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United States Patent	12392333
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Hines; Bradley H. et al.

Diaphragm pump drive for an electric pump

Abstract

A displacement pump includes an electrically powered drive having a drive housing. The drive is at least partially disposed in the drive housing and is configured to provide reciprocating linear motion to a diaphragm. The diaphragm is captured between an adaptor mountable to the drive housing and a fluid cover. The adaptor includes an inner mounting portion interfacing with the drive housing and an outer mounting portion interfacing with the diaphragm. Multiple adaptors having multiple outer mounting portion diameters can be mounted to the same drive housing. Each of the multiple adaptors have the same inner mounting portion configuration to mount to the same drive housing. The adaptors can mount to the drive housing in multiple orientations while the fluid cover can mount to the adaptor in a single orientation.

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Appl. No.: **17/613730**

Filed (or PCT Filed): **June 03, 2020**

PCT No.: **PCT/US2020/035844**

PCT Pub. No.: **WO2020/247442**

PCT Pub. Date: December 10, 2020

Prior Publication Data

Document Identifier	Publication Date
US 20220235754 A1	Jul. 28, 2022

Related U.S. Application Data

us-provisional-application US 62856354 20190603

Publication Classification

Int. Cl.: **F04B43/02** (20060101); **F04B9/02** (20060101); **F04B17/03** (20060101); **F04B35/04** (20060101); **F04B43/04** (20060101); **F04B43/073** (20060101); **F04B45/04** (20060101); **F04B45/047** (20060101); **F04B53/22** (20060101)

U.S. Cl.:

CPC **F04B43/026** (20130101); **F04B9/02** (20130101); **F04B17/03** (20130101); **F04B35/04** (20130101); **F04B43/025** (20130101); **F04B43/04** (20130101); **F04B43/0736** (20130101); **F04B45/043** (20130101); **F04B45/047** (20130101); **F04B53/22** (20130101);

Field of Classification Search

CPC: F04B (43/026); F04B (43/0736); F04B (9/02); F04B (45/047); F04B (17/03); F04B (35/04); F04B (43/04); F04B (43/025); F04B (45/043)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S) (1) This application claims the benefit of U.S. Provisional Application No. 62/856,354 filed Jun. 3, 2019, and entitled “DIAPHRAGM PUMP DRIVE,” the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND
(1) This disclosure relates generally to pumps. More particularly, this disclosure relates to pump drive systems.
(2) Positive displacement pumps discharge a process fluid at a selected flow rate. In a typical positive displacement pump, a fluid displacement member, usually a piston or diaphragm, drives the process fluid through the pump. When the fluid displacement member is drawn in, a suction condition is created in the fluid flow path, which draws process fluid into a fluid cavity from the inlet manifold. The fluid displacement member then reverses direction and forces the process fluid out of the fluid cavity through the outlet manifold.
(3) Displacement pumps include a drive system that powers the displacement member through the respective pumping and suction strokes. The drive system can be, pneumatic, hydraulic, or mechanical. For example, a pneumatic or hydraulic drive can route fluid to alternating chambers to cause reciprocation of the drive member. A mechanical drive converts a rotary output to a linear input to drive reciprocation. The mechanical drive can be powered electrically, pneumatically, or hydraulically and represents a relatively expensive component of the pump.
SUMMARY
(4) According to one aspect of the disclosure, a displacement pump includes an electric drive having a drive housing defining a pump axis and a first fluid module mountable to an end of the drive housing. The first fluid module includes a first adaptor configured to interface with the drive housing, the first adaptor comprising a first inner mounting portion and a first outer mounting portion, wherein the first inner mounting portion interfaces with the drive housing at a first interface; a first cover configured to interface with the first outer mounting portion at a second interface; and a first diaphragm captured between the first adaptor and the first cover. A drive component of the electric drive disposed within the drive housing is accessible from outside of the

drive housing through a central aperture of the first adaptor with the first adaptor interfacing with the drive housing.
(5) According to an additional or alternative aspect of the disclosure, a displacement pump assembly includes an electric drive having a drive housing defining a pump axis; a first fluid module mountable to an end of the drive housing; and a second fluid module mountable to the end of the drive housing. The first fluid module includes a first adaptor configured to interface with the drive housing, the first adaptor comprising a first inner mounting portion and a first outer mounting portion, the first inner mounting portion configured to interface with the drive housing at a first interface; a first cover configured to interface with the first outer mounting portion at a second interface; and a first diaphragm captured between the first adaptor and the first cover. The second fluid module includes a the second fluid module including a second adaptor configured to interface with the drive housing at the first interface, a second cover that mounts to the second adaptor, and a second diaphragm captured between the second adaptor and the second cover. The second adaptor includes a second inner mounting portion and a second outer mounting portion, the second inner mounting portion configured to interface with the drive housing at the first interface. A first diameter of the first diaphragm is different than a second diameter of the second diaphragm.
(6) According to another additional or alternative aspect of the disclosure, a method of servicing an electrically-powered displacement pump includes removing a first fluid cover from a first adaptor; and accessing, through the first adaptor, drive components disposed in a drive housing on which the first adaptor is mounted and within which at least one component configured to rotate about a motor axis is disposed.
(7) According to yet another additional or alternative aspect of the disclosure, a displacement pump includes an electric drive having a drive housing defining a pump axis and a first fluid module mountable to an end of the drive housing. The first fluid module includes a first adaptor configured to interface with the drive housing, the first adaptor comprising a first inner mounting portion and a first outer mounting portion, a first cover configured to interface with the first outer mounting portion at a second interface, and a first diaphragm captured between the first adaptor and the first cover. The first inner mounting portion interfaces with the drive housing at a first interface. The first interface allows the first adaptor to be mounted at a plurality of adaptor mount positions. The second interface is a clocked interface that allows the first cover to be mounted at a single cover mount position.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1**A is an isometric view of an electrically operated pumping assembly.
(2) FIG. **1**B is an exploded view of the electrically operated pumping assembly shown in FIG. **1**A.
(3) FIG. **2** is a cross-sectional view taken along line **2-2** in FIG. **1**A.
(4) FIG. **3**A is an isometric view of a second electrically operated pumping assembly.
(5) FIG. **3**B is a cross-sectional view taken along line B-B in FIG. **3**A.
(6) FIG. **4**A is an isometric view of an electrically operated pumping assembly with a first fluid module mounted.
(7) FIG. **4**B is an isometric view of the electrically operated pumping assembly showing a first fluid manifold removed.
(8) FIG. **4**C is an isometric view of the electrically operated pumping assembly showing the first fluid manifold and a first diaphragm removed.
(9) FIG. **4**D is an isometric view of the electrically operated pumping assembly showing the first fluid manifold, the first diaphragm, and a first adaptor removed.
(10) FIG. **4**E is an isometric view of the electrically operated pumping assembly showing a second

