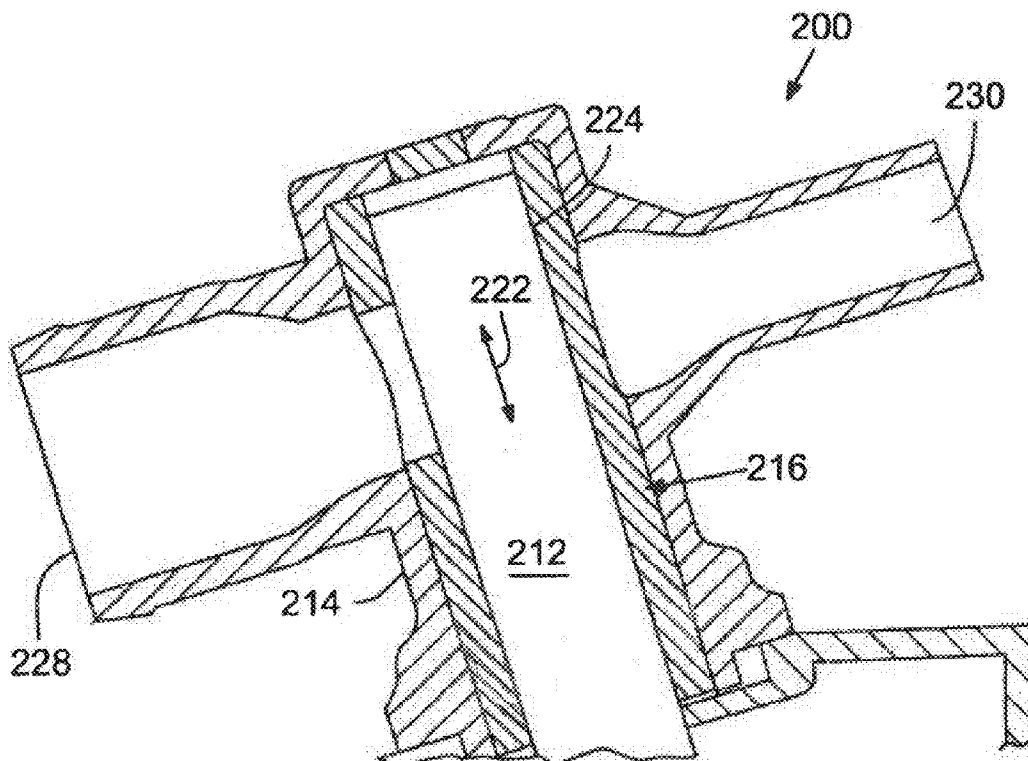




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(19) **United States**(12) **Patent Application Publication**
Grimes(10) **Pub. No.: US 2014/0161651 A1**(43) **Pub. Date: Jun. 12, 2014**(54) **COMPACT INTEGRATED-DRIVE PUMPS**(71) Applicant: **MICROPUMP, INC, A UNIT OF
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11, 2012.**Publication Classification**(51) **Int. Cl.**
F04B 17/03 (2006.01)(52) **U.S. Cl.**CPC **F04B 17/03** (2013.01)USPC **417/420**(57) **ABSTRACT**

Pump assemblies are disclosed that have a magnetically driven pump-head subassembly and a pump-driver subassembly coupled thereto, wherein the pump-driver subassembly includes a pump-driver enclosure. The pump-head subassembly comprises a rotatable magnet contained in a magnet cup extending into the pump-driver enclosure. The pump-driver subassembly has a printed circuit board (PCB) in the pump-driver enclosure and a stator mounted to the PCB. The stator coaxially surrounds the magnet cup. The magnet cup has a distal-end wall. The printed circuit board includes a stator-driving circuit and at least one signal-processing circuit. The PCB defines a void relative to the distal-end wall that exposes at least half the distal-end wall. The pump-driver enclosure has an aspect ratio of no greater than one (unity).



