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(54) **DIAPHRAGM PUMP**

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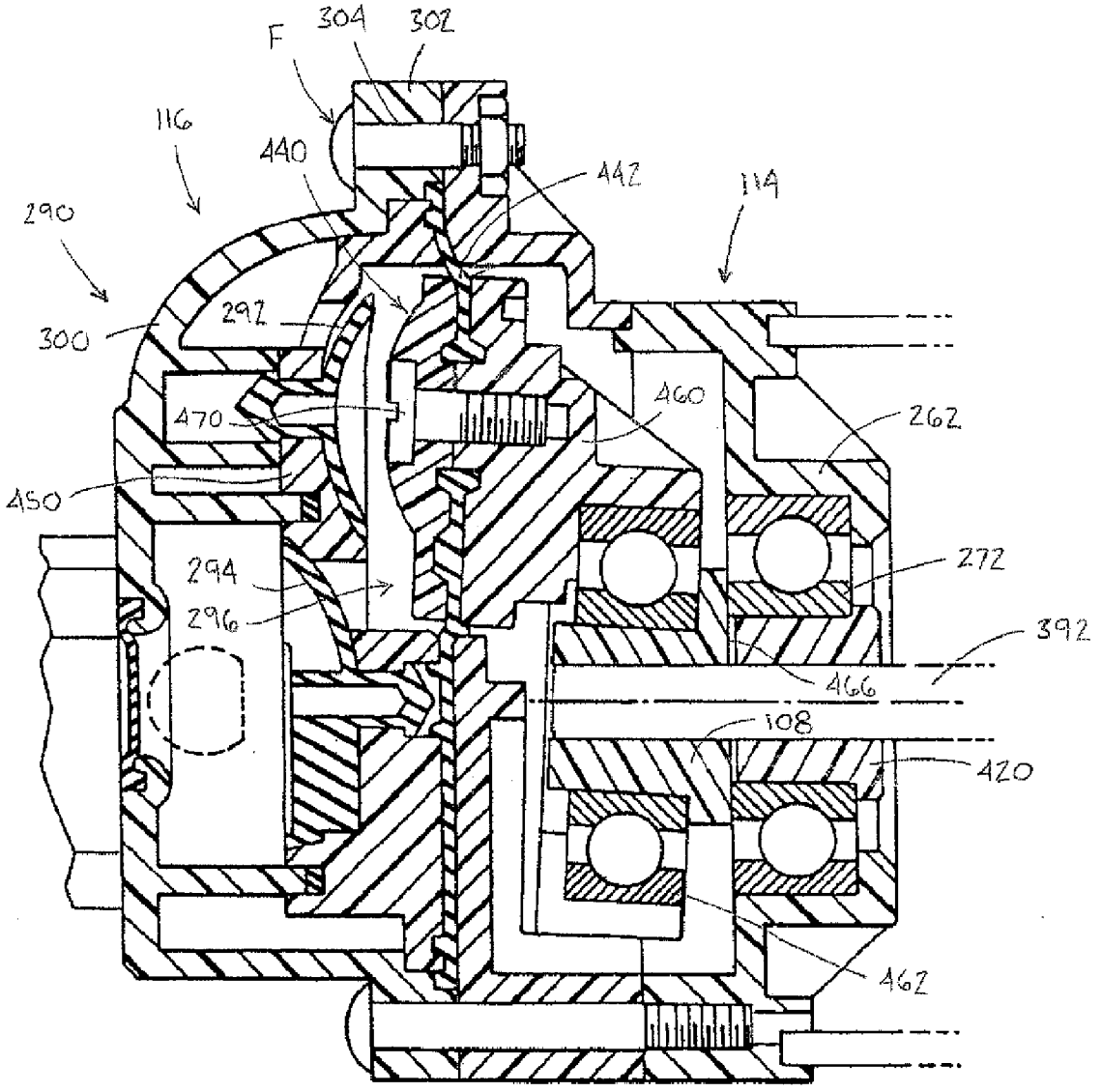
(52) **U.S. Cl.** **417/413.1**

(57) **ABSTRACT**

A diaphragm pump comprises a housing, a motor supported by the housing, a drive assembly operably connected to the motor and a wobble plate operably connected to the drive assembly. The motor includes a drive shaft defining a rotational axis. The wobble plate orbits about the rotational axis of the drive shaft. The drive assembly includes a reduction gear assembly and a drive member connected to the gear assembly. The gear assembly provides a predetermined gear reduction to reduce the speed of the motor and increase the torque needed to drive the pump.