fluid manifold, second diaphragm, and second adaptor removed.
(11) FIG. **4**F is an isometric view of the electrically operated pumping assembly showing the second adaptor installed.
(12) FIG. **4**G is an isometric view of the electrically operated pumping assembly showing the second adaptor and the second diaphragm installed.
(13) FIG. **4**H is an isometric view of the electrically operated pumping assembly showing a second fluid module installed.
(14) FIG. **5** is a cross-sectional view taken along line **5-5** in FIG. **4**H.
(15) FIG. **6**A is an exploded isometric view showing an electrically operated pumping assembly with fluid modules removed and parts of a first drive exploded from the drive housing.
(16) FIG. **6**B is an exploded isometric view showing the electrically operated pumping assembly with parts of the first drive removed.
(17) FIG. **6**C is an exploded isometric view showing the electrically operated pumping assembly with parts of a second drive exploded from the drive housing.
(18) FIG. **7**A is a rear elevation view of a second bearing shown in FIG. **6**C.
(19) FIG. **7**B is a front elevation view of the second bearing plate shown in FIG. **7**A.
(20) FIG. **7**C is a cross-sectional view taken along line C-C in FIG. **7**B.
(21) FIG. **8** is a cross-sectional view of an electrically operated pumping assembly having the second bearing plates shown in FIGS. **7**A-**7**C.
(22) FIG. **9**A is a front elevation view of an adaptor.
(23) FIG. **9**B is a rear elevation view of the adaptor.
(24) FIG. **9**C is a side elevation view of the adaptor.
(25) FIG. **10**A is a side elevation view of an electrically operated pumping assembly with a fluid cover and diaphragm removed.
(26) FIG. **10**B is an isometric view of the electrically operated pumping assembly showing removal of bearing plates through the adaptor.
(27) FIG. **10**C is a side elevation view of the electrically operated pumping assembly with the adaptor removed.
(28) FIG. **11** is a side elevation view of an electrically operated pumping assembly in a vertical orientation with the fluid cover and diaphragm removed.
(29) FIG. **12**A is a side elevation view of an electrically operated pumping assembly showing a fluid cover in a misaligned position.
(30) FIG. **12**B is an enlarged view of detail B in FIG. **12**A.
(31) FIG. **13**A is a side elevation view of an electrically operated pumping assembly showing a fluid cover correctly aligned.
(32) FIG. **13**B is an isometric view showing the electrically operated pumping assembly assembled in a vertical state.

DETAILED DESCRIPTION

(33) FIG. **1**A is an isometric view of pumping assembly **10**, which includes motor **12** and pump **14**. FIG. **1**B is an exploded view of pump **14**. FIGS. **1**A and **1**B will be discussed together. Pump **14** includes inlet manifold **16**, outlet manifold **18**, drive housing **20**, fluid modules **22***a*, drive **24**, inlet check valves **26**, and outlet check valves **28**. Drive housing **20** includes body **30** having ends **32**. Each fluid module **22***a* includes fluid cover **34***a*, diaphragm **36***a*, and adaptor **38***a*. Each adaptor **38***a* includes inner mounting portion **40**, outer mounting portion **42***a*, and central aperture **44**. Drive **24** includes bearing plates **46***a* and rods **48**.
(34) Pumping assembly **10** is configured to pump fluid from an upstream location to a downstream location. The fluid can be a liquid or a gas. Pump **14** pumps the fluid and motor **12** powers pump **14**. Motor **12** can be an electric motor configured to receive electrical energy, such as through a standard electrical outlet, and converts electrical energy to rotational output motion. For example, motor **12** can be a brushed or brushless DC motor, among other options. In some examples, a

gearbox is disposed between motor **12** and drive **24**. The rotational output of motor **12** is converted into linear reciprocating motion by drive **24** to displace diaphragms **36***a* through respective pumping and suction strokes.

(35) Pump **14** is connected to motor **12** and configured to be powered by motor **12**. Pump **14** includes inlet manifold **16** through which fluid is introduced to pump **14**. Pump **14** further includes outlet manifold **18** through which pumped fluid is output from pump **14**. Drive housing **20** is disposed between inlet manifold **16** and outlet manifold **18**. Drive housing **20** contains at least a portion of drive **24**. Drive housing **20** can be formed by one or more components. Drive housing **20** facilitates mounting of fluid modules **22**. Drive **24** is at least partially disposed within body **30** and is configured to covert the rotational output of motor **12** to a reciprocating linear input to power pump **14**. Drive **24** can be fully or partially contained within drive housing **20**.

(36) Fluid modules **22***a* are mounted to ends **32** of drive housing **20**. Drive housing **20** is thereby disposed axially between fluid modules **22***a*. Pump **14** is shown as including dual fluid modules **22**. It is understood, however, that pump **14** can include a single fluid module **22** in some examples. Fluid modules **22***a* are disposed coaxially on pump axis P-P.

(37) For each fluid module **22***a*, adaptor **38***a* is configured to mount to an end **32** of drive housing **20**. In some examples, adaptor **38***a* is in direct contact with drive housing **20**. Inner mounting portion **40** interfaces with drive housing **20**. Fasteners **50***a*, such as bolts, extend through inner mounting portion **40** and into drive housing **20** to secure adaptor **38***a* to drive housing **20**. As such, adaptor **38***a* mounts fluid module **22***a* to drive housing **20**. Fluid cover **34***a* is configured to mount to adaptor **38***a*. Fluid covers **34***a* define the axial ends of pump **14**. In some examples, fluid cover **34***a* is in direct contact with adaptor **38***a*. Outer mounting portion **42***a* interfaces with fluid cover **34***a*. Fasteners **50***b*, such as bolts, extend through fluid cover **34***a* and into adaptor **38***a* to secure fluid cover **34***a* to adaptor **38***a*. Diaphragm **36***a* is retained between adaptor **38***a* and fluid cover **34***a*. More specifically, diaphragm **36***a* is retained between and forms a seal between outer mounting portion **42***a* and fluid cover **34***a*. A pumping chamber **56** (FIG. **2**) is defined between diaphragm **36***a* and fluid cover **34***a*. The center of the diaphragm **36***a* is moved during a pump cycle while the peripheral edge of the diaphragm **36***a* is held in place between fluid cover **34***a* and adaptor **38***a* to increase and decrease the volume of the pumping chamber **56** to pump fluid. In the example shown, pump assembly **10** can be considered to be an electrically operated double diaphragm (EODD) pump.

(38) Adaptors **38***a* extend between inner mounting portion **40** and outer mounting portion **42***a*. Inner mounting portion **40** has a first diameter and outer mounting portion **42***a* has a second diameter. The second diameter is larger than the first diameter such that adaptor **38***a* expands the diameter of fluid module **22***a* relative drive housing **20**. As such, the diameter of fluid module **22***a* expands from a smaller diameter facing drive housing **20** to a larger diameter facing away from drive housing **20**.

(39) Inlet check valves **26** are disposed between inlet manifold **16** and fluid covers **34***a*. Outlet check valves **28** are disposed between outlet manifold **18** and fluid covers **34***a*. The flow of fluid being pumped is regulated by inlet check valves **26** and outlet check valves **28**. Inlet check valves **26** regulate flow into pumping chambers **56** and outlet check valves **28** regulate flow out of pumping chambers **56**.

(40) Bearing plates **46***a* are disposed within drive housing **20**. Rods **48** extend between and connect the bearing plates **46***a*. Each bearing plate **46***a* is connected to a diaphragm **36***a* through central aperture **44** of adaptor **38***a*. In the example shown, bearing plates **46***a* are configured to provide the linear input to diaphragms **36***a* to drive reciprocation of diaphragms **36***a*. Rods **48** link bearing plates **46***a* together such that bearing plates **46***a* are linked for simultaneous reciprocation.

(41) FIG. **2** is a cross-sectional view of pumping assembly **10** taken along line **2-2** in FIG. **1**A. Pumping assembly **10** includes motor **12** and pump **14**. Pump **14** includes inlet manifold **16**, outlet manifold **18**, drive housing **20**, fluid modules **22***a*, drive **24**, inlet check valves **26**, and outlet check

valves **28**. Drive housing **20** includes body **30** and ends **32** and at least partially defines drive chamber **52**. Drive housing **20** further includes rod sleeves **54**. Each fluid module **22***a* includes fluid cover **34***a*, diaphragm **36***a*, adaptor **38***a*, and pumping chamber **56**. Each adaptor **38***a* includes inner mounting portion **40**, outer mounting portion **42***a*, and transition portion **58***a*. Diaphragms **36***a* include diaphragm plates **60**, membranes **62**, circumferential edge **64**, and connectors **66**. Drive **24***a* includes bearing plates **46***a*, rods **48**, eccentric **68**, and bearing **70**. Bearing plates **46***a* including mounting bores **72** and bearing surface **74**.