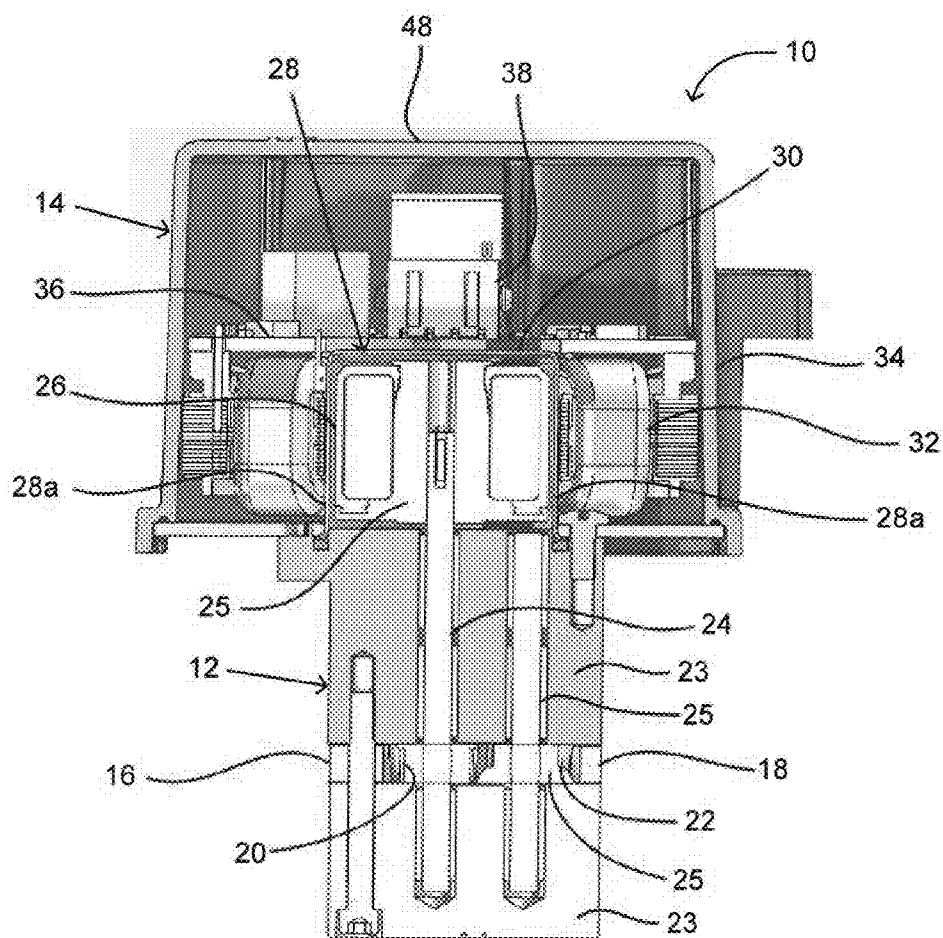


FIG. 1

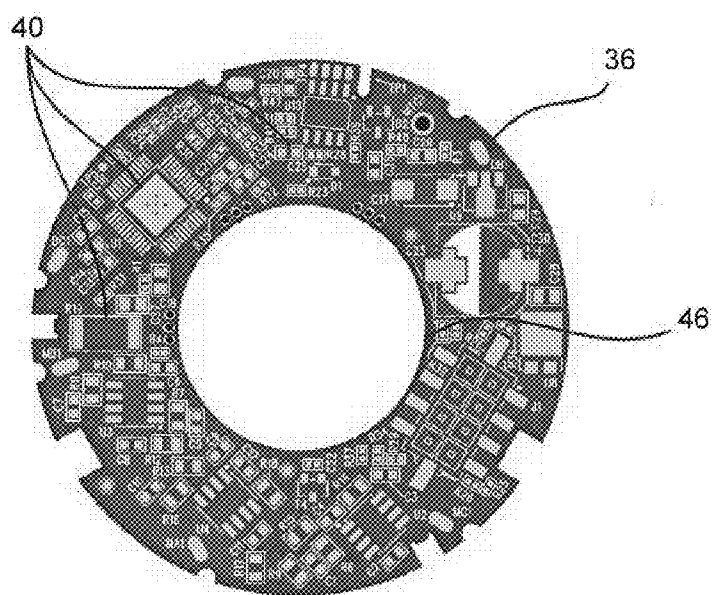


FIG. 2

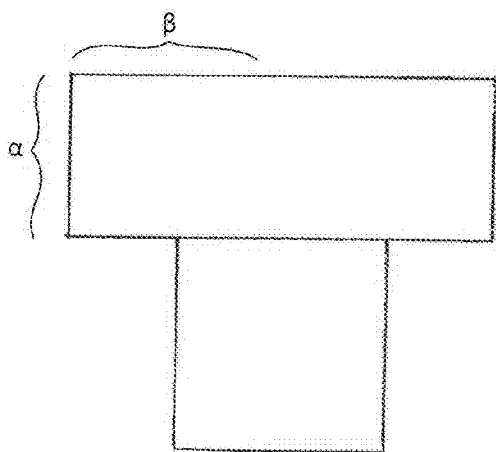


FIG. 3A

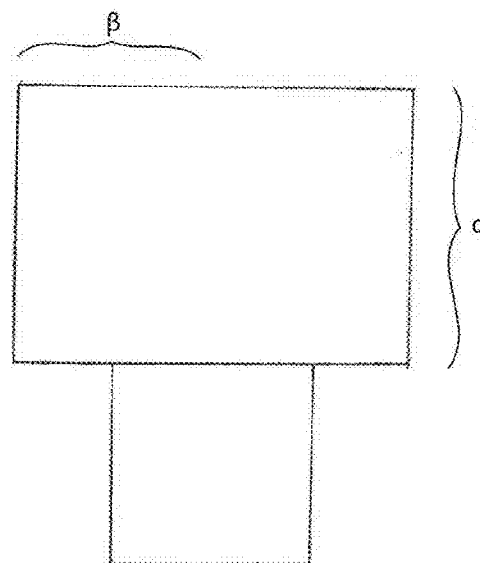


FIG. 3B

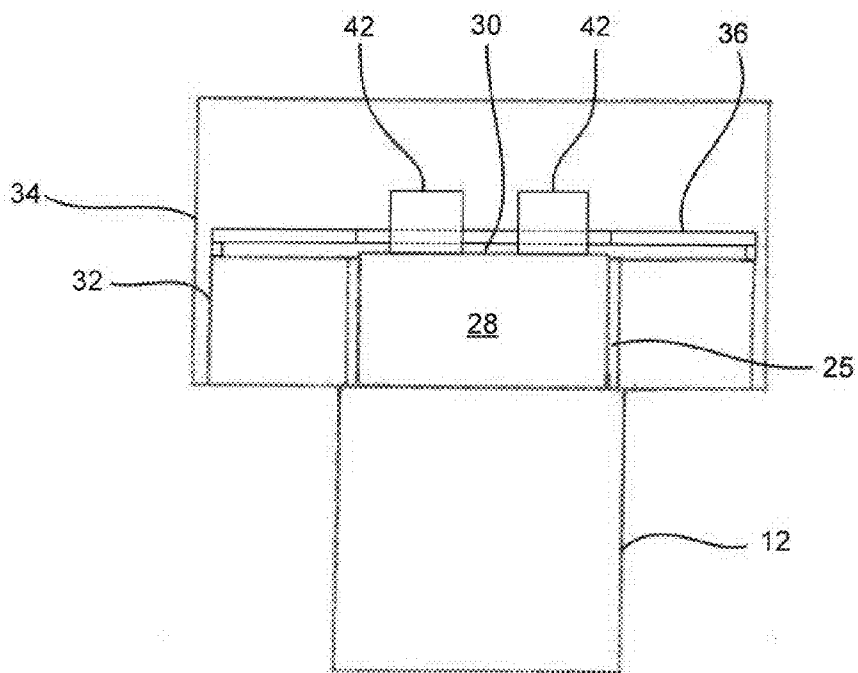


FIG. 4

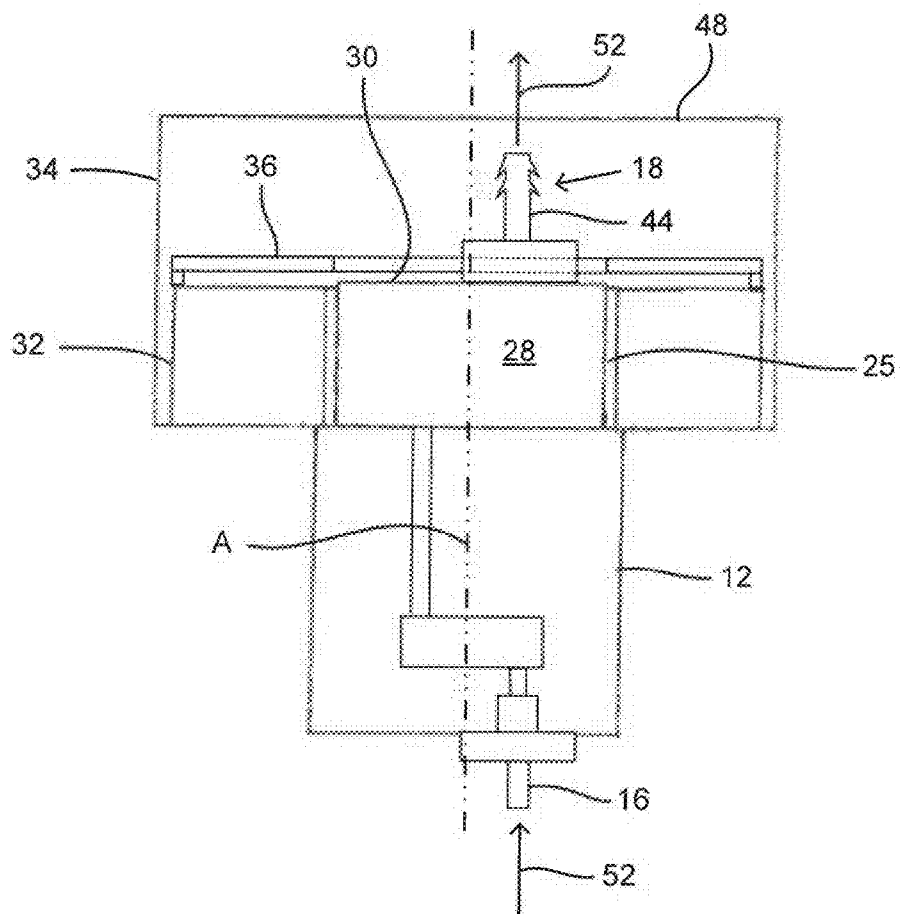


FIG. 5

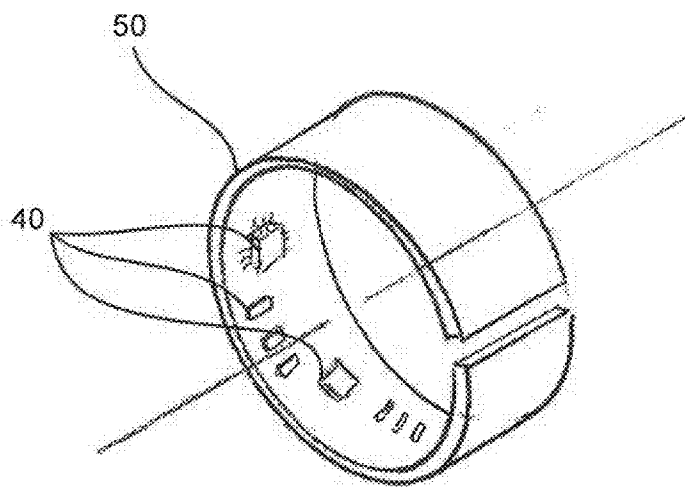


FIG. 6A

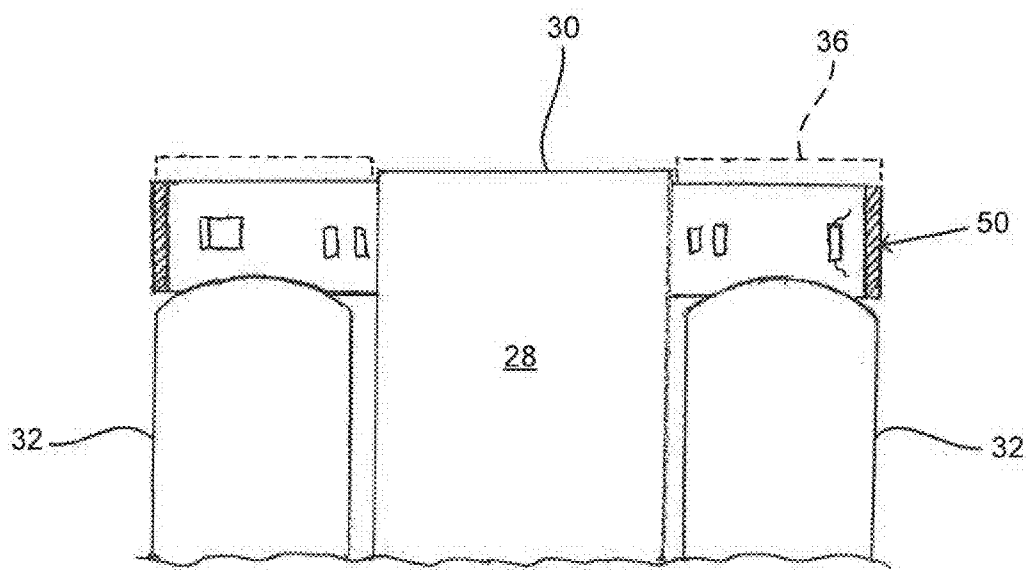


FIG. 6B

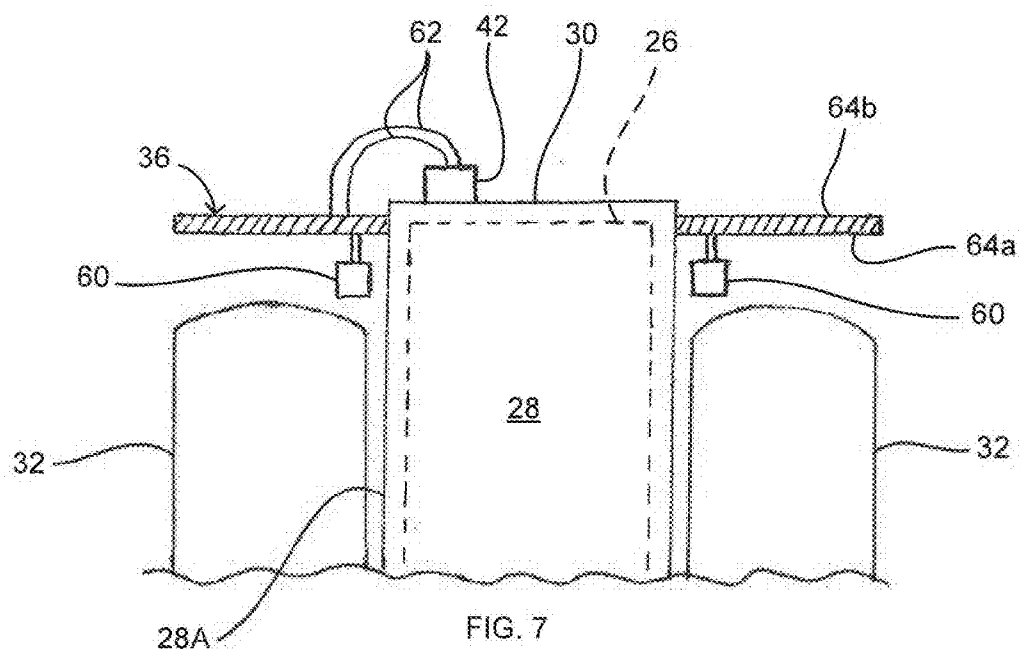


FIG. 7

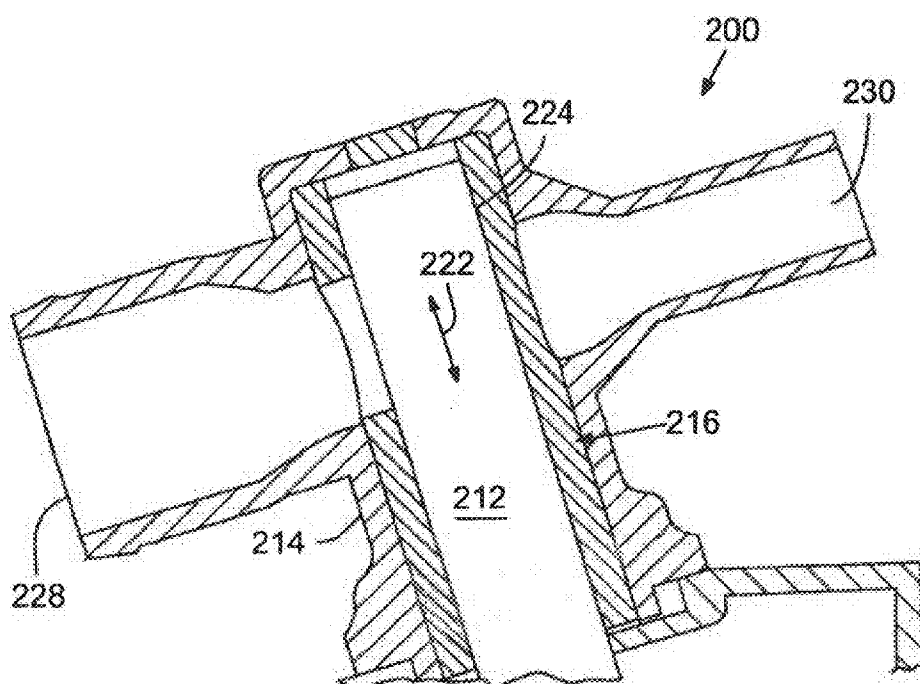


FIG. 8

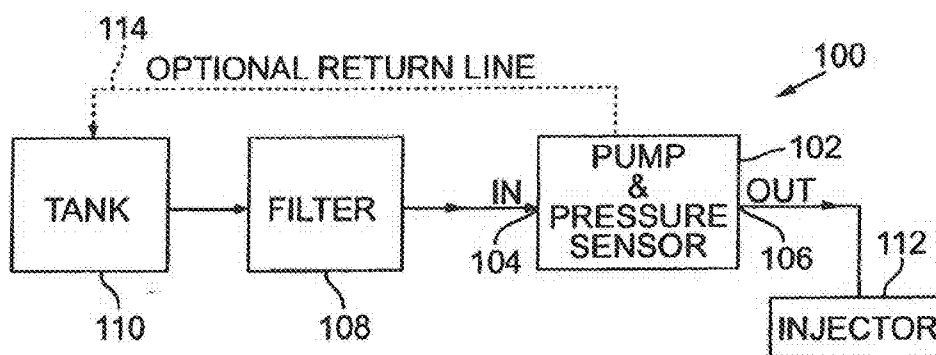


FIG. 9

COMPACT INTEGRATED-DRIVE PUMPS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to, and the benefit of, U.S. Provisional Patent Application No. 61/735,872, filed on Dec. 11, 2012, which is incorporated herein by reference in its entirety.

FIELD

[0002] This disclosure relates to various types of pumps that are magnetically driven. More specifically, it pertains to pumps in which a rotary or rotary-reciprocating element, such as a pump gear, is connected to a driven magnet housed in a magnet housing ("magnet cup") in which the magnet is wetted by the fluid being pumped by the pump.

BACKGROUND

[0003] Integrated-drive pumps are particularly advantageous for pumping systems that must operate under severe conditions, handle hazardous fluids, or operate trouble-free for extremely long periods of time. Such pumps often incorporate a magnetically coupled pump-drive mechanism in which a pump element, such as a pair of interdigitating gears or lobes, is connected to a driven magnet housed in a magnet housing or "magnet cup." The driven magnet is caused to rotate by a rotating magnetic field induced by a stator or other mechanism situated outside the magnet cup. This arrangement allows the driven magnet to be immersed in the fluid being pumped while isolating the rest of the system and eliminating the leak-prone hydraulic seals that would otherwise be required around the pump-drive shaft. Operation of the stator typically requires an electronic circuit for provision of power and control logic.

