. An apparatus according to claim 12 wherein the reaction force input engagement includes a spline adaptor and the reaction force output engagement includes a recess for a reaction surface formed adjacent to the fourth reaction housing portion.
16. An apparatus according to claim 15 wherein the reaction surface is a washer under the threaded fastener nonrotatably engageable with the recess, the washer acting as the stationary object.
17. An apparatus according to any preceding claim including a drive force idler assembly formed between the drive force input assembly and the drive force output assembly.
18. An apparatus according to any preceding claim wherein the reaction force is absorbed to minimize tilt and to maintain alignment between the apparatus, the device and the fastener.
19. An apparatus according to any preceding claim wherein the apparatus is connectable to and disconnectable from itself in components and the device as a unit, and wherein the apparatus is useable with devices of different types.

20. An apparatus according to any preceding claim including:
wherein previously unreachable fasteners due to, for example protruding threads, limited clearances and obstructions, are accessible;
wherein previously unusable devices driven either electrically, hydraulically, manually and/or pneumatically are practical;
wherein previously unusable advanced materials, such as, for example aircraft-grade aluminum, are feasible;
wherein modular components, such as, for example hex-reducing and -increasing drive bushings, male to female input drive adaptors, are creatable to meet bolting application characteristics;
wherein torque multiplication is accurate and customizable;
wherein drive force and reaction force application is guidable;
wherein corrosion, thread and facial deformation is overcome;
wherein bolt thread galling is avoided;
wherein side load is nullified;
wherein balanced bolt load is ensured for symmetrical joint compression;
wherein apparatus and device use is simplified;
wherein risk of operator error is minimized; and
wherein bolting safety is maximized.
21. An apparatus according to any preceding claim wherein either all of or portions of the drive force input assembly, the drive force output assembly, the reaction force assembly and/or the device are either adaptable, detachable, exchangeable, flexible, interchangeable, manageable, removable, separable and/or transferable.
22. An apparatus for transmission and multiplication of torque from a device for tightening or loosening a threaded fastener substantially as hereinbefore described with reference to and as shown in the accompanying drawings.
23. A method for transmission and multiplication of torque from a device for tightening or loosening a threaded fastener to an apparatus substantially as hereinbefore described with reference to and as shown in the accompanying drawings.
24. Any novel feature or novel combination of features described herein with reference to and as shown in the accompanying drawings.

