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(54) FIXED MOMENT ARM INTERNAL GEAR DRIVE APPARATUS

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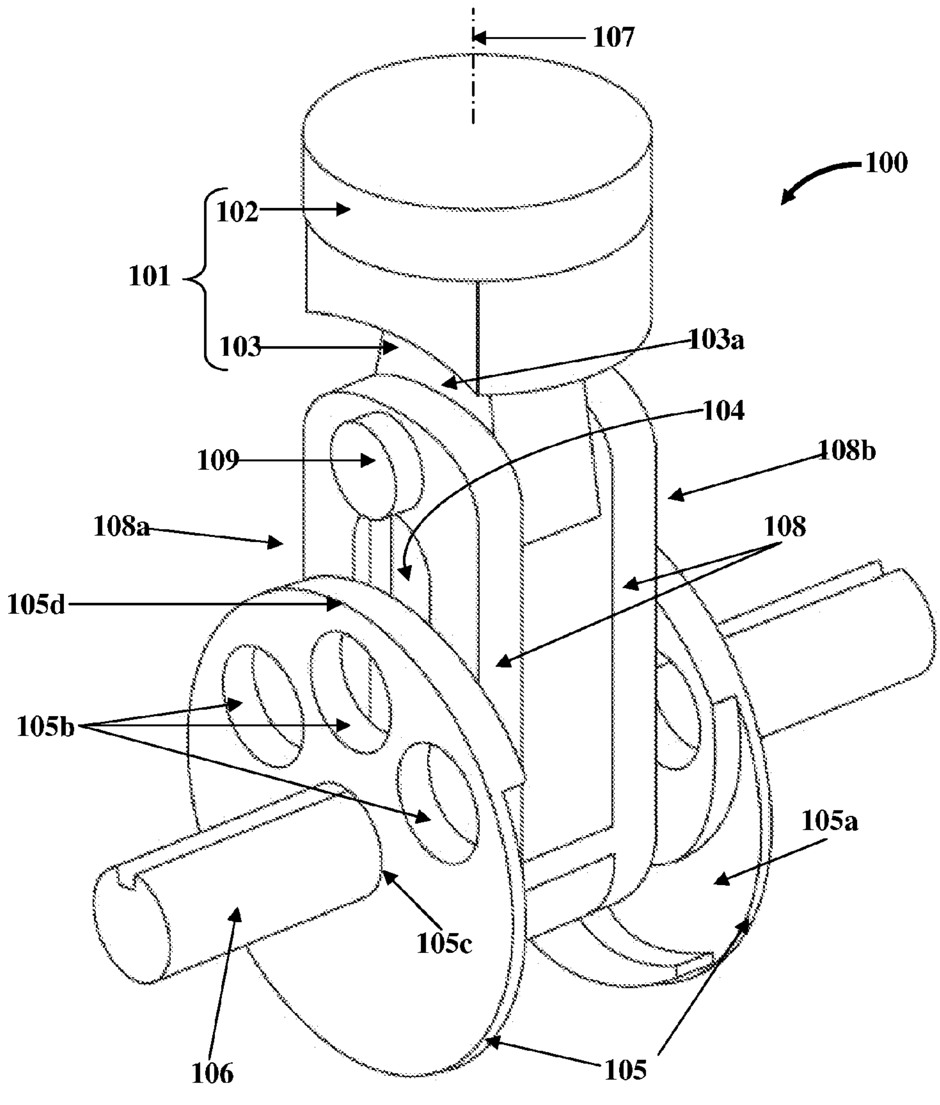
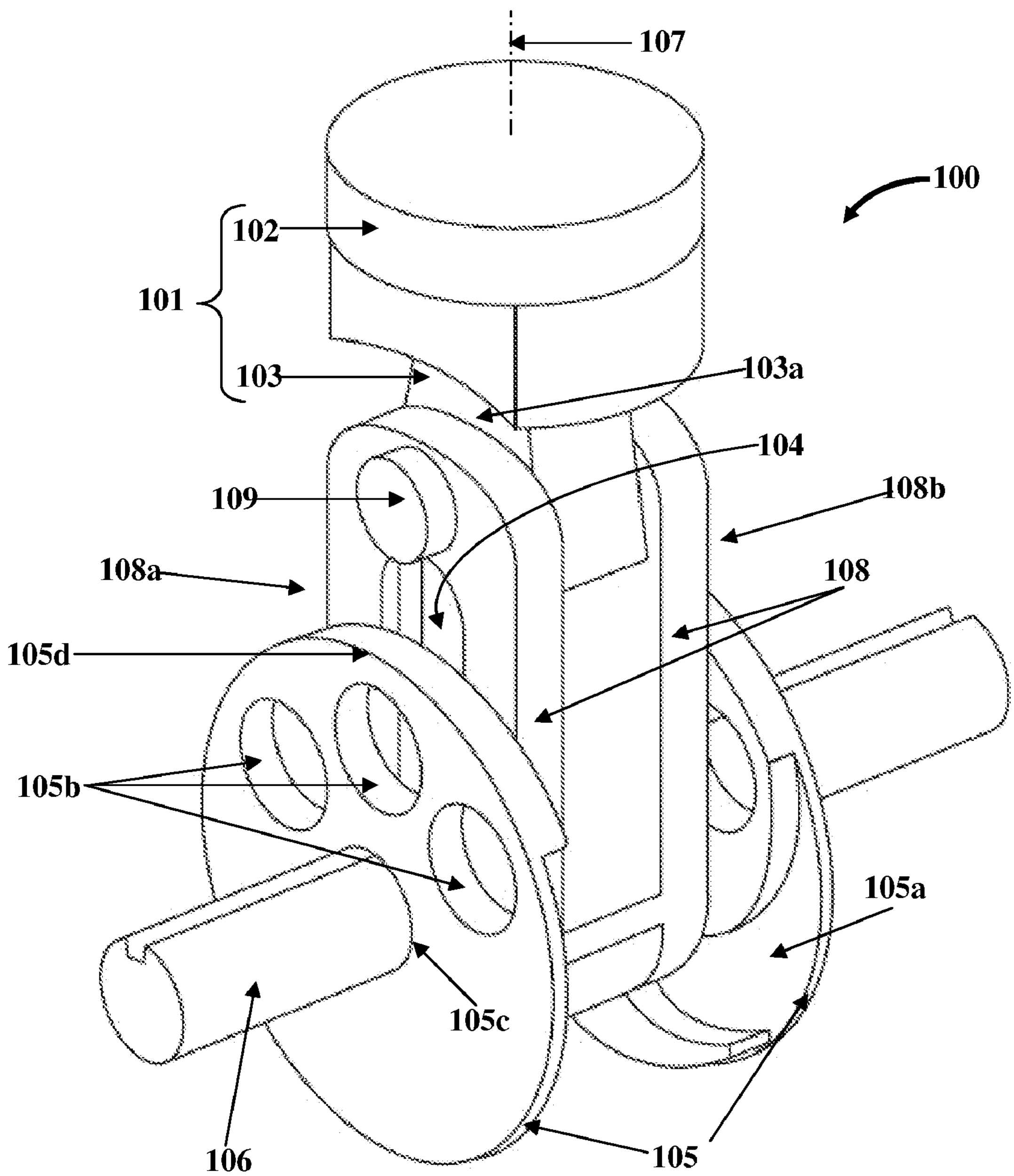
(57) ABSTRACT

An apparatus for converting linear reciprocal motion to rotary motion, comprising a reciprocating component and a reciprocating rod capable of linear reciprocal motion in unison, internal gear racks, a segmented gear, and transfer plates is provided. The internal gear racks are disposed on opposing internal sides of the reciprocating rod for inducing rotary motion in the segmented gear by linear reciprocal motion of the reciprocating rod. The segmented gear, disposed within a space defined between the opposing internal sides of the reciprocating rod and rigidly connected to a power shaft, alternately meshes with the internal gear racks to transmit rotary motion to the power shaft. The transfer plates, coaxially disposed on the segmented gear's centric axis, comprise profiled grooves for controlling transition of the reciprocating rod by contacting the reciprocating rod, when the reciprocating component is at a top dead center and a bottom dead center within an engine housing.

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100
102
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103
103a
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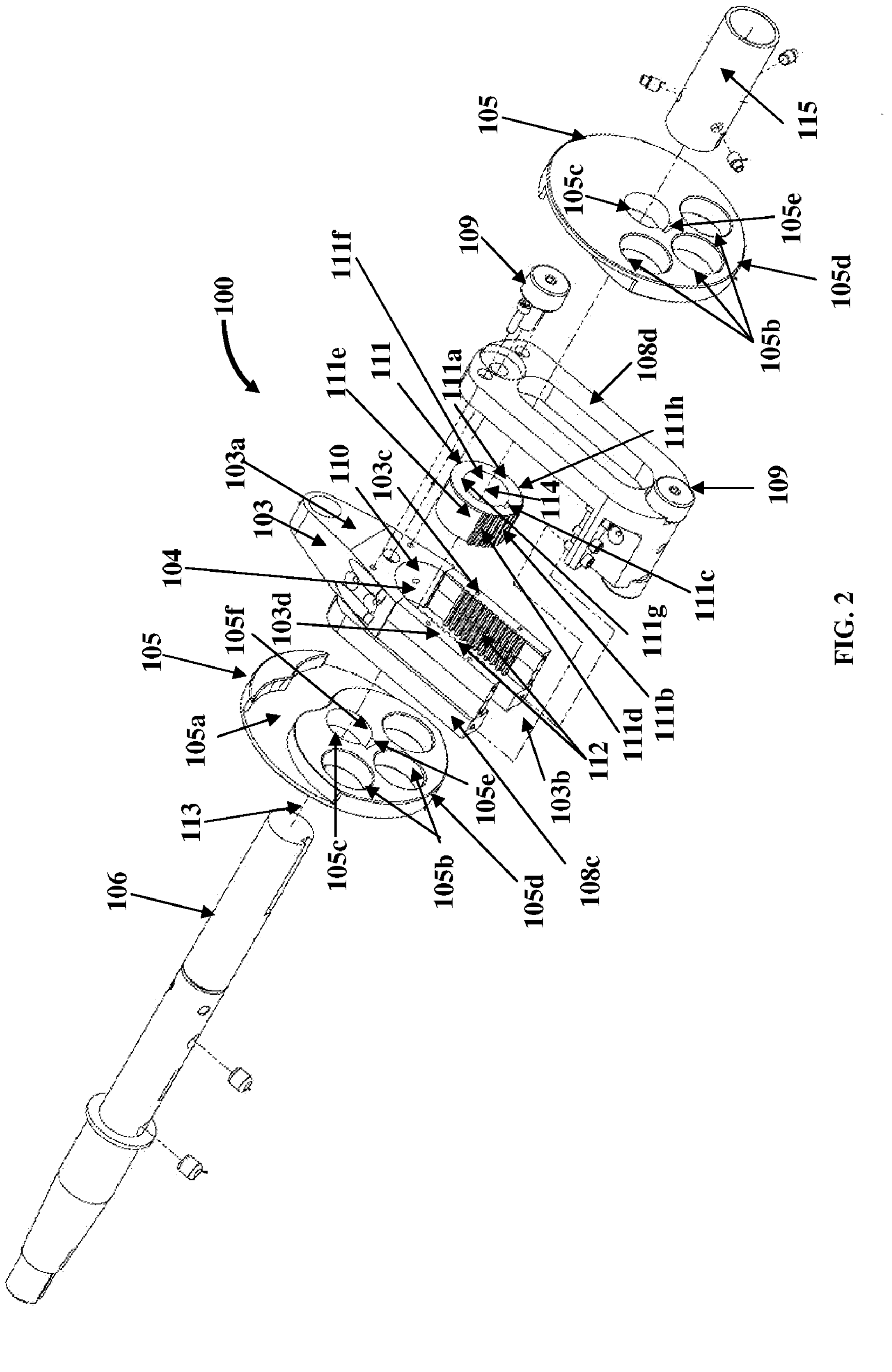
105c
106
105

FIG. 1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105c
105e
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105b
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109
103
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111c
111g
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105c
105b
105d
108c