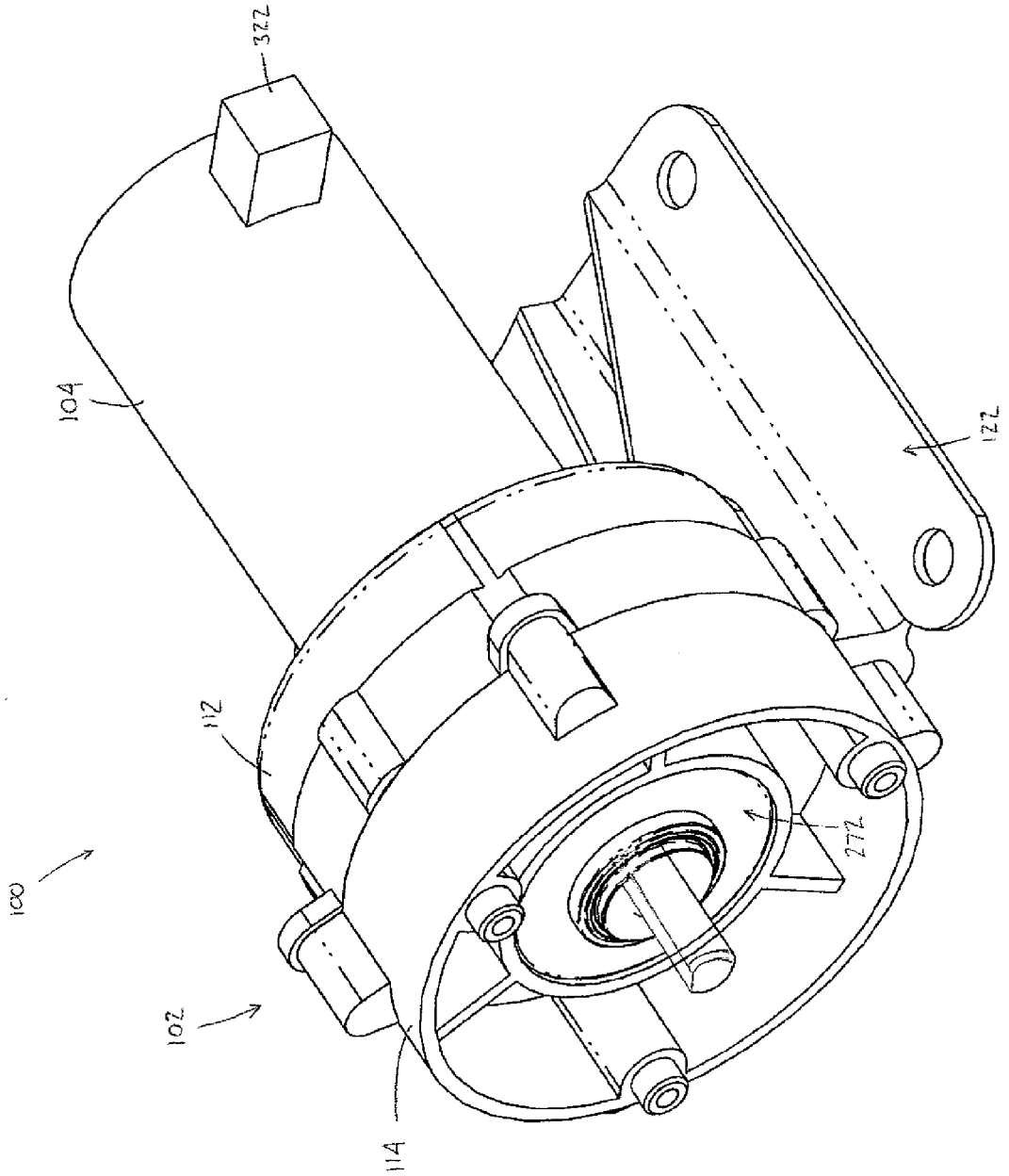


FIG. 1

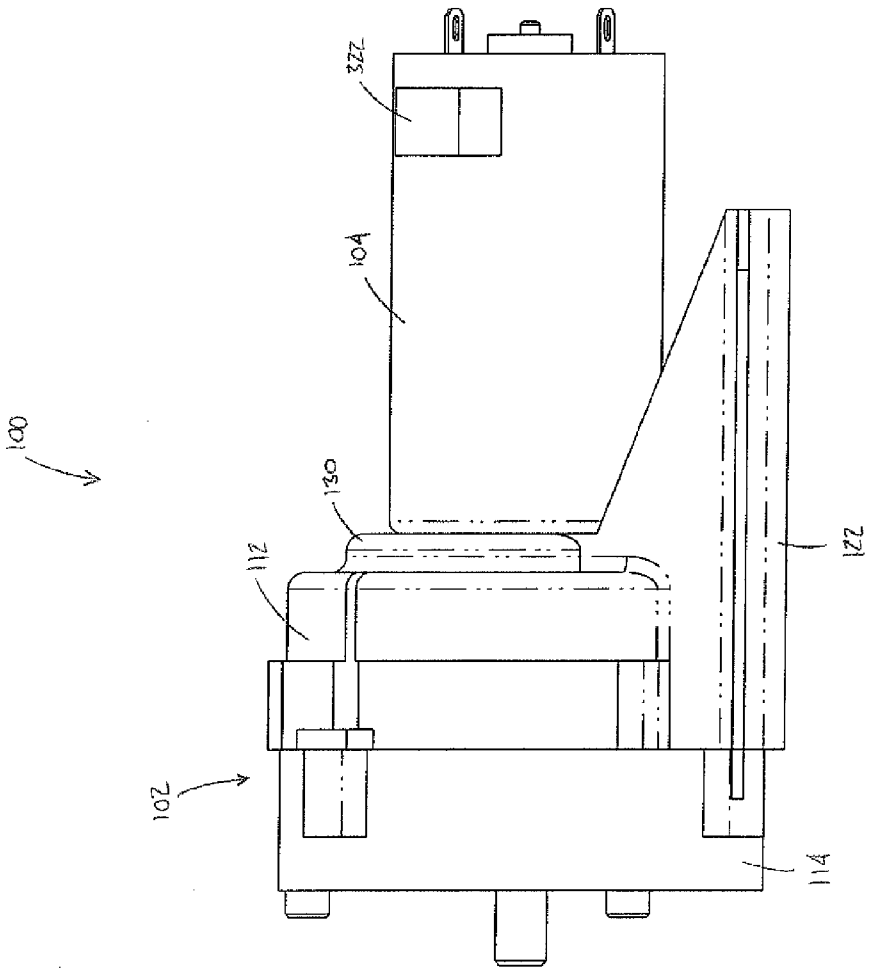


FIG. 2

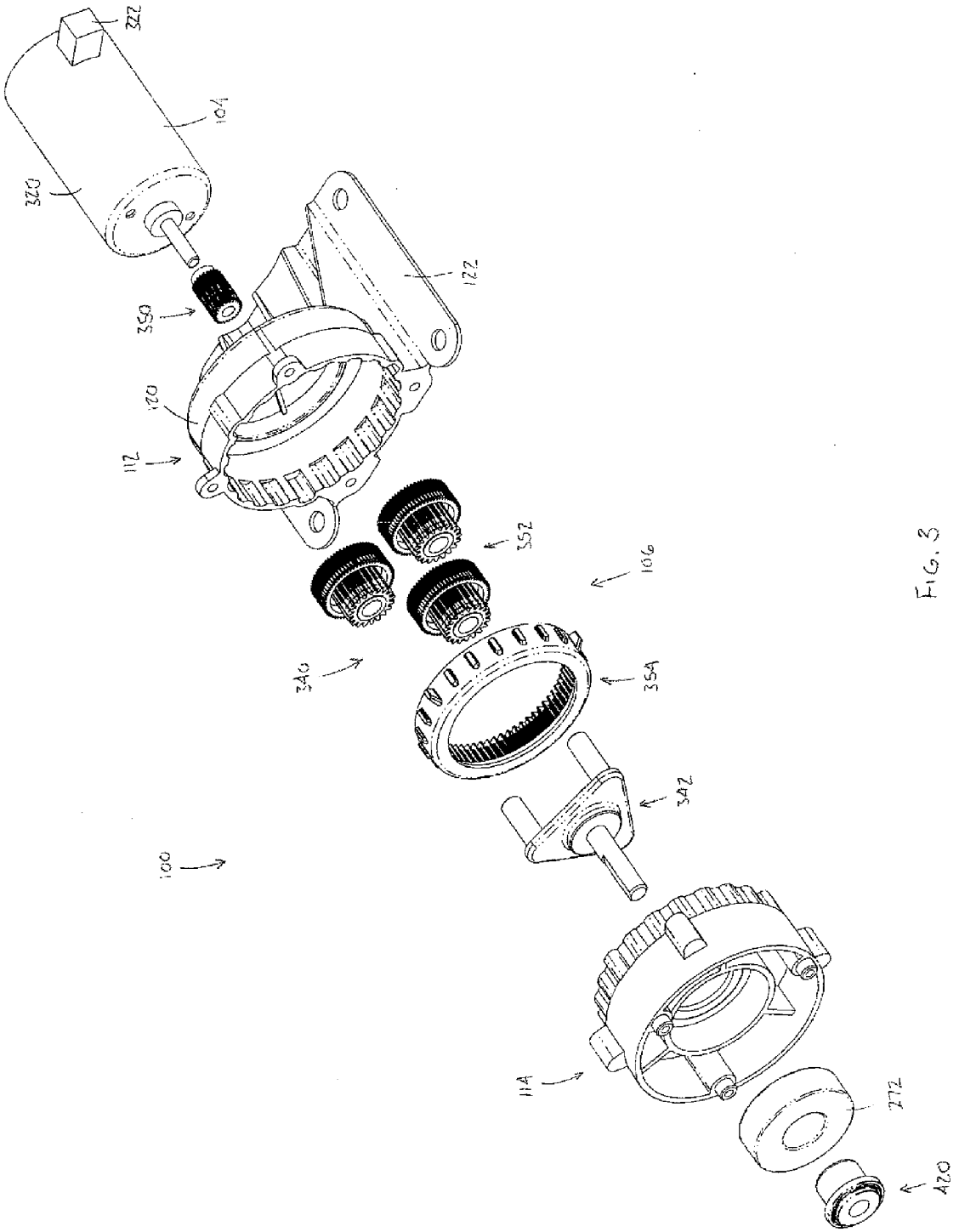


FIG. 3