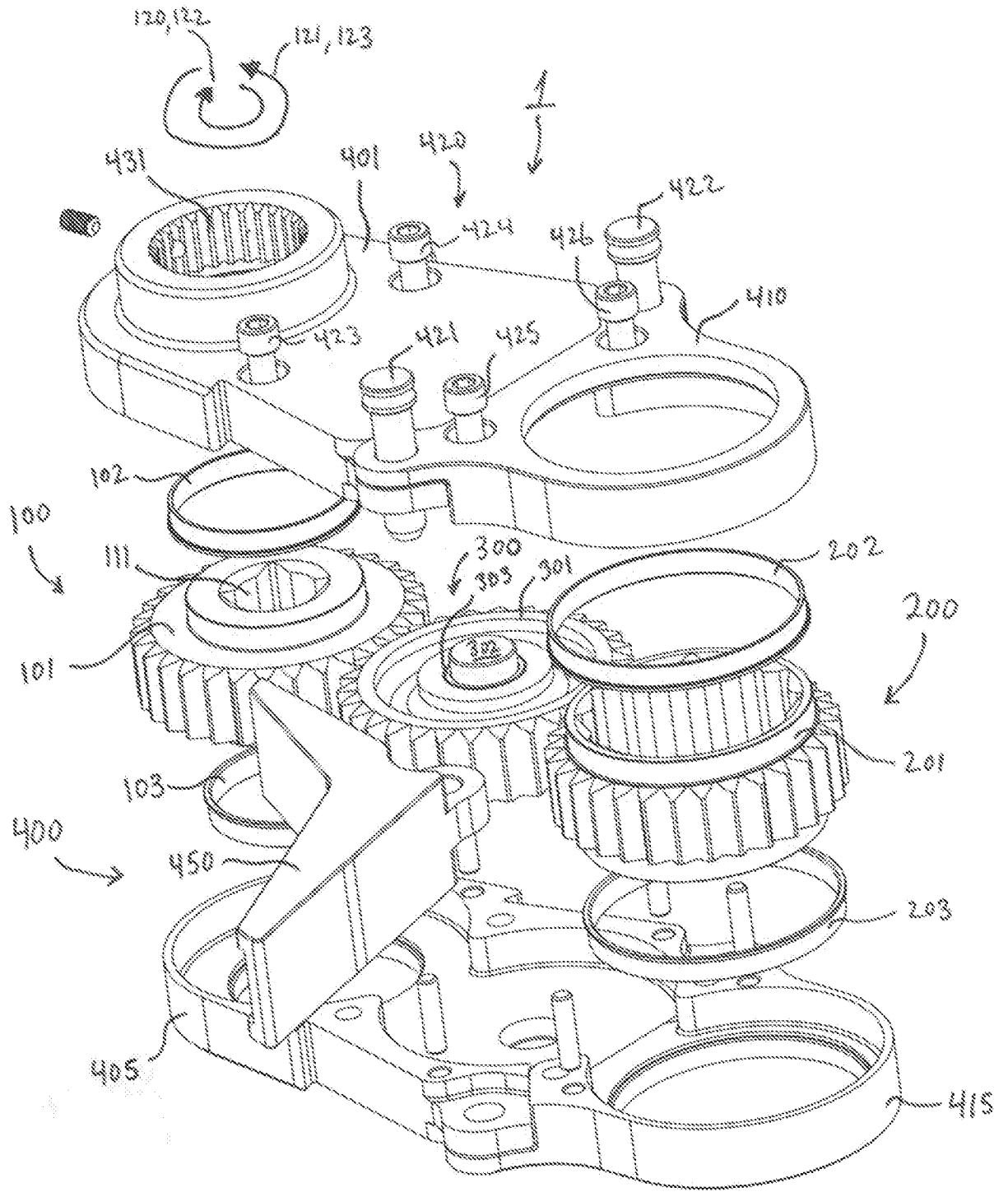


FIG. 1