(42) Motor **12** is connected to drive housing **20**. Drive **24** is at least partially disposed within drive chamber **52**. Motor **12** is configured to generate a rotational output and drive **24** is configured to convert that rotational output into a linear input to drive displacement of diaphragms **36***a* along pump axis P-P and cause pumping by pump **14**.

(43) Bearing **70** is connected to eccentric **68** to be moved in a circular path offset from a central axis of rotation M of eccentric **68**. Bearing **70** is disposed between and interfaces with bearing plates **46***a*, which are also disposed in drive chamber **52**. More specifically, bearing **70** interfaces with bearing surface **74** of each bearing plate **46***a*. Rods **48** extend between and fix bearing plates **46***a* relative each other such that bearing plates **46***a* move simultaneously. In some examples, rods **48** have threaded ends that are connected to nuts on the outer axial sides of bearing plates **46***a*. Rods **48** extend through rod sleeves **54** formed in drive chamber **52**. In the example shown, rod sleeves **54** are formed by drive housing **20**. Rods **48** reciprocate within rod sleeves **54**. Rod sleeves **54** fix rods **48** to reciprocate axially along pump axis P-P. The bearing plates **46***a* and rods **48** form a carriage that moves linearly along pump axis P-P to move, via connectors **66**, the centers of the diaphragms **36***a* as driven by the eccentric **68** and bearing **70**. Bearing plates **46***a* are pushed by the bearing **70** axially, left and right. Bearing **70** does not push on anything as it moves vertically, thus the eccentric **68**, bearing **70**, and bearing plates **46***a* convert rotational motion into axial reciprocating motion which drives the diaphragms **36***a*.

(44) Fluid modules **22***a* are mounted to opposite axial ends **32** of drive housing **20**. A first one of fluid modules **22***a* is mounted to a first end **32** and a second one of fluid modules **22***a* is mounted to a second end **32**. Adaptors **38***a* are mounted to drive housing **20** and support the other components of fluid modules **22***a*. Inner mounting portion **40** is connected to drive housing **20** to secure fluid modules **22***a* to drive housing **20**. Fasteners **50***a* extend through inner mounting portion **40** into drive housing **20** to secure adaptors **38***a* to drive housing **20**. In the example shown, at least a portion of the fastener **50***a* is exposed within drive chamber **52**.

(45) Inner mounting portion **40** interfaces with drive housing **20** at first interface **78**. Inner mounting portion **40** contacts drive housing **20** at first interface **78**. Inner mounting portion **40** seals with the end **32** of drive housing **20** with adaptor **38***a* mounted to drive housing **20**. In the example shown, annular seal **76** is disposed between drive housing **20** and inner mounting portion **40**. Annular seal **76** can be an o-ring, among other options. Annular seal **76** can be disposed in a notch formed in end **32** of drive housing **20**. It is understood that inner mounting portion **40** can include a groove or notch configured to receive annular seal **76**. The groove or notch in inner mounting portion **40** can be in addition to or replacement of the notch formed in drive housing **20**.

(46) Fluid covers **34***a* are disposed between and fluidly connected to inlet manifold **16** and outlet manifold **18**. Fluid covers **34***a* are connected to outer mounting portions **42***a* of adaptors **38***a*. Fluid covers **34***a* contact outer mounting portion **42***a* at second interface **80**. Diaphragms **36***a* are captured between fluid covers **34***a* and adaptors **38***a*. More specifically, circumferential edge **64** is captured between adaptor **38***a* and fluid cover **34***a*. Circumferential edge **64** can include a bead disposed within grooves formed in outer mounting portion **42***a* and fluid cover **34***a*. Circumferential edge **64** forms an annular seal between fluid covers **34***a* and outer mounting portion **42***a*. In the example shown, complimentary grooves are formed on each of outer mounting portion **42***a* and fluid cover **34***a* to receive circumferential edge **64**. Diaphragms **36***a* seal between drive chamber **52** and pumping chamber **56**. The inner side of each diaphragm **36***a* is exposed to

drive chamber **52** such that any fluid (e.g., air, hydraulic fluid, etc.) within drive chamber **52** can be in contact with either one of diaphragms **36***a*.
(47) Inner mounting portions **40** have a first diameter D**1** at first interface **78**. Outer mounting portions **42***a* have a second diameter D**2** at second interface **80**. The second diameter D**2** is larger than the first diameter D**1** such that adaptor **38***a* expands in diameter relative drive housing **20**. Transition portion **58***a* extends between and connects inner mounting portion **40** and outer mounting portion **42***a*. Transition portion **58***a* increases the diameter of adaptor **38***a* between inner mounting portion **40** and outer mounting portion **42***a*. The larger diameter of outer mounting portion **42***a* facilitates a larger diaphragm **36***a*. Diaphragm **36***a* has a diameter larger than a diameter of drive housing **20**.
(48) Membrane **62** of diaphragm **36***a* is a flexible membrane. Diaphragm plates **60** interface with membrane **62**. Connectors **66** extend through an inner one of diaphragm plates **60** and extend at least partially through an outer one of diaphragm plates **60**.
(49) Connectors **66** are disposed on axis P-P and are connected to bearing plates **46***a*. Connectors **66** extend into mounting bores **72** formed in bearing plates **46***a*. Connectors **66** fix bearing plates **46***a* to the centers of diaphragms **36***a*. Bearing plates **46***a* can thereby drive diaphragms **36***a* through each of the pressure stroke, during which the volume of pumping chamber **56** is reduced and fluid is driven through outlet check valve **28** from pumping chamber **56** to outlet manifold **18**, and the suction stroke, during which the volume of pumping chamber **56** is expanded and fluid is drawn through inlet check valve **26** to pumping chamber **56** from inlet manifold **16**.
(50) Drive chamber **52** is defined axially between an inner (facing towards drive housing **20**) side of each diaphragm **36***a*. Pumping chambers **56** are defined between the outer (facing away from drive housing **20**) side of each diaphragm **36***a* and fluid covers **34***a*.
(51) During operation, motor **12** receives electric power and generates a rotational output. Drive **24** converts the rotational output of motor **12** to linear movement of diaphragms **36***a*. Drive **24** moves the centers of the diaphragms **36***a* back and forth in axial directions AD**1** and AD**2**, increasing and decreasing the volumes of pumping chambers **56**. Inlet check valves **26** and outlet check valves **28** regulate the flow of fluid through the pumping chambers **56** from an upstream to downstream direction.
(52) The rotational output drives rotation of eccentric **68** about axis M. Bearing **70** rotates in a circular path about axis M. Bearing **70** interfaces with bearing surfaces **74** of bearing plates **46***a* and exerts a driving force on bearing plates **46***a*. Rods **48** link bearing plates **46***a* for simultaneous movement. For example, bearing **70** can move in a clockwise path from the position shown in FIG. **2**. Bearing **70** exerts a driving force on the bearing plate **46***a* disposed on the right-hand side of bearing **70** (in the view of FIG. **2**) and pushes that bearing plate **46***a* in axial direction AD**1** to drive the diaphragm **36***a* associated with that bearing plate **46***a* through a pumping stroke. Rods **48** pull the other bearing plate **46***a* in axial direction AD**1** to pull the diaphragm **36***a* associated with that bearing plate **46***a* through a suction stroke. Diaphragms **36***a* are reciprocated on pump axis P-P through alternating pumping and suction strokes to pump the fluid.
(53) FIG. **3**A is an isometric view of pumping system **10**′, which includes motor **12**′ and pump **14**. FIG. **3**B is a cross-sectional view taken along line B-B in FIG. **3**A. Pumping system **10**′ is substantially similar to pumping system **10** (FIGS. **1**A-**2**) except motor **12**′ of pumping system **10**′ is disposed within drive housing **20**.
(54) Motor **12**′ is disposed within drive housing **20** and is coaxial with pump axis P-P. Motor **12**′ is disposed axially between fluid modules **22***a*. Motor **12**′ is electrically powered and configured to drive diaphragms **36***a* in at least one of first axial direction AD**1** and second axial direction AD**2**. Drive **24** is disposed coaxially with motor **12**′ on pump axis P-P. Drive **24** is connected to diaphragms **36***a* to drive diaphragms **36***a* linearly along pump axis P-P.
(55) In some examples, motor **12**′ is configured to generate a rotational output and drive **24** is configured to convert the rotational output to a linear input to displace diaphragms **36**. For

example, motor **12**′ can be a rotor/stator motor and drive **24** can receive the rotational output from the rotor, convert that rotational output to a linear input, and provide the linear input to diaphragms **36**. For example, drive **24** can include a ball screw or roller screw. The screw can be connected to the diaphragms **36** to displace diaphragms. The motor **12**′ can be a reversible motor that rotates in a first rotational direction about pump axis P-P to cause diaphragms **36** to displace in one of first axial direction AD**1** and second axial direction AD**2** and rotates in a second, opposite rotational direction to cause diaphragms to displace in the other one of first axial direction AD**1** and second axial direction AD**2**.