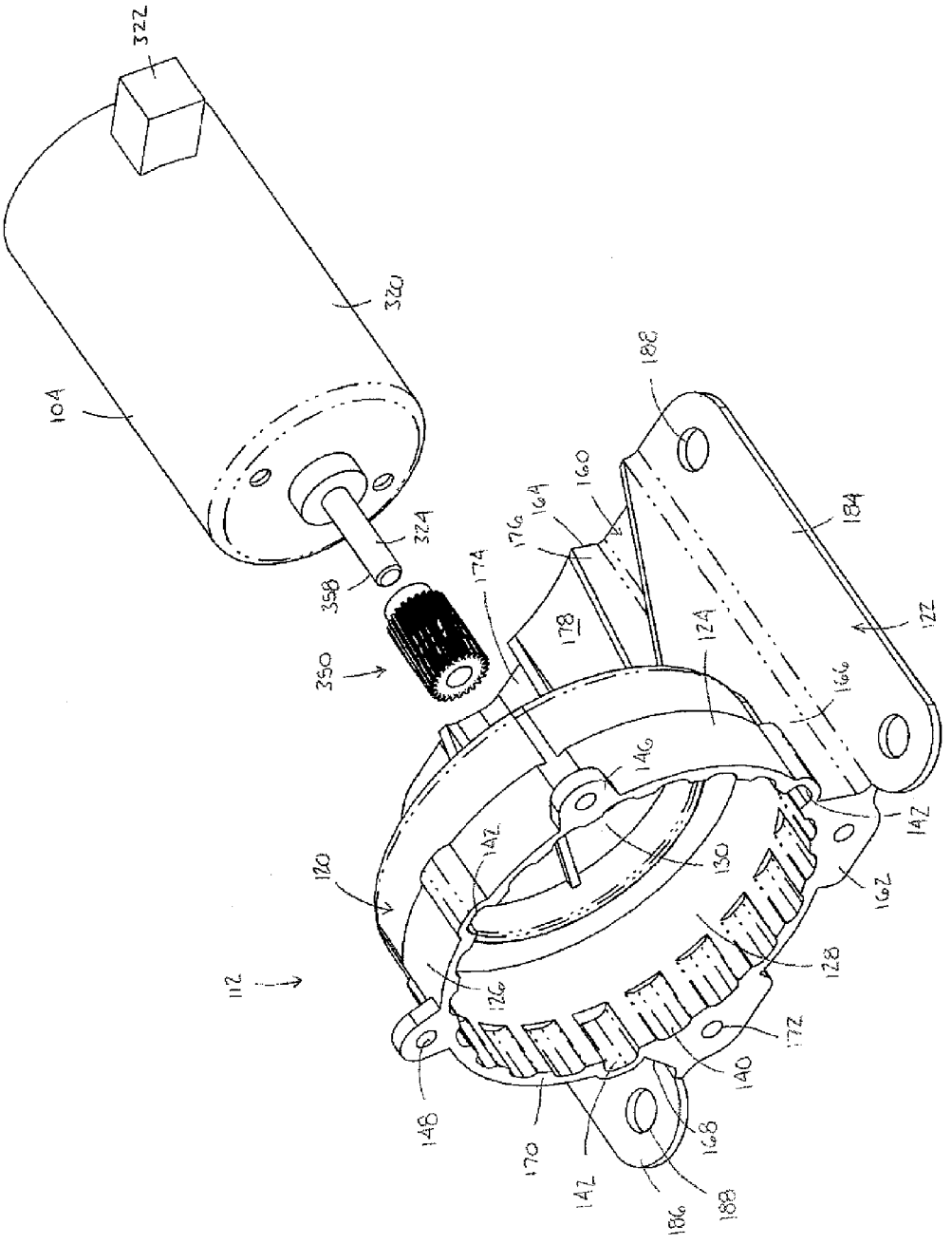

322
320
104
324
358
174
350
178
176
164
160
188
184
122
124
166
146
142
130
120
112
126
128
172
140
148
170
168
186