[0004] In addition to the electronic circuits required for operation of the pump, integrated-drive pumps are often incorporated into hydraulic systems that require sensors or indicators of any of various parameters such as pressure, temperature, conductivity, etc., of the fluid flowing in the system. A sensor usually includes a transducer or the like that converts the parameter being sensed (e.g., pressure or temperature) into a corresponding signal (e.g., an electronic or optical signal). The sensor usually also includes or is connected to an electronic circuit that receives data directly from the transducer and processes the data for use by other electronics for, e.g., providing a measure of the parameter or for use in control circuits. It is possible that the sensor(s) not actually include or function as a transducer. As used herein, the term "sensor" encompasses both transducer-based sensors as well as sensors not utilizing a transducer.

[0005] In hydraulic systems including a pump, the pump is typically a discrete stand-alone component, by which is meant that the pump is manufactured and sold separately to original equipment manufacturers (OEMs) for incorporation into the OEM's own system. The trend in many OEM hydraulic systems requiring a pump is toward miniaturization, particularly with respect to the aspect ratio of a pump assembly (i.e., the ratio of a pump assembly's axial length as compared to its diameter) without sacrificing performance or reliability. Thus, the electronic circuitry for operating both the pump and the sensors ideally must be self-contained (i.e., located on or

within the housing or enclosure of a pump-driver portion), and incorporated into a pump assembly that is as small and compact as possible.

[0006] However, the circuitry needed to operate the stator in an integrated-drive pump is often required to operate at a much higher voltage and/or current than the circuitry for operating the sensors due to the higher electrical power requirements of the stator relative to the sensors. Additionally, each respective circuit type requires numerous circuit elements which can vary in size. The disparity in power requirements, the relatively large number and size of the circuit elements, and the space constraints imposed by the pump-driver portion often necessitate that the stator and sensor elements be operated on two or more independent electrical circuits. Moreover, these independent electrical circuits must often be laid out on multiple printed circuit boards that fully extend the full transverse dimension of the enclosure of the pump-driver portion (or be located outside the enclosure) to accommodate the required circuit elements. This, in turn, blocks access to the magnet cup, complicates sensor location, precludes a flow-through pump configuration, and requires a large pump-driver portion that negatively impacts the size of the pump assembly.

