(51) International Patent Classification:
F04D 13/12 (2006.01) F04C 11/00 (2006.01)

(21) International Application Number:
PCT/IB20 14/0600 13

(22) International Filing Date:
20 March 2014 (20.03.2014)

(25) Filing Language:
English

(26) Publication Language:
English

(30) Priority Data:
61/803,688 20 March 2013 (20.03.2013) US

(71) Applicant: MAGNA INTERNATIONAL INC.
[CA/CA]; 50 Casmir Court, Concord, Ontario L4K 4J5 (CA).

(72) Inventors:
and

(71) Applicants (for US only): MUIZELAAR, Richard
[CA/CA]; 2693 Jerring Mews, Mississauga, Ontario L5L
2M7 (CA). MILLS, Kyle [CA/CA]; 205-9 Michael Power
Place, Toronto, Ontario M9A 0A5 (CA). HADAR, Gil
[CA/CA]; 30 Oakridge Cres., Guelph, Ontario N1L 1J3
(CA).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HI, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TI, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): A IPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(iii))
— as to the applicant's entitlement to claim the priority of the
earlier application (Rule 4.17(ii))

(54) Title: TANDEM ELECTRIC PUMP

(57) Abstract: A tandem pump with a pump housing that includes a first pump portion with a first pump inlet and first pump outlet. The pump housing further includes a second pump portion having a second pump inlet and a second pump outlet. Within the pump housing is a rotatable common shaft that extends between the first and second pump portions. A first pump chamber that includes a first pump element with a first pump outer rotor surrounding a first pump inner rotor. The first pump inner rotor is connected to a first end of the common shaft. A second pump chamber has a second pump element operationally connected to a second end of the common shaft located opposite the first end of the common shaft. A stator is positioned in the first pump portion of the pump housing and circumscribes the first pump outer rotor.

[Continued on next page]
Published:
— with international search report (Art. 21(3))
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
TANDEM ELECTRIC PUMP

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a PCT International Application and claims benefit of United States Patent Application No. 61/803,688 filed on March 20, 2013.

TECHNICAL FIELD

The present invention relates to a tandem electric pump combing two independent pump chambers within the same housing.

BACKGROUND OF THE INVENTION

Generally, pumps include a stator and rotor. The rotor is in communication with a pump element for moving a fluid. The fluid flows into pump through an inlet when it flows past the pump element and through an outlet in the pump. Generally, the rotor and stator are separated by a magnetic air gap and the rotor and stator include rare earth metals so that magnetic air gap between the rotor and stator may be bridged so that the rotor is rotated during use and so that the rotor, the stator, or both are isolated from the fluids during use and continue to operate. However, the use of rare earth metals may be damaged by the fluid such that the rare earth metals may require additional packaging so that damage is prevented.

It would be attractive to have a pump with a reduced volume and mass so that the pump may fit within a smaller space of a machine such as a vehicle engine. It would be attractive to have a pump that includes fewer components while maintaining motor efficiency, pumping efficiency, and noise, vibration, and harshness characteristics. It would be attractive to have a pump arrangement for dissipating heat. It would be attractive to have a pump that includes a family of standardized components across platform(s).
SUMMARY OF THE INVENTION

A tandem pump with a pump housing that includes a first pump portion with a first pump inlet and first pump outlet. The pump housing further includes a second pump portion having a second pump inlet and a second pump outlet. Within the pump housing is a rotatable common shaft that extends between the first and second pump portions.

The first pump portion has a first pump chamber that includes a first pump element with a first pump outer rotor surrounding a first pump inner rotor. The first pump inner rotor is connected to a first end of the common shaft. A second pump chamber of the second pump portion has a second pump element operationally connected to a second end of the common shaft located opposite the first end of the common shaft.

A stator is positioned in the first pump portion of the pump housing and circumscribes the first pump outer rotor. The stator and the first pump outer rotor are magnetically coupled so that energization of the stator causes the first pump outer rotor to rotate and pump a first fluid through said first pump chamber, between the first pump inlet and the first pump outlet. Rotation of the first pump outer rotor causes rotation of the first pump inner rotor, which is translated to the second pump element through the common shaft. The second pump element rotates causing a second fluid to pump through the second pump chamber between the second pump inlet and the second pump outlet.

Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of a tandem pump in accordance with a first embodiment of the present invention;
Fig. 2 an exploded perspective view of the tandem pump of Fig. 1 in accordance with a first embodiment of the present invention;

Fig. 3 is a cross-sectional side plan view of a tandem pump in accordance with the second embodiment of the present invention;

Fig. 4 is a cross-sectional side plan view of a tandem pump in accordance with a third embodiment of the present invention;

Fig. 5A is a cross-sectional side plan view of a tandem pump in accordance with a fourth embodiment of the present invention;

Fig. 5B is a cross-sectional side plan view of a tandem pump in accordance with a fifth embodiment of the present invention;

Fig. 6 is a cross-sectional side plan view of a tandem pump in accordance with a sixth embodiment of the present invention; and

Fig. 7 is a side perspective view of the tandem pump in accordance with the sixth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

Referring now to Figs. 1 and 2, a first embodiment of the invention is shown which includes a tandem pump 10 that has two electric oil pumps contained within a pump housing 12. Inside the pump housing 12 is a first pump portion 14 having a first pump inlet 16 and first pump outlet 18. A second pump portion 20 has a second pump inlet 22 and second pump outlet 24 disposed through the pump housing 12. In the present embodiment of the invention, the first pump portion 14 of the tandem pump 10 is a main oil pump, while the second pump portion 20 of the tandem pump 10 is a transmission fluid pump. It is within the scope of this invention for the first pump portion 14 and second pump portion 20 to be other types of pumps; examples include a pump that moves oil, air, water, anti-freeze, coolant or a combination thereof.
Additionally, with regard to all other embodiments of the invention described herein, the two pumps can also include the aforementioned various types of applications. In all embodiments of the invention, the first pump portion 14 pumps a first fluid, while the second pump portion 20 pumps a second fluid, that may be same or different from the first fluid. Thus, the tandem pump 10 can be used in place of two separate pumps.