FIG. 4

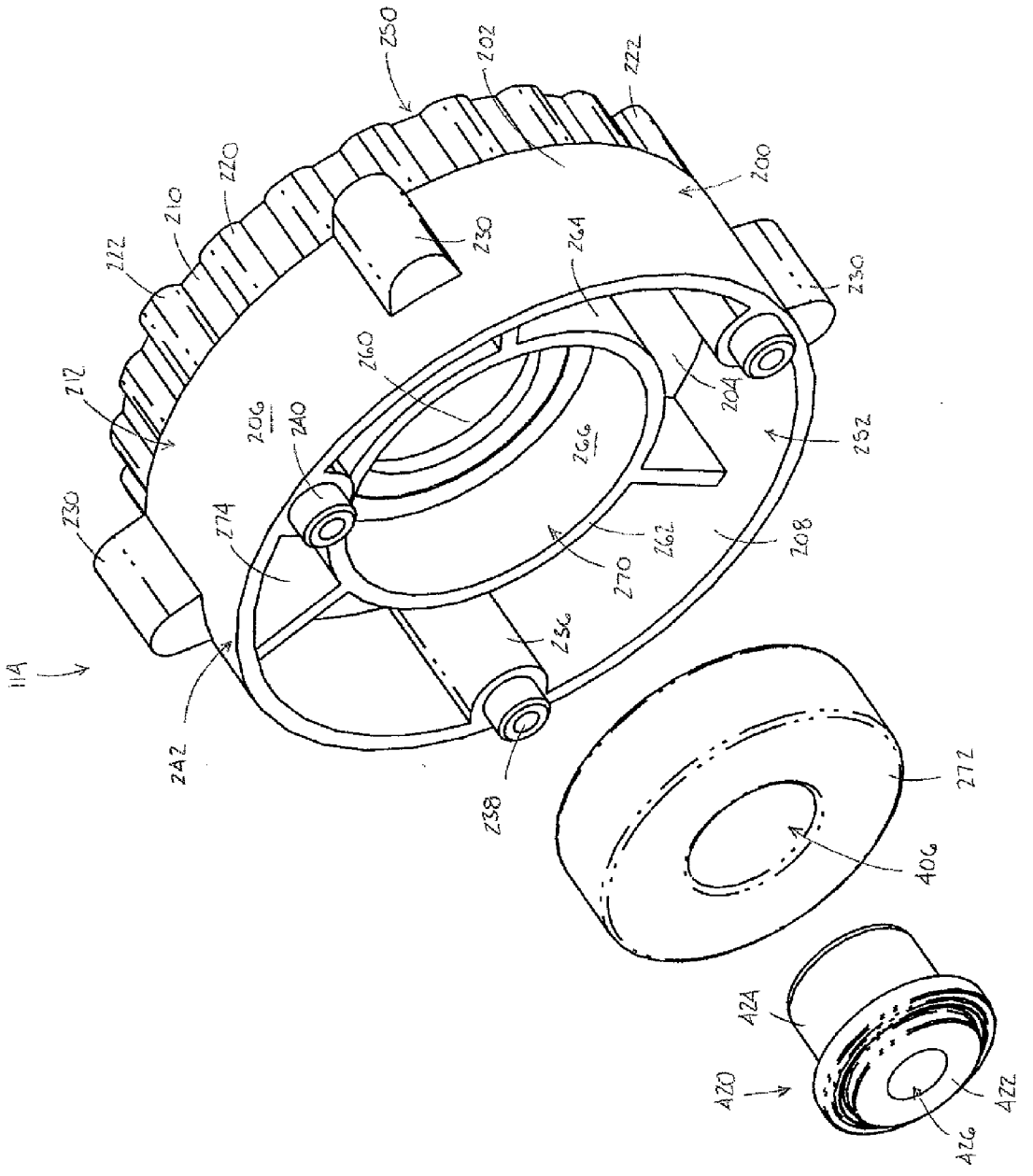

250
202
222
200
220
210
212
230
264
230
260
204
206
240
252
266
230
274
262
208
270
256
114
242
238
272
406
424
420
422
426