FIG. 2

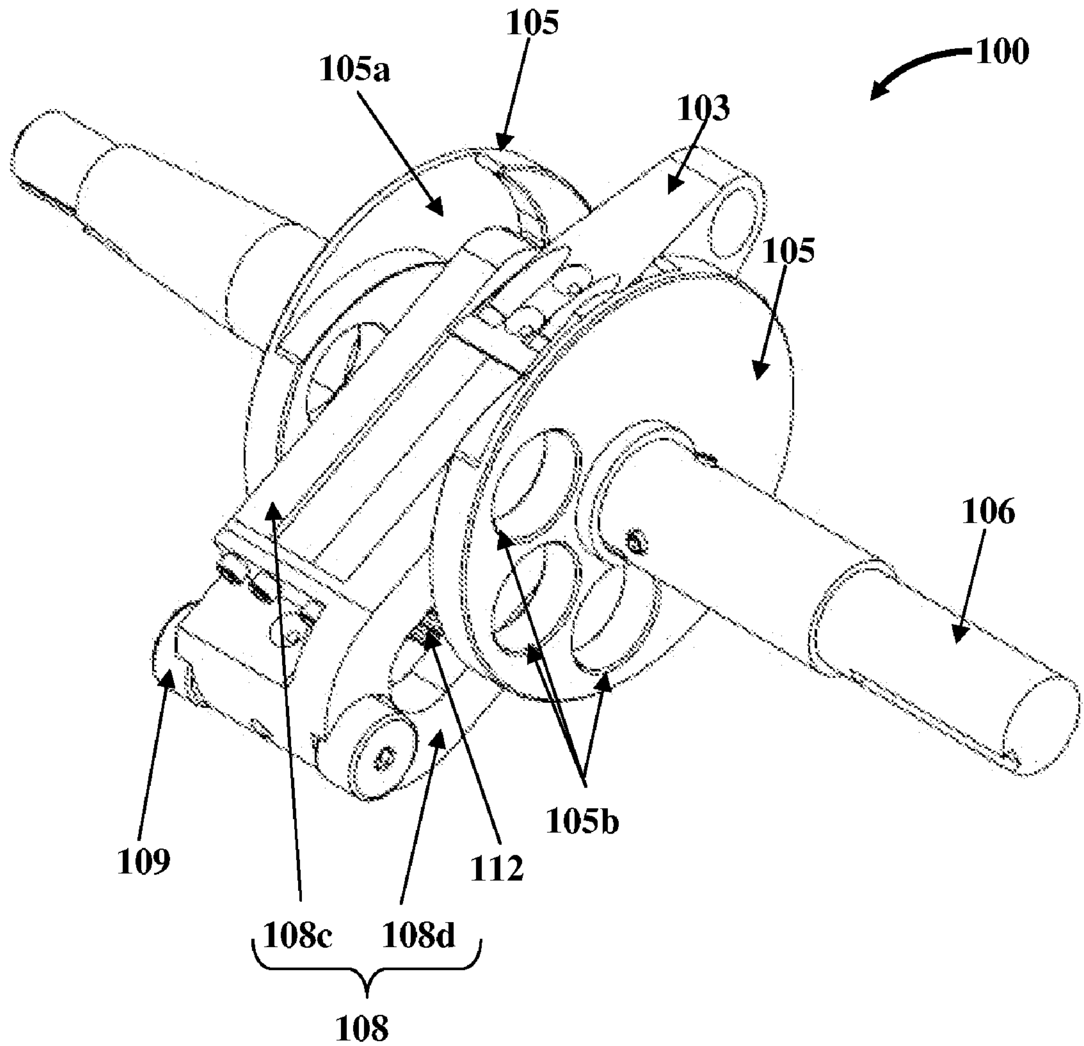


FIG. 3

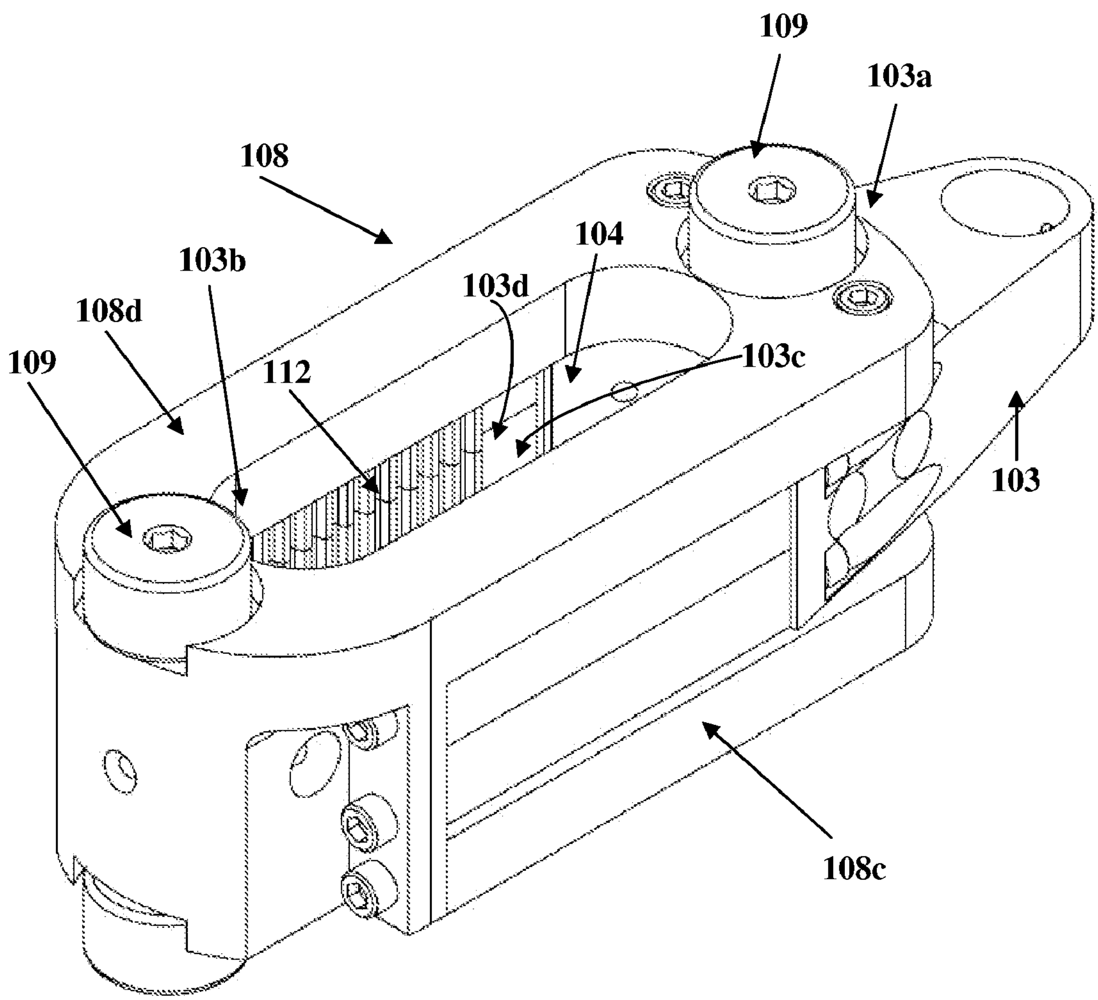


FIG. 4

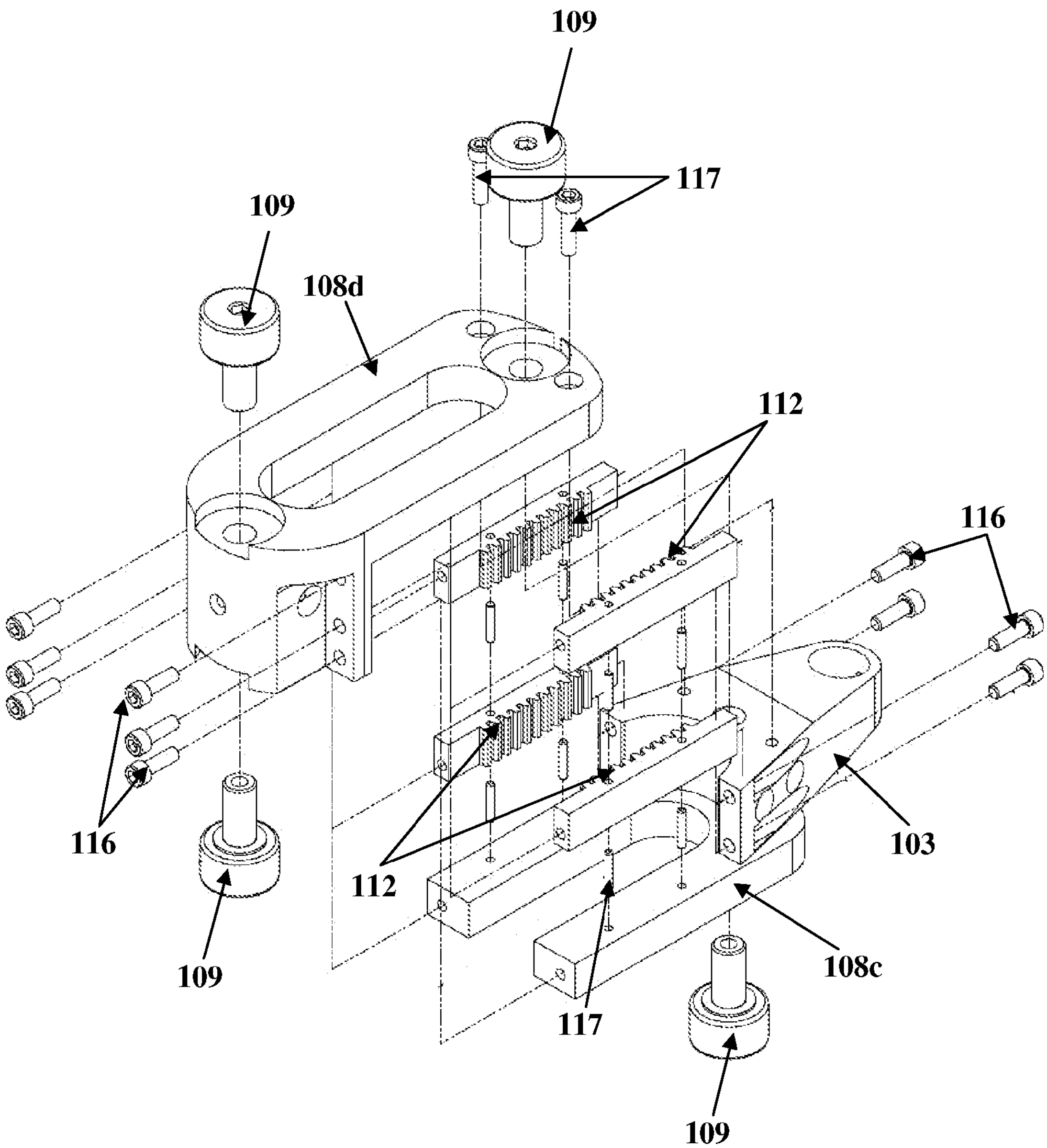


FIG. 5

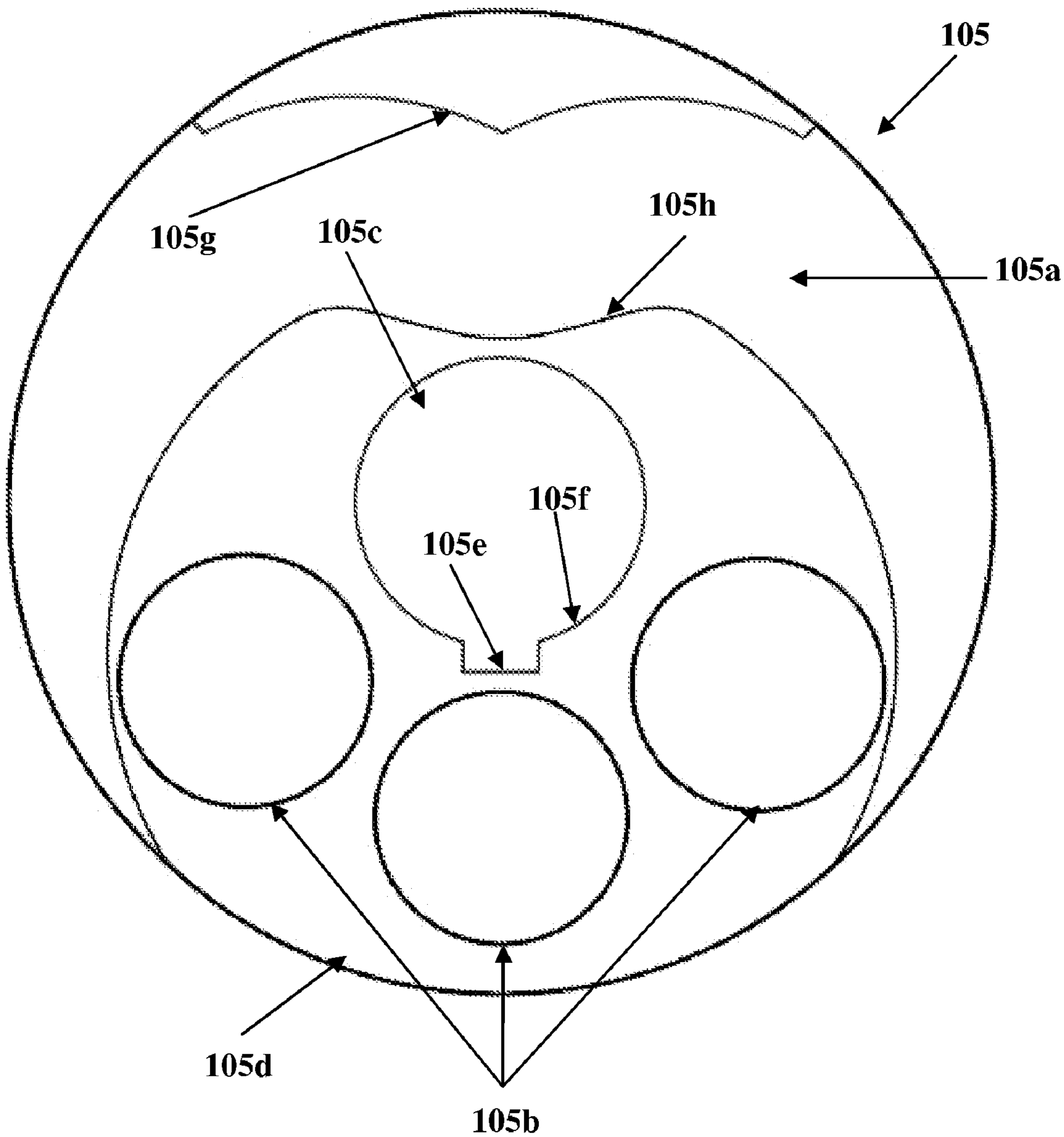


FIG. 6A

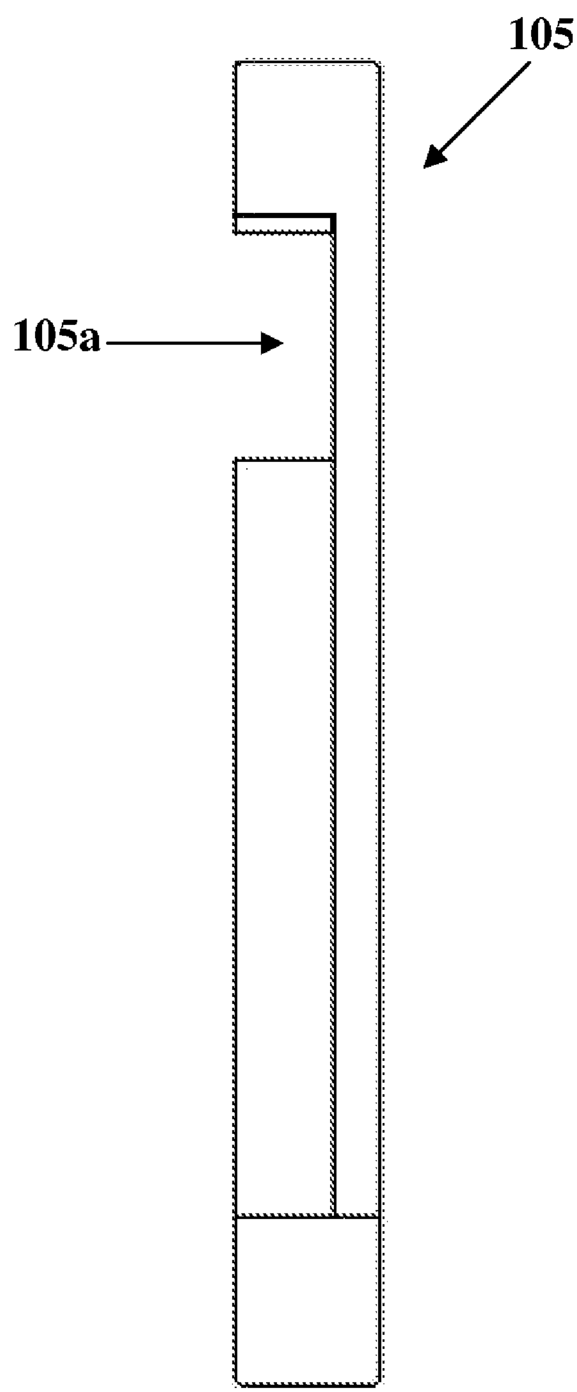
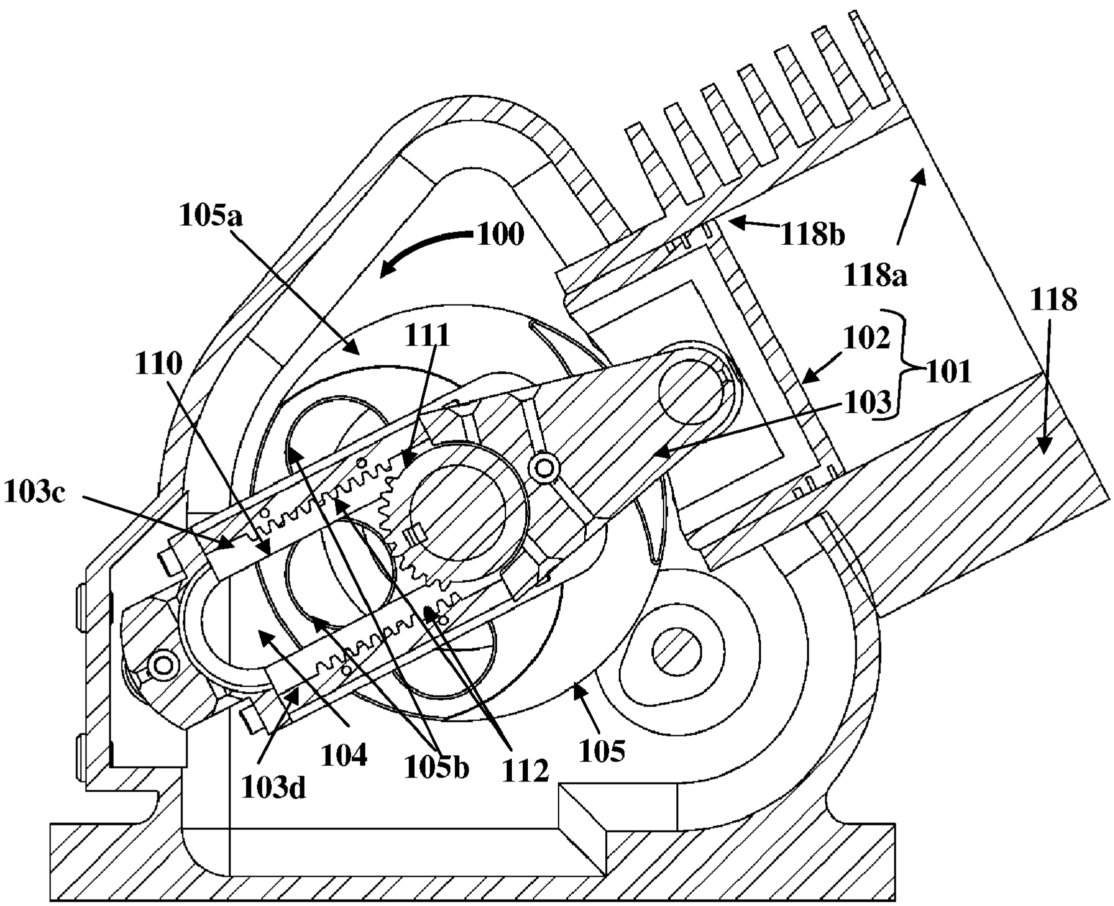


