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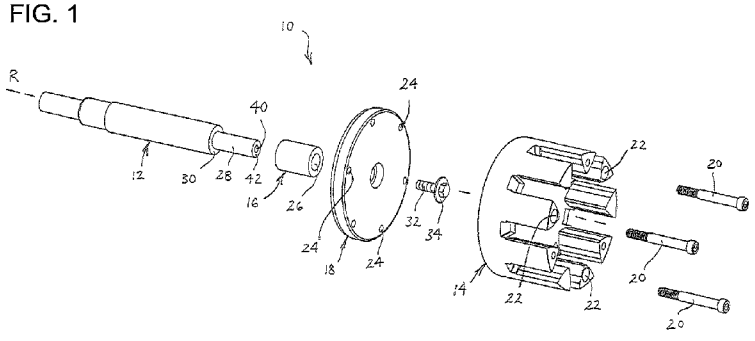
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(54) Title: MODULAR PUMP ROTOR ASSEMBLIES

FIG. 1



(57) Abstract: Modular pump rotor assemblies having a rotatable driving element and a rotor that is removably connected to the driving element by at least one removable fastener are disclosed. The assemblies also have a rotor support bearing that is disposed between the rotatable driving element and the rotor. The assemblies may have a rotatable driving element that is of a type that is dynamically sealed to a pump housing, or a rotatable driving element that is of a type that is statically sealed to a pump housing, such as for use in a magnetically coupled pump or a canned- motor device.

TITLE OF THE INVENTION

MODULAR PUMP ROTOR ASSEMBLIES

Cross-Reference to Related Application

[0001] This application claims priority from U.S. Non-Provisional Patent Application No. 12/987,727, filed on January 10, 2011, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention generally relates to pump rotor and rotatable driving element assemblies, and more particularly to pump rotor assemblies that include a rotor and rotatable driving element that are connected together. The assemblies have two main versions, based on the type of driving element and seal between the housing and the driving element, with the first being dynamically-sealed and the second being statically-sealed, such as with a magnetically coupled or canned-motor version.

Discussion of the Prior Art

[0003] There are a variety of pump assembly designs that include a rotor, otherwise known as a drive pump element, such as for example an impeller, drive gear, drive screw or lobe. It is common for such a rotor or drive pump element to be integrally formed with a rotatable driving element, such as for example a drive shaft, inner magnet or armature of a centrifugal or rotary pump. Such structures may be used in a variety of pumps, such as for example pumps that are in the form of an internal gear, external gear, vane, lobe, circumferential piston, screw pump, or other pump structures.

[0004] The existing pump designs can be classified as being in one of two categories, namely dynamically-sealed or statically-sealed, with the statically-sealed having a driving element that is magnetically driven and being of the magnetically coupled or canned-motor type. In the first category of dynamically-sealed pumps, the pump includes a dynamic shaft seal. These pumps typically have a rotor integrally formed with a rotatable driving element in the form of a drive shaft.

[0005] In the second category, which includes statically-sealed pumps in the form of magnetically-coupled or canned-motor pumps, the pump includes a rotatable driving element that includes an inner magnet assembly or an armature assembly. In some instances, it is desirable to avoid potential seal leakage by not using seals in conjunction with rotating parts. Accordingly, it has become fairly common in the pump arts to employ a magnetic drive system to eliminate the need for seals along rotating surfaces. While such pumps may still employ static seals, because of their lack of dynamic or rotational seals, they have become known as "sealless" pumps.

[0006] The existing designs have inherent disadvantages because the pump rotor, which is a primary wear component, is expensive and difficult to repair, replace or upgrade. With existing designs, the rotor is not accessible while the pump is installed and connected to a piping system, foundational base plate, motor driver, an intermediate driving structure and to other necessary support systems, such as heating, cooling, quench, or flush fluid systems and/or insulation. The existing designs require users to remove the pump from service and bring it to a service facility for cleaning, disassembly and repair. Because this process is time consuming, some users keep spare pumps on hand in an effort to maintain production uptime. This increases inventory costs and requires a complete interim pump installation, with the accompanying connections of all structural and system elements.

[0007] The prior art rotor support bearings, which could be in the form of ball or roller bearings or bushings, which will be collectively referred to herein as rotor support bearings, are another primary wear component. The rotor support bearings also are expensive to repair, replace or upgrade. As with the rotor, the rotor support bearings are not accessible while the pump is in place and connected to the foundational base plate and other system components. Thus, the pump must be removed from service, incurring the same setbacks as when servicing a rotor.

[0008] Another disadvantage of existing designs is that the rotor and rotor support bearings are unique to a given pump type and installation. Thus, if it is desired to change the pumping principle or performance of such a prior art pump, one must remove the entire integral rotatable drive element and rotor to exchange it for a different integral rotatable drive element and rotor. The disassembly also typically involves a complex repair that can include interference press fits, heat shrink fits, special tools or fixtures and welded assemblies. In addition, when repairing, replacing or upgrading the rotor or rotor support bearings on a magnetically-coupled pump, the driving portion that is configured as an inner magnet assembly of a magnetically coupled pump must be separated from the outer magnet assembly. This raises a significant safety issue because separating the magnets of the driving portion from the outer magnet assembly requires overcoming large magnetic forces, which requires very significant decoupling forces applied to separate the magnetic coupling and then difficulty in controlling the driving portion once it is decoupled.

[0009] The present disclosure addresses shortcomings found in prior art integral rotor and drive portion assemblies.

SUMMARY OF THE INVENTION

[00010] The present disclosure generally provides modular pump rotor assemblies having improvements in construction wherein a rotor and a rotatable driving element are removably connected together with removable fasteners. The improvements further include a rotor support bearing that is disposed between the rotor and the rotatable driving element, and that may be held in place by a clamping force between the rotor and the rotatable driving element.

[00011] In a first aspect, a modular pump rotor assembly includes a rotatable driving element and a rotor, with the rotor being removably connected to the rotatable driving element by at least one removable fastener.

[00012] In another aspect, the modular pump rotor assembly may include a rotor support bearing that is disposed between the rotatable driving element and the rotor.

[00013] In a further aspect, the rotatable driving element of the modular pump rotor assembly may include a rotatable shaft.

[00014] In another aspect, the modular pump rotor assembly may include a clamp plate disposed between and connected to the rotatable shaft and the rotor.

[00015] In yet another aspect, the modular pump rotor assembly may include a rotor support bearing disposed between the rotatable shaft and the clamp plate.

[00016] In a further aspect, the rotatable driving element of the modular pump rotor assembly may be constructed to include an inner magnet assembly.

[00017] In a further aspect, the modular pump rotor assembly may include a rotor support bearing disposed between the inner magnet assembly and the rotor.

[00018] In another aspect, the modular pump rotor assembly may be configured to be separately removably connected to at least two rotors having different configurations.

[00019] In a further aspect, the modular pump rotor assembly may include at least one removable fastener that removably connects the rotor to the rotatable driving element and the at least one removable fastener may include a plurality of fasteners that are located in a symmetrical configuration with respect to a rotational axis of the rotor.

[00020] In another aspect, a modular pump rotor assembly for use in a pump having a housing and a seal that engages the housing, may include a rotatable driving element and a rotor, with the rotor being removably connected to the rotatable driving element by at least one removable fastener.

[00021] In another aspect, the modular pump rotor assembly may further include a rotor support bearing disposed between the rotatable driving element and the rotor.