(56) In some examples, motor **12**′ can be a solenoid configured to linearly displace drive **24**. For example, motor **12**′ can be a double-acting solenoid configured to magnetically displace drive **24** in each of first axial direction AD**1** and second axial direction AD**2**. Drive **24** can be an armature including a permanent magnet. In other examples, motor **12**′ can be a single-acting solenoid configured to magnetically displace drive **24** in one of first axial direction AD**1** and second axial direction AD**2**, while drive **24** is mechanically displaced in the other one of first axial direction AD**1** and second axial direction AD**2**. For example, a spring can displace drive **24** in the other one of the first axial direction AD**1** and the second axial direction AD**2**.

(57) Fluid modules **22** can be utilized across a variety of pumps **14** having the same drive housing **20** but different motor configurations. Fluid modules **22** can thereby be changed between pumps **14** having different drive and motor configurations and/or components and can provide access to those configurations and components without requiring dismounting of adaptors **38**.

(58) FIGS. **4**A-**4**H illustrate a sequence of removing fluid modules **22***a* from drive housing **20** and installing second fluid modules **22***b* on drive housing **20**. The removal of one of fluid modules **22***a* and replacement with one of second fluid modules **22***b* is discussed in detail. It is understood that the process is the same for removing the other one of fluid modules **22***a* and installing the other one of second fluid modules **22***b*. Fluid modules **22***a*, **22***b* can be referred to collectively herein as “fluid modules **22**.” Both fluid modules **22** would typically be removed and replaced at the same time, in the same way. FIGS. **4**A-**4**D show the process of removing fluid module **22***a*. It is understood that fluid module **22***a* can be installed in the reverse order of removal. FIGS. **4**E-**4**H show the process of installing fluid module **22***b* on drive housing **20**. It is understood that fluid module **22***b* can be removed in the reverse order of installation.

(59) In FIG. **4**A, pumping assembly **10** is shown with fluid modules **22***a* assembled to drive housing **20**. In FIG. **4**B, inlet manifold **16**, outlet manifold **18**, and fluid cover **34***a* are removed. Inlet manifold **16** and outlet manifold **18** are removed from fluid cover **34***a*. Fasteners, such as bolts, are released to remove inlet manifold **16** and outlet manifold **18**. Fluid cover **34***a* is detached from adaptor **38***a* by removing fasteners **50***b*.

(60) In FIG. **4**C, diaphragm **36***a* is detached from drive **24** and removed. The diaphragm **36***a* can be removed by release of the connector **66**, which may involve releasing parts of the connector **66** and/or diaphragm **36***a* which sandwich the center of the diaphragm **36***a*. For example, the connector **66** may be unthreaded from a diaphragm plate of the diaphragm **36***a*. In some examples, the diaphragm **36***a* can be rotated about pump axis P-P to disconnect diaphragm **36** from drive **24**, such as by unthreading the connector **66** from bearing plate **46**. With diaphragm **36***a* removed, fasteners **50***a* securing adaptor **38***a* to drive housing **20** are exposed. Components of drive **24** are also exposed through central aperture **44** of adaptor **38***a*. As discussed in more detail below, components of drive **24** can be accessed and serviced through central aperture **44** of adaptor **38***a*. In some examples of drive **24**, components of drive **24** can be removed through central aperture **44** while adaptor **38***a* remains mounted to drive housing **20**.

(61) In FIG. **4**D, adaptor **38***a* is detached from and removed from drive housing **20**. Fasteners **50***a* are removed to release adaptor **38***a* from drive housing **20**. Fasteners **50***a* are removed from inner mounting portion **40** and drive housing **20**, disconnecting adaptor **38***a* from drive housing **20**. Fluid module **22***a* is thereby removed from pump **14**.

(62) FIG. **4**E shows the introduction of fluid module **22***b*. Fluid module **22***b* is different than, but similar to, fluid module **22***a*. Fluid module **22***b* includes like components to fluid module **22***a* except components of fluid module **22***b* are larger than those of fluid module **22***a*.

(63) FIG. **4**F shows adaptor **38***b* mounted to drive housing **20**. Adaptor **38***b* includes inner mounting portion **40** and outer mounting portion **42***b*. Inner mounting portion **40** of adaptor **38***b* is configured to interface with and mount to drive housing **20** in the same manner as inner mounting portion **40** of adaptor **38***a*. Inner mounting portions **40** of each of adaptor **38***a* and adaptor **38***b* can have the same fastener opening configuration, the same diameters, and the same sealing faces. Adaptor **38***a* and adaptor **38***b* having inner mounting portions **40** of the same configuration facilitates mounting of the differently sized fluid module **22***a* and fluid module **22***b* to the same drive housing **20**. Adaptor **38***b* can be mounted to drive housing **20** by fasteners **50***a*.

(64) FIG. **4**G shows diaphragm **36***b* connected to drive **24** and disposed in place relative adaptor **38***b*. Diaphragm **36***b* of fluid module **22***b* has a larger diameter than diaphragm **36***a* of fluid module **22***a*. The larger size of diaphragm **36***b* facilitates pump **14** displacing a larger volume of fluid for each stroke. Diaphragm **36***b* is mounted to drive **24** in the same manner as diaphragm **36***a* and driven by drive **24** in the same manner as diaphragm **36***a*.

(65) FIG. **4**H shows fluid cover **34***b* mounted to adaptor **38***b* and inlet manifold **16** and outlet manifold **18** connected to fluid modules **22***b*. Fluid cover **34***b* is mounted to outer mounting portion **42***b* of adaptor **38***b*. Fluid cover **34***b* is placed over diaphragm **36***b* to capture diaphragm **36***b* between outer mounting portion **42***b* and fluid cover **34***b*. Fluid cover **34***b* can be mounted to outer mounting portion **42***b* by fasteners **50***b*. Outer mounting portion **42***b* has a larger diameter than outer mounting portion **42***a*. Fluid cover **34***b* has a larger diameter than fluid cover **34***a*. The larger diameters facilitate mounting of diaphragm **36***b* to cause the higher displacement per pump stroke.

(66) Pumping assembly **10** provides significant advantages. Pumping assembly **10** has an electrically powered drive **24** that causes pumping by pump **14**. The drive **24** and motor **12** are relatively costly components of pumping assembly **10**. Pumping assembly **10** is modular and can be modified to output larger or smaller volumes of fluid per stroke. Each of fluid module **22***a* and fluid module **22***b* are configured to mount to drive housing **20**. Each of diaphragm **36***a* and diaphragm **36***b* connect to and can be displaced by drive **24**. Various fluid modules having different sizes and displacements can be mounted to the same drive housing **20** and powered by the same drive **24**. As such, the user can have a single motor **12**, drive **24**, and drive housing **20** and can modify pumping assembly **10** by mounting fluid modules **22** having any desired size to provide any desired displacement to the drive housing **20**.