FIG. 6B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118b
118a
118
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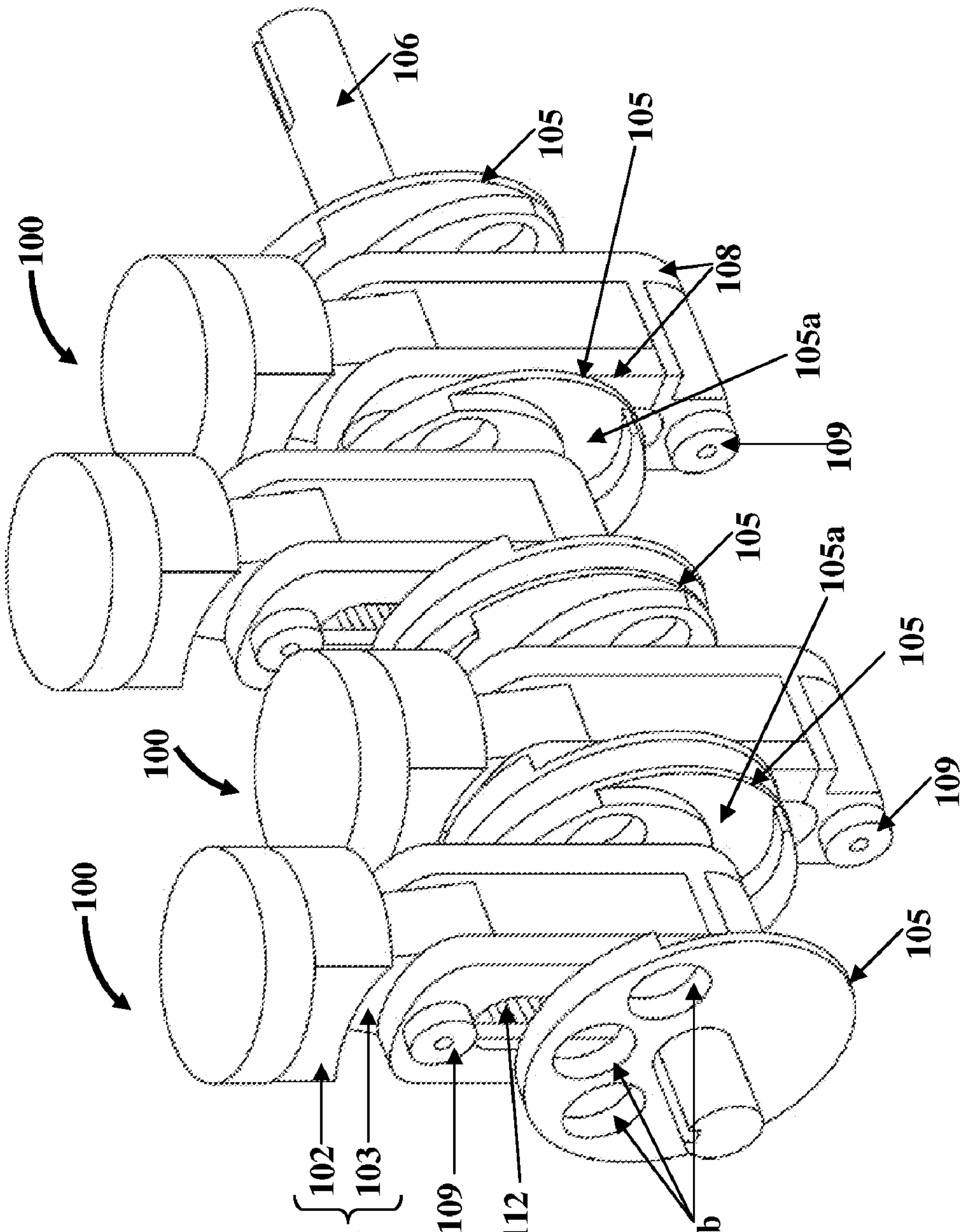
103
103c
104
105b
112
105
103d

FIG. 7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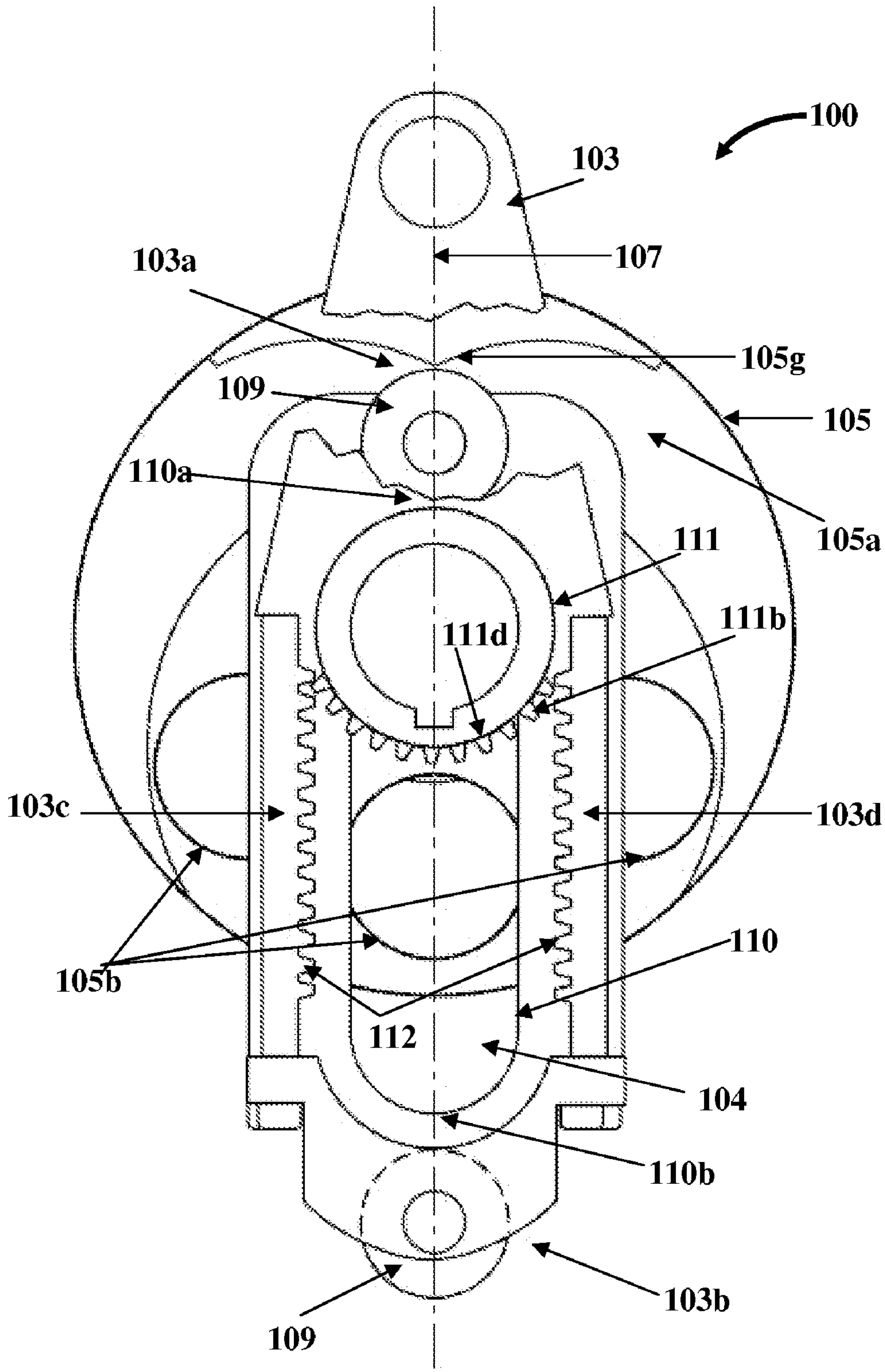
103
112
105b