SUMMARY

[0007] Disclosed embodiments of the present invention provide compact integrated-drive pumps that address the deficiencies of known integrated-drive pumps. Certain embodiments of the present invention concern a pump assembly, comprising a magnetically driven pump-head subassembly and a pump-driver subassembly coupled to the pump-head subassembly. The pump-driver subassembly includes a pump-driver enclosure. The pump-head subassembly comprises a rotatable magnet contained in a magnet cup, which has a distal-end wall and extends into the pump-driver enclosure. The pump-driver subassembly also comprises a printed circuit board contained in the pump-driver enclosure, and a stator mounted to the printed circuit board. The stator coaxially surrounds the magnet cup. The printed circuit board includes a stator-driving circuit, at least one signal-processing circuit, and at least one pump-parameter sensor mounted on the printed circuit board. The printed circuit board also defines a void that is situated relative to the distal-end wall so as to expose at least half of the distal-end wall while placing the sensor relative to the magnet cup. In addition, the pump-driver enclosure has an aspect ratio of no greater than one (unity).

[0008] Another embodiment concerns a pump assembly, comprising a pump-head portion including a pump cavity. The pump assembly includes a pump-driver enclosure coupled to the pump-head portion that has an axial length and a transverse dimension. A movable pumping member is situated inside the pump cavity and connected to a driven magnet so that induced motion of the driven magnet causes corresponding induced motion of the pumping member. The pump assembly also includes a magnet cup, being a respective portion of the pump cavity, and containing the driven magnet. The induced motion of the driven magnet occurs in the magnet cup as the driven magnet and interior of the magnet cup are being wetted by fluid being pumped by induced motion of the pumping member. The magnet cup also includes a distal-end wall.