FIG. 5

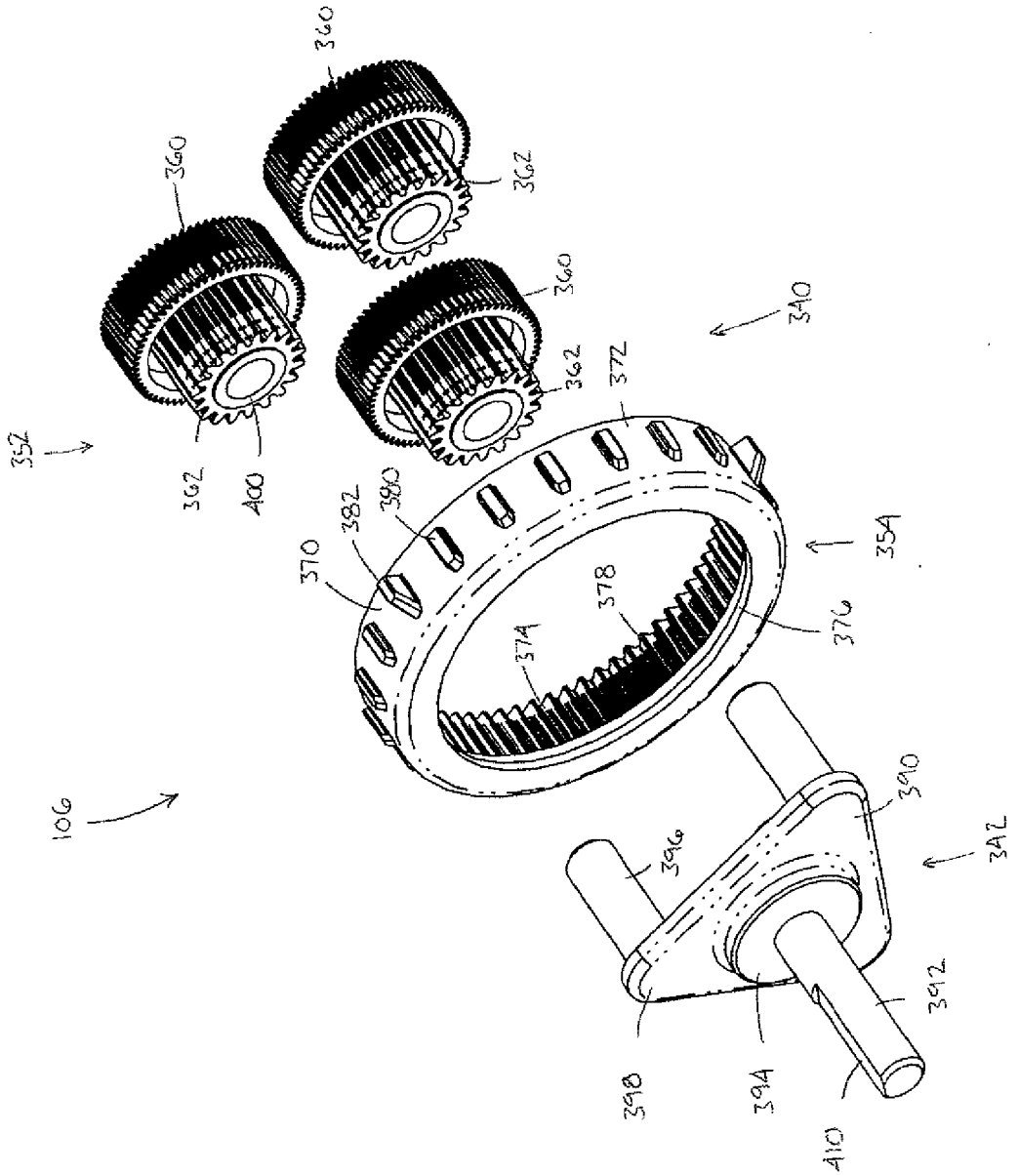

360
362
360
362
360
362
400
352
340
372
382
380
370
378
374
376
354
106
390
396
342
392
398
394
410

FIG. 6

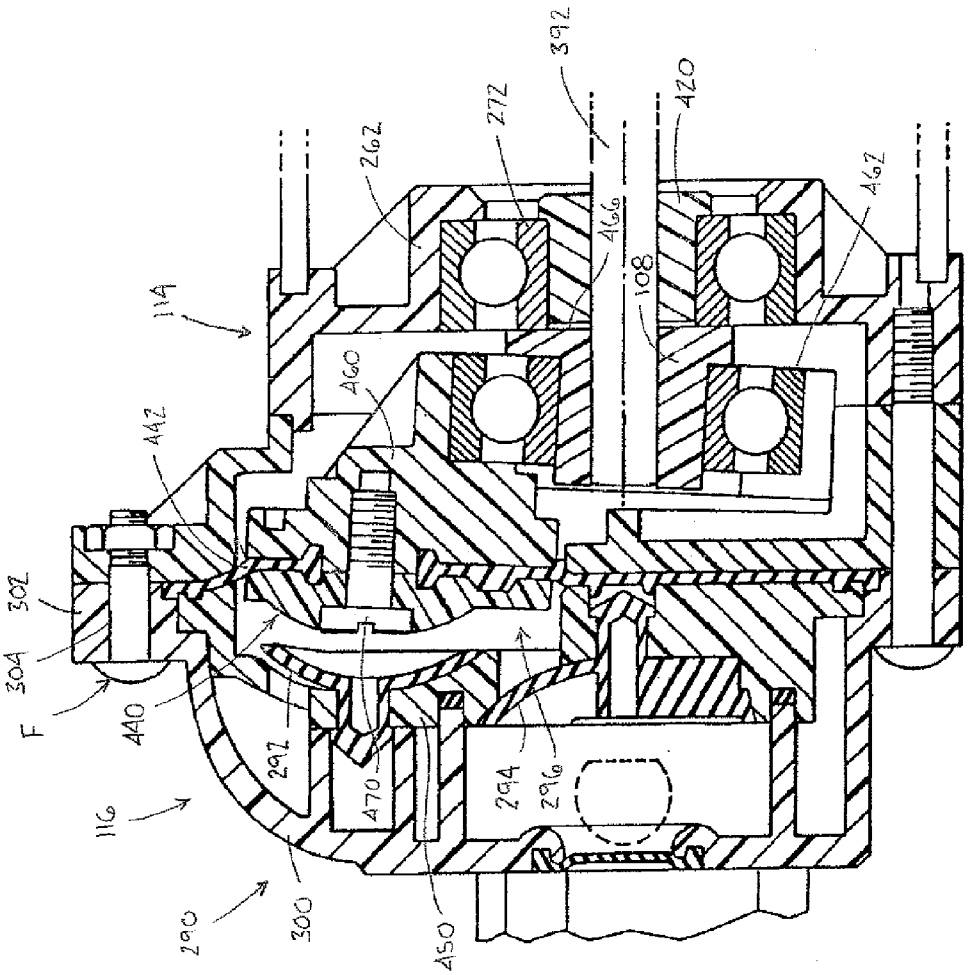

392
420
272
262
462
466
108
114
460
442
302
304
F
440
292
470
294
296
116
290
300
450

FIG. 7

DIAPHRAGM PUMP

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority from U.S. Provisional Patent Application Ser. No. 611082,370 filed Jul. 21, 2008; which provisional patent application is expressly incorporated herein by reference, in its entirety.

BACKGROUND

[0002] Exemplary embodiments herein relate to a diaphragm pump for a hydraulic system. Diaphragm pumps possess many advantages and are widely used. Generally, the diaphragm pump defines a variable volume chamber by using a space between a pump casing and a diaphragm, which is controlled by a wobble plate. Typically, the wobble plate, driven by a shaft, operates to lift away from and then compress against the diaphragm in a wavelike or peristaltic motion. An inlet and an outlet are provided through the pump casing with one-way valves for preventing backflow. These cooperate with the diaphragm to create an appropriate variable pumping chamber with a peristaltic action. The conventional diaphragm pumps require a relatively large motor to generate the torque needed to drive the pump. However, the use of the large motors increases the weight, size and cost of the diaphragm pumps.