FIG. 8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107
103a
105g
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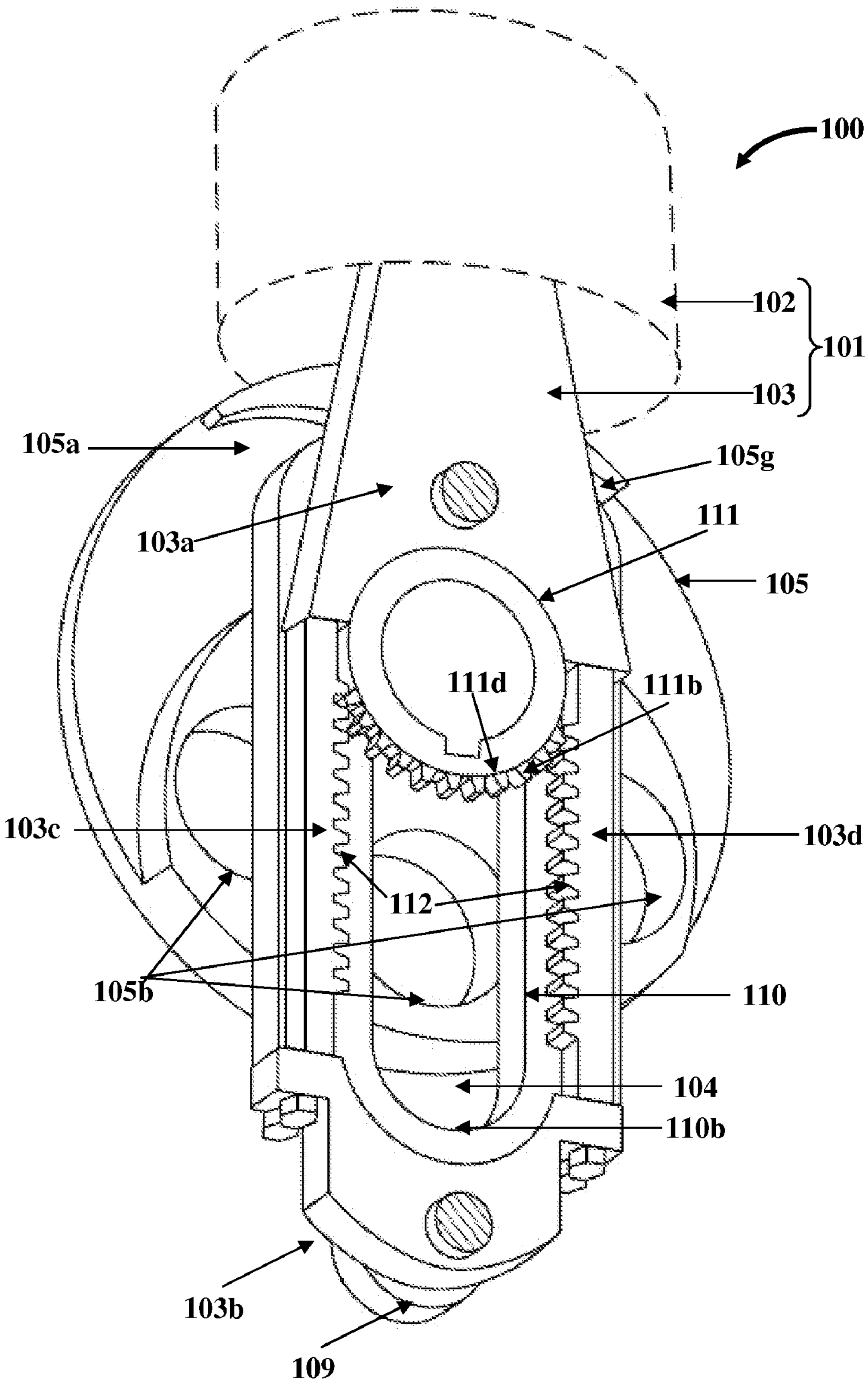
104
110b
103b
109

FIG. 9A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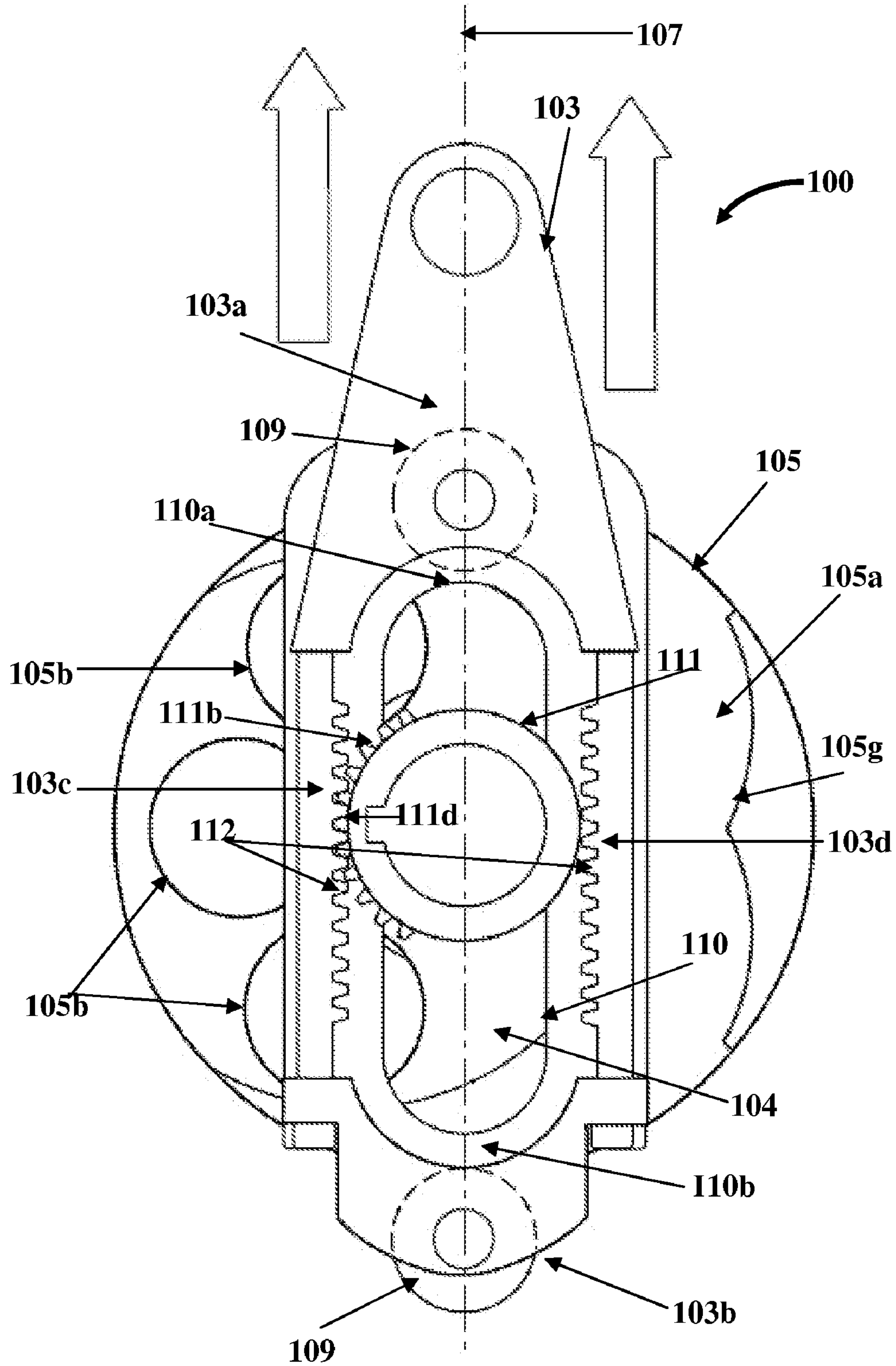
103b
109

FIG. 9B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I10b
103b
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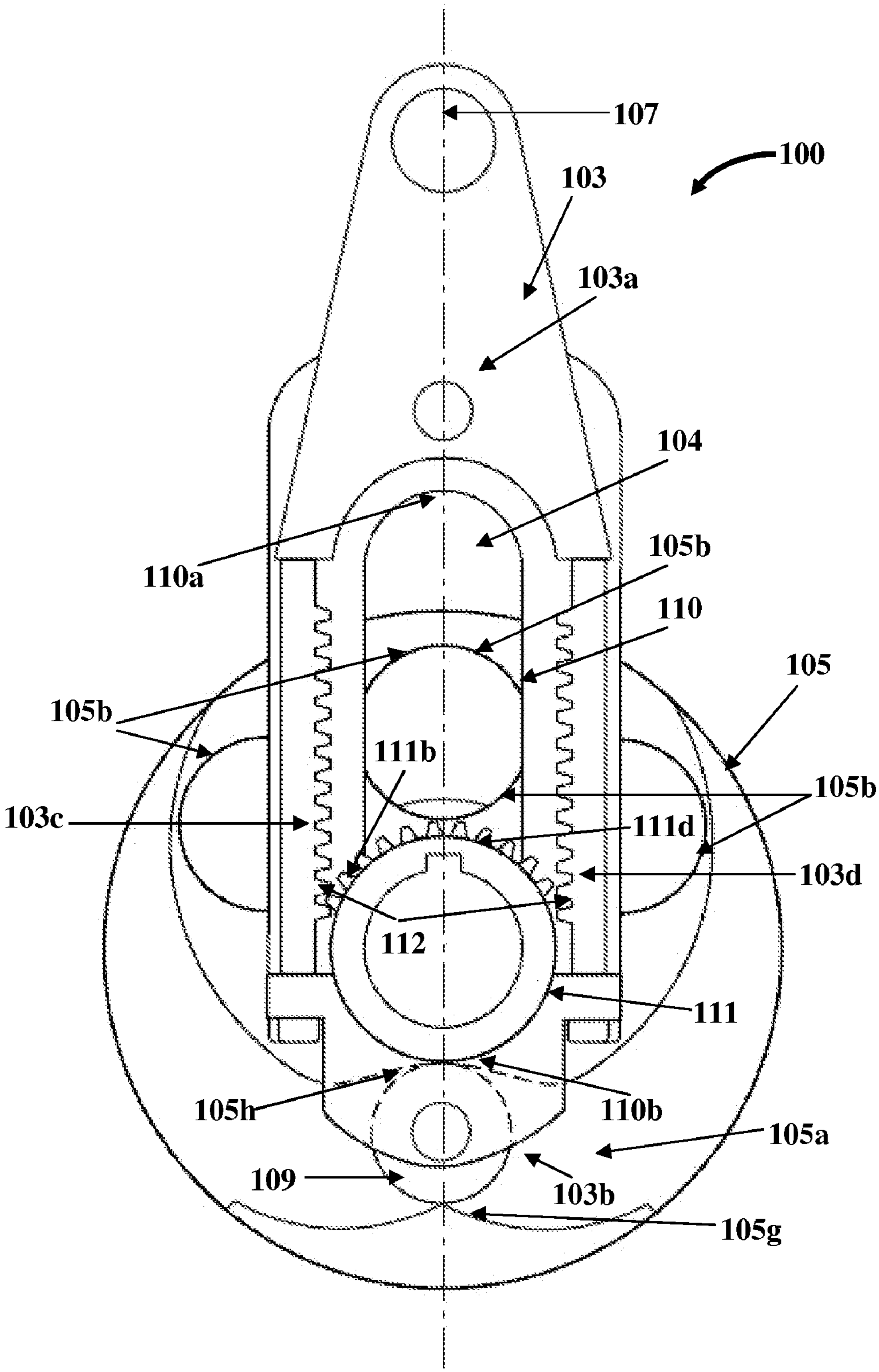
FIG. 10



107
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103c
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103d
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105a
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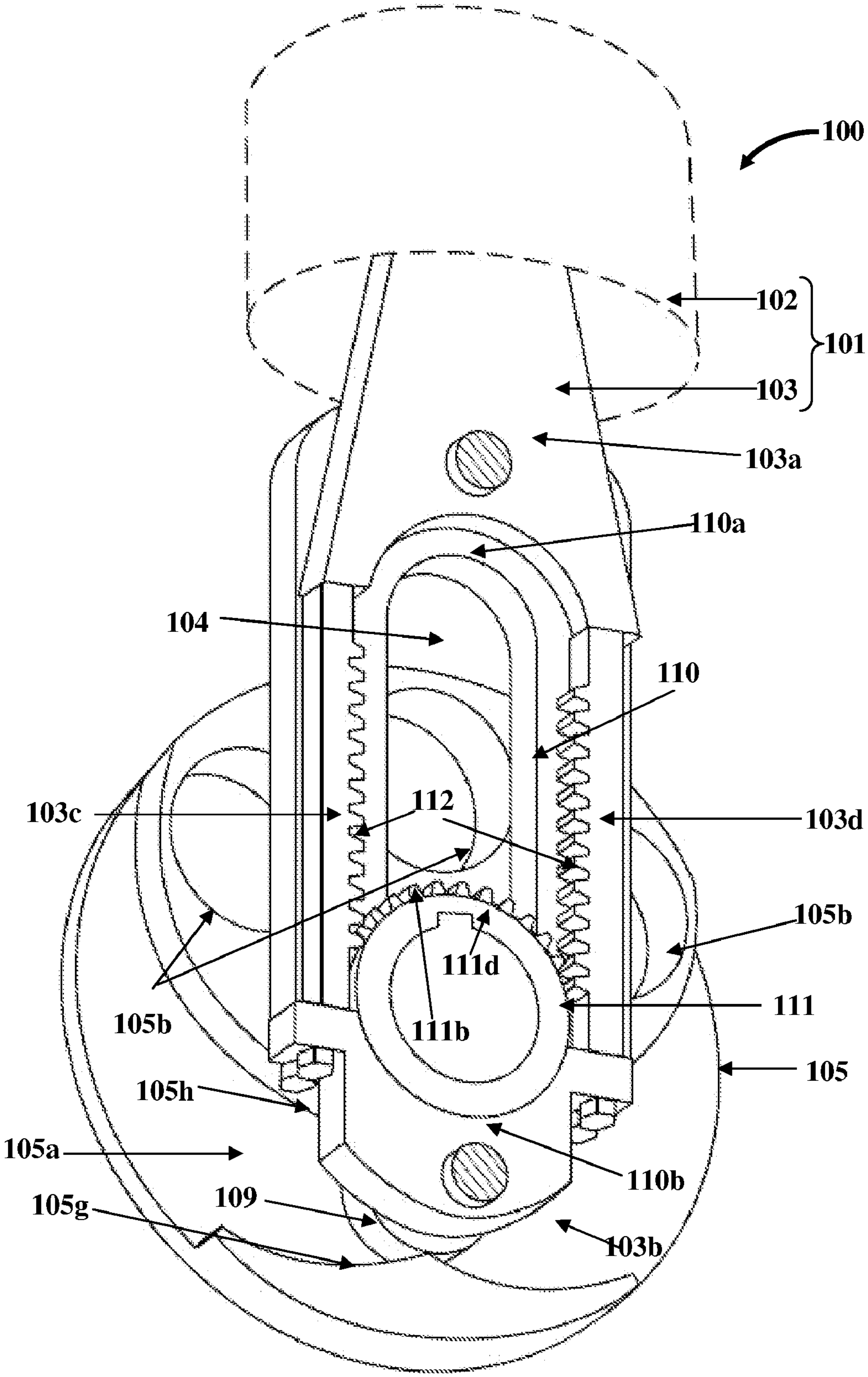
103b
105g