[00022] In a further aspect, the modular pump rotor assembly may be for use in a pump housing having a dynamic shaft seal and the rotatable driving element may include a rotatable shaft that engages the dynamic shaft seal.

[00023] In another aspect, the modular pump rotor assembly for use in a pump may include a clamp plate removably connected to a rotatable shaft by at least one removable fastener, and the rotor may be removably connected to the clamp plate by at least one removable fastener.

[00024] In a further aspect, the modular pump rotor assembly for use in a pump may further include a rotor support bearing that is disposed between the rotatable shaft and the clamp plate.

[00025] In a further aspect, the modular pump rotor assembly for use in a pump may be configured to have the rotor support bearing clamped between the rotatable shaft and the clamp plate when at least one removable fastener that connects the clamp plate to the rotatable shaft is installed.

[00026] In another aspect, the modular pump rotor assembly for use in a pump may be configured to include that the at least one removable fastener that removably connects the rotor to the clamp plate also includes a plurality of removable fasteners that are located in a symmetrical configuration with respect to a rotational axis of the rotor.

[00027] In a further aspect, the modular pump rotor assembly for use in a pump may include a rotatable driving element that is configured to be separately removable connected to at least two rotors that have different configurations.

[00028] In a further aspect, the modular pump rotor assembly is for use in a pump housing that may have a static seal between the pump housing and the rotatable driving element and the rotatable driving element may include a rotatable magnetic driving element that does not engage the static seal.

[00029] In another aspect, the modular rotor assembly is for use in a pump housing that may have the rotor removably connected to the rotatable driving element by at least one removable fastener, and the modular pump rotor assembly may include a rotor support bearing that may be disposed between a rotatable magnetic driving element and the rotor.

[00030] In a further aspect, the rotatable driving element of the modular rotor assembly for use in a pump housing may include an inner magnet assembly that includes magnets.

[00031] In a further aspect, the rotatable driving element of the modular rotor assembly for use in a pump housing may include an inner magnet assembly that includes a sleeve that covers magnets.

[00032] In another aspect, the rotatable inner magnet assembly of the modular driving element of the modular rotor assembly for use in a pump housing may include a magnet mounting portion and a sleeve that covers magnets and is sealed to the magnet mounting portion.

[00033] In further aspect, the sleeve that may cover a rotatable inner magnet assembly of the modular driving element of the modular rotor assembly for use in a pump housing may include indentations that correspond to and bias magnets inward against a magnet mounting portion.

[00034] Thus, the present disclosure presents alternatives to integrally formed rotor and rotatable drive portions that previously were not modular in design and that exhibited the aforementioned disadvantages. The present disclosure provides structures that permit removal of a rotor and/or rotor support bearing from a rotatable drive element without requiring the time and labor-intensive full removal of a pump from a piping system, and in some instances the potentially dangerous conditions such as the need to decouple a magnetic drive element from an outer driven element in a magnetically coupled arrangement.

[00035] It is to be understood that both the foregoing general description and the following detailed description are exemplary and provided for purposes of explanation only, and are not restrictive of the subject matter claimed. Further features and objects of the present disclosure will become more fully apparent in the following description of example embodiments and from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[00036] In describing the preferred examples, reference is made to the accompanying drawing figures wherein like parts have like reference numerals, and wherein:

[00037] FIG. 1 is a perspective exploded view of a first example modular pump rotor assembly for use in a pump having a dynamic seal, where the assembly includes a rotatable driving element and a rotor, and with a rotor support bushing and clamp plate disposed between the rotatable driving element and the rotor.

[00038] FIG. 2 is a cross-sectional view of the first example modular pump rotor assembly of FIG. 1 within a pump housing having a dynamic seal.

[00039] FIG. 3 is a perspective exploded view of a second example modular pump rotor assembly for use in a pump having a static seal, where the assembly includes a driving element and a rotor, with a bearing being disposed between the rotatable driving element and the rotor.

[00040] FIG. 4 is a cross-sectional view of the second example modular pump rotor assembly of FIG. 3 within a pump housing having a static seal.

[00041] FIG. 5 is a perspective exploded view of a third example modular pump rotor assembly for use in a pump housing having a static seal, where the assembly includes a rotatable driving element and a rotor, where the rotatable driving element includes an inner magnetic assembly and a sleeve covering the inner magnetic assembly.

[00042] FIG. 6 is a perspective partially exploded view showing an example of the interchangeability of modular pump rotor assemblies for use in a pump housing having a dynamic seal, a pump having a static seal and a canned-motor pump having a static seal, in conjunction with two different rotors having different configurations.

[00043] It should be understood that the drawings are not to scale. While some mechanical details of dynamically sealed and magnetically driven pumps or canned-motor pumps, including details of fastening means and other plan and section views of the particular components, have been omitted, such details are considered within the comprehension of those skilled in the art in light of the present disclosure. It also should be understood that the present disclosure is not limited to the examples illustrated.

DETAILED DESCRIPTION

[00044] Referring generally to FIGS. 1 and 2, it will be appreciated that a modular rotor assembly 10 is illustrated and it includes a rotatable driving element 12 and a rotor 14 removably

connected to the rotatable driving element 12 by at least one removable fastener. In this example, a rotor support bearing 16 is disposed between the rotatable driving element 12 and the rotor 14. In this example, the rotatable driving element 12 is in the configuration of and may also be referred to as a rotatable shaft. The rotor 14 of this example also may be referred to as an outer gear, such as may be used in an internal gear pump.

[00045] This example further includes a clamp plate 18 that is disposed between the rotatable driving element 12 and the rotor 14. While it will be understood that one or more other connecting elements or fasteners may be used, the clamp plate 18 is shown as being connected to the rotor 14 by removable fasteners 20. The removable fasteners 20 are shown as threaded bolts that are configured to pass through respective bores 22 in the rotor 14 and to engage threaded bores 24 in the clamp plate 18. It will be appreciated that if a plurality of removable fasteners will be used, then using a configuration wherein a corresponding plurality of the threaded bores 24 are located in a symmetrical configuration with respect to a rotational axis R of the rotor 14 will, in turn, allow the removable fasteners 20 to be located in a symmetrical configuration with respect to the rotational axis R of the rotor 14, so as not to cause any rotational imbalance. As shown with respect to the clamp plate 18, there may be additional bores provided to accommodate more connection variations with respect to a given clamp plate. This will be discussed later herein in regard to FIG. 6.

[00046] As seen in the example shown in FIG. 1-2, the rotor support bushing 16 has a central longitudinal bore 26 and is received on the rotatable shaft 12 at a reduced diameter stem 28 that has a shoulder 30 at a transition to a larger diameter of the rotatable shaft 12. The clamp plate 18 is removably connected to the rotatable driving element 12 by at least one removable fastener 32. The removable fastener 32 is shown as a threaded bolt that is configured to be used with a washer 34 and to pass through a stepped central bore 36, 38 in the clamp plate 18 (best

seen in FIG. 2) and to engage a threaded bore 40 in the end 42 of the rotatable driving element 12. Therefore, when the removable fastener 32 is installed to removably connect the clamp plate 18 to the rotatable driving element 12, the rotor support bushing 16 is clamped between the rotatable driving element 12 and the rotor 14 by being disposed between the clamp plate 18 and the shoulder 30 of the rotatable shaft 12.