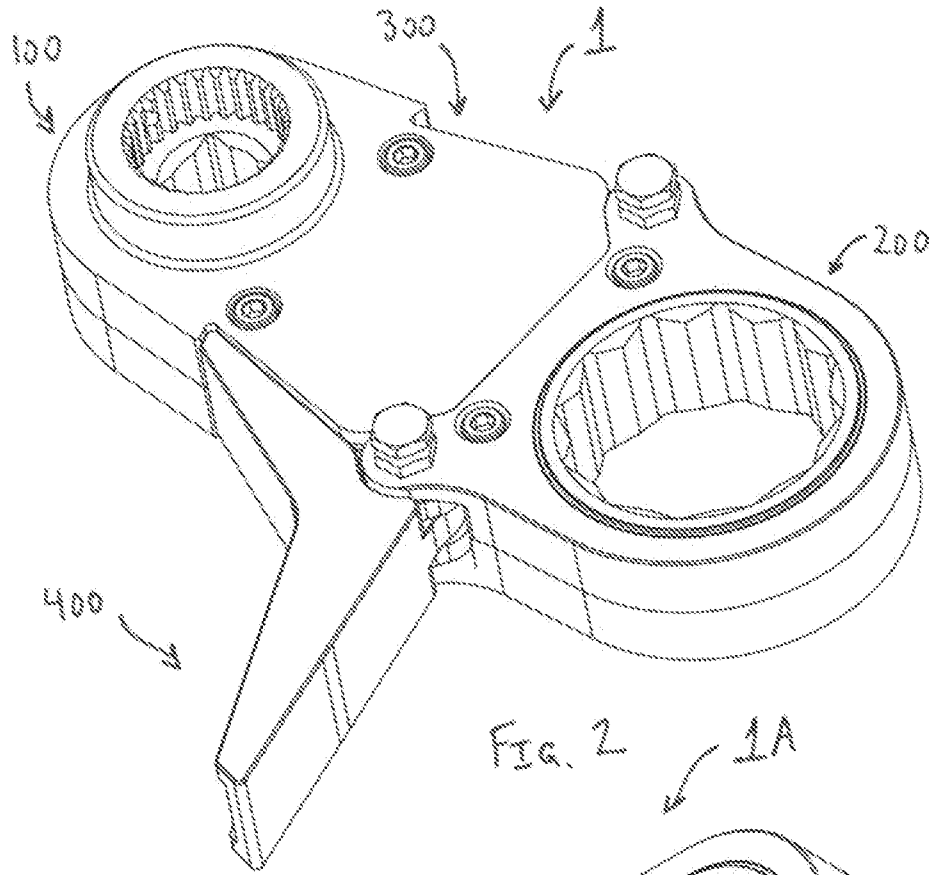


FIG. 2 1A