FIG. 11A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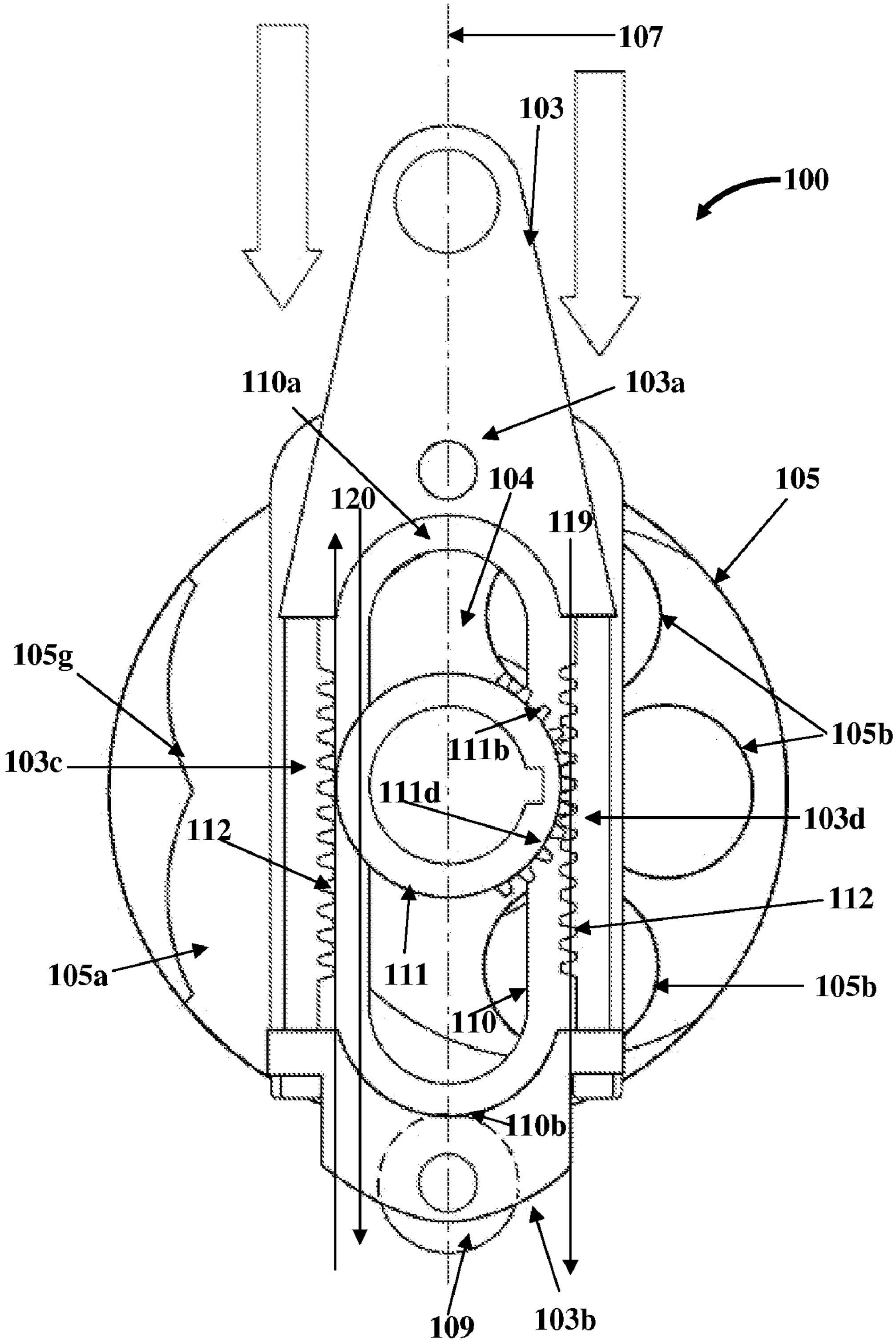
103b

FIG. 11B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105b
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110b
109
103b

FIG. 12

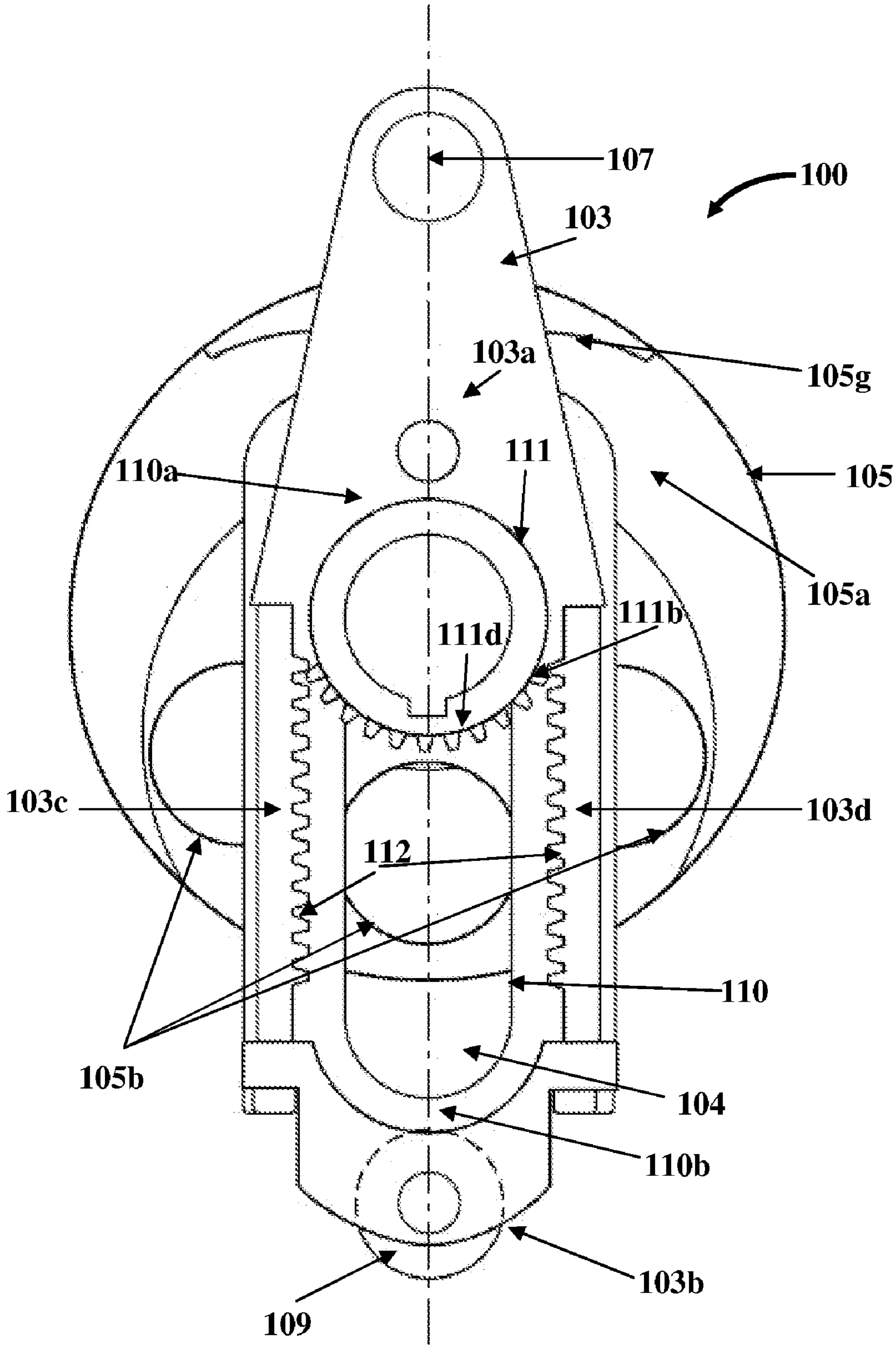
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FIG. 13

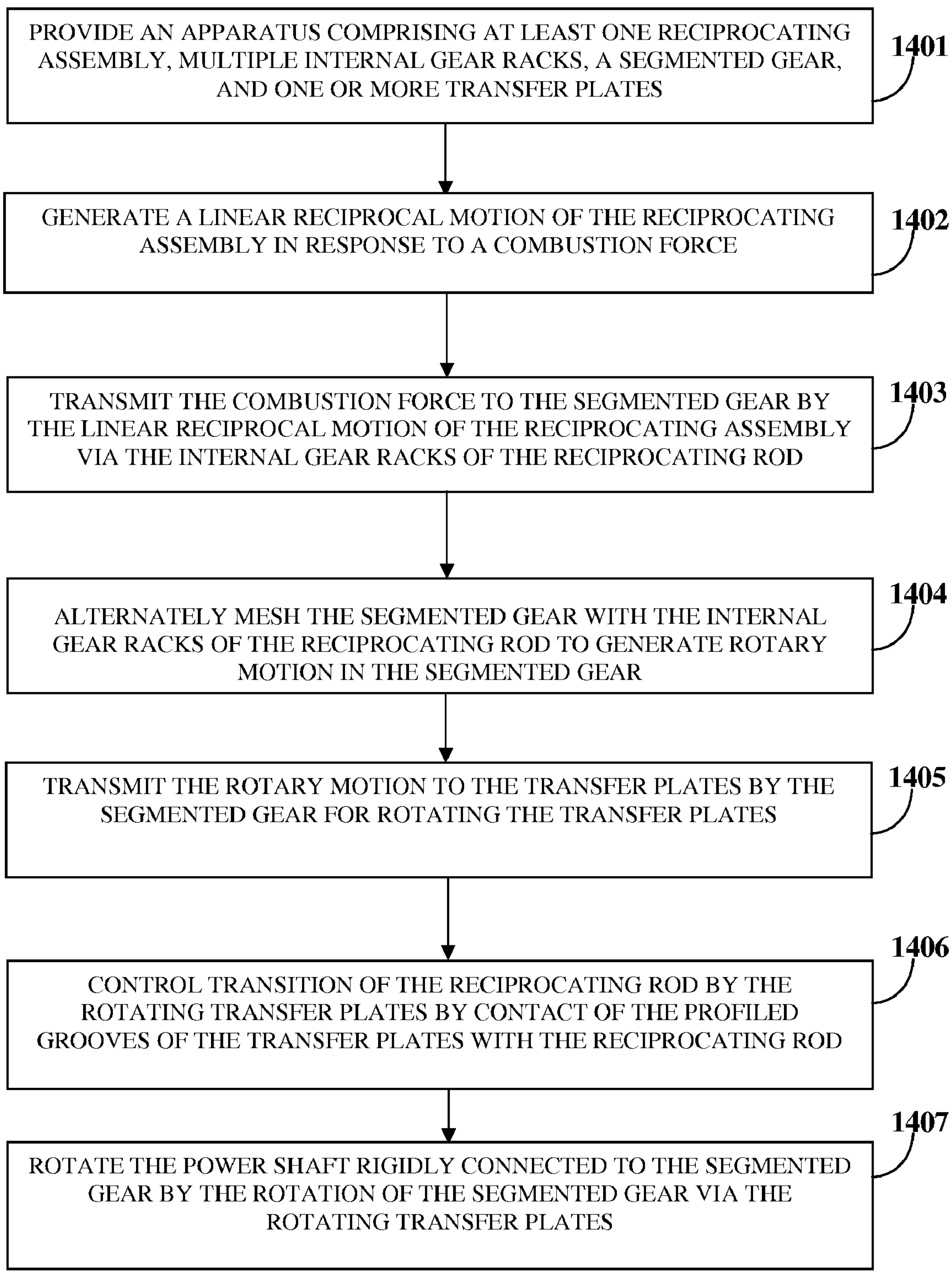
PROVIDE AN APPARATUS COMPRISING AT LEAST ONE RECIPROCATING ASSEMBLY, MULTIPLE INTERNAL GEAR RACKS, A SEGMENTED GEAR, AND ONE OR MORE TRANSFER PLATES
1401
GENERATE A LINEAR RECIPROCAL MOTION OF THE RECIPROCATING ASSEMBLY IN RESPONSE TO A COMBUSTION FORCE
1402
TRANSMIT THE COMBUSTION FORCE TO THE SEGMENTED GEAR BY THE LINEAR RECIPROCAL MOTION OF THE RECIPROCATING ASSEMBLY VIA THE INTERNAL GEAR RACKS OF THE RECIPROCATING ROD
1403
ALTERNATELY MESH THE SEGMENTED GEAR WITH THE INTERNAL GEAR RACKS OF THE RECIPROCATING ROD TO GENERATE ROTARY MOTION IN THE SEGMENTED GEAR
1404
TRANSMIT THE ROTARY MOTION TO THE TRANSFER PLATES BY THE SEGMENTED GEAR FOR ROTATING THE TRANSFER PLATES
1405
CONTROL TRANSITION OF THE RECIPROCATING ROD BY THE ROTATING TRANSFER PLATES BY CONTACT OF THE PROFILED GROOVES OF THE TRANSFER PLATES WITH THE RECIPROCATING ROD
1406
ROTATE THE POWER SHAFT RIGIDLY CONNECTED TO THE SEGMENTED GEAR BY THE ROTATION OF THE SEGMENTED GEAR VIA THE ROTATING TRANSFER PLATES
1407

FIG. 14

FIXED MOMENT ARM INTERNAL GEAR DRIVE APPARATUS

BACKGROUND

[0001] Conventional reciprocating engines consist of a cylinder body and a piston with a connecting rod and a crank assembly. During operation of a conventional reciprocating engine, the connecting rod and the crank assembly convert linear reciprocal motion to rotary motion. A mixture of fuel and air is ignited in the cylinder body and a combustion force is produced as a result of the ignition of the mixture of fuel and air. The piston executes linear reciprocal motion in response to the combustion force. The connecting rod is displaced along a vertical plane when the piston executes the linear reciprocal motion. This displacement of the connecting rod angularly displaces the combustion force while transmitting the combustion force to the crank assembly. The angular displacement of the combustion force varies with respect to the position of the piston in the cylinder body. Thus, a variable moment arm exists and subsequently a constantly varying component of the combustion force is transmitted to the crank assembly over a cycle of operation of the conventional reciprocating engine. The displacement of the connecting rod allows only a component of the combustion force to be transmitted to the crank assembly and hence results in wastage of energy and high fuel consumption for a rated power output.