[00047] As best seen in FIG. 2, the modular rotor assembly 10 of FIG. 1 is configured for use in a pump 50 having a housing 52 and having a dynamic seal 54 that is mounted to the pump housing 52 and engages an outer surface 56 of a central portion 58 of the rotatable shaft 12. The pump housing 52 of the present example includes a first head 59 including bearings 60 that rotatably support the rotatable shaft 12 at a drive end of the shaft, where the rotatable shaft 12 of the pump 50 may be coupled to an external power source (not shown), such as a motor or the like. The bearings 60 may be of any suitable type to provide rotational support, such as ball or roller bearings, fixed sleeve bushings or the like.

[00048] The pump housing 52 also includes a first housing portion 62 that has a first end 64 and a second end 66. The first housing portion 62 is connected at its first end 64 to the first head 59 by conventional means. A centrally located second housing portion 68 has a first end 70 and a second end 72. The second housing portion 68 is connected at its first end 70 to the second end 66 of the first housing portion 62. A third housing portion 74 has a first end 76 and a second end 78. The third housing portion 74 is connected at its first end 76 to the second end 72 of the second housing portion 68 by conventional means. The second end 78 of the third housing portion 74 is connected to a second head 80 by conventional means. The second head 80 includes a bore 82 for a fixed shaft 84 for rotatable support of an inner gear 86. The conventional means by which the various housing components are connected together are not shown and may include, for instance, threaded fasteners, press fits, welding or other suitable

means as would be consistent with the need to connect and seal some of the respective connections, and to be able to disassemble the pump housing 52 at particular connections.

[00049] The structure of the pump 50 and modular rotor assembly 10 permit a user to open the pump housing 52 by removing the second head 80 from the second end 78 of the third housing portion 74. This permits one to gain access to the modular rotor assembly 10 while the pump 50 continues to have the housing 52 mounted to a foundational base plate (not shown) and connected to a piping system (not shown), for example, at a port 88. This then allows one to remove the removable fasteners 20 from the threaded bores 24 in the clamp plate 18 to permit withdrawal of the rotor 14 from the pump 50. The rotor 14 then may be serviced or individually replaced, without having removed the pump 50 from service, without affecting the dynamic seal 52, and virtually without any further disruption to the remaining components of the pump 50.

[00050] One will appreciate that the rotor 14 may otherwise be withdrawn with the clamp plate 18 and removed from the pump 50 by removing the removable fastener 32 from the stepped bores 36, 38 in the clamp plate 18 and from the threaded bore 40 in the end 42 of the rotatable shaft 12. This then also would allow one to remove the rotor support bearing 16 from the stem 28 of the rotatable shaft 12 to be repaired or replaced. To affect such a removal of the rotor support bearing 16, the rotor support bearing 16 may be constructed with threaded bores at its outer end or other means for attaching a pulling instrument (not shown) to the rotor support bearing 16 to grasp and pull the rotor support bearing 16 from the rotatable shaft 12. While servicing the rotor support bearing 16, the rotor 14 also may be separated from the clamp plate 18 and replaced or otherwise serviced, as needed. Reassembly of the removed components merely would require reversal of the particular disassembly steps and tightening or engagement of any respective removable fasteners 20 or 32, such as are shown in this example as threaded bolts.

[00051] One of skill in the art also will appreciate that the pump 50 may be modified by reassembling the pump with a different rotor outer gear and a different inner gear and second head and fixed shaft, as desired. One also may modify the pump upon reassembly to utilize a different pumping principle by replacing the rotor 14 that is in a configuration of an outer gear of an internal gear pump with a different rotor having a different configuration, such as may be used with a sliding vane design, or other pump. This may be done while installing a corresponding, new second head in place of the second head 80 that was used with a fixed shaft 84 and an inner gear 86, or as otherwise desired. Thus, beyond the improvements in serviceability and uptime that would be provided for a pump, one may alternatively utilize the disclosed structures to implement a pump that is easily modifiable to accommodate changes in the pumping means or pumping principle by including a rotatable driving element that is configured to be separately removably connected to at least two rotors having different configurations. This will be better appreciated when viewing FIG. 6, where it will be appreciated that interchangeability may be designed into the respective rotatable driving element and rotor components by virtue of having at least partially common removable fastener connection patterns for the modular pump rotor assembly.

[00052] Turning to FIGS. 3 and 4, another example of a modular pump rotor assembly 110 is illustrated. In this example, the modular pump rotor assembly 110 includes a rotatable driving element 112 and a rotor 114 removably connected to the rotatable driving element 112 by at least one removable fastener. A rotor support bearing 116 is disposed between the rotatable driving element 112 and the rotor 114. Here, the rotatable driving element 112 is in the configuration of and also may be referred to as a rotatable magnetic driving element or a rotatable inner magnet assembly. The rotor 114 of this example also may be referred to as an outer gear, such as may be used in a gear pump.

[00053] The rotatable driving element 112 of this example includes a magnet mounting portion 118 preferably having an end 119, and an outer surface 120 having a plurality of magnet landings 122 for receiving and locating a plurality of magnets 124. When constructed for use in pumping corrosive materials, it is preferable to make the rotatable driving element 112 and rotor 114 of stainless steel, but it is advantageous to include an annular carbon steel portion between the magnet mounting portion 118 and the magnets 124.

[00054] The rotor 114 is shown as being removably connected to the rotatable inner magnet assembly 112 by removable fasteners 126. While it will be understood that one or more other connecting elements or fasteners may be used, the removable fasteners 126 are shown as threaded bolts that are configured to pass through respective bores 128 in the rotor 114 and to engage threaded bores 130 in the end 119 of the rotatable driving element 112. The removable fasteners 126 are located in a symmetrical configuration with respect to a rotational axis R' of the rotor 114. Similarly to the example shown in FIG. 1, it will be appreciated that if a plurality of removable fasteners 126 will be used to removably connect a rotor 114 to a rotatable driving element 112, then using a configuration wherein a corresponding plurality of the threaded bores 130 are located in a symmetrical configuration with respect to a rotational axis R' of the rotor 114 will allow the removable fasteners 126 to be located in a symmetrical configuration with respect to the rotational axis R' of the rotor 114, so as not to cause any rotational imbalance. Also, there may be additional bores provided to accommodate more connection variations with respect to a given rotatable driving element 112. This will be discussed later herein and is illustrated with respect to a rotatable driving element 112" shown in FIG. 6.

[00055] Returning to the example shown in FIGS. 3 and 4, the rotor support bearing 116 of this example includes an annular rim 116' of a larger diameter than the main body 116" of the rotor support bearing 116. The annular rim 116' is disposed between the rotatable driving

element 112 and the rotor 114, in that the annular rim 116' is received by a recess in the rear 117 of the rotor 114, and oppositely rests against the end 119 of the rotatable driving element 112. Thus, when the removable fasteners 126 are installed to removably connect the rotor 114 to the rotatable driving element 112, the rotor support bearing 116 is clamped into place between the rotor 114 and the rotatable driving element 112. Use of the removable fasteners 126 applies a clamping force to positively hold the rotor support bearing 116 in place, such as when, in this example, the removable threaded fasteners 126 are tightened. In turn, one will appreciate that the rotor 114 may be removed from the rotatable driving element 112 by removal of the removable fasteners 126 for service or replacement and that this, in turn, permits removal of the rotor support bearing 116 from the rotatable driving element 112 for service or replacement.