[0009] A magnet-driver is situated outside the magnet cup but inside the pump-driver enclosure, and is magnetically

coupled to the driven magnet such that a changing magnetic field produced by the magnet-driver induces motion of the driven magnet and hence of the pumping member in the magnet cup. The pump assembly also includes a circuit board and at least one sensor located in the pump-driver enclosure. The sensor is located on, aside, or at least partially in the distal-end wall, and the circuit board is electrically connected to the magnet-driver and to the at least one sensor.

[0010] The circuit board comprises a high-current circuit and a low-current circuit, wherein the high-current circuit is connected to and provides controlled electrical power to the magnet-driver, and the low-current circuit is connected to and provides controlled electrical power to the at least one sensor. The circuit board extends orthogonally to the axial length around the magnet cup while defining a void, which allows access through the circuit board to the distal-end wall of the magnet cup.

[0011] The foregoing and other objects, features, and advantages of the invention will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a side-elevational section of an embodiment of an integrated-drive pump assembly.

[0013] FIG. 2 is a top view of a printed circuit board used in the embodiment of FIG. 1.

[0014] FIG. 3A is a schematic depiction of an integrated-drive pump assembly having a pump-driver enclosure with an aspect ratio of approximately 0.4.

[0015] FIG. 3B is a schematic depiction of an integrated-drive pump assembly having a pump-driver enclosure with an aspect ratio of approximately 0.7.

[0016] FIG. 4 is a side-elevation cross-sectional view of an embodiment of an integrated-drive pump assembly having a sensor.

[0017] FIG. 5 is a side-elevational section of an embodiment of an integrated-drive pump assembly including a fitting mounted to the distal-end wall of the magnet cup.

[0018] FIG. 6A is a perspective view of an exemplary configuration of a flexible printed circuit.

[0019] FIG. 6B is an elevational section showing the printed circuit of FIG. 6A and nearby portions of the magnet cup and stator.

[0020] FIG. 7 is an elevational view of a portion of a pump-driver assembly situated relative to the magnet cup.

[0021] FIG. 8 is a section through a portion of the head of an embodiment of a piston pump as an alternative pump-head.

[0022] FIG. 9 is a schematic diagram of an exemplary hydraulic circuit including an integrated-drive pump assembly.

DETAILED DESCRIPTION

[0023] This disclosure is set forth in the context of representative embodiments that are not intended to be limiting in any way.

[0024] As used herein, the singular forms “a,” “an,” and “the” include the plural forms unless the context clearly dictates otherwise. Additionally, the term “includes” means “comprises.” Further, the term “coupled” encompasses mechanical as well as other practical ways of coupling or linking items together, and does not exclude the presence of intermediate elements between the coupled items.

[0025] The things and methods described herein should not be construed as being limiting in any way. Instead, this disclosure is directed toward all novel and non-obvious features and aspects of the various disclosed embodiments, alone and in various combinations and sub-combinations with one another. The disclosed things and methods are not limited to any specific aspect or feature or combinations thereof, nor do the disclosed things and methods require that any one or more specific advantages be present or problems be solved.

[0026] Although the operations of some of the disclosed methods are described in a particular, sequential order for convenient presentation, it should be understood that this manner of description encompasses rearrangement, unless a particular ordering is required by specific language set forth below. For example, operations described sequentially may in some cases be rearranged or performed concurrently. Moreover, for the sake of simplicity, the attached figures may not show the various ways in which the disclosed things and methods can be used in conjunction with other things and method. Additionally, the description sometimes uses terms like “produce” and “provide” to describe the disclosed methods. These terms are high-level abstractions of the actual operations that are performed. The actual operations that correspond to these terms will vary depending on the particular implementation and are readily discernible by one of ordinary skill in the art.

[0027] In the following description, certain terms may be used such as “up,” “down,” “upper,” “lower,” “horizontal,” “vertical,” “left,” “right,” and the like. These terms are used, where applicable, to provide some clarity of description when dealing with relative relationships. But, these terms are not intended to imply absolute relationships, positions, and/or orientations. For example, with respect to an object, an “upper” surface can become a “lower” surface simply by turning the object over. Nevertheless, it is still the same object.

[0028] Referring to FIG. 1, there is shown a cross-sectional view of an embodiment of an integrated-drive pump assembly 10 having a pump-head portion 12 and a pump-driver portion 14. The pump-head portion 12 includes an inlet 16, an outlet 18, a driving gear 20, a driven gear 22, a shaft 24, a driven magnet 26, and a magnet cup 28. The magnet cup 28 extends into the pump-driver portion 14. The magnet cup 28 has side walls 28a and a distal-end wall 30 that surround and are coaxial with the driven magnet 26. The side walls 28a and the distal-end wall 30 separate the driven magnet 26 from electrical parts of the assembly that are kept dry (i.e., not wetted by the fluid being pumped). Meanwhile, the pump-head portion 12 comprises a pump housing 23 (usually a sealed housing) that defines a pump cavity 25. The pump cavity 25 is generally bathed in the fluid being pumped. In other words, the pump cavity 25 is defined by the fluid-wetted interiors of the pump-head portion 12 and the magnet cup 28. Thus, the driven magnet 26 and gears 20, 22 are situated in the pump cavity 25. Coaxially surrounding the magnet cup 28 is a stator 32 that is located outside the pump cavity 25 and is magnetically coupled to the driven magnet 26 across the side walls 28a of the magnet cup. The stator 32 is contained in a pump-driver enclosure 34. The pump-driver enclosure 34, being outside the pump cavity 25, is dry. In the embodiment shown in FIG. 1, the pump-driver enclosure 34 and pump-head portion 12 are mounted end-to-end so that a large part of the pump-head portion 12 extends from and is axially aligned with the pump-driver portion 14.

[0029] In this embodiment, a printed circuit board (PCB) 36 is located within the pump-driver enclosure 34 immediately above and substantially adjacent the stator 32, as shown in FIG. 1. The PCB 36 of this embodiment has a substantially annular shape and defines a central hole 46 coaxial with and having a diameter substantially equal to or slightly larger than the outside diameter of the magnet cup 28. Mounted to the PCB 36 are an electrical connector housing 38 for providing electrical power to the pump assembly and a plurality of circuit elements 40, as shown in FIGS. 1-2. The PCB 36 is electrically connected to the stator 32 and to one or more sensors 42 (FIG. 4) for sensing any of a variety of respective parameters (e.g., pressure, temperature, etc.) of the fluid being pumped.