[0002] Consider a conventional reciprocating engine with a fixed stroke length, for example, a two-inch stroke length. The length of the variable moment arm, approximately averaging 0.333-inch moment arm for a two-inch stroke length, would be a varying one, for example, 0 inch to 1 inch, at different instants of operation. A 2" stroke average moment arm for the crank/piston relationship is 0.333". This is achieved by taking the moment arm at the start, which is 0, the moment arm at the middle, which is 1, and the moment arm at the finish, which is 0. On adding these moment arms together and dividing by three, the average moment arm is 0.333". The moment arm here is a variable moment arm due to its varying length, that is, 0 inch to 1 inch. Hence, the varying length of the variable moment arm in a conventional reciprocating engine allows only a component of the combustion force to be transmitted to an output shaft via the crank assembly due to the pivotal arrangement of the connecting rod and the crank assembly.

[0003] Furthermore, as the connecting rod reciprocates there is a tendency for the connecting rod to lose a part of its energy to frictional losses in every stroke that the connecting rod undertakes. Prolonged use of the connecting rod without the use of external fixtures results in wear and tear of the material of the connecting rod. Hence, there is a need for an apparatus that facilitates smooth frictionless movement of the connecting rod during each stroke, which in turn facilitates smooth transfer of power from the connecting rod to an output shaft. Moreover, in a geared system, the inability to control the connecting rod causes misalignment and locking of mating gears which affects the working of the engine. Hence, there is a need for a mechanism that facilitates soft engagement of the mating gears and prevents any misalignment between the gears during the working of the engine.

[0004] Hence, there is a long felt but unresolved need for a fixed moment arm internal gear drive apparatus that converts linear reciprocal motion to rotary motion, recovers a part of the wasted energy, and uses the recovered energy to drive a power shaft. Furthermore, there is a need for controlling transition of the connecting rod to enable smooth frictionless movement of the connecting rod.

SUMMARY OF THE INVENTION

[0005] This summary is provided to introduce a selection of concepts in a simplified form that are further described in the detailed description of the invention. This summary is not intended to identify key or essential inventive concepts of the claimed subject matter, nor is it intended for determining the scope of the claimed subject matter.

[0006] The fixed moment arm internal gear drive apparatus disclosed herein addresses the above stated need for converting linear reciprocal motion to rotary motion by eliminating and replacing a crank assembly with a fixed moment arm. This is achieved by means of a fixed moment arm orientation between an internal gear rack of a reciprocating rod and a segmented gear that is in alternate mesh with the internal gear rack of the reciprocating rod, in which the combustion force is always perpendicular to the surface on which the combustion force is transmitted. Therefore, the apparatus disclosed herein, with the fixed moment arm orientation between the internal gear rack of the reciprocating rod and the segmented gear, possesses an inherent advantage over conventional reciprocating engines. The reciprocating rod of the apparatus disclosed herein transmits all or most part of the combustion force into driving the segmented gear. Furthermore, the apparatus disclosed herein has a larger effective moment arm compared to a conventional reciprocating engine. In operation, the apparatus disclosed herein inherently eliminates the presence of angularity while transmitting the combustion force from the reciprocating rod to the segmented gear, and also transmits the combustion force perpendicularly from the reciprocating rod to the segmented gear at all times. The apparatus disclosed herein recovers a part of the wasted energy and uses the recovered energy to drive a power shaft.

[0007] The fixed moment arm internal gear drive apparatus disclosed herein comprises at least one reciprocating assembly comprising a reciprocating component and a reciprocating rod, multiple internal gear racks, a segmented gear, and one or more transfer plates. The reciprocating component and the reciprocating rod are capable of linear reciprocal motion in unison. The reciprocating component is, for example, a piston. The reciprocating component is rigidly attached to the reciprocating rod along a vertical axis of the reciprocating rod. The reciprocating component is supported in an engine housing. The reciprocating rod comprises an elongated aperture along the vertical axis of the reciprocating rod. The elongated aperture defines a space between opposing internal sides of the reciprocating rod for accommodating the segmented gear.

[0008] The internal gear racks are disposed on the opposing internal sides of the reciprocating rod for inducing torque and hence rotary motion in the segmented gear by the linear reciprocal motion of the reciprocating rod. Each of the internal gear racks is integrated on the opposing internal sides of the reciprocating rod or internally attached to the opposing internal sides of the reciprocating rod. The segmented gear is in alternate mesh with the internal gear racks rigidly attached on the opposing internal sides of the reciprocating rod. The internal gear racks of the reciprocating rod and the segmented gear are constructed, for example, in a spur gear configuration, a helical gear configuration, a herringbone gear configuration, etc.

[0009] The segmented gear is disposed within a space defined between the opposing internal sides of the reciprocating rod. The segmented gear is rigidly connected to a power shaft. The power shaft is rotatably supported in the engine housing. The centric axis of the segmented gear is collinear to a longitudinal axis of the power shaft during operation of the apparatus. The segmented gear comprises a partial gear area on a surface of the segmented gear. The partial gear area on the surface of the segmented gear is in alternate mesh with one of the internal gear racks on one of the opposing internal sides of the reciprocating rod. The segmented gear alternately meshes with the internal gear racks on the opposing internal sides of the reciprocating rod to transmit the rotary motion of the segmented gear to the power shaft. The segmented gear and each of the internal gear racks together define a fixed moment arm.

[0010] The transfer plates are coaxially disposed on a centric axis of the segmented gear and rigidly connected to the power shaft. The transfer plates are rigidly connected and timed to the segmented gear. Each of the transfer plates comprises one or more profiled grooves for controlling transition of the reciprocating rod by contacting the reciprocating rod, when the reciprocating component is at the top dead center and the bottom dead center within the engine housing to enable smooth frictionless movement of the reciprocating rod. The segmented gear transmits the rotary motion to the transfer plates for rotating the transfer plates.

[0011] The transfer plates receive power from the segmented gear. The transfer plates, rigidly connected and timed to the segmented gear, assist and facilitate smooth alternate meshing of the segmented gear with the internal gear racks of the reciprocating rod. The transfer plates further comprise one or more balancing reliefs defined along a circumference of the transfer plates for stabilizing the transfer plates.

[0012] The apparatus disclosed herein further comprises one or more followers rigidly connected to the opposing ends of the reciprocating rod for following the rotary motion of the transfer plates. The followers rotatably contact the profiled grooves of the transfer plates, when the reciprocating component is at the top dead center and the bottom dead center within the engine housing. The profiled grooves of the transfer plates comprise curvedly shaped walls for contacting the followers rigidly connected to the opposing ends of the reciprocating rod, when the reciprocating component is at the top dead center and the bottom dead center within the engine housing.

[0013] In an embodiment, a keyway is defined on an inner periphery of a central opening of each of the segmented gear and the transfer plates. The power shaft is inserted into the central opening of each of said segmented gear and the transfer plates, and locked to the segmented gear and the transfer plates through the keyway. The rotary motion of the segmented gear rotates the power shaft rigidly connected to the segmented gear via the rotating transfer plates. The rotary motion of the segmented gear thereby converts the linear reciprocal motion of the reciprocating assembly to the rotary motion of the power shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The foregoing summary, as well as the following detailed description of the invention, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, exemplary constructions of the invention are shown in the drawings. However, the invention is not limited to the specific components and methods disclosed herein.

[0015] FIG. **1** exemplarily illustrates a perspective view of a fixed moment arm internal gear drive apparatus for converting linear reciprocal motion to rotary motion.

[0016] FIG. **2** exemplarily illustrates an exploded view of the fixed moment arm internal gear drive apparatus.

[0017] FIG. **3** exemplarily illustrates an assembled perspective view of the fixed moment arm internal gear drive apparatus.

[0018] FIG. **4** exemplarily illustrates an isometric view of a reciprocating rod of the fixed moment arm internal gear drive apparatus, supported in a rod housing.

[0019] FIG. **5** exemplarily illustrates an exploded view of the reciprocating rod.

[0020] FIG. **6**A exemplarily illustrates a front orthogonal view of one of the transfer plates of the fixed moment arm internal gear drive apparatus.

[0021] FIG. **6**B exemplarily illustrates a side orthogonal view of one of the transfer plates of the fixed moment arm internal gear drive apparatus.

[0022] FIG. **7** exemplarily illustrates a sectional view of an engine housing incorporated with the fixed moment arm internal gear drive apparatus.

[0023] FIG. **8** exemplarily illustrates an isometric view of an inline engine incorporated with multiple fixed moment arm internal gear drive apparatuses.

[0024] FIG. **9**A exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus, when a reciprocating component is at a bottom dead center within the engine housing.

[0025] FIG. **9**B exemplarily illustrates a perspective view of the fixed moment arm internal gear drive apparatus, when the reciprocating component is at the bottom dead center within the engine housing.

[0026] FIG. **10** exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus, when the reciprocating component is traversing from the bottom dead center to a top dead center within the engine housing.

[0027] FIG. **11**A exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus, when the reciprocating component is at the top dead center within the engine housing.

[0028] FIG. **11**B exemplarily illustrates a perspective view of the fixed moment arm internal gear drive apparatus, when the reciprocating component is at the top dead center within the engine housing.

[0029] FIG. **12** exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus, when the reciprocating component is traversing from the top dead center to the bottom dead center within the engine housing.

[0030] FIG. **13** exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus, when the reciprocating component is at the bottom dead center within the engine housing.

[0031] FIG. **14** illustrates a method for converting linear reciprocal motion to rotary motion.

DETAILED DESCRIPTION OF THE INVENTION

[0032] FIG. **1** exemplarily illustrates a perspective view of a fixed moment arm internal gear drive apparatus **100** for converting linear reciprocal motion to rotary motion. The fixed moment arm internal gear drive apparatus **100** disclosed herein comprises at least one reciprocating assembly **101**, multiple internal gear racks **112**, a segmented gear **111**, and one or more transfer plates **105** as exemplarily illustrated in FIG. **2** and FIG. **7**. The reciprocating assembly **101** comprises a reciprocating component **102** and a reciprocating rod **103** capable of linear reciprocal motion in unison. The reciprocating component **102** is a piston **102**. The reciprocating component **102** is supported in an engine housing **118** as exemplarily illustrated in FIG. **7**. The reciprocating component **102** is rigidly attached to the reciprocating rod **103** along a vertical axis **107** of the reciprocating rod **103**. The reciprocating rod **103** is enclosed and supported by a rod housing **108**. The reciprocating rod **103** comprises an elongated aperture **110** along the vertical axis **107** of the reciprocating rod **103**. The elongated aperture **110** defines a space **104** between opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** for accommodating the segmented gear **111** as exemplarily illustrated in FIG. **7**.

[0033] One or more transfer plates **105** are coaxially disposed on a centric axis **114** of the segmented gear **111**, as exemplarily illustrated in FIG. **2**, and rigidly connected to a power shaft **106**. In an embodiment, the transfer plates **105** are positioned on opposing sides **108***a* and **108***b* of the rod housing **108** that supports the reciprocating rod **103**. The fixed moment arm internal gear drive apparatus **100** disclosed herein further comprises one or more followers **109** rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103** through the rod housing **108** are disclosed in the detailed description of FIG. **2**.

[0034] Each of the transfer plates **105** comprises one or more profiled grooves **105***a* for controlling transition of the reciprocating rod **103** by contacting the reciprocating rod **103**, when the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* within the engine housing **118** as disclosed in the detailed descriptions of FIGS. **9A-9B**, FIG. **10**, FIGS. **11A-11B**, and FIGS. **12-13**. As used herein, the term "top dead center" refers to a location of the reciprocating component **102** at its uppermost point of reciprocal travel relative to a cylinder in an engine housing **118** and is a point at which the reciprocating component **102** is at a dead stop or zero velocity. Correspondingly, the term "bottom dead center" refers to a location of the reciprocating component **102** at its lowermost point of reciprocal travel relative to the cylinder and is also a point at which the reciprocating component **102** is at a dead stop or zero velocity.

[0035] Each of the transfer plates **105** further comprises one or more balancing reliefs **105***b* defined along a circumference **105***d* of the transfer plates **105** for stabilizing the transfer plates **105**. The balancing reliefs **105***b* are, for example, openings drilled in the transfer plates **105** that stabilize the transfer plates **105** while the transfer plates **105** are rotating. The balancing reliefs **105***b* on the transfer plates **105** cause the transfer plates **105** to rotate at a constant angular moment leading to a stabilized rotation of the transfer plates **105**.

[0036] FIG. **2** exemplarily illustrates an exploded view of the fixed moment arm internal gear drive apparatus **100**. FIG. **2** shows the reciprocating rod **103**, the rod housing **108** that supports the reciprocating rod **103**, the segmented gear **111**, the transfer plates **105**, and the power shaft **106**. Multiple internal gear racks **112** are disposed on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** for inducing rotary motion in the segmented gear **111** by the linear reciprocal motion of the reciprocating rod **103**. Each of the internal gear racks **112** is a linear gearing element that converts the linear reciprocal motion of the reciprocating rod **103** to a rotary motion of the segmented gear **111**, on engagement of the segmented gear **111** with the internal gear racks **112**. The internal gear racks **112** are made, for example, by forging, casting, machining, etc. Each of the internal gear racks **112** is integrated on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** or internally attached to the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**, for example, using fasteners **116** as exemplarily illustrated in FIG. **5**.