[00056] As best seen in FIG. 4, the modular pump rotor assembly 110 of FIG. 3 is configured for use in a pump 150 having a housing 152 with a static seal 154 used to seal an annular canister 155 at an outer rim 156 to the pump housing 152. The pump housing 152 of this example has a first housing portion 158 that includes bearings 160 that are mounted within the first housing portion 158 near a first end 159 to rotatably support a rotatable shaft 162 of an outer magnet assembly 164. The bearings 160 may be of any suitable type to provide rotational support, such as ball or roller bearings, fixed sleeve bushings or the like. The shaft 162 of the outer magnet assembly 164 may be coupled at a first end 163 to an external power source (not shown), such as a motor or the like. Mounted at a second end 165 of the rotatable shaft 162 of the outer magnetic assembly 164 is a cup-shaped drive member 166. The drive member 166 is connected at a first end 168 to the second end 165 of the rotatable shaft 162 and has a recess 170 at a second end 172.

[00057] Alternatively, the bearings 160 and shaft 162 may be eliminated in favor of mounting the cup-shaped drive member 166 directly on the shaft of an external power source.

Similarly, the drive member 166 and rotatable shaft 162 may be integrally formed as one piece. The drive member 166 may be constructed of a rigid material, such as that which is used in the housing, for instance, steel, stainless steel, cast iron or other metallic materials, or structural plastics or the like. The outer magnet assembly 164 has magnets 174 within the recess 170 where they are connected to the inner walls of the cup-shaped drive member 166. The magnets 174 may be of any configuration, but are preferably rectangular and may be connected to the drive member 166 by any suitable means, such as by chemical means, including by epoxy, adhesives or the like, or mechanically by fasteners, such as by rivets or the like, or by an outer retaining member, such as will be described with respect to the structures shown in FIG. 5.

[00058] Disposed at least partially within the recess 170 of the outer magnet assembly 164 is the canister 155, which generally is in the shape of a bell or a cup having an outer rim 156. The canister 155 may be constructed of any of a variety of rigid materials, and the material is typically chosen based on the medium to be pumped, but is preferably constructed of stainless steel, such as alloy C-276, but also may be constructed of other metals, alloys, plastic, composite materials or the like. The canister 155 is open at one end forming a recess 176 surrounded by the outer rim 156. A second housing portion 180 is connected at a first end 182 to the second end 179 of the first housing portion 158, by conventional means, such as discussed above with respect to the example embodiment in FIG. 2. The outer rim 156 of the canister 155 is mounted with the static seal 154 in sealing engagement to the first end 182 of the second housing portion 180 of the pump housing 152.

[00059] In this example of a magnetically coupled pump 150, when fully assembled, the magnet mounting portion 118, and magnets 124 are disposed within the recess 176 of the canister 155, so as to be separated from the magnets 174 of the outer magnet assembly 164 by the annular canister 155. The rotatable driving element 112 and its magnet mounting portion 118

are arranged to place the respective magnets 174, 124 in substantial magnetic alignment to form a magnetic coupling. This magnetic coupling allows the magnet mounting portion 118 and the rotatable driving element 112 to have no physical contact with but be rotated and thereby driven by rotation of the outer magnet assembly 164.

[00060] A second end 184 of the second housing portion 180 of the pump housing 152 is connected (and understood to be sealed) to a head assembly 186, by conventional means, such as by fasteners 188. In this example pump 150, an offset stationary shaft 190 has a first shaft portion 192 having a first longitudinal axis and a second shaft portion 196 having a second longitudinal axis that is parallel to but spaced from the longitudinal axis of the first shaft portion 192. The first shaft portion 192 is held within a bore 194 in the head assembly 186. The first shaft portion 192 of the offset stationary shaft 190 rotatably supports an inner gear 195 that acts with an outer gear, in the form of the rotor 114, to pump a medium. In this example, the second shaft portion 196 of the offset stationary shaft 190 is held within a bore 198 in a shaft support 200 that is configured as a canister insert that is supported by the canister 155. However, it will be appreciated that other shaft and supporting arrangements are possible.

[00061] The rotatable driving element 112 includes a bore 202 that receives the rotor support bearing 116 for rotatable coupling to the stationary shaft 190. The rotor 114 is connected to the rotatable driving element 112, as discussed above. With this structure of the example pump 150 and the modular pump rotor assembly 110, it will be appreciated that a user may open the pump housing 152 by removing the head 186 from the second end 184 of the second housing portion 180, thereby gaining access to the inner gear 195, the offset shaft 190 and the modular rotor assembly 110. This access is available while the pump 150 continues to have the housing 152 mounted to a foundational base plate (not shown) and connected to a piping system (not shown), for example, at a port 204. The inner gear 195 and/or offset

stationary shaft 190 may be serviced or replaced. This further allows one to remove the removable fasteners 126 from the threaded bores 130 in the rotatable driving element 112 to permit withdrawal of the rotor 114 from the pump 150. The rotor 114 then may be serviced or individually replaced, without having removed the pump 150 from service, without affecting the static seal 154 of the canister 155, and virtually without any further disruption of the remaining components of the pump 150.

[00062] One will appreciate that after removing the head 186, the inner gear 195, offset stationary shaft 190, and rotor 114, the rotor support bearing 116 is accessible for removal from the rotatable driving element 112 to be repaired or replaced. To affect such a removal of the rotor support bearing 116, the rotor support bearing 116 may be constructed with threaded bores at its outer end or other means for attaching a pulling instrument (not shown) to the rotor support bearing 116 to grasp and pull the rotor support bearing 116 from the rotatable driving element 112. Reassembly of the removed components merely would require reversal of the particular disassembly steps and tightening or engagement of any respective removable fasteners 126, such as are shown in this example in the form of threaded bolts.

[00063] One of skill in the art also will appreciate that the pump 150 may be modified by reassembling the pump with a different rotor outer gear and a different inner gear and second head and corresponding fixed shaft, respectively, as desired. One also may modify the pump upon reassembly to utilize a different pumping principle by replacing the rotor that is in a configuration of an outer gear of an internal gear pump with a different rotor having a different configuration, such as may be used with a sliding vane design, or other pump. This may be done while installing a corresponding stationary shaft and/or a new head in place of the head 186, as needed to cooperate with a different stationary shaft and/or inner gear, or as otherwise desired. Thus, beyond the improvements in serviceability and uptime that would be provided for a pump,

one may alternatively utilize the disclosed structures to implement a pump that is easily modifiable to accommodate changes in the pumping means or pumping principle by including a rotatable driving element that is configured to be separately removably connected to at least two rotors having different configurations. As noted above, this will be better appreciated when viewing FIG. 6 which illustrates the interchangeability that may be designed into the respective rotatable driving element and rotor components by virtue of having at least partially common removable fastener connection patterns.

[00064] The rotor 114 may be of various constructions, such as in the form of an outer gear of an internal gear pump. The gear portion of rotor 114 also may be constructed of various rigid materials, depending on the medium to be pumped. For instance, it may be preferable to make the rotor 114, as well as the magnet mounting portion 118 of steel when such a pump is intended for use in pumping non-corrosive materials.

[00065] As noted above, the magnet mounting portion 118 preferably has magnets 124, connected to its outer surface 120 at magnet landings 122. When a pump 150 is made for use in pumping corrosive materials, it is preferable to make the magnet mounting portion 118 of stainless steel, but it is advantageous to include an annular carbon steel portion (not shown) between the magnet mounting portion 118 and the magnets 124. As best seen in the alternative modular pump rotor assembly 110' shown in FIG. 5, a stainless steel sleeve 206 may be mounted over the magnets 124 and annular carbon steel portion for further protection, otherwise having similar components to those of the above-discussed rotatable driving element 112 but yielding a different rotatable driving element 112' in the form of an inner magnet assembly having a respective sleeve 206.