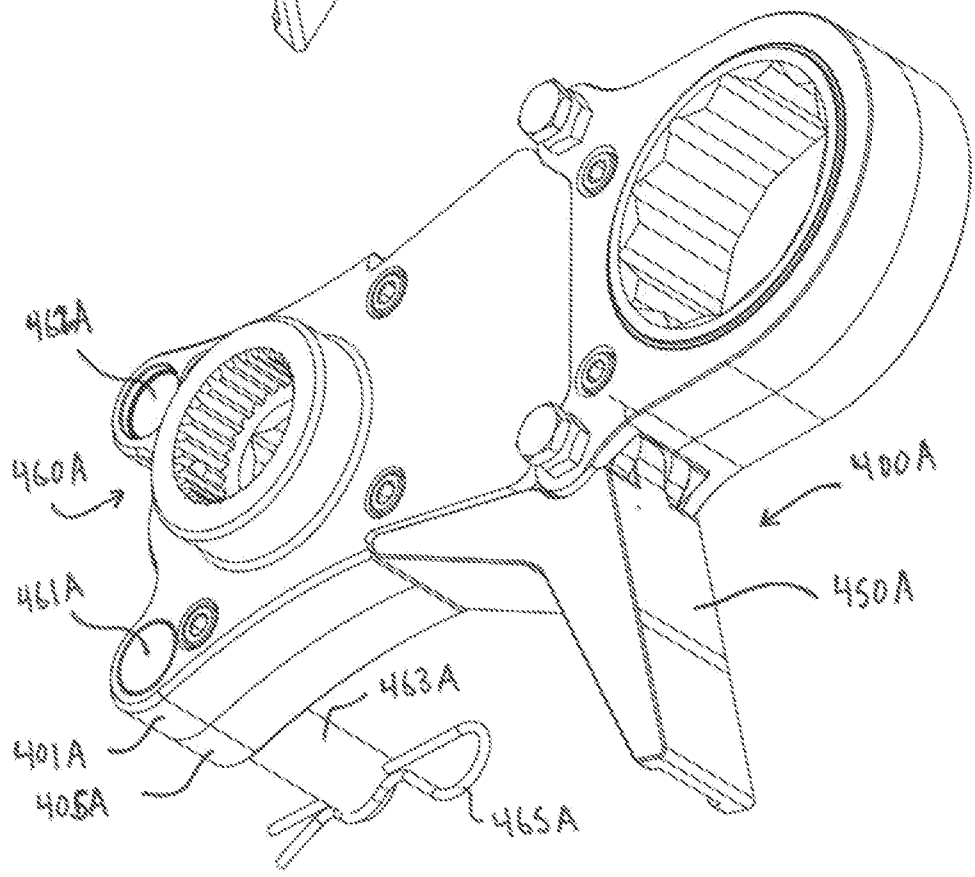
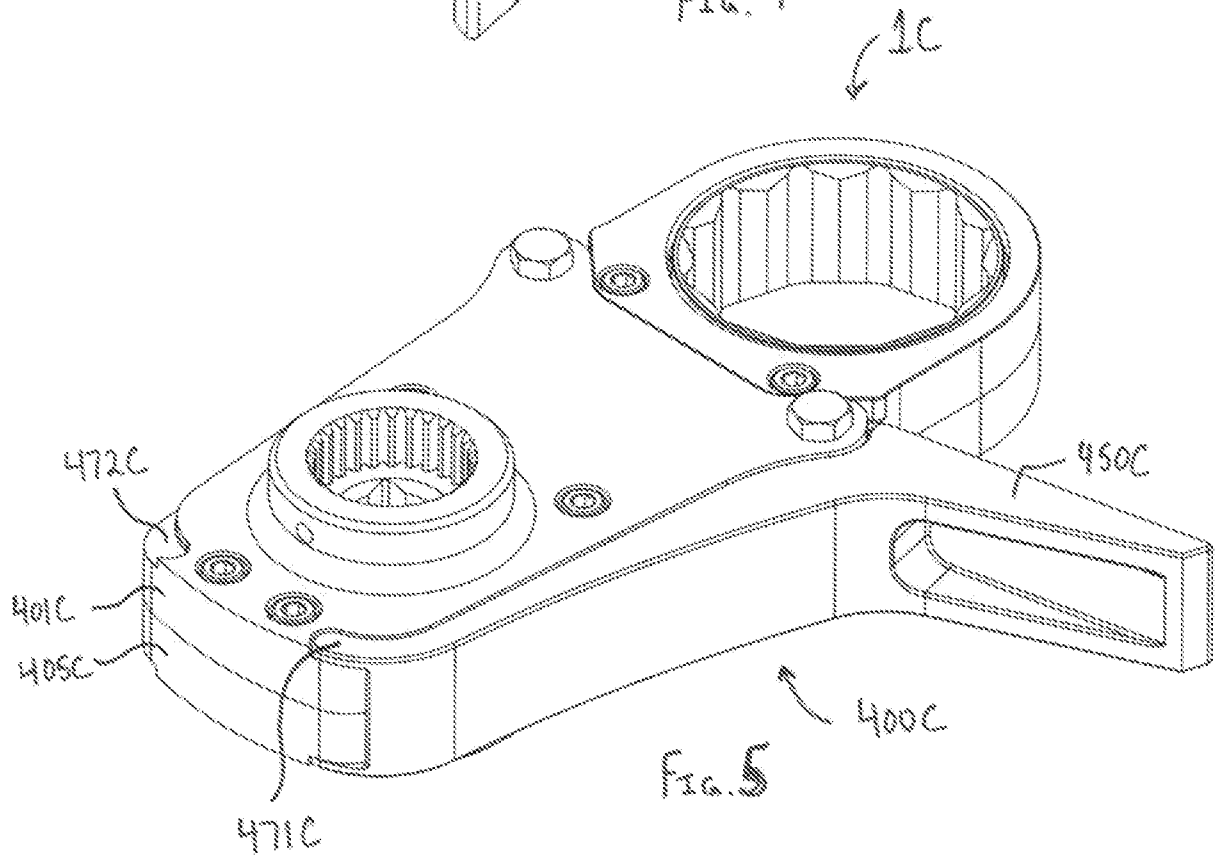