[0037] The segmented gear **111** is a pinion having a cam **111***a* and gear teeth **111***b* that produces a smooth reciprocating motion. The segmented gear **111** is disposed within the space **104** defined between the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** and is rigidly connected to the power shaft **106**. The segmented gear **111** comprises a partial gear area **111***d* on a surface **111***e* of the segmented gear **111**. The partial gear area **111***d* on the surface **111***e* of the segmented gear **111** having the gear teeth **111***b* is in alternate mesh with one of the internal gear racks **112** on one of the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**. As used herein, the term "alternate mesh" refers to an alternation in meshing of the partial gear area **111***d* of the segmented gear **111** having the gear teeth **111***b* with the internal gear racks **112** on one opposing internal side **103***c* of the reciprocating rod **103** to the other opposing internal side **103***d* of the reciprocating rod **103**. The gear teeth **111***b* on the partial gear area **111***d* of the segmented gear **111** alternately engages with the internal gear racks **112**, thereby causing rotation of the segmented gear **111** when the reciprocating rod **103** undergoes linear reciprocal motion.

[0038] The segmented gear **111** further comprises a central opening **111***f* and a keyway **111***c* defined on an inner periphery **111***g* of the central opening **111***f* of the segmented gear **111**. The keyway **111***c* of the segmented gear **111** enables locking of the power shaft **106** to the segmented gear **111**. The segmented gear **111** alternately meshes with the internal gear racks **112** on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** to transmit the rotary motion of the segmented gear **111** to the power shaft **106**. The segmented gear **111** and each of the internal gear racks **112** together define a fixed moment arm **119** as disclosed in the detailed description of FIG. **12**. The internal gear racks **112** of the reciprocating rod **103** and the segmented gear **111** are constructed, for example, in a spur gear configuration, a helical gear configuration, a herringbone gear configuration, etc.

[0039] The transfer plates **105** are coaxially disposed on the centric axis **114** of the segmented gear **111** and rigidly connected to the segmented gear **111** and the power shaft **106**. Each of the transfer plates **105** is, for example, a cam plate that transforms rotary motion into linear motion and vice versa. The centric axis **114** of the segmented gear **111** is collinear to a longitudinal axis **113** of the power shaft **106**. The segmented gear **111** transmits its rotary motion to the transfer plates **105** for rotating the transfer plates **105**. Each of the transfer plates **105** further comprises a central opening **105***c* and a keyway **105***e* defined on an inner periphery **105***f* of the central opening **105***c* as disclosed in the detailed description of FIG. **6A**.

[0040] The followers **109** of the fixed moment arm internal gear drive apparatus **100** are rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103** through the rod housing **108** for following the rotary motion of the transfer plates **105**. The rod housing **108** comprises supporting elements **108***c* and **108***d* that enclose the reciprocating rod **103**. The followers **109** rotatably contact the profiled grooves **105***a* of the transfer plates **105**, when the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* of the engine housing **118**. An adapter **115** is rotatably connected to the power shaft **106** along the longitudinal axis **113** of the power shaft **106**. The adapter **115** is used for enhancing oil seal life of the power shaft **106** during lubrication.

[0041] FIG. **3** exemplarily illustrates an assembled perspective view of the fixed moment arm internal gear drive apparatus **100**. The power shaft **106** is inserted into the central openings **111***f* and **105***c* of the segmented gear **111** and the transfer plates **105** respectively and locked to the segmented gear **111** and the transfer plates **105** through the keyways **111***c* and **105***e* respectively as exemplarily illustrated in FIG. **2**. The fixed moment arm internal gear drive apparatus **100** disclosed herein is used, for example, in aircrafts, trains, buses, trucks, cars, motorcycles, lawnmowers, pumps, motors, generators, other engine driven devices, etc.

[0042] FIG. **4** exemplarily illustrates an isometric view of the reciprocating rod **103** of the fixed moment arm internal gear drive apparatus **100**, supported in the rod housing **108**. The reciprocating rod **103** is positioned between and is enclosed by the supporting elements **108***c* and **108***d* of the rod housing **108**. The elongated aperture **110** of the reciprocating rod **103** defines a space **104** between the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** for accommodating the segmented gear **111**. One or more followers **109** are rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103** through the rod housing **108** for following the rotary motion of the transfer plates **105**. For example, a follower **109** is connected to the reciprocating rod **103** through each of the supporting elements **108***c* and **108***d* of the rod housing **108**. The follower **109** is, for example, a cam follower. The follower **109** is a rotating component used to transform rotary motion to a reciprocal motion, or a reciprocal motion to a rotary motion. Multiple internal gear racks **112** are disposed on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**.

[0043] FIG. **5** exemplarily illustrates an exploded view of the reciprocating rod **103** supported in the rod housing **108**. As exemplarily illustrated in FIG. **5**, about two internal gear racks **112** are rigidly attached on each of the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**, for example, using fasteners **116**. The fasteners **116** lock the internal gear racks **112** to the reciprocating rod **103**. The supporting elements **108***c* and **108***d* of the rod housing **108** are connected to the reciprocating rod **103** via the followers **109** and fasteners **117**.

[0044] FIG. **6**A and FIG. **6**B exemplarily illustrate a front orthogonal view and a side orthogonal view of one of the transfer plates **105** of the fixed moment arm internal gear drive apparatus **100** respectively. The transfer plates **105** assist in alternate meshing of the segmented gear **111** with the internal gear racks **112** of the reciprocating rod **103**. The transfer plates **105** control, for example, about 21 degrees of rotation of the power shaft **106**, when the reciprocating component **102** is at the top dead center **118***a* or the bottom dead center **118***b* of the engine housing **118**. One or more followers **109** are rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103** for following the rotary motion of the transfer plates **105**. The profiled grooves **105***a* of each of the transfer plates **105** comprise curvedly shaped walls **105***g* and **105***h* for contacting the followers **109** rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103**, when the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* within the engine housing **118**. Each of the transfer plates **105** comprises a keyway **105***e* defined on an inner periphery **105***f* of the central opening **105***c*. The keyway **105***e* locks each of the transfer plates **105** to the power shaft **106**. The power shaft **106** is rotatably supported in the engine housing **118**.

[0045] A 21 degree of rotation of the segmented gear **111** and the power shaft **106** while the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* of the engine housing **118**, translates to a total of 42 degrees at both the dead centers **118***a* and **118***b*. The remaining 318 degrees of rotation of the power shaft **106** is accomplished by the timed segmented gear **111** rigidly connected to the power shaft **106**. The segmented gear **111** reacts by alternately meshing with the internal gear racks **112** rigidly attached on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**. The transfer plates **105** are rigidly connected and timed to the segmented gear **111**. As disclosed herein, the term "timed" refers to synchronization of the transfer plates **105** with the segmented gear **111** for ensuring precise movement of the segmented gear **111** and the transfer plates **105**.

[0046] The transfer plates **105** control the movement of the reciprocating rod **103** for 21 degrees, that is 10.5 degrees to the right of the vertical axis **107** and 10.5 degrees to the left of the vertical axis **107**, when the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* within the engine housing **118**. As the transfer plates **105** rotate, the transfer plates **105** slowly transfer control to the segmented gear **111** rigidly connected to the power shaft **106**, thereby creating a soft gear engagement. The transfer plates **105** thereby facilitate smooth alternate meshing between the segmented gear **111** and the internal gear racks **112** of the reciprocating rod **103**. The keyway **105***e* in the central opening **105***c* of each of the transfer plates **105** enables locking of each of the transfer plates **105** to the power shaft **106**. Locking is performed to enable continuous transfer of torque from the segmented gear **111** to the power shaft **106** and to hold the power shaft **106** and the transfer plates **105** together. One or more balancing reliefs **105***b* are defined along the circumference **105***d* of each of the transfer plates **105** for stabilizing the transfer plates **105**.

[0047] FIG. **7** exemplarily illustrates a sectional view of an engine housing **118** incorporated with the fixed moment arm internal gear drive apparatus **100**. During operation of an engine, a mixture of fuel and air is ignited when the reciprocating component **102** is at the top dead center **118***a* of the engine housing **118**. The reciprocating component **102**, herein referred to as a "piston" exhibits a linear reciprocal motion. The reciprocating rod **103** rigidly attached to the piston **102** consequently exhibits the linear reciprocal motion along with the piston **102**. The internal gear racks **112** rigidly attached on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** transmit the linear reciprocal motion to the segmented gear **111**. The segmented gear **111** is in alternate mesh with the internal gear racks **112** on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**. The segmented gear **111** converts the linear reciprocal motion into a rotary motion and transmits this rotary motion to the power shaft **106**. The power shaft **106** is rotatably supported in the engine housing **118**. A pair of transfer plates **105** disposed on the centric axis **114** of the segmented gear **111** take the load while the piston **102** is transitioning from the top dead center **118***a* to the bottom dead center **118***b* of the engine housing **118** and vice versa. In this manner, the rotary motion of the segmented gear **111** converts the linear reciprocal motion of the reciprocating assembly **101** comprising the reciprocating rod **103** and the piston **102** to rotary motion of the power shaft **106**.

[0048] FIG. **8** exemplarily illustrates an isometric view of an inline engine incorporated with multiple fixed moment arm internal gear drive apparatuses **100**. In the inline engine, multiple fixed moment arm internal gear drive apparatuses **100** are mounted on the power shaft **106** with no offset and operate to rotate the power shaft **106**. The inline engine with the fixed moment arm internal gear drive apparatuses **100** can be used, for example, in automobiles, locomotives, aircrafts, etc. Inline engines are compact, easier to build, and assemble.

[0049] FIG. **9**A and FIG. **9**B exemplarily illustrate an orthogonal view and a perspective view of the fixed moment arm internal gear drive apparatus **100** respectively, when the reciprocating component **102** herein referred to as the "piston" is at a bottom dead center **118***b* within the engine housing **118**. The segmented gear **111** is disposed within the space **104** defined by the elongated aperture **110** between the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103**. When the piston **102** is at the bottom dead center **118***b*, the segmented gear **111** is at the top end **110***a* of the elongated aperture **110** of the reciprocating rod **103**. The profiled grooves **105***a* of the transfer plates **105** contact the followers **109** rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103**, when the piston **102** is at the bottom dead center **118***b* as exemplarily illustrated in FIG. **9**A. The segmented gear **111** transmits the rotary motion induced by the linear reciprocal motion of the reciprocating rod **103** to the transfer plates **105** for rotating the transfer plates **105**. One of the followers **109** at one opposing end **103***a* of the reciprocating rod **103** rotatably contacts a first curvedly shaped wall **105***g* and a second curvedly shaped wall **105***h* of the profiled grooves **105***a* of the transfer plates **105**, when the piston **102** is at the bottom dead center **118***b* to control transition of the reciprocating assembly **101**.

[0050] FIG. **10** exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus **100**, when the piston **102** is traversing from the bottom dead center **118***b* to the top dead center **118***a* within the engine housing **118**. During the compression stroke of an engine, the piston **102** traverses from the bottom dead center **118***b* to the top dead center **118***a*. The movement of the piston **102** from the bottom dead center **118***b* to the top dead center **118***a* converts the linear reciprocating motion of the reciprocating rod **103** to rotary motion of the segmented gear **111**. The gear teeth **111***b* on the partial gear area **111***d* of the segmented gear **111** meshes with the internal gear racks **112** rigidly attached on one opposing internal side **103***c* of the reciprocating rod **103** to transmit the rotary motion of the segmented gear **111** to the power shaft **106**. The segmented gear **111** transmits the rotary motion to the transfer plates **105** for rotating the transfer plates **105**. The followers **109** along with the transfer plates **105** controls the movement of the reciprocating rod **103** for approximately 21 degrees at the top dead center **118***a* and the bottom dead center **118***b*. The segmented gear **111** and each of the internal gear racks **112** together define a fixed moment arm **119** as disclosed in the detailed description of FIG. **12**.

[0051] FIG. **11**A and FIG. **11**B exemplarily illustrate an orthogonal view and a perspective view of the fixed moment arm internal gear drive apparatus **100** respectively, when the piston **102** is at the top dead center **118***a* within the engine housing **118**. As one stroke of the piston **102** from the bottom dead center **118***b* to the top dead center **118***a* is complete, the segmented gear **111** is at the bottom end **110***b* of the elongated aperture **110** of the reciprocating rod **103**. The curvedly shaped walls **105***g* and **105***h* of the profiled grooves **105***a* of the transfer plates **105** contact the followers **109** rigidly connected to the reciprocating rod **103**, when the piston **102** is at the top dead center **118***a*. The segmented gear **111** transmits the rotary motion to the transfer plates **105** for rotating the transfer plates **105**. One of the followers **109** at the other opposing end **103***b* of the reciprocating rod **103** rotatably contacts the first curvedly shaped wall **105***g* and the second curvedly shaped wall **105***h* of the profiled grooves **105***a* of the transfer plates **105**, when the piston **102** is at the top dead center **118***a* to control transition of the reciprocating assembly **101**. The profile grooves **105***a* on the transfer plates **105** enable smooth transition of the segmented gear **111** from the internal gear racks **112** on one opposing internal side **103***c* of the reciprocating rod **103** to the internal gear racks **112** on the other opposing internal side **103***d* of the reciprocating rod **103** to begin the next stroke of the piston **102** from the top dead center **118***a* to the bottom dead center **118***b*.

[0052] FIG. **12** exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus **100**, when the piston **102** is traversing from the top dead center **118***a* to the bottom dead center **118***b* within the engine housing **118**. During this stroke of the piston **102**, the segmented gear **111** meshes with the internal gear racks **112** on the other opposing internal side **103***d* of the reciprocating rod **103**. As the piston **102** moves downwards, the internal gear racks **112** disposed on the opposing internal side **103***d* of the reciprocating rod **103** engages with the gear teeth **111***b* on the partial gear area **111***d* of the segmented gear **111** that transmits power to the power shaft **106**. As this stroke of the piston **102** is complete, the segmented gear **111** reaches the top end **110***a* of the elongated aperture **110** of the reciprocating rod **103** as exemplarily illustrated in FIG. **13** and the process repeats. In this way, a linear reciprocating motion of the reciprocating rod **103** is converted to a rotary motion of the segmented gear **111**, which is then transferred to the power shaft **106** via the transfer plates **105**.