[0003] An improved diaphragm pump is provided which employs a relatively smaller, lighter and more cost effective motor and drive assembly which can produce equivalent speed and torque as the previously used larger motors.

BRIEF DESCRIPTION

[0004] According to one aspect, a diaphragm pump comprises a housing, a motor supported by the housing, a drive assembly operably connected to the motor and a wobble plate operably connected to the drive assembly. The motor includes a drive shaft defining a rotational axis. The wobble plate orbits about the rotational axis of the drive shaft. The drive assembly includes a reduction gear assembly and a drive member connected to the gear assembly. The gear assembly provides a predetermined gear reduction to reduce the speed of the motor and increase the torque needed to drive the pump.

[0005] According to another aspect, a diaphragm pump comprises a housing and a generally small, lightweight motor supported by the housing. The motor includes a drive shaft defining a rotational axis. A drive assembly is operably connected to the motor. The drive assembly includes a reduction gear assembly including a planetary gear train having a plurality of compound gears and a ring gear. A wobble plate is rotatably connected to the gear assembly. The wobble plate orbits about the rotational axis of the drive shaft. The gear assembly provides a predetermined gear reduction to reduce the speed of the motor and increase the torque needed to drive the pump.

[0006] According to yet another aspect, a diaphragm pump comprises a housing and a permanent magnet motor supported by the housing. The motor includes a drive shaft defining a rotational axis. A drive assembly is positioned within the housing and is operably connected to the motor. The drive assembly includes a reduction gear assembly for reducing the speed and increasing the torque of the permanent magnet motor needed to drive the pump. The gear assembly includes a planetary gear train comprised of a plurality of drive gears and a stationary ring gear. Rotation of the drive shaft causes the plurality of drive gears to rotate about the ring gear. A drive member is rotatably connected to the reduction gear assembly. A wobble plate is rotatably connected to the drive member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a side perspective view of a diaphragm pump with a portion thereof removed according to the present disclosure.

[0008] FIG. **2** is a side elevational view of the diaphragm pump of FIG. **1**.

[0009] FIG. **3** is an exploded perspective view of the diaphragm pump of FIG. **1**.

[0010] FIGS. **4-6** are enlarged perspective views of the illustrated components of the diaphragm pump of FIG. **3**.

[0011] FIG. **7** is a partial cross-sectional view of the diaphragm pump of FIG. **1**.

DETAILED DESCRIPTION

[0012] It should, of course, be understood that the description and drawings herein are merely illustrative and that various modifications and changes can be made in the structures disclosed without departing from the present disclosure. It will also be appreciated that the various identified components of the diaphragm pump disclosed herein are merely terms of art that may vary from one manufacturer to another and should not be deemed to limit the present disclosure. All references to direction and position, unless otherwise indicated, refer to the orientation of the diaphragm pump illustrated in the drawings and should not be construed as limiting the claims appended hereto.

[0013] Referring now to drawings, wherein like numerals refer to like parts throughout the several views, a diaphragm pump **100** according to the present disclosure is illustrated. With reference to FIGS. **1-3** and **7**, the diaphragm pump **100** comprises a housing **102**, a motor **104** supported by the housing, a drive assembly **106** operably connected to the motor and a wobble or swash plate **108** operably connected to the drive assembly. The housing **102**, which houses the drive assembly **106**, includes a first housing part **112**, an intermediate, second housing part **114**, and a third housing part **116**.

[0014] As shown in FIGS. **3** and **4**, the first housing part **112** includes a first enclosure **120** supported on a suitable base **122**. The first enclosure **120** includes a generally cylindrical shaped wall **124** having an outer surface **126** and an inner surface **128**, and a back wall **130**. The inner surface includes a plurality of circumferentially spaced first notches **140** and second notches **142**. The first and second notches are generally U-shaped and extend axially on the inner surface **128**, an end of each notch being spaced from the end wall **130**. As will be discussed in greater detail below, the second notches **142**, which can be slightly larger than the first notches, serve as guides to properly align the first and second housing parts **112** and **114**. Located on the wall **124** are a pair of tabs **146** having openings **148** which are dimensioned to receive fasteners (not shown). A suitable fastener is shown in FIG. **7**.

[0015] With continued reference to FIG. **4**, the base **122** includes a center member **160** having a front wall **162** and a rear wall **164** and opposed side walls **166** and **168**. The front wall is generally flush with an end **170** of the first enclosure **120** and includes openings **172** dimensioned to receive fasteners. The rear wall **164** is spaced from the back wall **130**. A

top surface **174** of the center member includes an upwardly extending shelf **176** that spans from the rear wall **164** to the back wall **130** and has a top surface **178** configured to support the motor **104**. First and second flanges **184** and **186** extend from the respective side walls **166** and **168**. Each flange includes mounting holes **188** which allow the base **122** to be mounted to a subjacent flat surface.

[0016] With reference now to FIG. **5**, the second housing part **114** includes a second enclosure **200** having a generally cylindrical shaped wall **202** and a vertical wall **204** located within the enclosure. The wall **202** includes an outer surface **206** and an inner surface **208**. A flange **210** extends outwardly from a first end portion **212** of the wall **202**. The flange includes a plurality of circumferentially spaced first projections **220** and second projections **222**. The first and second projections **220**, **222** are generally U-shaped and are dimensioned to be received in the respective first and second notches **140**, **142** of the first housing part **112**. Located on the wall **202** are spaced apart first bosses **230** having openings (not shown). Spaced apart second bosses **236** having openings **238** are disposed on the inner surface **208** of the wall **202**. Ends **240** of the second bosses **236** project from a second end portion **242** of the wall **202**.

[0017] The vertical wall **204**, which separates the second enclosure **200** into a first portion **250** and a second portion **252**, includes an opening **260**. A generally circular flange **262** is secured to the wall **204** and extends into the second portion **252**. The flange **262** includes an outer wall **264** and an inner wall **266**. The inner wall defines an opening **270** having an axis which is coincident with an axis defined by the wall opening **260**. The opening **270** is dimensioned to receive a first bearing **272**. At least one support **274** is provided for the flange **262**. The support is connected to the wall **204** and spans between the inner surface **208** of the wall **202** and the outer surface **264** of the flange **262**. As shown, three spaced apart supports **274** are provided for the flange **262**; although, this is not required.