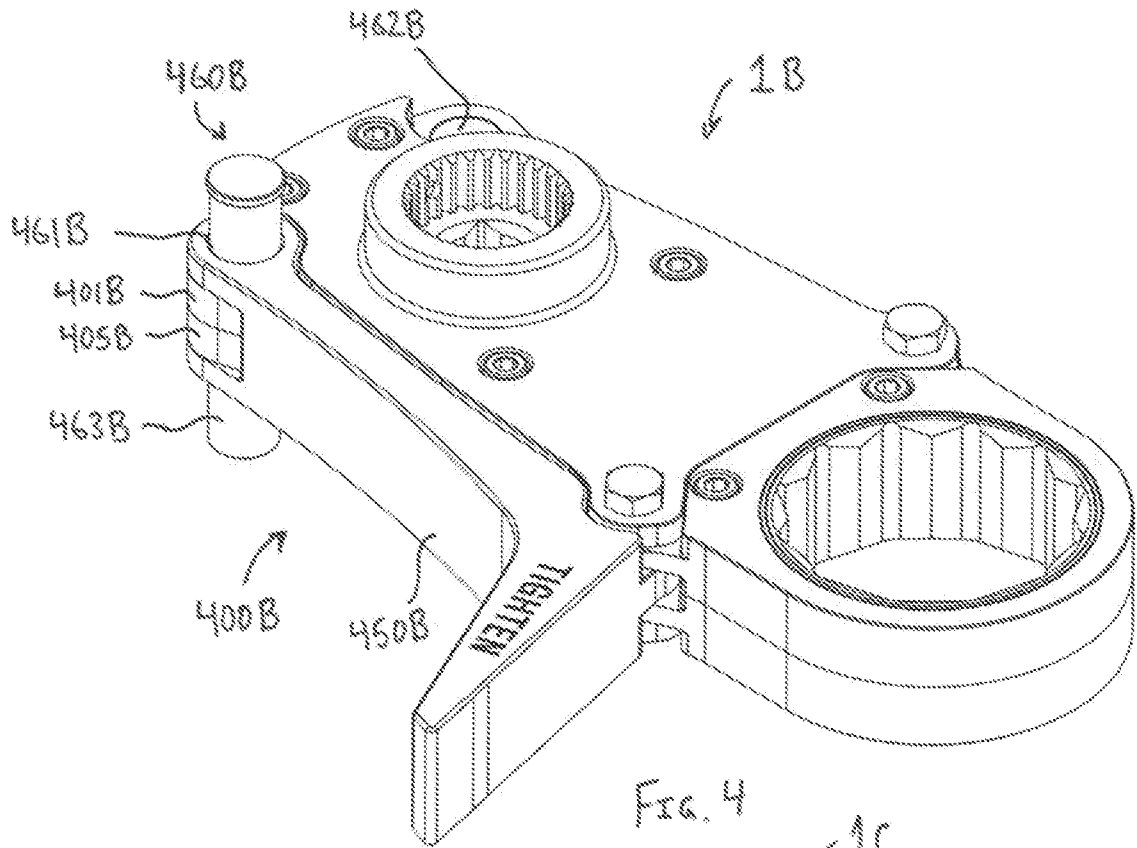