[0053] When the segmented gear **111** rotates, a moment arm is produced by a combined effort of a radial force and a tangential force generated during rotation of the segmented gear **111**. Rotation of the segmented gear **111** generates a force that is tangential to the segmented gear **111** along a line of action **120** of the reciprocating rod **103**. The line of action **120** represents a linear motion of the reciprocating rod **103** during operation. The fixed moment arm **119** is achieved through the interaction between the segmented gear **111** and each of the internal gear racks **112**. As the segmented gear **111** rotates and engages with the internal gear racks **112**, the tangential force generated remains constant as the piston **102** traverses from the top dead center **118***a* to the bottom dead center **118***b* and vice versa, and causes the rotation of the power shaft **106**.

[0054] FIG. **13** exemplarily illustrates an orthogonal view of the fixed moment arm internal gear drive apparatus **100**, when the piston **102** is at the bottom dead center **118***b* within the engine housing **118**. When the piston **102** is at the bottom dead center **118***b*, the segmented gear **111** is at the top end **110***a* of the elongated aperture **110** of the reciprocating rod **103** as disclosed in the detailed description of FIGS. **9**A-**9**B.

[0055] The fixed moment arm internal gear drive apparatus **100** disclosed herein comprises a fixed stroke length of the piston **102**, for example, a two-inch stroke length, for which a fixed moment arm **119** exists, for example, a 0.633-inch moment arm. In the fixed moment arm internal gear drive apparatus **100** disclosed herein, a mixture of fuel and air is ignited in the engine housing **118** and a combustion force is produced as a result of the ignition of the mixture of fuel and air. This combustion force is transmitted, with its maximum magnitude, to the power shaft **106**, thereby increasing efficiency by approximately **93** percent for a two-inch stroke length as disclosed below.

[0056] The fixed moment arm internal gear drive apparatus **100** disclosed herein using a two-inch stroke length develops a fixed moment arm **119**. For a 2" stroke length, the circumferences **111***h* of the segmented gear **111**, as exemplarily illustrated in FIG. **2**, must be a working 4", thereby creating a working diameter of 1.27" for the segment gear **111**. By dividing the working diameter by two, about 0.633" fixed moment arm **119** is obtained. This fixed moment arm **119** yields approximately a 93% increase in power output and torque of the fixed moment arm internal gear drive apparatus **100** by evaluating the percentage change in moment arm length, 0.3", over the original moment arm length 0.33" of a conventional reciprocating engine.

[0057] Hence, the fixed moment arm internal gear drive apparatus **100** having a two-inch stroke length is approximately 93% more efficient compared to the conventional reciprocating engine having the same stroke length. Alternatively, the fixed moment arm internal gear drive apparatus **100** can be reduced in size by approximately 93% when compared to the 2" stroke length conventional reciprocating engine for the same power output. The fixed moment arm internal gear drive apparatus **100** disclosed herein is retrofitable to different engine configurations, for example, a single cylinder configuration, a dual cylinder configuration, a vee engine configuration, etc., and to engines operating on different cycles, for example, a four stroke, a two stroke, Otto, diesel, etc. The fixed moment arm internal gear drive apparatus **100** disclosed herein is applicable to all types of piston-operated devices, for example, four cycle, two cycle, and diesel engines, for pump and motor applications, etc.

[0058] FIG. **14** illustrates a method for converting linear reciprocal motion to rotary motion. The fixed moment arm internal gear drive apparatus **100** comprising at least one reciprocating assembly **101**, multiple internal gear racks **112**, a segmented gear **111**, and one or more transfer plates **105** as disclosed in the detailed descriptions of FIGS. **1-13** is provided **1401**. The reciprocating assembly **101** comprising a reciprocating component **102** and a reciprocating rod **103** are capable of a linear reciprocal motion in unison. A linear reciprocal motion of the reciprocating assembly **101** is generated **1402** in response to a combustion force produced by ignition of the mixture of fuel and air in the engine housing **118**. The linear reciprocal motion of the reciprocating assembly **101** transmits **1403** the combustion force to the segmented gear **111** via the internal gear racks **112** of the reciprocating rod **103**. The segmented gear **111** alternately meshes **1404** with the internal gear racks **112** on the opposing internal sides **103***c* and **103***d* of the reciprocating rod **103** to generate rotary motion in the segmented gear **111**. The segmented gear **111** transmits **1405** the rotary motion to the transfer plates **105** rigidly connected and timed to the segmented gear **111** for rotating the transfer plates **105**. The transfer plates **105** assist and facilitate smooth alternate meshing of the segmented gear **111** with the internal gear racks **112** of the reciprocating rod **103**.

[0059] The rotating transfer plates **105** control **1406** the transition of the reciprocating rod **103** by contact of the profiled grooves **105***a* of the transfer plates **105** with the reciprocating rod **103**, when the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* within the engine housing **118**. The curvedly shaped walls **105***g* and **105***h* of the profiled grooves **105***a* contact one or more followers **109** rigidly connected to the opposing ends **103***a* and **103***b* of the reciprocating rod **103**, when the reciprocating component **102** is at the top dead center **118***a* and the bottom dead center **118***b* for controlling transition of the reciprocating rod **103**. The rotation of the segmented gear **111** rotates **1407** the power shaft **106** rigidly connected to the segmented gear **111** via the rotating transfer plates **105**, thereby generating rotary motion of the power shaft **106**. The centric axis **114** of the segmented gear **111** is collinear to the longitudinal axis **113** of the power shaft **106** during operation of the fixed moment arm internal gear drive apparatus **100**. The transfer plates **105** are stabilized using one or more balancing reliefs **105***b* defined along a circumference **105***d* of each of the transfer plates **105**.

[0060] The foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention disclosed herein. While the invention has been described with reference to various embodiments, it is understood that the words, which have been used herein, are words of description and illustration, rather than words of limitation. Further, although the invention has been described herein with reference to particular means, materials and embodiments, the invention is not intended to be limited to the particulars disclosed herein; rather, the invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims. Those skilled in the art, having the benefit of the teachings of this specification, may affect numerous modifications thereto and changes may be made without departing from the scope and spirit of the invention in its aspects.

I claim:

1. An apparatus for converting linear reciprocal motion to rotary motion, comprising:

at least one reciprocating assembly comprising a reciprocating component and a reciprocating rod capable of said linear reciprocal motion in unison, wherein said reciprocating component is rigidly attached to said reciprocating rod along a vertical axis of said reciprocating rod, and wherein said reciprocating component is supported in an engine housing;

a plurality of internal gear racks disposed on opposing internal sides of said reciprocating rod for inducing rotary motion in a segmented gear by said linear reciprocal motion of said reciprocating rod, wherein said segmented gear is in alternate mesh with said internal gear racks rigidly attached on said opposing internal sides of said reciprocating rod;

said segmented gear disposed within a space defined between said opposing internal sides of said reciprocating rod and rigidly connected to a power shaft, wherein said segmented gear alternately meshes with said internal gear racks on said opposing internal sides of said reciprocating rod to transmit said rotary motion of said segmented gear to said power shaft, wherein said segmented gear and each of said internal gear racks together define a fixed moment arm; and

one or more transfer plates coaxially disposed on a centric axis of said segmented gear and rigidly connected to said power shaft, wherein each of said one or more transfer plates comprises one or more profiled grooves for controlling transition of said reciprocating rod by contacting said reciprocating rod, when said reciprocating component is at a top dead center and a bottom dead center within said engine housing, and wherein said segmented gear transmits said rotary motion to said one or more transfer plates rigidly connected and timed to said segmented gear for rotating said one or more transfer plates;

whereby said rotary motion of said segmented gear converts said linear reciprocal motion of said reciprocating assembly to rotary motion of said power shaft.

2. The apparatus of claim **1**, wherein said centric axis of said segmented gear is collinear to a longitudinal axis of said power shaft.

3. The apparatus of claim **1**, wherein said segmented gear comprises a partial gear area on a surface of said segmented gear, wherein said partial gear area on said surface of said segmented gear is in said alternate mesh with one of said internal gear racks on one of said opposing internal sides of said reciprocating rod.

4. The apparatus of claim **1**, wherein said power shaft is rotatably supported in said engine housing.

5. The apparatus of claim **1**, wherein said internal gear racks of said reciprocating rod and said segmented gear are constructed in one of a spur gear configuration, a helical gear configuration, and a herringbone gear configuration.

6. The apparatus of claim **1**, wherein said reciprocating component is a piston.

7. The apparatus of claim **1**, wherein said reciprocating rod comprises an elongated aperture along said vertical axis of said reciprocating rod, wherein said elongated aperture defines said space between said opposing internal sides of said reciprocating rod for accommodating said segmented gear.

8. The apparatus of claim **1**, wherein said one or more transfer plates assist and facilitate smooth said alternate meshing of said segmented gear with said internal gear racks of said reciprocating rod.

9. The apparatus of claim **1**, further comprising one or more followers rigidly connected to opposing ends of said reciprocating rod for following said rotary motion of said one or more transfer plates, wherein said one or more followers rotatably contact said one or more profiled grooves of said one or more transfer plates, when said reciprocating component is at said top dead center and said bottom dead center within said engine housing.

10. The apparatus of claim **9**, wherein said one or more profiled grooves of said one or more transfer plates comprise curvedly shaped walls for contacting said one or more followers rigidly connected to said opposing ends of said reciprocating rod, when said reciprocating component is at said top dead center and said bottom dead center within said engine housing.

11. The apparatus of claim **1**, further comprising a keyway defined on an inner periphery of a central opening of each of said segmented gear and said one or more transfer plates, wherein said power shaft is inserted into said central opening of said each of said segmented gear and said one or more transfer plates and locked to said segmented gear and said one or more transfer plates through said keyway.

12. The apparatus of claim **1**, wherein said one or more transfer plates further comprise one or more balancing reliefs defined along a circumference of said one or more transfer plates for stabilizing said one or more transfer plates.

13. The apparatus of claim **1**, wherein each of said internal gear racks is one of integrated on said opposing internal sides of said reciprocating rod and internally attached to said opposing internal sides of said reciprocating rod.

14. A method for converting linear reciprocal motion to rotary motion, comprising:

providing an apparatus comprising:

at least one reciprocating assembly comprising a reciprocating component and a reciprocating rod capable of said linear reciprocal motion in unison, wherein said reciprocating component is rigidly attached to said reciprocating rod along a vertical axis of said reciprocating rod, and wherein said reciprocating component is supported in an engine housing;

a plurality of internal gear racks disposed on opposing internal sides of said reciprocating rod for inducing rotary motion in a segmented gear by said linear reciprocal motion of said reciprocating rod;

said segmented gear disposed within a space defined between said opposing internal sides of said reciprocating rod and rigidly connected to a power shaft, wherein said segmented gear is configured to alternately mesh with said internal gear racks rigidly attached on said opposing internal sides of said reciprocating rod to transmit said rotary motion of said segmented gear to said power shaft, said power shaft being rotatably supported in said engine housing, wherein said segmented gear and each of said internal gear racks together define a fixed moment arm; and

one or more transfer plates coaxially disposed on a centric axis of said segmented gear and rigidly connected to said power shaft, wherein each of said one or more transfer plates comprises one or more profiled grooves configured for contacting said reciprocating rod, when said reciprocating component is at a top dead center and a bottom dead center within said engine housing;

generating said linear reciprocal motion of said reciprocating assembly in response to a combustion force;

transmitting said combustion force to said segmented gear by said linear reciprocal motion of said reciprocating assembly via said internal gear racks on said opposing internal sides of said reciprocating rod, wherein said segmented gear alternately meshes with said internal gear racks on said opposing internal sides of said reciprocating rod to generate rotary motion in said segmented gear, wherein said segmented gear transmits said rotary motion to said one or more transfer plates rigidly connected and timed to said segmented gear for rotating said one or more transfer plates;

controlling transition of said reciprocating rod by said rotating one or more transfer plates by contact of said one or more profiled grooves of said one or more transfer plates with said reciprocating rod, when said reciprocating component is at said top dead center and said bottom dead center within said engine housing; and rotating said power shaft rigidly connected to said segmented gear by said rotation of said segmented gear, via said rotating one or more transfer plates;

whereby rotary motion is generated in said power shaft.

15. The method of claim **14**, wherein said segmented gear comprises a partial gear area on a surface of said segmented gear, wherein said partial gear area on said surface of said segmented gear is in said alternate mesh with one of said internal gear racks on one of said opposing internal sides of said reciprocating rod.

16. The method of claim **14**, wherein a centric axis of said segmented gear is collinear to a longitudinal axis of said power shaft during operation of said apparatus.

17. The method of claim **14**, wherein said reciprocating rod comprises an elongated aperture along said vertical axis of said reciprocating rod, wherein said elongated aperture defines said space between said opposing internal sides of said reciprocating rod for accommodating said segmented gear.

18. The method of claim **14**, wherein said one or more transfer plates assist and facilitate smooth said alternate meshing of said segmented gear with said internal gear racks of said reciprocating rod.

19. The method of claim **14**, wherein said apparatus further comprises one or more followers rigidly connected to opposing ends of said reciprocating rod for following said rotary motion of said one or more transfer plates, wherein said one or more followers rotatably contact said one or more profiled grooves of said one or more transfer plates, when said reciprocating component is at said top dead center and said bottom dead center within said engine housing.

20. The method of claim **19**, wherein said one or more profiled grooves of said one or more transfer plates comprise curvedly shaped walls for contacting said one or more followers rigidly connected to said opposing ends of said reciprocating rod, when said reciprocating component is at said top dead center and said bottom dead center within said engine housing.

21. The method of claim **14**, further comprising locking said power shaft to each of said segmented gear and said one or more transfer plates through a keyway defined on an inner periphery of a central opening of said each of said segmented gear and said one or more transfer plates.

22. The method of claim **14**, further comprising stabilizing said one or more transfer plates using one or more balancing reliefs defined along a circumference of said one or more transfer plates.

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