(67) The modular nature of pumping assembly **10** provides cost savings as the user is not required to purchase a different motor **12**, drive **24**, and drive housing **20** to obtain a different displacement and can instead mount different fluid modules **22**. The modular nature of pumping assembly **10** also provides a space savings as the user is not required to store full pump assemblies **10** and can instead simply store various fluid modules **22**, which require less storage space. The modular nature of pumping assembly **10** further provides for efficient changeover between pumps having various displacements. The other components of pumping assembly **10** can remain installed while the user swaps out fluid modules **22** to change the displacement of pump **14**. The user does not have to manipulate and remove the entire motor **12**, drive **24**, and/or drive housing **20**, providing savings in time and labor.

(68) FIG. **5** is a cross-sectional view taken along line **5-5** in FIG. **4**H. Fluid modules **22***b* are mounted to drive housing **20**. Fluid modules **22***b* are disposed coaxially on pump axis P-P.

(69) Inner mounting portion **40** interfaces with drive housing **20** at first interface **78**. Inner mounting portion **40** contacts end **32** of drive housing **20** at first interface **78**. Inner mounting portion **40** seals with the end **32** of drive housing **20** with adaptor **38***b* mounted to drive housing **20**. In the example shown, annular seal **76** is disposed between drive housing **20** and inner mounting portion **40**. Inner mounting portions **40** of adaptors **38***b* have diameters D**1** that are the same

diameter as that of inner mounting portions **40** of adaptors **38***a*. The same diameters of inner mounting portion **40** of adaptor **38***b* and inner mounting portion **40** of adaptor **38***a* facilitates fluid module **22***b* mounting to the same drive housing **20**, in the same manner, and at the same location as fluid module **22***b*.

(70) Fluid covers **34***b* are disposed between and fluidly connected to inlet manifold **16** and outlet manifold **18**. Fluid covers **34***b* are connected to outer mounting portions **42***b* of adaptors **38***b*. Fluid covers **34***b* contact outer mounting portion **42** at third interface **82**. Diaphragms **36***b* are captured between fluid covers **34***b* and adaptors **38***b*. More specifically, circumferential edge **64** is captured between adaptor **38***b* and fluid cover **34***b*. Circumferential edge **64** can include a bead disposed within grooves formed in outer mounting portion **42***b* and fluid cover **34***b*. Circumferential edge **64** forms an annular seal between fluid cover **34***b* and outer mounting portion **42***b* at third interface **82**. In the example shown, complimentary grooves are formed on each of outer mounting portion **42***b* and fluid cover **34***b* to receive circumferential edge **64**.

(71) Diaphragms **36***b* are connected to drive **24** and powered by drive **24** in the same manner as diaphragms **36***a*. Connectors **66** extend into mounting bores **72** formed in bearing plates **46***a* to fix bearing plates **46***a* to the centers of diaphragms **36***b*. Drive **24** can displace diaphragms **36** through each of the pressure stroke and the suction stroke.

(72) Pumping assembly **10** with fluid modules **22***b* installed operates in the same manner as pumping assembly **10** with fluid modules **22***a* installed. Eccentric **68** rotates about axis M to drive bearing **70** in a circular path about axis M. Bearing **70** pushes on bearing plates **46***a* and rods **48** connect bearing plates **46***a* to simultaneously displace diaphragms **36***b* in one of the first axial direction AD**1** and second axial direction AD**2**.

(73) Transition portion **58***b* extends between and connects inner mounting portion **40** and outer mounting portion **42***b*. Transition portion **58***b* increases the diameter of adaptor **38***b* between the diameter D**1** of inner mounting portion **40** and the diameter D**3** of outer mounting portion **42***b*. Diameter D**3** is larger than diameter D**2**. The larger diameter D**3** of outer mounting portion **42***b* relative to the diameter D**2** of outer mounting portion **42***a* facilitates use of the larger diaphragm **36***b* to generate higher flow. Diaphragm **36***b* has a diameter larger than a diameter of diaphragm **36***a*. The process discussed can also be utilized to mount a diaphragm having a smaller relative diameter to generate higher pressures and/or lower flow.

(74) It is contemplated that a variety of sizes of fluid modules **22** can be connected to the same drive housing **20**. For example, ten different sizes having different diaphragm diameters can alternately be attached to the same drive housing **20** and driven by the same drive **24**. Each of the different sized fluid modules **22** is able to attach to the same end **32** of drive housing **20** at the same first interface **78** by the respective adaptor **38** of each fluid module **22** having the same fastener hole pattern and spacing to interface with the fastener holes of the drive housing **20**, yet each adaptor **38** can have a different size outer mounting portion **42** (e.g., different diameter) to accommodate the different sizes of diaphragms **36**. In this way, the adaptors **38** adapt between the single size of the first interface **78** with drive housing **20** and multiple different diaphragm configurations.

(75) FIGS. **6**A-**6**C show a process of removing drive components configured to displace the diaphragms **36** through both pumping and suction strokes and replacing those drive components with drive components configured to displace diaphragms **36** through the suction stroke while working fluid within drive chamber **52** displaces the diaphragms **36** through a pumping stroke.

(76) The drive **24** including bearing plates **46***a* is configured to drive the diaphragms **36** through both the suction and the pumping strokes. However, the pump **14** can be adapted so that the drive **24** moves the diaphragms **36** only through the suction strokes while the diaphragms **36** are then pneumatically or hydraulically pushed through the pumping strokes. The benefit of such a configuration is that the output pressure of the pump **14** will be at or near the pneumatic or hydraulic pressure that pushes on the diaphragms **36**, whereas only mechanical pushing through

both the pumping and suction strokes can result in pressure spikes, particularly in deadhead conditions. FIGS. **6**A-**6**C demonstrate the conversion of the drive **24**.

(77) Each bearing plate **46***a* includes plate body **84**, mounting bore **72**, first receiving opening **86**, and second receiving opening **88**. Mounting bore **72** is formed in static projection **90**. Each bearing plate **46***b* includes plate body **84**, mounting bore **72**, first receiving opening **86**, and second receiving opening **88**. Mounting bore **72** is formed in pull **92**. Rods **48** include rod body **94** extending between contoured end **96** and cylindrical end **98**.

(78) In FIG. **6**A, bearing plates **46***a* and rods **48** have been removed from drive housing **20**. Bearing plates **46***a* are shown in the inverse orientation relative each other. The bearing plate **46***a* to the left of drive housing **20** in the view of FIG. **6**A is oriented such that first receiving opening **86** is at a lower end of plate body **84** and second receiving opening **88** is at a top end of plate body **84**. The bearing plate **46***a* to the right of drive housing **20** in the view of FIG. **6**A is oriented such that first receiving opening **86** is at a top end of plate body **84** and second receiving opening **88** is at a lower end of plate body **84**.

(79) Similar to bearing plates **46***a*, rods **48** are oriented inverse each other. The upper one of rods **48** shown is oriented with contoured end **96** facing in first axial direction AD**1** to be received by first receiving opening **86** of the bearing plate **46***a* spaced in first axial direction AD**1** from drive housing **20**. Cylindrical end **98** of the upper one of rods **48** is facing in second axial direction AD**2** to be received by second receiving opening **88** of the bearing plate **46***a* spaced in second axial direction AD**2** from drive housing **20**. The lower one of rods has contoured end **96** facing in second axial direction AD**2** and cylindrical end **98** facing in first axial direction AD**1**.

(80) Contoured end **96** is configured to extend into first receiving opening **86**. Contoured ends **96** include a contour configured to mate with a contour of first receiving opening **86**. The mating contours prevent rod **48** from rotating relative bearing plate **46***a*, **46***b*. For example, contoured ends **96** can include flats and first receiving openings **86** can be slots configured to mate with the flats. Contoured end **96** can be partially cylindrical and partially flat. In addition, the slot forming first receiving opening **86** can be vertically larger than contoured end **96**. The interface between contoured end **96** and first receiving opening **86** provides vertical play during assembly into drive housing **20** to allow rods **48** to properly mount within rod sleeves **54**. Cylindrical end **98** extends into second receiving opening **88**. Contoured end **96** and cylindrical end **98** have reduced diameters relative rod body **94**.