[00066] In the alternative example of a rotatable driving element 112' shown in FIG. 5, the sleeve 206 includes an outer annular wall 208 between a first end 210 and a second end 212.

The sleeve 206 may be sealed to the magnet mounting portion 118 at first end 210 and second end 212. The outer annular wall 208 of the sleeve 206 also may include indentations 214 that correspond to positions of respective magnets 124 and bias the magnets against the magnet mounting portion 118 of the rotatable driving element 112'. In use, such as within a magnetically coupled pump structured like pump 150 shown in FIG. 4, the rotatable driving element 112' with the sleeve 206 is disposed within the canister 155 of the pump 150, although it will be appreciated that the dimensions of the components may need to be adjusted to accommodate the presence of the sleeve 206 while still permitting the magnetic coupling with the outer magnet assembly 164.

[00067] Turning to FIG. 6, the aforementioned potential interchangeability of rotor and rotatable driving element configurations is illustrated via use of a few examples. Thus, one can appreciate the potential combinations between the example rotor types, such as the previously mentioned rotor 114 that includes an outer gear for an internal gear pump design, as well as a rotor 314 generally configured for use in a sliding vane pump design, either of which may be removably connected to any one of several suitable example rotatable driving elements. For instance, FIG. 6 shows a rotatable driving element 12 relating to pumps having a dynamic seal, such as is discussed above with respect to FIGS. 1-2, a rotatable driving element 112" for a magnetically coupled pump assembly, which is similar to the above-described sleeved, rotatable driving element 112', and a rotatable driving element 412 which is configured for use in a canned motor assembly.

[00068] To enhance the interchangeability of the respective components, each of the rotatable driving elements 12, 112" and 412 is shown with a respective symmetrical pattern of six threaded bores 24, 130" and 430, which may be utilized interchangeably with the pattern having three bores 22 in the rotor 114 or with the pattern that will be understood to include six

similarly symmetrically spaced bores 322 of the alternative rotor 314 for pumps having a sliding vane design. These are but a few of what will be understood to be many different rotor and rotatable driving element combinations that may be provided for based on the teachings of the present disclosure.

[00069] It will be appreciated that a modular rotor assembly in accordance with the present disclosure may be provided in various configurations. Any variety of suitable materials of construction, configurations, shapes and sizes for the components and methods of connecting the components may be utilized to meet the particular needs and requirements of an end user. It will be apparent to those skilled in the art that various modifications can be made in the design and construction of such a modular rotor assembly without departing from the scope of the attached claims, and that the claims are not limited to the preferred embodiments illustrated.

What is claimed is:

1. A modular pump rotor assembly comprising a rotatable driving element and a rotor, wherein the rotor is removably connected to the rotatable driving element by at least one removable fastener.

2. The modular pump rotor assembly of claim 1, further comprising a rotor support bearing, wherein the rotor support bearing is disposed between the rotatable driving element and the rotor.

3. The modular pump rotor assembly of claim 1, wherein the rotatable driving element further comprises a rotatable shaft.

4. The modular pump rotor assembly of claim 3, further comprising a clamp plate disposed between and removably connected to the rotatable shaft and the rotor.

5. The modular pump rotor assembly of claim 4, wherein modular pump rotor assembly further comprises a rotor support bearing, and wherein the rotor support bearing is disposed between the rotatable shaft and the clamp plate.

6. The modular pump rotor assembly of claim 1, wherein the rotatable driving element further comprises a rotatable inner magnet assembly.

7. The modular pump rotor assembly of claim 6, wherein the modular pump rotor assembly further comprises a rotor support bearing, and wherein the rotor support bearing is disposed between the rotatable inner magnet assembly and the rotor.

8. The modular pump rotor assembly of claim 1, wherein the rotatable driving element is configured to be separately removably connected to at least two rotors having different configurations.

9. The modular pump rotor assembly of claim 1, wherein the at least one removable fastener that removably connects the rotor to the rotatable driving element further comprises a

plurality of fasteners that are located in a symmetrical configuration with respect to a rotational axis of the rotor.

10. A modular pump rotor assembly for use in a pump having a housing and a seal that engages the housing, the modular pump rotor assembly comprising a rotatable driving element and a rotor, wherein the rotor is removably connected to the rotatable driving element by at least one removable fastener.

11. The modular pump rotor assembly for use in a pump of claim 10, further comprising a rotor support bearing, wherein the rotor support bearing is removably disposed between the rotatable driving element and the rotor.

12. The modular pump rotor assembly for use in a pump of claim 10, wherein the modular pump rotor assembly is for use in a pump housing having a dynamic shaft seal and the rotatable driving element includes a rotatable shaft that engages the dynamic shaft seal.

13. The modular pump rotor assembly for use in a pump of claim 12, wherein the modular pump rotor assembly further comprises a clamp plate removably connected to the rotatable shaft by at least one removable fastener and wherein the rotor is removably connected to the clamp plate by at least one removable fastener.

14. The modular pump rotor assembly for use in a pump of claim 13, further comprising a rotor support bearing, wherein the rotor support bearing is disposed between the rotatable shaft and the clamp plate.

15. The modular pump rotor assembly for use in a pump of claim 14, wherein the rotor support bearing is clamped between the rotatable shaft and the clamp plate when the at least one removable fastener that connects the clamp plate to the rotatable shaft is installed.

16. The modular pump rotor assembly for use in a pump of claim 15, wherein the at least one removable fastener that removably connects the rotor to the clamp plate further

comprises a plurality of removable fasteners that are located in a symmetrical configuration with respect to a rotational axis of the rotor.

17. The modular pump rotor assembly for use in a pump of claim 10, wherein the rotatable driving element is configured to be separately removably connected to at least two rotors having different configurations.

18. The modular pump rotor assembly for use in a pump of claim 10, wherein the modular pump rotor assembly is for use in a pump housing having a static seal between the pump housing and the rotatable driving element of the modular pump rotor assembly and wherein the rotatable driving element includes a rotatable magnetic driving element and the rotatable magnetic driving element does not engage the static seal.

19. The modular pump rotor assembly for use in a pump of claim 18, wherein the rotor is removably connected to the rotatable magnetic driving element by at least one removable fastener, and the modular pump rotor assembly further comprises a rotor support bearing wherein the rotor support bearing is disposed between the rotatable magnetic driving element and the rotor.

20. The modular pump rotor assembly for use in a pump of claim 18 wherein the rotatable magnetic driving element further comprises a rotatable inner magnet assembly that includes magnets.

21. The modular pump rotor assembly for use in a pump of claim 20 wherein the rotatable inner magnet assembly further comprises a sleeve that covers the magnets.

22. The modular pump rotor assembly for use in a pump of claim 21, wherein the rotatable inner magnet assembly further comprises a magnet mounting portion and the sleeve that covers the magnets is sealed to the magnet mounting portion.

23. The modular pump rotor assembly for use in a pump of claim 22, wherein the sleeve further comprises an annular outer wall having indentations that correspond to and bias the magnets inward against the magnet mounting portion.