[0030] The PCB 36 contains one or more electronic circuits that, for example, provide controlled electrical power (i.e., electrical power, logical control, signal conditioning, signal processing, etc.) to the stator 32 and to the one or more sensors 42. For example, the PCB 36 of this embodiment comprises a high-current electrical circuit for operating the stator 32 and at least one low-current electrical circuit for operating the one or more sensors 42. Desirably, the PCB 36 accommodates all the circuit elements 40 of the circuits required to operate the stator 32 and the one or more sensors 42 such that only a single printed circuit board is required. In this manner, all the electrical components are contained on or within the pump-driver enclosure 34 such that all that is required from outside (i.e., from the OEM system) is electrical power input. The integrated-drive pump assembly 10 can also include an output for signals to or from the sensors 42 for use by, for example, OEM systems remote from the pump assembly.

[0031] Alternatively, the necessary electronic circuits can be laid out on two or more PCBs (not necessarily of similar size) substantially adjacent one another (e.g., coaxially “stacked”) or otherwise in close proximity within the pump-driver enclosure 34. Also, the PCB 36 need not be annular, but can comprise any shape that would fit in the pump-driver enclosure 34 and allow access to the distal-end wall 30 of the magnet cup 28 for location of sensors or fittings. For example, the PCB 36 can comprise one or more semi-annular printed circuit boards configured and arranged within the pump-driver enclosure 34 such that the distal-end wall 30 of the magnet cup 28 is accessible.

[0032] In the embodiment shown, the PCB 36 is configured such that the distal-end wall 30 of the magnet cup 28 is at least partially exposed through the central hole 46 of the PCB 36 when the PCB 36 is located above the stator 32 (i.e., at least a portion of the distal-end wall 30 of the magnet cup 28 can be accessed through the annular-shaped PCB 36), as best shown in FIGS. 1-2. In this manner, the distal-end wall 30 of the magnet cup 28 can be accessed and used for sensor location, as shown in FIG. 4, or for location of a fitting 44 in a flow-through pump, as shown in FIG. 5. In this application, a “flow-through pump” refers to a pump configured such that the fluid being pumped enters an inlet 16 defined in or on the pump cavity 25 and exits through an outlet 18 in the form of a hydraulic fitting 44 or the like located on the distal-end wall 30 of the magnet cup 28 within the pump-driver enclosure 34. The hydraulic fitting 44 mounted on the distal-end wall 30 of the magnet cup 28 allows pumped fluid to follow a flow path extending substantially in an axial direction with respect to the integrated-drive pump assembly 10 (note axis A and flow lines 52), as shown in FIG. 5. Alternatively, the hydraulic fitting 44 can be mounted on the side wall 28a of the magnet

cup 28 and the fluid can follow a flow path that extends through the pump-driver portion 14 in a direction substantially normal to the axis A of the integrated-drive pump assembly 10. In the embodiment shown, desirably between approximately 50% to approximately 100% of the surface area of the distal-end wall 30 is exposed through the central hole 46 of the PCB 36. Most desirably, 75% or more of the surface area of the distal-end wall 30 is exposed.

[0033] In an alternative embodiment, the PCB 36 is configured as a flexible printed circuit sheet or “board”, such as a polymeric substrate in/on which circuit wiring is printed and circuit elements are mounted. The flexible printed circuit can be configured as a looped strip or ribbon 50, as shown in FIG. 6A. The ribbon 50 is bent or urged into a substantially cylindrical loop that is mountable inside the pump-driver enclosure 34. Thus, the ribbon 50 at least partially surrounds the magnet cup 28 while leaving the distal-end wall 30 exposed. A flexible printed circuit can reduce the volume of the circuitry required to operate the integrated-drive pump assembly 10, thereby reducing the size of the pump-driver enclosure 34. A flexible printed circuit can also provide enhanced possibilities for locating circuitry inside the pump-driver enclosure 34 without compromising access to the distal-end wall 30 of the magnet cup 28. For example, a flexible printed circuit, such as the ribbon 50, could be used in combination with the PCB 36 in the manner shown in FIG. 6B. As shown in FIG. 6B, the ribbon 50 can be urged into a substantially cylindrical loop with the PCB 36 (shown in phantom) located above and substantially adjacent the ribbon 50 such that the distal-end wall 30 of the magnet cup 28 is exposed. In other embodiments the printed circuit has characteristics of both a looped ribbon and an annulus.

[0034] Referring to FIG. 7, the PCB 36 can be configured such that certain sensor(s), such as Hall sensors 60, are connected to one face 64a of the PCB 36 while other sensor(s) 42 are connected (via conductors 62) to the opposite face 64b of the PCB. This places the Hall sensors 60 advantageously relative to the side wall 28a of the magnet cup 28 for sensing rotation of the magnet 26, while placing other sensors 42 advantageously relative to the distal-end wall 30 of the magnet cup. Similarly, other electronic components mounted to the PCB 36 need not all be located on one face of the PCB (e.g., face 64b); rather both faces of the PCB can be used for mounting components as conditions and/or size constraints dictate.

[0035] Further with respect to sensor location, one or more sensors 42 can be located on or relative to the distal-end wall 30 of the magnet cup 28 and electrically connected to the PCB 36, as shown in FIG. 4 (see also FIG. 7). In some embodiments, the one or more sensors 42 can also be integrally formed with the distal-end wall 30 of the magnet cup 28 (i.e., a portion of the distal-end wall 30 can be configured to act as, or as a portion of, the sensor 42). As a result, the sensor 42 is not actually wetted by the fluid. However, if the parameter being sensed requires that the sensor(s) 42 be wetted by the fluid (e.g., conductivity sensors, pH sensors, etc.), then the one or more sensors 42 can also be sealingly mounted to the distal-end wall 30. (See, e.g., U.S. patent application Ser. No. 13/151,188, incorporated herein by reference.) In this application, “sealingly mounted” means that the sensor 42 or other element being mounted is held in a position so as to maintain contact with at least a portion of the mounting surface at one or more contact points at which a static seal prevents fluid from passing through or across the surface. The static seal

may take the form of, for example, the surface itself, an o-ring, an absorbent material, an adhesive material, or the like. In this manner, one or more sensors **42** can extend through the distal-end wall **30** of the magnet cup into the pump cavity **25**, where they can be wetted by the fluid, without leakage into the pump-driver enclosure **34**. Similarly, with respect to the location of a fitting **44**, the fitting **44** can be sealingly mounted to the distal-end wall **30** of the magnet cup **28** such that the pump **10** can be configured as a flow-through pump.

[0036] The pump-driver enclosure **34** desirably is cylindrical, with an axial length dimension α and a transverse or radial dimension β , as shown in FIGS. 3A-3B, such that an aspect ratio of the pump-driver enclosure **34** can be defined by the expression $\alpha/2\beta$. Desirably, the aspect ratio of the pump-driver enclosure **34** is as low as practicable to accommodate the necessary driver components and stator while allowing the pump **10** to be incorporated into ever smaller OEM hydraulic systems. As a practical matter, the radial dimension β is limited by the diameter of the driven magnet **26** and by the diameter of the stator **32**, which must surround the driven magnet **26** to cause axial rotation of the magnet. Similarly, the axial length dimension α is limited by the need to accommodate the axial length of the driven magnet **26** and hence the stator **32**, the PCB **36** and other necessary electronic circuitry thereon, the one or more sensors **42** and/or the fitting **44**, and the electrical-connector housing **38**. Thus, the aspect ratio of the enclosure **34** is generally limited to between approximately 0.25 and 1, depending upon the dimensions and orientation of the components that must be accommodated.