(81) Extensions **100** project axially from each of contoured end **96** and cylindrical end **98**. With rods **48** interfacing with bearing plates **46***a*, **46***b*, extensions **100** are disposed on opposite axial sides of plate body **84** from rod body **94**. Extensions **100** are removably connected to locks **102** to secure rods **48** to bearing plates **46***a*. In the example shown, extensions **100** are threaded shafts and locks **102** are nuts configured to threadingly engage mounting extensions. It is understood, however, that extensions **100** and locks **102** can interface in any manner suitable for securing rod **48** to bearing plate **46***a*, **46***b*. Only one pair of locks **102** are shown, but it is understood that a pair of locks **102** is utilized to secure the pair of rods **48** to each bearing plate **46***a*, **46***b*.

(82) During disassembly, locks **102** are removed from extensions **100** and bearing plates **46***a*, **46***b* are pulled axially away from drive housing **20**. In some examples, the locks **102** associated with one of bearing plates **46***a*, **46***b* are removed and then the rods **48** and other bearing plate **46***a*, **46***b* can be removed while still assembled together. Rods **48** are disconnected from bearing plates **46**.

(83) In FIG. **6**B, bearing plates **46***a* have been removed. In FIG. **6**C, bearing plates **46***b* are introduced. As discussed further below, bearing plates **46***b* have a different configuration than bearing plates **46***a*. Rods **48** are connected to bearing plates **46***b* and locked to bearing plates **46***b* by locks **102**. In some examples, contoured ends **96** are inserted into first receiving openings **86** and secured such that each bearing plate **46***b* has an associated rod **48** extending from it. Each bearing plate **46***b* and its rod **48** can then be inserted into drive housing **20** such that cylindrical ends **98** extend into second receiving openings **88** of the other bearing plate **46***b*.

(84) The carriage formed by bearing plates **46***a* and rods **48** or bearing plates **46***b* and rods **48** can be converted between different configurations within the same drive housing **20** and the different configurations are powered by the same motor **12**. Pumping assembly **10** provides significant advantages by facilitating the user switching between configurations by changing components of drive **24** without replacing the full pumping assembly **10**.
(85) FIG. **7**A is a rear elevation view of bearing plate **46***b*. FIG. **7**B is a front elevation view of bearing plate **46***b*. FIG. **7**C is a cross-sectional view taken along line C-C in FIG. **7**B. FIGS. **7**A-**7**C will be discussed together. Bearing plate **46***b* includes plate body **84**, mounting bore **72**, first receiving opening **86**, and second receiving opening **88**. Mounting bore **72** is formed in pull **92**. Pull **92** includes inner section **104** and outer section **106**. Plate body **84** defines pull chamber **108** and includes cover plate **110** enclosing pull chamber **108** and at least partially forming bearing surface **74**.
(86) Pull **92** is at least partially disposed within pull chamber **108**. Inner section **104** includes an outwardly extending flange configured to mate with an inwardly extending flange to retain inner section **104** at least partially within pull chamber **108**. Outer section **106** includes an outwardly extending flange configured to mate with an inwardly extending flange to retain outer section **106** at least partially within inner section **104**. Inner section **104** and outer section **106** are each movable relative to plate body **84** and relative to each other. Mounting bore **72** is formed in outer section **106**.
(87) Pull **92** is configured such that bearing plate **46***b* can exert a tensile pulling force on diaphragm **36** to pull diaphragm **36** through a suction stroke. Inner section **104** and outer section **106** form a series of telescopic parts that prevent bearing plate **46***b* from driving the diaphragm **36** through a pumping stroke. Pull **92** can collapse into pull chamber **108** to prevent bearing plate **46***b* from driving diaphragm **36** through a pumping stroke.
(88) FIG. **8** is a cross-sectional view of pumping assembly **10** with drive **24**′ including bearing plates **46***b* assembled within drive housing **20**. In this configuration, drive chamber **52** is pressurized with a working fluid to charge drive chamber **52**. For example, drive chamber **52** can be pressurized with compressed air or hydraulic fluid. Drive chamber **52** is fluidly sealed to prevent leakage of the working fluid from drive chamber **52**. A single charge of working fluid can provide pumping force over multiple pump cycles. The working fluid is not exhausted between pump cycles. The charge pressure of the working fluid corresponds to the pumping pressure output by pump **14**.
(89) During operation, eccentric **68** causes bearing **70** to rotate about axis M to move the bearing plates **46***b* in a reciprocating manner in the first axial direction AD**1** and second axial direction AD**2**. Pull **92** is connected to connector **66** of diaphragm **36**. Pull **92** allows the bearing plate **46***b* to pull the connector **66** connected to outer section **106** toward the center of the drive housing **20**, corresponding to the suction stroke. As the bearing **70** reverses axial direction to push the bearing plate **46***b* through the pumping stroke, pull **92** can collapse in a telescopic manner within pull chamber **108**. Outer section **106** can collapse within inner section **104**. Both outer section **106** and inner section **104** can collapse within pull chamber **108**. Bearing plate **46***b* does not convey mechanical pumping force via the connector **66** to the diaphragm **36**. Instead, the working fluid within the drive chamber **52** pushes on the inner side of the diaphragm **36** to move the diaphragm **36** through the pumping stroke. While telescopic pull **92** is shown herein, other pull **92** options are possible, such as belts (e.g., chains, ropes, tendons, etc.) which can convey a pulling force but not a pushing force similar to the telescopic pull **92** shown.
(90) Drive **24**′ is configured to displace diaphragms **36** through respective suction strokes. Drive **24**′ is prevented from displacing diaphragms **36** through respective pumping strokes by pulls **92** and bearing plates **46***b*. Instead, the working fluid charging drive chamber **52** is used to provide the force on the diaphragm **36** to drive diaphragm **36** through the pumping stroke.
(91) As discussed with regard to FIGS. **6**A-**8**, pumping assembly **10** can be converted from having

a purely mechanical drive **24** to a hybrid drive **24′**. The mechanical drive **24** mechanically displaces diaphragms **36** through each of the pumping stroke and the suction stroke. The hybrid drive **24′** mechanically displaces diaphragms **36** through the suction stroke and fluidically (e.g., pneumatically or hydraulically) displaces diaphragms **36** through the pumping stroke. The same drive housing **20** and motor **12** can be utilized with both the purely mechanical configuration and the hybrid configuration. The modular nature of pumping assembly **10** provides flexibility to the user, increases efficiency, and reduces costs. It is understood that hybrid drive **24′** can be utilized with any desired motor. For example, pulls **92** or other pulling options can be utilized with the arrangement shown in FIG. **3**B where motor **12′** is fully within drive housing **20**.

(92) FIG. **9**A is a rear elevation view of adaptor **38**. FIG. **9**B is a front elevation view of adaptor **38**. FIG. **9**C is a side elevation view of adaptor **38**. FIGS. **9**A-**9**C will be discussed together. Adaptor **38** is substantially similar to adaptor **38***a* and adaptor **38***b*. Adaptor **38** includes inner mounting portion **40**, outer mounting portion **42**, central aperture **44**, and transition portion **58**. Inner mounting portion **40** includes inner ring **112** and outer mounting portion **42** includes outer ring **114**. Inner ring **112** includes voids **116**, projections **118**, and inner holes **120**. Outer ring **114** includes indicator **122** and outer holes **124**. Outer holes **124** include first subset **126** and second subset **128**.

(93) Inner mounting portion **40** is disposed at a first end of transition portion **58** and outer mounting portion **42** is disposed at a second end of transition portion **58**. Transition portion **58** increases the diameter of adaptor **38** between the smaller diameter of inner mounting portion **40** and the larger diameter of outer mounting portion **42**. Central aperture **44** extends fully through adaptor **38**.