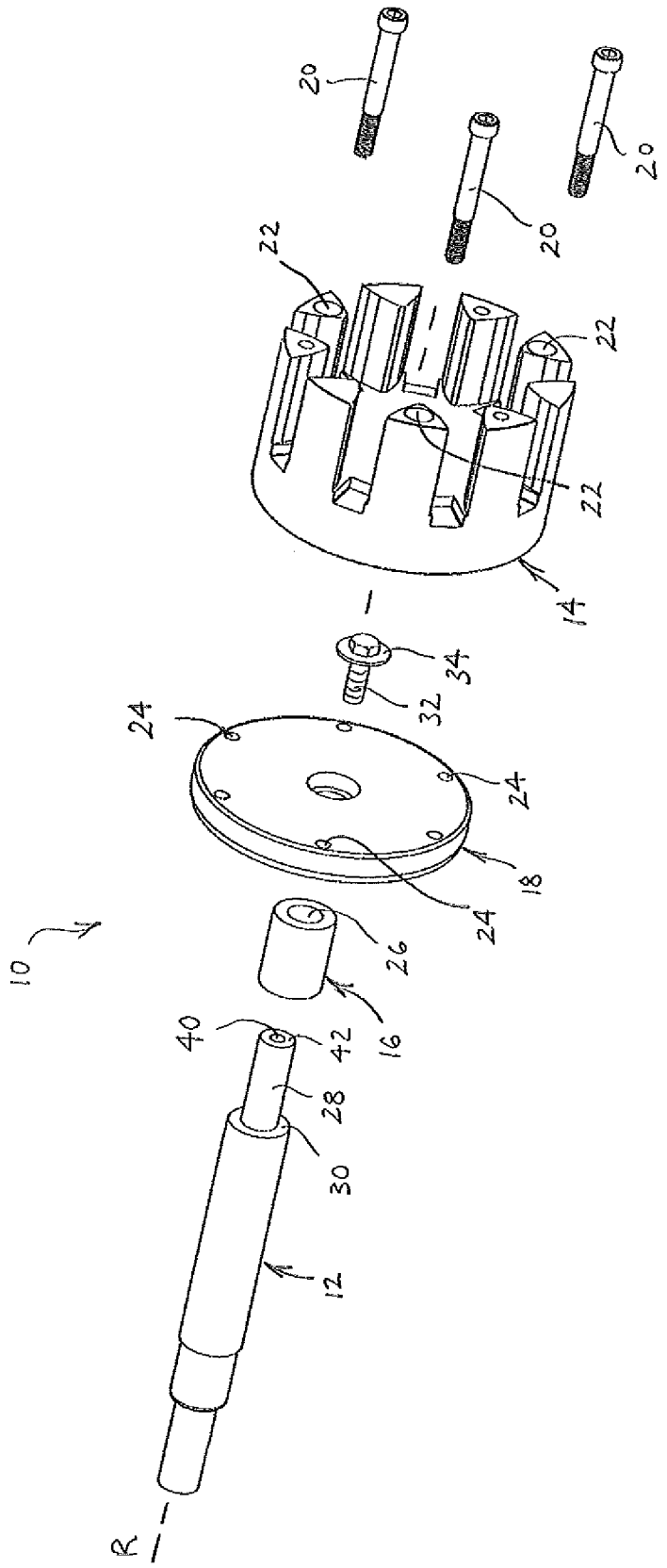


FIG. 1

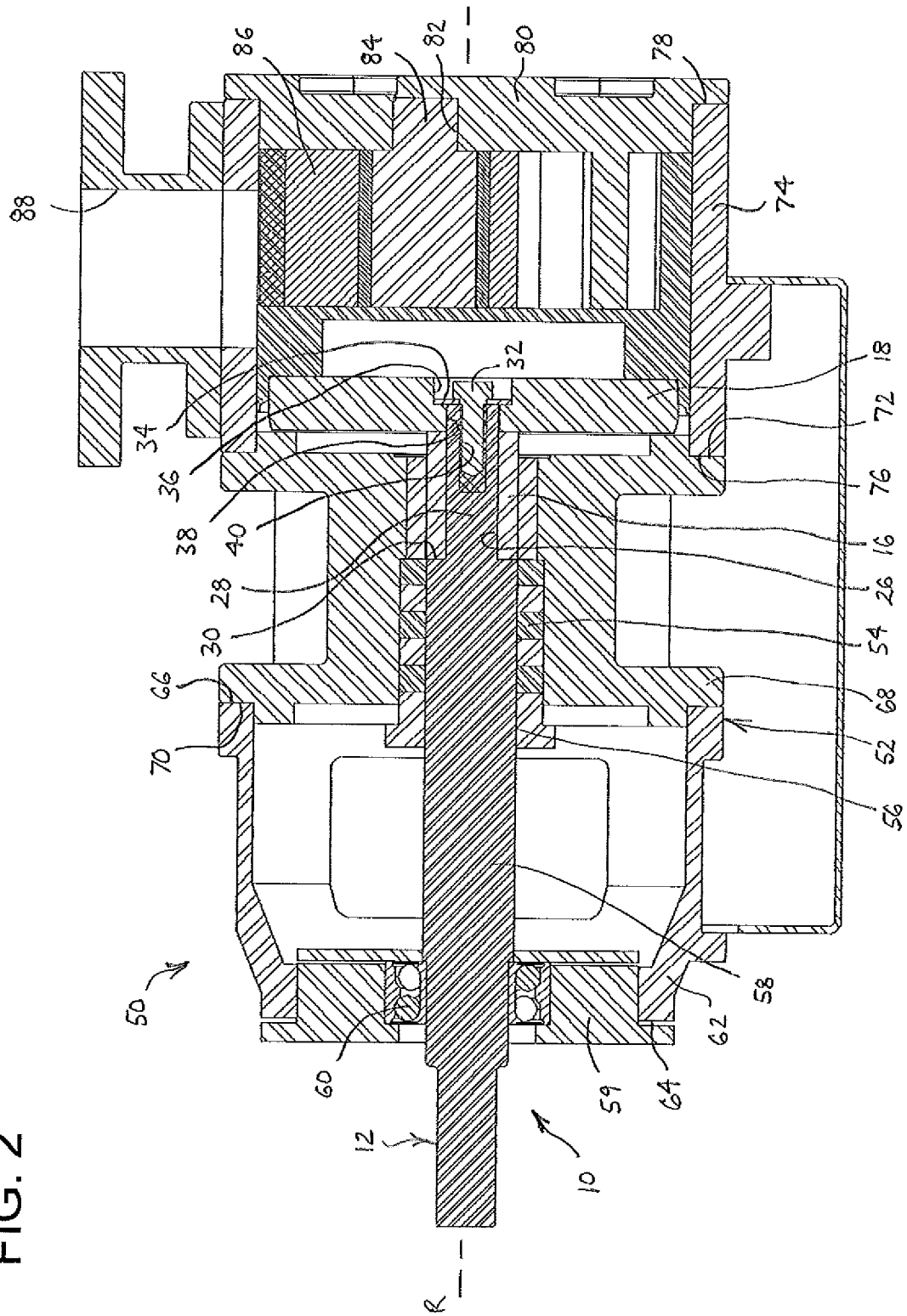
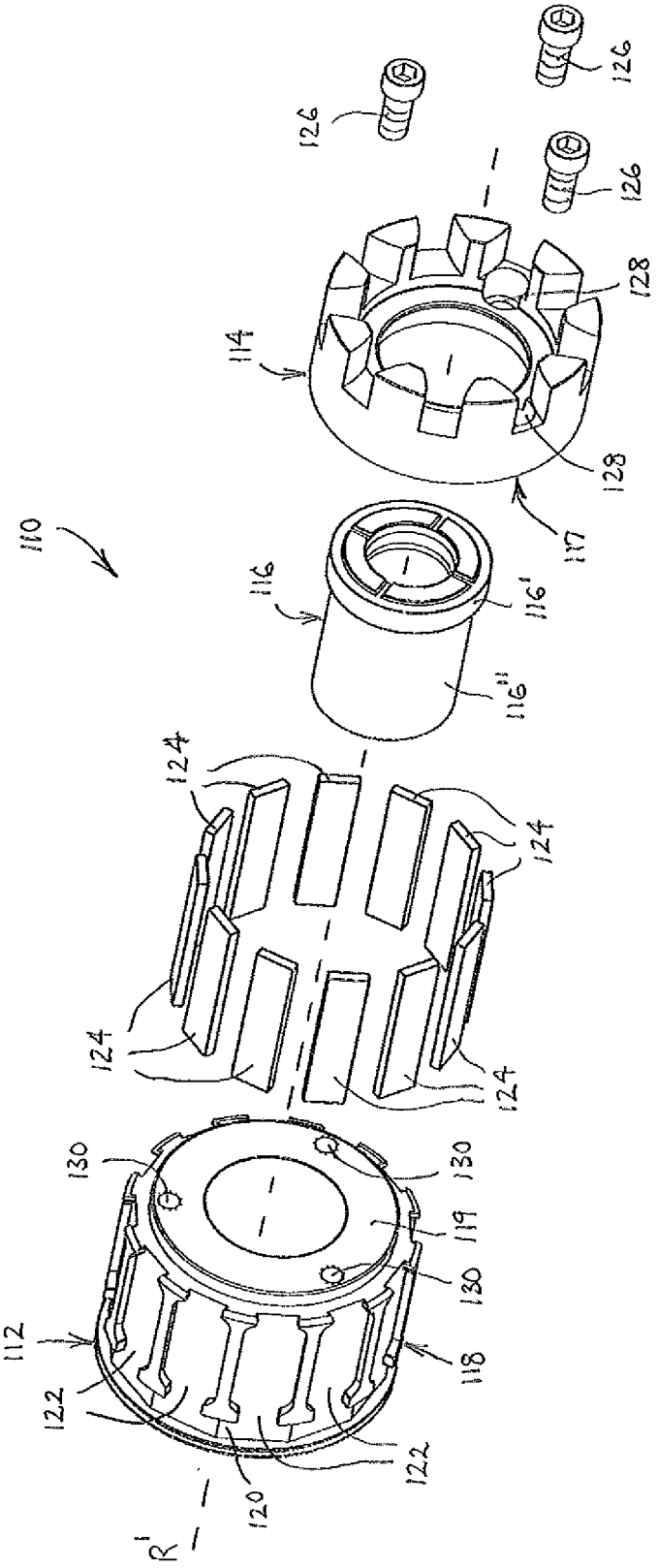