[0018] With reference to FIG. **7**, the third housing part **116** includes a third enclosure **290** having fluid inlet section (not shown) and a fluid outlet section (not shown). An inlet valve **292** is operably connected to the inlet section and an outlet valve **294** is operably connected to the outlet section. The third enclosure at least partially defines a pump chamber **296**. Located on a wall **300** of the third enclosure are tabs **302** having openings **304** which are dimensioned to receive fasteners F.

[0019] To secure the second housing part **114** to the first housing part **112**, the first and second projections **220**, **222** are aligned with the first and second notches **140**, **142**. Once properly aligned, the projections can be at least partially slidingly received in the notches. In this position, the openings of the first bosses register with the openings **148** of the tabs **142** and the openings **172** of the base **122**. Fasteners (not shown) extend through the openings **148**, **172** and threadingly engage the boss openings. To secure the third housing part **116** to the second housing part **114**, the openings **304** of the tabs **302** are aligned with the openings **238** of the second bosses **236**. The fasteners F extend through the tab openings **304** and threadingly engage the boss openings **238**.

[0020] With reference again to FIGS. **3** and **4**, the motor **104**, which can be a relatively small, lightweight permanent magnet motor, includes a motor housing **320**, a power switch or connection to the power source **322** located on the housing and an output or drive shaft **324**. The power source can be alternating current or direct current batteries or a cable attached to a dc power source, like a motor vehicle battery. The at least one battery can have, for a non-limiting example, a voltage in the range of about 6 to around 42 volts. The watt rating for the motor can be for a non-limiting example in the range of 1 to 500. The output shaft of the motor defines a longitudinal axis. As indicated above, the motor **104** can be supported on the shelf **176** of the base **122**. The output shaft extends through an opening (not visible) located on the wall **130** of the first housing part **112** (see FIG. **2**). With additional reference to FIG. **6**, the drive assembly **106** can comprise a reduction gear assembly **340** and a drive member **342** operably coupled to the reduction gear assembly. In the depicted embodiment, the reduction gear assembly is a planetary gear train including a spur gear **350**, a plurality of compound gears **352** and a ring gear **354**. The spur gear is mounted to an end portion **358** of the motor output shaft **324** which projects through the opening of the wall **130**. Each compound gear **352** includes a first gear **360** and a smaller second gear **362**. An axis of rotation of the first gear is coincident with an axis of rotation of the second gear. The second gear **362** is at least partially surrounded by the first gear **360**; although, this is not required. For each compound gear **352**, a portion of the second gear **362** extends outwardly from the first gear **360** to engage the ring gear **354**.

[0021] The ring gear **354** includes a wall **370** having an outer surface **372** and an inner surface **374**. The inner surface defines an opening **376**. The inner surface includes a plurality of circumferentially spaced teeth **378** configured to simultaneously engage the second gears **362**. This configuration provides for a compact gear assembly. The outer surface includes a plurality of circumferentially spaced first projections **380** and second, larger projections **382**. The first and second projections **380**, **382** engage the first and second projection **220**, **222**. Particularly, the first and second projections **380**, **382** are dimensioned to be received in respective recesses (not visible) formed by the generally U-shaped first and second projections **220**, **222** of the second housing part **114**. Once positioned within the recesses, the ring gear **354** is non-rotatably secured to the second housing part **114**.

[0022] The drive member **342** comprises a base **390** and a shaft **392** extending outwardly from a central raised portion **394** of the base. The base is generally triangular in shape; although, it should be appreciated that alternative shapes for the base are contemplated. To some extent, the shape of the base **390** would be dependent on the number of compound gears **352** in the gear assembly **340**. The base is dimensioned to be rotatably positioned within the opening **376** of the ring gear and includes posts **396** which extend from corner sections **398** of the base. Each post **396** extends through an opening **400** of each compound gear **352** to non-rotatably secure the compound gear **352** to the drive member **342**. In the assembled condition, the compound gears are spaced from each other so that the spur gear **350** can simultaneously engage the first gears **360**. The raised portion **394** is received in the opening **260** of the wall **204**. The shaft **392** defines a longitudinal axis which is coincident with the rotational axis of the drive shaft **324**. The shaft **392** extends through an opening **406** of the first bearing **272** (see FIG. **5**) and includes a keyed section **410**. As shown in FIG. **5**, a coupling **420** is secured to the shaft keyed section. The coupling can be generally mushroom shaped and includes a head **422**, a post **424** projecting from the head, and an opening **426** for receiving the shaft **392**. The post **424** is sized to be frictionally received within the bearing opening **406**. Once positioned with the opening, the head **422** engages a surface of the bearing.

[0023] With reference to FIG. **7**, housed within the third housing part **116** is the wobble plate **108**. The wobble plate is

rotated by the shaft **392** of the drive member **342**, which is, in turn, rotated by the drive shaft **324** of the motor **104**. A plurality of pistons (only one piston **440** is shown) are reciprocated by the wobble plate **108**. The piston **440** is attached to a diaphragm **442** which provides an internal seal for the pump. The piston reciprocates within the pump chamber **296** that is at least partially defined by a manifold plate **450**. The manifold plate includes the one-way inlet valve **292** that allows water to flow into the pump chamber and the one-way outlet valve **294** that allows water to flow out of the pump chamber.

[0024] The wobble plate **108** is coupled to a rocker arm **460** by a second bearing **462**. The wobble plate provides an inclined and radially offset mounting for the second bearing. The second bearing defines the normal central axis of the wobble plate. This normal central axis of the wobble plate **108** is angularly displaced about 3° to 6° from the rotational axis of the shaft **392**. The wobble plate has a surface **466** which cooperates with the first bearing **272** to move the rocker arm in a reciprocating motion in response to a rotation of the shaft **392**. The pistons are attached to the rocker arm **460** by a plurality of screws **470**. The pistons are located symmetrically about the drive shaft and swing about a radial arc relative to the drive shaft centerline. The swinging motion of the pistons cause the outer portion of the diaphragm **442** to move a greater distance than the inner portion of the diaphragm.