[0037] For example, the axial length dimension α can be reduced by configuring the pump-driver enclosure **34** such that the hydraulic fitting **44** extends through a distal-end wall **48** of the pump-driver enclosure **34**, or by configuring the electrical-connector housing **38** with an angular (e.g., right-angular) bend. Desirably, the aspect ratio can be between approximately 0.4 and 0.7, as shown in FIGS. 3A and 3B, respectively. Most desirably, the aspect ratio can be approximately 0.5 or less, as shown in FIGS. 4-5.

[0038] In alternative embodiments the pump-driver enclosure **34** is not cylindrical, but rather has a different shape with sufficient interior volume to accommodate the components necessary to operate the pump assembly. For example, the pump-driver enclosure **34** could be square or rectangular, and could have an aspect ratio defined by the expression α/β , where α is an axial dimension and β is a transverse dimension.

[0039] Although the foregoing embodiments include one or more sensors for sensing pump parameters (such as temperature, pressure, etc.) and/or Hall sensors **60** for sensing rotation of the driven magnet **26**, alternative embodiments need not include such sensors or include any sensors at all. For example, it is possible to use brushless direct current (BLDC) motor controllers wherein the stator is driven by a circuit that does not require Hall sensors. Similarly, depending upon the requirements of the OEM system into which the integrated-drive pump assembly **10** is incorporated, the pump assembly need not include any parameter-sensing. However, in such alternative embodiments, the distal-end wall **30** of the magnet cup **28** remains exposed, thereby preserving the ability to mount sensors on the distal-end wall **30**.

[0040] The range of candidate pump-heads is not limited to gear pumps. Exemplary alternative types of pump-head, without intending to be limiting, are valved or valveless piston pumps. A valveless piston pump is disclosed in, for

example, U.S. Patent Publication No. 2007-0237658, incorporated herein by reference. See particularly FIG. 11 of this reference and accompanying discussion on pages 9-14 thereof.

[0041] Reference is now made to FIG. 8, depicting a portion of a piston pump-head **200**, including a piston **212**, a housing **214**, a liner **216**, an inlet port **228**, and an outlet port **230**. The piston **212** is coupled to a driven magnet (not shown). As the magnet rotates as described above, the piston **212** moves in a reciprocating manner (arrows **222**) in a bore **224** defined in the housing **214**.

[0042] Another aspect of this disclosure pertains to hydraulic circuits comprising a pump such as any of those described above. An embodiment of a circuit **100** is shown in FIG. 9, which includes a pump and pressure sensor **102** having an inlet **104** and an outlet **106**. The pump and pressure sensor **102** can be as denoted by the pump assembly **10** described hereinabove, or any other embodiment. The inlet **104** is situated downstream of a filter **108**, which is situated downstream of a tank **110** serving as a reservoir for liquid to be pumped by the pump **102**. The outlet **106** is hydraulically connected to a downstream injector **112** or other component from which pumped liquid is discharged from the circuit. If desired, the circuit **110** can include a return line **114** for returning liquid to the tank **100** that is not actually discharged from the injector **112**.

[0043] It will be understood that this disclosure is directed not only to pump assemblies including pump head, stator, and pump driver, but also to “pump-driver” assemblies comprising the stator mounted to a PCB to which other electronic components are also mounted. Both types of assemblies represent convenient OEM-supplied products.

[0044] In view of the many possible embodiments to which the principles of the disclosed invention may be applied, one of ordinary skill in the art will recognize that the illustrated embodiments are only preferred examples and should not be taken as limiting the scope of this disclosure. Rather, the spirit and scope of the invention is defined by the following claims.

What is claimed is:

1. A pump assembly, comprising:

a magnetically driven pump-head subassembly and a pump-driver subassembly coupled to the pump-head subassembly, the pump-driver subassembly including a pump-driver enclosure;

the pump-head subassembly comprising a rotatable magnet contained in a magnet cup extending into the pump-driver enclosure;

the pump-driver subassembly comprising a printed circuit board contained in the pump-driver enclosure and a stator mounted to the printed circuit board, the stator coaxially surrounding the magnet cup;

the magnet cup comprising a distal-end wall;

the printed circuit board including a stator-driving circuit, and at least one signal-processing circuit; and
the printed circuit board defining a void that is situated relative to the distal-end wall so as to expose at least half the distal-end wall; and

the pump-driver enclosure having an aspect ratio of no greater than one (unity).

2. The pump assembly of claim 1, wherein the printed circuit board further comprises at least one pump-parameter sensor mounted thereto.

3. The pump assembly of claim 2, wherein the sensor is placed on, aside, or at least partially in the distal-end wall.

4. The pump assembly of claim 1, wherein the printed circuit board is annular in shape, and the void is a central hole of the annular printed circuit board.

5. The pump assembly of claim 1, wherein:
the magnet cup includes a substantially cylindrical side wall; and
the printed circuit board is a flexible printed circuit curved into a cylinder and situated to surround the side wall in a coaxial manner.

6. The pump assembly of claim 1, wherein the movable pumping member comprises a pump gear.

7. The pump assembly of claim 1, wherein the movable pumping member comprises a piston.

8. A pump assembly, comprising:
a pump-head portion including a pump housing defining a pump cavity;

a pump-driver enclosure coupled to the pump-head portion having an axial length and a transverse dimension;
a movable pumping member situated inside the pump cavity;

a driven magnet connected to the pumping member so that induced motion of the driven magnet causes corresponding induced motion of the pumping member;

a magnet cup being a respective portion of the pump cavity and containing the driven magnet so that the induced motion of the driven magnet occurs in the magnet cup as the driven magnet and interior of the magnet cup are being wetted by fluid being pumped by induced motion of the pumping member, the magnet cup including a distal-end wall;

a magnet-driver situated outside the magnet cup but inside the pump-driver enclosure, the magnet driver being magnetically coupled to the driven magnet such that a changing magnetic field produced by the magnet-driver induces motion of the driven magnet and hence of the pumping member in the magnet cup;

a circuit board and at least one sensor being located in the pump-driver enclosure; wherein

the sensor is located on, aside, or at least partially in the distal-end wall; and

the circuit board is electrically connected to the magnet-driver and to the at least one sensor; and

wherein the circuit board comprises a high-current circuit and a low-current circuit, the high-current circuit being connected to and providing controlled electrical power to the magnet-driver, the low-current circuit being connected to and providing controlled electrical power to the at least one sensor; and

the circuit board extends orthogonally to the axial length around the magnet cup while defining a void allowing access through the circuit board to the distal-end wall of the magnet cup.

9. The pump assembly of claim 8, wherein the sensor is sealingly mounted with respect to a wall of the magnet cup such that the sensor is not wetted by the fluid.

10. The pump assembly of claim 8, wherein the pump-driver enclosure is substantially cylindrical in shape, with an axial length and a diameter.