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FIG. 2

FIG. 3



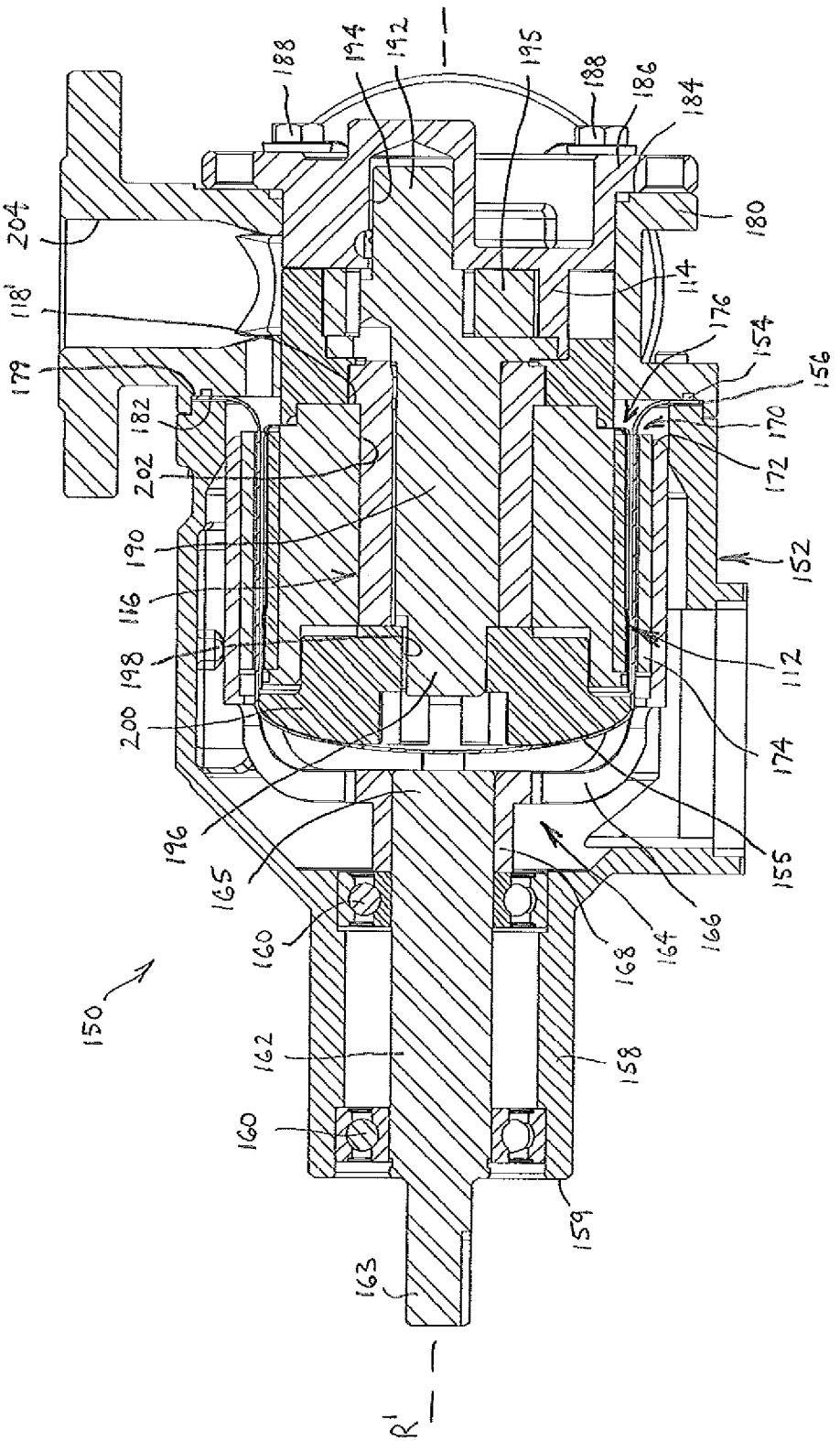
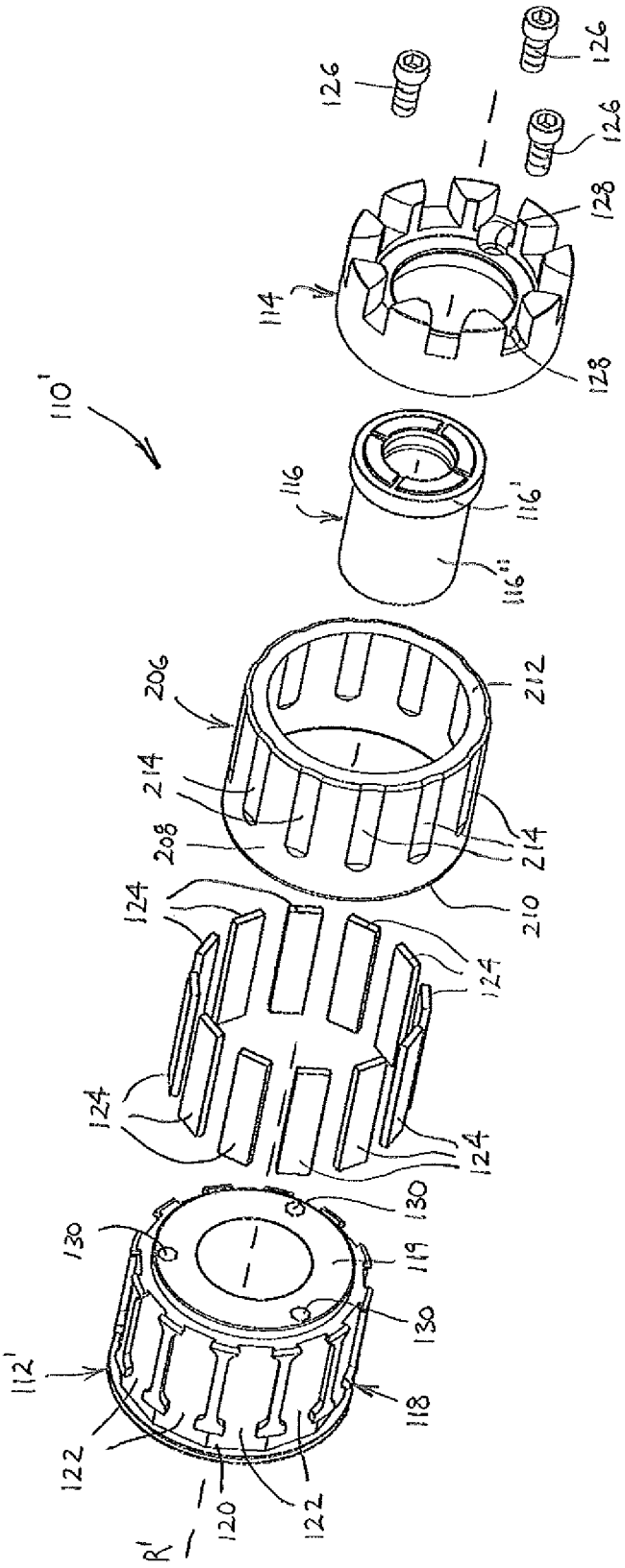