(94) Inner ring **112** projects radially inward relative transition portion **58**. Inner ring **112** projects radially inward from a location where inner mounting portion **40** interfaces with and seals against end **32** of drive housing **20**. Voids **116** are disposed between projections **118**. Projections **118** are disposed between voids **116**. Inner holes **120** extend through projections **118** and are evenly arrayed about inner ring **112**. Inner holes **120** are disposed radially inward of the seal between inner mounting portion **40** and drive housing **20**. Inner holes **120** are evenly spaced about inner ring **112**. Inner holes **120** are symmetric about inner ring **112**. Inner holes **120** are configured to align with housing holes **130** (FIG. **10**C) formed in end **32** of drive housing **20**. Fasteners, such as fasteners **50***a*, can extend through inner holes **120** and housing holes **130** to mount adaptor **38** to drive housing **20**. Inner holes **120** are evenly arrayed about inner ring **112** such that adaptor **38** can mount to drive housing **20** in any desired orientation. Any one of inner holes **120** can be aligned with any one of housing holes **130** to mount adaptor **38** to drive housing **20**. As such, adaptor **38** can be mounted at any desired clocked orientation relative to drive housing **20**.

(95) Outer ring **114** projects radially outward relative transition portion **58**. Outer ring **114** projects radially outward from a location where outer mounting portion **42** interfaces with diaphragm **36** to form a seal between outer ring **114** and fluid cover **34**. Outer holes **124** extend through outer ring **114** and are configured to align with cover holes **132** (FIGS. **12**A-**13**A) through fluid cover **34**. Outer holes **124** are disposed radially outward of the seal between outer mounting portion **42** and fluid cover **34**. Fasteners, such as fasteners **50***b*, can extend through aligned ones of outer holes **124** and cover holes **132** to mount fluid cover **34** to adaptor **38**. Unlike inner holes **120** that are evenly arrayed about inner ring **112**, outer holes **124** are not evenly arrayed about outer ring **114**. At least some of outer holes **124** have asymmetric spacing. First subset **126** of outer holes **124** have a first spacing therebetween and second subset **128** of outer holes **124** have a second spacing therebetween. The first spacing is different from the second spacing. In the example shown, the outer holes **124** forming first subset **126** are spaced closer together than the outer holes **124** forming second subset **128**. The difference in the spacing provides mistake-proofing that ensures fluid module **22** is properly aligned to pump fluid, as discussed further herein. The uneven spacing between outer holes **124** prevents fluid cover **34** from being mounted to adaptor **38** in an incorrect orientation.

(96) Indicator **122** is disposed on outer ring **114**. In the example shown, indicator **122** is formed between second subset **128**. Indicator **122** is formed on a portion of outer ring **114** that is easily visible by the user with adaptor **38** installed on drive housing **20**. Indicator **122** shows the proper orientation of fluid cover **34** relative adaptor **38** to align outer holes **124** and cover holes **132** such that fluid cover **34** can mount to adaptor **38**. Indicator **122** can be of any desired form for informing the user of the proper orientation of adaptor **38**. For example, indicator **122** can be a bump, notch, gap, projection, symbol, difference in coloring, etc. suitable for indicating the proper orientation of adaptor **38**.
(97) FIG. **10**A is a side elevation view of pumping assembly **10** showing components of drive **24** mounted within the drive housing **20** while adaptor **38** is mounted to drive housing **20**. FIG. **10**B is an isometric view of pumping assembly **10** showing removal of bearing plate **46** through adaptor **38**. FIG. **10**C is a side elevation view of pumping assembly **10** showing components of drive **24** mounted within drive housing **20** with adaptor **38** removed. FIGS. **10**A-**10**C will be discussed together.
(98) The ends of plate body **84** are aligned with voids **116** formed in inner ring **112** of adaptor **38**. Projections **118** in inner ring **112** support the material surrounding inner holes **120**, facilitating mounting of adaptor **38** to drive housing **20**. Voids **116** facilitate installation and removal of bearing plates **46** within drive housing **20** while adaptor **38** remains mounted to drive housing **20**. The ends of plate body **84** are aligned with voids **116** such that bearing plate **46** can be removed from drive housing **20** through voids **116** and central aperture **44**. Bearing plate **46** can thereby be removed from drive housing **20** while adaptor **38** remains installed on drive housing **20**.
(99) As shown, the inner diameter of projections **118** generally would not allow (would block) the bearing plate **46** from being moved past inner ring **112** and out of drive housing **20**. The alignment of the ends of plate body **84** with voids **116** between projections **118** allows bearing plate **46** to be removed through adaptor **38** while adaptor **38** remains attached to drive housing **20**.
(100) As seen in FIG. **10**B, bearing plate **46** has been moved axially outward from drive housing **20** past projections **118** while adaptor **38** remains mounted to drive housing **20**. The same or a different bearing plate **46** can be inserted into drive housing **20** through central aperture **44** and past projections **118**. Adaptor **38** allows for servicing of drive **24**, or for the exchange of different bearing plate **46** types (e.g. fully mechanical or partially mechanical and partially pneumatic/hydraulic as previously described) without removal of the adaptors **38**. Adaptor **38** allows for access to and servicing of various components of drive **24**. For example, components of motor **12**′ (FIG. **3**B) and its associated drive **24** are disposed fully within drive housing **20**. Such components can be accessed and serviced through adaptor **38** while adaptor **38** remains mounted. In some examples, a ball or roller screw forming such a drive **24** can be accessed through central aperture **44** and serviced. For example, such components can be lubricated through central aperture **44**.
(101) Accessing drive **24** through central aperture **44** allows the connection between adaptor **38** and drive housing **20** to be maintained during servicing and/or replacement of components of drive **24**. Maintaining the connection between adaptor **38** and drive housing **20** while accessing components of drive **24** ensures that the annular seal (e.g., rubber O-ring) disposed at first interface **78** between inner mounting portion **40** and drive housing **20** is maintained. Maintaining first interface **78** ensures sealing of drive chamber **52** (e.g., of the pneumatic or hydraulic charge within the drive chamber **52**) and it may be convenient to leave the annular seal in place during servicing, such that it is convenient to remove the bearing plates **46** for servicing and/or changing of configuration without removal of the adaptors **38**.
(102) The drive housing **20** includes an extension that is shown orientated horizontally in FIGS. **10**-**10**C. For example, the extension can be a control housing for housing control components of an internally mounted motor or can be the motor and drive train for an externally mounted motor. In some cases, a user might want to change the orientation of the extension to orientate the extension

in a more convenient way, such as to minimize the footprint of pump assembly **10** in a crowded facility. For example, the user may desire to orientate the extension vertically instead of horizontally. Either orientation is possible, but inlet check valves **26** and outlet check valves **28** are required to be orientated vertically because the check valves rely at least partially on gravity to transition to a closed state because springs are not used in this embodiment.

(103) Housing holes **130** are evenly arrayed about end **32** of drive housing **20**. Housing holes **130** and inner holes **120** being evenly arrayed about pump axis P-P allows drive housing **20** to be oriented in any desired clocked orientation relative to gravity (eight orientations are possible in the example shown) while maintaining the check valves in the required vertical orientation. Due to the asymmetric pattern of outer holes **124** in the adaptor **38**, the adaptor **38** must be removed when the orientation of the drive housing **20** is changed.

(104) The different spacing the first subset **126** of outer holes **124** and the second subset **128** of outer holes **124** ensures proper orientation of the inlet check valves **26** and outlet check valves **28** when pump **14** is assembled. The orientation of inlet check valves **26** and outlet check valves **28** follow the orientation of fluid covers **34**. As shown in FIG. **10**A, indicator **122** is a gap formed between second subset **128** of outer holes **124**. In such an example, indicator **122** and second subset **128** of outer holes **124** are intended to always be closest to the ground (relative to the direction of gravity), whereas first subset **126** of outer holes **124** is disposed furthest from the ground (relative to the direction of gravity). The relative position of indictor **122** and thus of first subset **126** and second subset **128** indicate proper orientation of adaptor **38** to ensure that fluid cover **34** is properly orientated. It is understood, however, that indicator **122** can be formed at any desired position on adaptor **38** to indicate the proper orientation of adaptor **38** relative to gravity. For example, indicator **122** can be disposed between first subset **126** of outer holes **124** such that indicator **122** is intended to always be furthest from the ground (relative to the direction of gravity), among other options.