FIG. 3



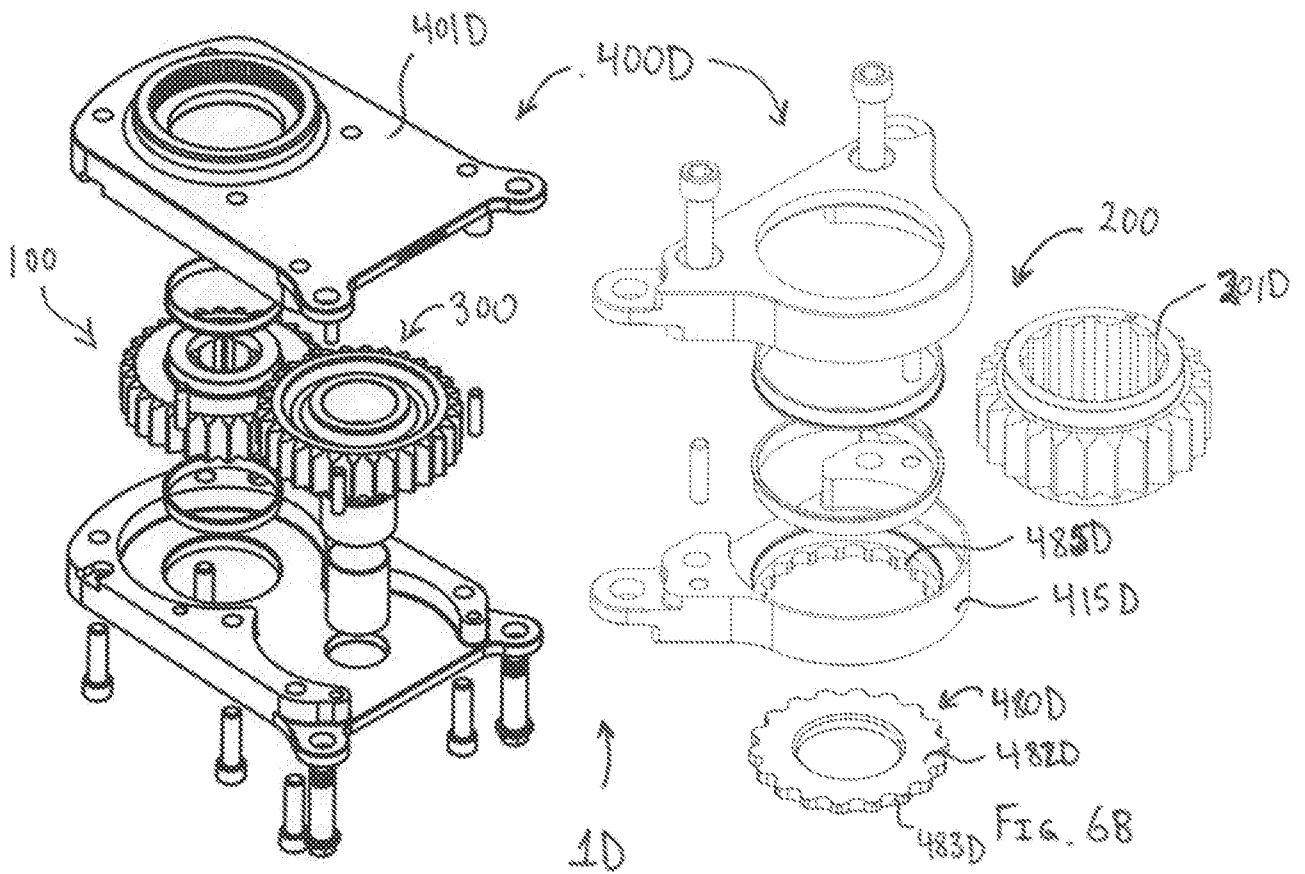


Fig. 6A

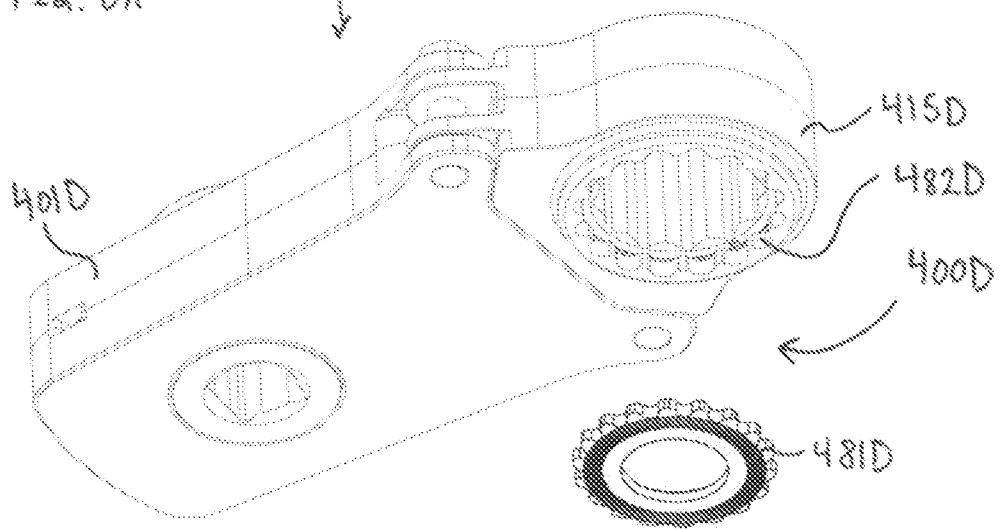


Fig. 6C