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FIG. 4

FIG. 5


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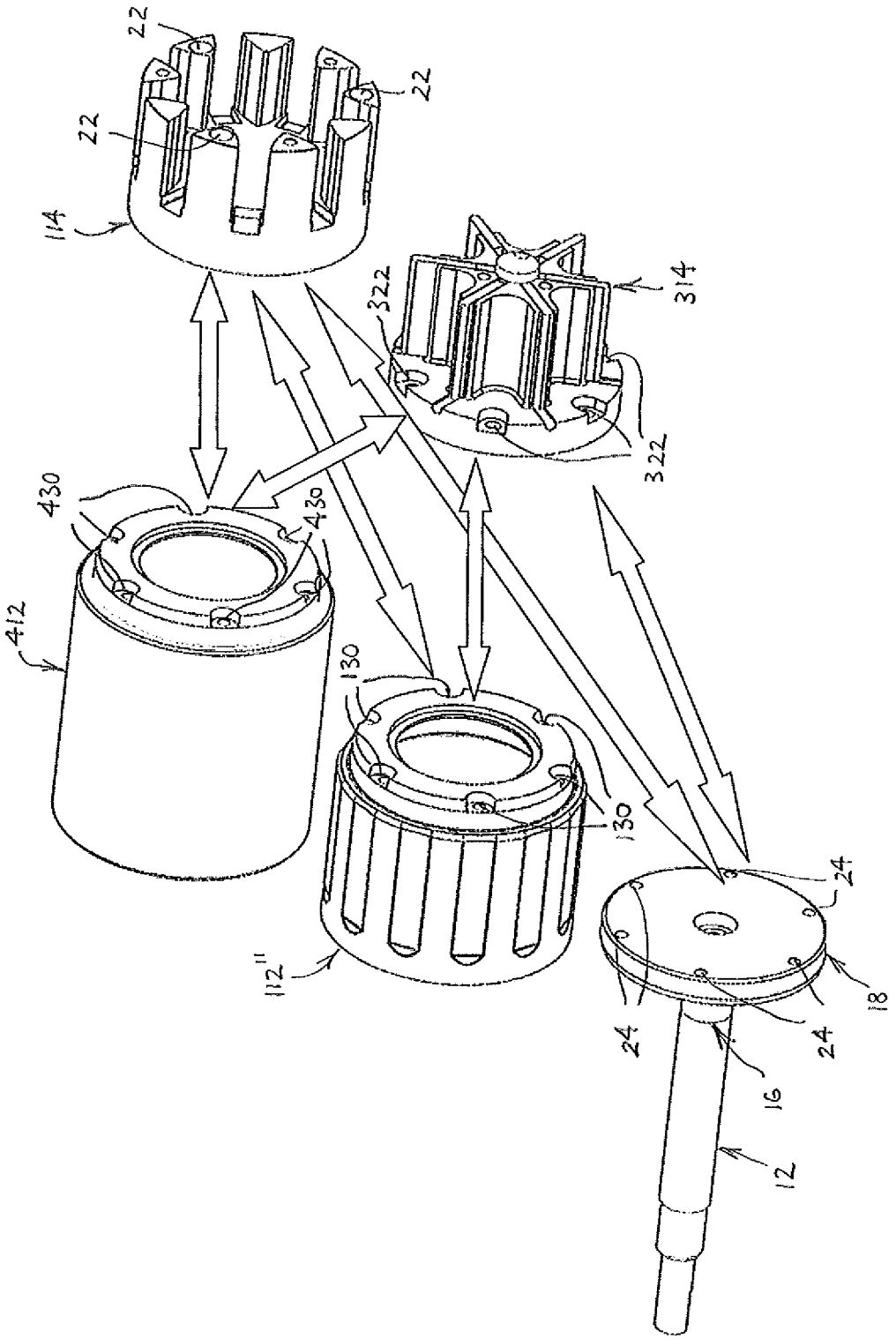


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/065990

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F04B 17/00 (2012.01)
USPC - 417/420
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - F04D 13/00 (2012.01)
USPC - 29/402.08, 889.1; 417/238, 420, 423.12, 423.14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 7,029,246 B2 (MILLER et al) 18 April 2006 (18.04.2006) entire document	1-7, 9-11, 18-20 --- 8, 12-17, 21-23
Y	US 6,607,351 B1 (HABLANIAN) 19 August 2003 (19.08.2003) entire document	8, 17
Y	US 6,352,419 B1 (THOMPSON et al) 05 March 2002 (05.03.2002) entire document	12-16
Y	US 7,183,683 B2 (SHAFER et al) 27 February 2007 (27.02.2007) entire document	21-23
A	US 4,871,301 A (BUSE) 03 October 1989 (03.10.1989) entire document	1-23
A	US 5,322,421 A (HANSEN) 21 June 1994 (21.06.1992) entire document	1-23

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 April 2012	13 APR 2012
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)