(105) Adaptors **38** including inner holes **120** having consistent spacing so that the adaptor **38** can be mounted to drive housing **20** in any clocked orientation. Adaptors **38** include outer holes **124** having inconsistent spacing so that fluid cover **34** can be mounted to adaptor **38** only in an orientation which properly orientates the inlet check valves **26** and outlet check valves **28**. It is expected that adaptor **38** will largely remain in place on drive housing **20** for an extended period (such as initial install by a technician likely to know how to orientate the adaptor **38** for proper fluid cover **34** alignment) while fluid cover **34** will be removed on a more frequent basis to access and service drive **24**. Any misalignment between fluid cover **34** and adaptor **38** when fluid cover **34** is reinstalled will be quickly discovered by the technician performing maintenance if adaptor **38** remains in place on drive housing **20** while fluid cover **34** is removed to perform the maintenance. Cover holes **132** (best seen in FIGS. **12**A-**13**A) and outer holes **124** will be misaligned if fluid cover **34** is attempted to be installed in an incorrect orientation. Such misalignment prevents the insertion of fasteners **50***b* through cover holes **132** and outer holes **124** so fluid cover **34** cannot be mounted in an incorrect orientation relative adaptor **38**. So long as adaptor **38** remains attached during maintenance, then fluid cover **34** can only be properly connected to adaptor **38** in one orientation, which is the proper orientation.

(106) FIG. **11** is an elevation view of pumping assembly **10** showing pumping assembly **10** in a vertical orientation. FIG. **11** is substantially similar to FIG. **10**A except drive housing **20** has been rotated 90-degrees counterclockwise such that the extension from drive housing **20** extends vertically above drive housing **20**. As discussed above, the even spacing between inner holes **120** facilitates mounting of adaptor **38** to drive housing **20** in any clocked orientation such that the extension from drive housing **20** extends in any desired direction. Adaptor **38** is mounted to drive housing **20** such that fluid cover **34** must be oriented vertically to ensure proper function of inlet check valves **26** and outlet check valves **28**. Indicator **122** is disposed at the bottom of pump assembly **10** and closest to ground relative the direction of gravity, ensuring that fluid cover **34**, and

thus inlet check valves **26** and outlet check valves **28**, are in the proper orientation when pump **14** is fully assembled.

(107) FIG. **12**A is an isometric view of pumping assembly **10** showing fluid cover **34** misaligned with adaptor **38** (best seen in FIGS. **9**A-**9**C). FIG. **12**B is an enlarged view of detail B in FIG. **12**A. Fluid cover **34** includes cover holes **132** that align with outer holes **124** when fluid cover **34** is properly oriented relative to adaptor **38**. Cover holes **132** include third subset **134** and fourth subset **136**.

(108) Third subset **134** of cover holes **132** have a first spacing therebetween and fourth subset **136** of cover holes **132** have a second spacing therebetween. The first spacing is different from the second spacing. The difference in the spacing provides mistake-proofing that ensures fluid cover **34** is properly aligned with adaptor **38**. The uneven spacing between cover holes **132** prevents fluid cover **34** from being mounted to adaptor **38** in an incorrect orientation.

(109) The spacing between third subset **134** of cover holes **132** and first subset **126** of outer holes **124** is the same. The spacing between fourth subset **136** of cover holes **132** and second subset **128** of outer holes **124** is the same. Such spacing ensures that third subset **134** of cover holes **132** interface with first subset **126** of outer holes **124** and that fourth subset **136** of cover holes **132** interface with second subset **128** of outer holes **124** when fluid cover **34** is mounted. Fluid cover **34** cannot be mounted to adaptor **38** except by aligning third subset **134** of cover holes **132** with first subset **126** of outer holes **124** and fourth subset **136** of cover holes **132** with second subset **128** of outer holes **124**.

(110) Fluid cover **34** is shown as misaligned in FIGS. **12**A and **12**B. Fluid cover **34** is shown in the orientation corresponding to the motor extension extending horizontally (as shown in FIGS. **10**A-**10**C). As best seen in FIG. **12**B, the difference in hole pattern spacing results in a mismatch at hole **132***a* of fluid cover **34** such that there is no corresponding outer hole **124** aligned with hole **132***a*. The pathway through hole **132***a* is thereby blocked preventing the insertion of a fastener **50***b* through fluid cover **34** and adaptor **38** at that location. A portion of adaptor **38** is visible through hole **132***a*, which portion prevents the insertion of the fastener **50***b* through hole **132***a*. Fluid cover **34** cannot be fixed to adaptor **38** due to the misalignment. The inability to insert a fastener **50***b* provides a signal to the technician that fluid cover **34** is misaligned on adaptor **38**. Inlet manifold **16** and outlet manifold **18** are shown in their proper positions in FIG. **12**A, but it is understood that inlet manifold **16** and outlet manifold **18** are typically installed after fluid covers **34**, such that their positioning does not indicate the proper orientation of fluid cover **34** to the user.

(111) FIG. **13**A is a side elevation view of pumping assembly **10** showing fluid cover **34** properly aligned on pumping assembly **10** and mounted to adaptor **38**. FIG. **13**B is an isometric view of pumping assembly **10** with motor **12** oriented vertically. Fluid cover **34** is shown as correctly oriented such that all cover holes **132** are aligned with an outer hole **124** through adaptor **38**. Fasteners **50***b* can thereby be inserted through cover holes **132** and into outer holes **124** to fix fluid cover **34** to adaptor **38**. Inlet manifold **16** and outlet manifold **18** are mounted to fluid cover **34** and inlet check valves **26** and outlet check valves **28** are in the proper orientation relative gravity.

(112) While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

Claims

1. A displacement pump comprising: an electric drive having a drive housing defining a pump axis; a first fluid module mountable to an end of the drive housing, the first fluid module including: a first adaptor configured to interface with the drive housing, the first adaptor comprising a first inner mounting portion and a first outer mounting portion, wherein the first inner mounting portion interfaces with the drive housing at a first interface; a first cover configured to interface with the first outer mounting portion at a second interface; and a first diaphragm captured between the first adaptor and the first cover; wherein the first interface allows the first adaptor to be mounted at a plurality of adaptor mount positions; and wherein the second interface is a clocked interface that allows the first cover to be mounted at a single cover mount position and prevents the first cover from being mounted at orientations other than the single cover mount position.

2. A displacement pump comprising: an electric drive having a drive housing defining a pump axis; a first fluid module mountable to an end of the drive housing, the first fluid module including: a first adaptor configured to interface with the drive housing, the first adaptor comprising a first inner mounting portion and a first outer mounting portion, wherein the first inner mounting portion interfaces with the drive housing at a first interface; a first cover configured to interface with the first outer mounting portion at a second interface; and a first diaphragm captured between the first adaptor and the first cover; wherein the first outer mounting portion includes a plurality of outer openings configured to receive fasteners to mount the first cover to the first adaptor; and wherein the plurality of outer openings are unevenly arrayed about the first outer mounting portion.

3. The displacement pump of claim 2, wherein the plurality of outer openings includes a first subset of outer openings having a first spacing and a second subset of outer openings having a second spacing, and wherein the first spacing differs from the second spacing.

4. The displacement pump of claim 3, wherein an indicator is disposed between one of the first subset of outer openings and the second subset of outer openings, wherein the indicator is configured to signify an orientation of the first cover corresponding to the cover mount position.