11. The pump assembly of claim 10, wherein the circuit board is substantially annular in shape.

12. The pump assembly of claim 10, wherein the ratio of the axial length of the pump-driver enclosure to the diameter of the pump-driver enclosure is approximately 0.25 to approximately 1.

13. The pump assembly of claim 12, wherein the ratio of the axial length of the pump-driver enclosure to the diameter of the pump-driver enclosure is between approximately 0.4 and 0.7.

14. The pump assembly of claim 10, wherein the ratio of the axial length of the pump-driver enclosure to the diameter of the pump-driver enclosure is approximately 0.5.

15. The pump assembly of claim 8, wherein the circuit board and the distal-end wall of the magnet cup are substantially coplanar.

16. The pump assembly of claim 8, wherein the at least one sensor is sealingly mounted to the distal-end wall of the magnet cup.

17. The pump assembly of claim 8, configured as a flow-through pump.

18. The pump assembly of claim 17, wherein the pump assembly comprises a first fitting mounted to the pump cavity and a second fitting mounted to the distal-end wall of the magnet housing.

19. The pump assembly of claim 18, wherein the first fitting is an outlet fitting, and the second fitting is an inlet fitting.

20. A pump assembly, comprising:

a pump-head portion including a pump housing defining a pump cavity;

a pump-driver enclosure;

a movable pumping member situated inside the pump housing;

a driven magnet connected to the pumping member so that induced motion of the driven magnet causes corresponding induced motion of the pumping member;

a magnet cup being a respective portion of the pump cavity and containing the driven magnet so that the induced motion of the driven magnet occurs in the magnet cup as the driven magnet and interior of the magnet cup are being wetted by fluid being pumped by induced motion of the pumping member, the magnet cup including a distal-end wall;

a magnet-driver situated outside the magnet cup but inside the pump-driver enclosure, the magnet-driver being magnetically coupled to the driven magnet such that a changing magnetic field produced by the magnet-driver induces motion of the driven magnet and hence of the pumping member in the magnet cup;

a fitting mounted to the distal-end wall of the magnet cup; and

a circuit board and at least one sensor being located in the pump-driver enclosure; wherein

the sensor is located on, aside, or at least partially in the distal-end wall;

the circuit board is electrically connected to the magnet-driver and to the at least one sensor;

the circuit board is substantially annular in shape relative to the magnet cup; and

the circuit board defines a central void allowing access to the distal-end wall of the magnet cup.

21. The pump assembly of claim 20, wherein the circuit board allows access to substantially the entire surface area of the distal-end wall of the magnet cup.

22. The pump assembly of claim 20, wherein the circuit board allows access to between approximately 50% and approximately 100% of the surface area of the distal-end wall of the magnet cup.

23. The pump assembly of claim 22, wherein the circuit board allows access to at least approximately 75% of the surface area of the distal-end wall of the magnet housing.

24. The pump assembly of claim 20, configured as a flow-through pump.

25. The pump assembly of claim 24, wherein the pump assembly comprises a first fitting mounted to the pump-head portion and a second fitting mounted to the distal-end wall of the magnet cup.

26. The pump assembly of claim 20, wherein the aspect ratio of the pump-driver enclosure is from about 0.5 to about 1.

27. A pump assembly, comprising:

a pump-head portion comprising a pump housing defining a pump cavity;

a pump-driver enclosure coupled to the pump-head portion and having an axial length and a transverse dimension; a movable pumping member situated inside the pump cavity;

a driven magnet connected to the pumping member so that induced motion of the driven magnet causes corresponding induced motion of the pumping member;

a magnet cup being a respective portion of the pump cavity and containing the driven magnet so that the induced motion of the of the driven magnet occurs in the magnet cup as the driven magnet and the interior of the magnet cup are being wetted by fluid being pumped by induced motion of the pumping member, the magnet cup having a distal-end wall;

a magnet-driver situated outside the magnet cup but inside the pump-driver enclosure, the magnet-driver being magnetically coupled to the driven magnet such that a changing magnetic field produced by the magnet-driver induces motion of the driven magnet and hence of the pumping member in the magnet cup;

an annular circuit board defining a central void;

a first sensor mounted to the distal-end wall and connected to the circuit board;

a second sensor mounted to the circuit board and being situated relative to an outside wall of the magnet cup; and

the distal-end wall of the magnet cup being exposed by the central void of the circuit board.

28. A pump assembly, comprising:

a pump-head portion comprising a pump housing defining a pump cavity;

a pump-driver enclosure coupled to the pump-head portion and having an axial length and a transverse dimension; a movable pumping member situated in the pump cavity;

a driven magnet connected to the pumping member so that induced motion of the driven magnet causes corresponding induced motion of the pumping member;

a magnet cup being a respective portion of the pump cavity and containing the driven magnet so that the induced motion of the of the driven magnet occurs in the magnet

cup as the driven magnet and the interior of the magnet cup are being wetted by fluid being pumped by induced motion of the pumping member, the magnet cup having a distal-end wall;

a magnet-driver situated outside the magnet cup but inside the pump-driver enclosure, the magnet-driver being magnetically coupled to the driven magnet such that a changing magnetic field produced by the magnet-driver induces motion of the driven magnet and hence of the pumping member in the magnet cup; and

a flexible printed circuit electrically connected to the magnet-driver and at least one sensor, the flexible printed circuit and the at least one sensor being located in the pump-driver enclosure; wherein

the sensor is located on, aside, or at least partially in the distal-end wall; and

the flexible printed circuit is urged into an arcuate shape and mounted within the pump-driver enclosure such that the flexible printed circuit at least partially surrounds the magnet cup while leaving the distal-end wall exposed.

29. The pump assembly of claim 28, wherein the pumping member comprises at least one pump gear.

30. The pump assembly of claim 28, wherein the pumping member comprises a piston.

32. A pump-driver assembly for rotatably driving a magnet located in a magnet cup of a pump housing and connected to a pump element located in the pump housing, the assembly comprising:

a printed circuit sized and configured to surround a portion of the magnet cup, the printed circuit defining a central void through which a distal-end face of the magnet cup is exposed, the printed circuit including a high-current circuit and a low-current circuit;

a stator mounted to the high-current circuit on the printed circuit and configured to surround the magnet cup in a coaxial manner whenever the pump-driver assembly is fitted to the pump housing; and

at least one pump-parameter sensor electrically connected to the low-current circuit on the printed circuit, the sensor being positioned relative to the magnet cup to produce pump-parameter data whenever the pump-driver assembly is fitted to the pump housing.

33. The pump-driver assembly of claim 32, wherein the printed circuit comprises a rigid annular board that is situated coaxially with the magnet cup whenever the pump-driver assembly is fitted to the pump housing.

34. The pump-driver assembly of claim 32, wherein the printed circuit is flexibly configured as a strip looped into a cylinder that is coaxial with the magnet cup whenever the pump-driver assembly is fitted to the pump housing.

35. The pump-driver assembly of claim 27, further comprising a housing enclosing the pump-driver assembly.

36. The pump-driver assembly of claim 35, wherein the housing has an aspect ratio of no greater than unity.

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