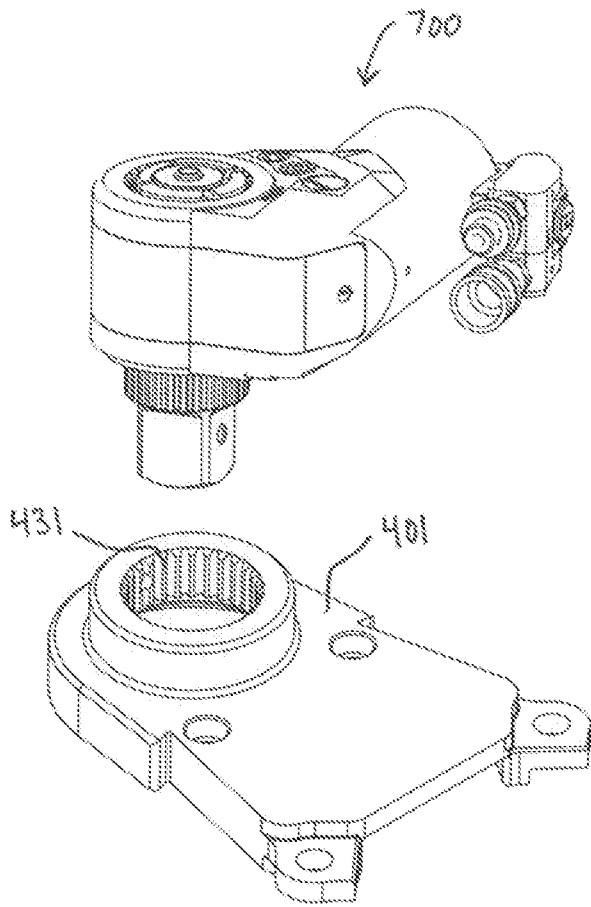


FIG. 7

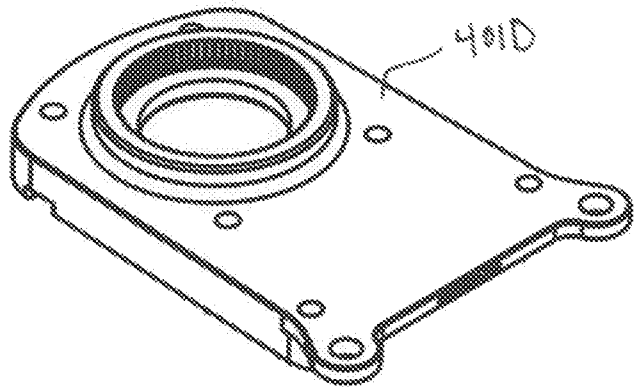
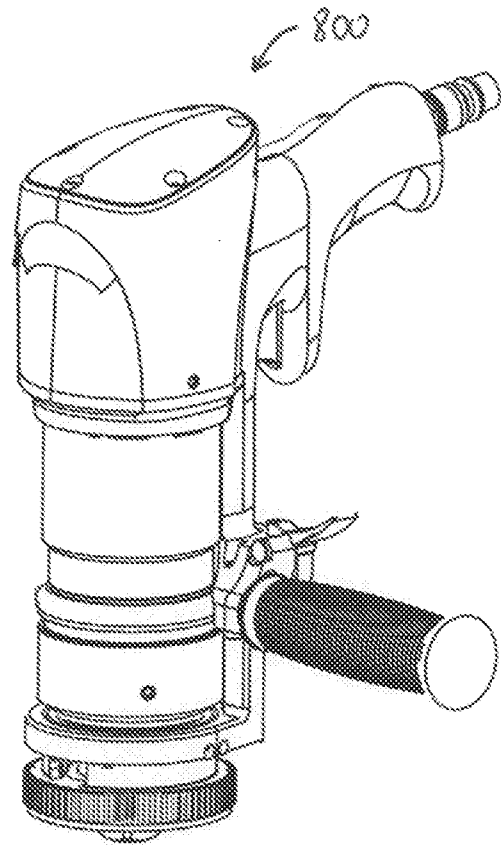