[0025] In use, rotation of the motor drive shaft **324** causes the spur gear **350** secured thereto to simultaneously engage the first gears **360** of the compound gears **352**. Rotation of the first gears rotates the second gears **362** within the ring gear **354**. The gear assembly provides a predetermined gear reduction (for example, a 13.8:1 gear reduction) to reduce the speed of the drive shaft **324** thereby allowing the smaller, lighter and more cost effective motor **104** to generate the increased torque needed to drive the diaphragm pump **100**. As the compound gears **352** rotate, the shaft **392** of the drive member **342** rotates about the axis of the drive shaft **324**. The drive shaft, in turn, engages the wobble plate **108** which reciprocates the pistons **440**. During an intake stroke, the volume of the pump chamber **296** increases and draws in water through the inlet section and inlet valve **292**. During the power stroke, the piston pushes the water out of the pump chamber and through the outlet valve **294** and outlet section. The cycle is repeated as the output shaft **392** rotates the wobble plate **108**.

[0026] The housing **102**, drive member **342** and coupling **420** can be made of a suitable metal or polymeric material. The diaphragm can be made of a suitable flexible, resilient material, which can be a polymeric material or an elastomer.

[0027] It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art. It is intended that all of these, or equivalents thereof are encompassed by the following claims.

What is claimed is:

1. A diaphragm pump comprising:

a housing;

a motor supported by the housing, the motor including a drive shaft defining a rotational axis;

a drive assembly operably connected to the motor, the drive assembly including a reduction gear assembly and a wobble plate rotatably connected to the gear assembly, the wobble plate orbiting about the rotational axis of the drive shaft; and

wherein the gear assembly provides a predetermined gear reduction to reduce the speed of the motor and increase the torque needed to drive the pump.

2. The diaphragm pump of claim **1**, wherein the reduction gear assembly comprises a planetary gear train.

3. The diaphragm pump of claim **2**, wherein the planetary gear train includes a plurality of compound gears and a ring gear, the ring gear at least partially surrounding the plurality of compound gears providing for a compact reduction gear assembly.

4. The diaphragm pump of claim **3**, wherein the reduction gear assembly further comprises a spur gear coupled to the drive shaft of the motor, each compound gear including a first gear and a second smaller diameter gear, the spur gear simultaneously engaging the first gears of the plurality of compound gears.

5. The diaphragm pump of claim **4**, wherein the ring gear includes a wall having an outer surface and an inner surface, the inner surface including a plurality of circumferentially spaced teeth configured to simultaneously engage the second gears of the plurality of compound gears.

6. The diaphragm pump of claim **3**, wherein the ring gear is non-rotatably secured to the housing.

7. The diaphragm pump of claim **3**, wherein the drive assembly further includes a separate drive member rotatably coupled to the housing and located between the reduction gear assembly and wobble plate.

8. The diaphragm pump of claim **7**, wherein the drive member is at least partially positioned within the ring gear.

9. The diaphragm pump of claim **7**, wherein the drive member includes a base, a first outwardly extending shaft for engaging the wobble plate and a plurality of second outwardly extending shafts, each compound gears being non-rotatably secured to one of the second shafts.

10. The diaphragm pump of claim **9**, wherein the first shaft of the drive member defines a longitudinal axis which is coincident with the rotational axis of the drive shaft and each second shaft of the drive member defines a longitudinal axis offset from and parallel to the rotational axis of the drive shaft.

11. The diaphragm pump of claim **9**, wherein the second shafts extend in a direction opposite to the direction that the first shaft extends.

12. The diaphragm pump of claim **1**, wherein the reduction gear assembly provides about a 14:1 gear reduction to reduce the speed of the drive shaft thereby allowing the motor to generate increased torque needed to drive the diaphragm pump.

13. A diaphragm pump comprising:

a housing;

a generally small, lightweight motor supported by the housing, the motor including a drive shaft defining a rotational axis;

a drive assembly operably connected to the motor, the drive assembly including:

a reduction gear assembly including a planetary gear train having a plurality of compound gears and a ring gear, and

a wobble plate rotatably connected to the gear assembly, the wobble plate orbiting about the rotational axis of the drive shaft; and

wherein the gear assembly provides a predetermined gear reduction to reduce the speed of the motor and increase the torque needed to drive the pump.

14. The diaphragm pump of claim **13**, wherein the housing includes a first housing part and a second housing part releasably connected to the first housing part, the first and second housing parts together defining a chamber for housing the reduction gear assembly.

15. The diaphragm pump of claim **14**, wherein the ring gear is non-rotatably secured to one of the first housing part and the second housing part, the ring gear including an inner surface configured to engage the plurality of compound gears allowing rotation of the plurality of compound gears about the inner surface of the ring gear.

16. The diaphragm pump of claim **15**, wherein the reduction gear assembly further comprises a spur gear coupled to the drive shaft of the motor for simultaneously engaging the plurality of compound gears.

17. The diaphragm pump of claim **14**, wherein the drive assembly further includes a separate drive member rotatably coupled to both the reduction gear assembly and wobble plate, the drive member being at least partially positioned within the ring gear.

18. The diaphragm pump of claim **13**, wherein the motor is a permanent magnet motor and the reduction gear assembly provides about a 14:1 gear reduction to reduce the speed of the drive shaft thereby allowing the permanent magnet motor to generate increased torque needed to drive the diaphragm pump.

19. A diaphragm pump comprising:

a housing;

a permanent magnet motor supported by the housing, the motor including a drive shaft defining a rotational axis;

a drive assembly positioned within the housing and operably connected to the motor, the drive assembly including:

a reduction gear assembly for reducing the speed and increasing the torque of the permanent magnet motor needed to drive the pump, the gear assembly including a planetary gear train comprised of a plurality of drive gears and a stationary ring gear, a rotation of the drive shaft causing the plurality of drive gears to rotate about the ring gear,

a drive member rotatably connected to the reduction gear assembly, and

a wobble plate rotatably connected to the drive member.

20. The diaphragm pump of claim **19**, wherein each drive gear includes a first gear and a second gear, the first gears being simultaneously engaged by the drive shaft, the second gears being mounted to the drive member and simultaneously engaging the ring gear.

* * * * *