FIG. 8

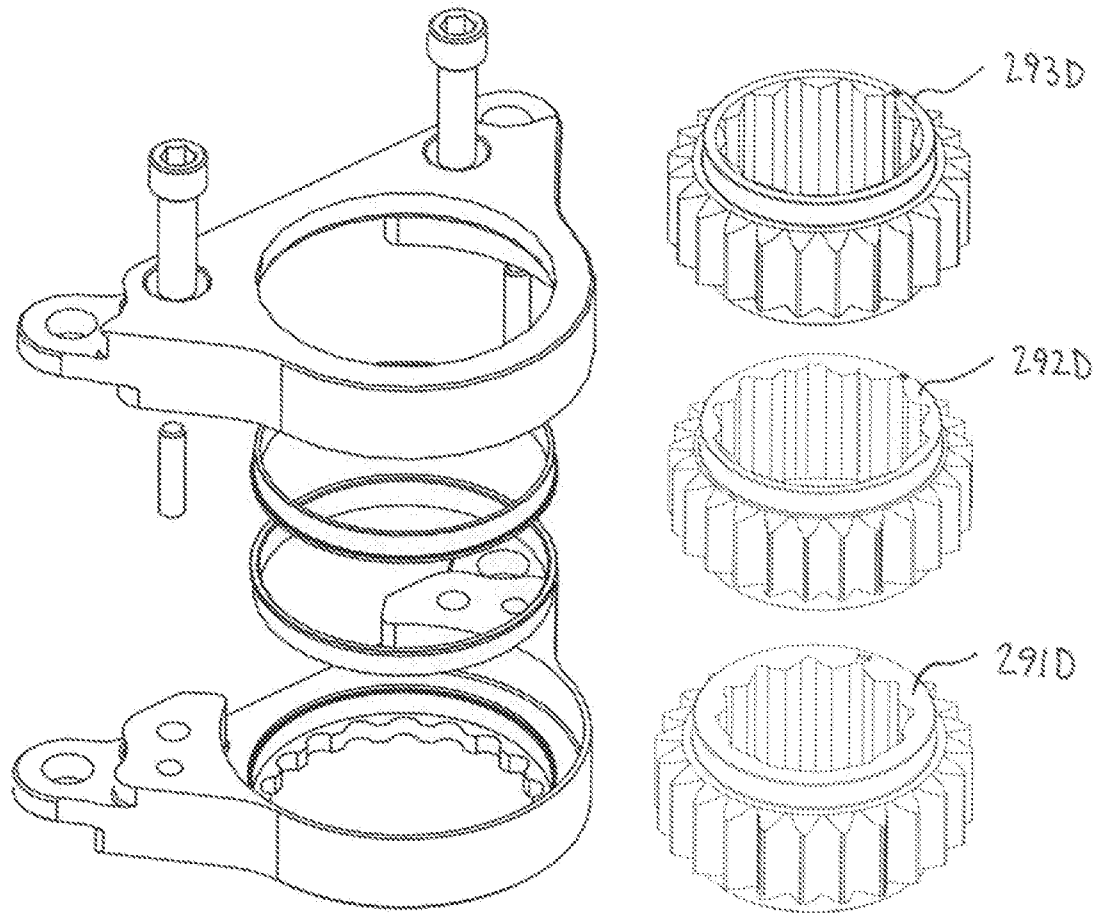


FIG. 9

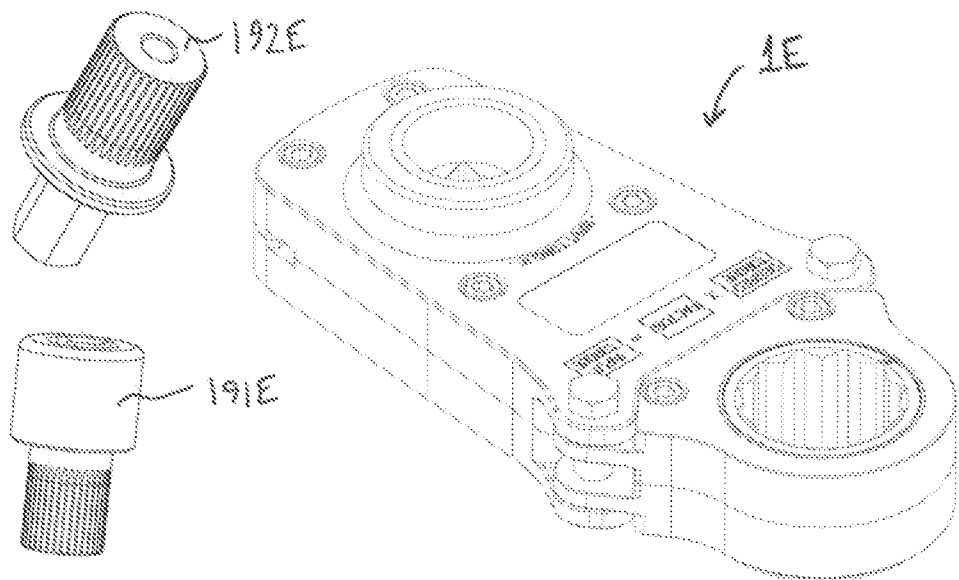


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/035375

A. CLASSIFICATION OF SUBJECT MATTER
 INV. B25B13/48 B25B17/00 B25B17/02 B25B23/00
 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.
X	US 4 063 475 A (PERKINS ROBERT L) 20 December 1977 (1977-12-20) the whole document	1-3,5-9, 12-14, 17,19,21
X	FR 1 466 461 A (DESPLAND ARMAND) 20 January 1967 (1967-01-20) claims; figures 1,2	1-3,5-9, 12,17, 19,21
X	US 5 179 876 A (GADEA MANTILLA CARLOS E [NE]) 19 January 1993 (1993-01-19) claims; figures -/--	1-3,5-9, 12,19,21

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"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</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 29 July 2014	Date of mailing of the international search report 05/08/2014
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Majerus, Hubert
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/035375

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/073122 A1 (XACT DESIGN & ENGINEERING PTY [AU]; DEIN KEVIN ARTHUR [AU]) 11 August 2005 (2005-08-11) page 36, line 5 - page 37, line 21; figures 72a-73c -----	1-3,5-9, 12,17, 19,21
X	US 1 762 515 A (HIERSCH FREDRICK A) 10 June 1930 (1930-06-10) -----	1-3,5
Y	page 2, line 63 - line 74; claims; figures -----	10,15
Y	EP 2 210 709 A2 (LOESOMAT SCHRAUBTECHNIK NEEF G [DE] LOESOMAT SCHRAUBTECHNIK NEEF GMBH) 28 July 2010 (2010-07-28) paragraph [0018]; figures -----	10,15
Y	DE 203 18 021 U1 (HAZET WERK ZERVER HERMANN [DE]) 5 February 2004 (2004-02-05) paragraph [0034]; claims; figures -----	1-3,5-7, 17,19,21
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