A common shaft 26 is rotatably positioned in the pump housing 12 and extends between first pump portion 14 and second pump portion 20. The first pump portion 14 includes a first pump chamber 28 and has a first pump element 30 that includes a first pump outer rotor 32 surrounding a first pump inner rotor 34. The first pump inner rotor is rotatably connected to a first end of the common shaft 26.

A second pump portion 20 has a second pump chamber 36 that contains a second pump element 38 having components connected to a second end of the common shaft 26. The second pump element 38 includes a second pump outer rotor 40 circumscribing a second pump inner rotor 42.

The tandem pump 10 further includes a stator 44 contained within the pump housing 12. In the present embodiment of the invention, shown in Fig. 1, the stator 44 is located in the first pump portion 14, circumscribes and is magnetically coupled to the first pump outer rotor 32 so that energization of the stator 44 causes the first pump outer rotor 32 to rotate. Rotation of the first pump outer rotor 32 causes the first fluid to pump through the first pump chamber 28 between the first pump inlet 16 and first pump outlet 18. The rotation of the first pump outer rotor 32 about the first pump inner rotor 34 causes the first pump inner rotor 34 to rotate because the first pump inner rotor 34 is in meshed engagement with the first pump outer rotor 32. In the present embodiment of the invention, the first pump outer rotor 32 and first pump inner rotor 34 are gerotor or gears. As the first pump inner rotor 34 rotates, the common shaft 26 will also rotate thereby translating the rotation of the first pump inner rotor 34 through the common shaft 26 to the second pump element 38. More specifically, the rotation of the common shaft 26 causes the second pump inner rotor 42 to rotate which causes the second
pump fluid to pump through the second pump chamber 36 between said
second pump inlet 22 and the second pump outlet 24.

In the present embodiment of the invention, the second pump outer
rotor 40 and second pump inner rotor 42 are also two gears which form a
gerotor type pump. However, it is within the scope of this invention for the
first pump element 30 and second pump element 38 to be another type of
pump element. For example, it is within the scope of this invention for the first
pump element 30 and second pump element 38 to be a vane pump or any
other major pump category including but not limited to a screw pump,
progressing cavity pump, gear pump, roots-type pump, parastolitic pump,
plunger pump, impulse pump and centrifugal pump. It is also within the scope
of this invention for all other embodiments to have pump elements that include
one of the aforementioned specific types of pumps.

With regard to the pump housing 12, it is a single housing, meaning a
single housing containing two pumps that is formed of several pieces
including a first pump portion housing 13, second pump portion housing 15.
The pump housing also has a stator sleeve 17 and divider 21 positioned
between the first pump portion housing 13 and the second pump portion
housing 15. Additionally, the pump housing 12 in accordance with the present
embodiment of the invention further includes an electronics cover 19 that
connects to the second pump portion housing 15.

The tandem pump 10 in accordance with the present invention further
includes a single electronics controller 46 that is connected to the electronics
cover 19 and is mounted to the external side of the first pump portion housing
13. The single electronics controller 46 is in heat sink contact with the
electronics cover 19 in order to remove heat from the single electronics
controller 46. The single electronics controller 46 controls the energization of
the stator 44. The single electronics controller 46 includes one or more
insulated-gate bipolar transistors which is capable of providing a rapid voltage
signal to the stator 46 if required by a particular application. It is within the
scope of this invention for all embodiments of the present invention to include
a single electronics controller 46 which may include one or more insulated
gate bipolar transistors.
Referring now to Fig. 3, a second embodiment of the invention is shown where a tandem pump 10' includes a combination of an oil pump and water pump. Similar or identical reference numerals from Figs. 1 and 2 have been carried forward to Fig. 3 while new or different structures are identified with new reference numerals or using prime numbers. In the present embodiment of the invention, the first pump portion 14 is similar or nearly identical to the first pump portion 14 shown in Fig. 1. The first pump portion 14 includes a first pump chamber 28 with a first pump outer rotor 32 and first pump inner rotor 34 circumscribed by the first pump outer rotor 32. The first pump inner rotor 34 is connected to the common shaft 26 which extends to a second pump portion 20'. The second pump portion 20' has a second pump chamber 36' that is defined by a wet sleeve 48 and volute 50. The volute 50 has a second pump inlet (not shown) and a second pump outlet 24' formed through the volute 50. The second pump chamber 36' is a wet area where a second fluid moves through the second pump chamber 36', therefore the wet sleeve 48 and volute 50 are connected to the pump housing 12' using seals 52 that prevent leakage of the second fluid in the second pump chamber 36.

The present embodiment of the invention also includes a second pump element 38' that includes a magnetic rotor 54 having magnets 56 attached to the magnetic rotor 54. The magnetic rotor 54 is rotatably positioned within the wet sleeve 48 and volute 50.

The second pump element 38 in the present embodiment of the invention also includes a magnetic coupling 58 connected to an end of the common shaft 26, where the magnetic coupling 58 has magnets 59 that circumscribe a portion of the wet sleeve 48 and are magnetically coupled to the magnets 56 on the magnetic rotor 54.

The tandem pump 10' shown in Fig. 3 operates in a manner similar to the tandem pump shown in Fig. 1 in that the stator 44 is energized and causes the rotation of the first pump outer rotor 32 about the first pump inner rotor 34 in order to pump fluid through the first pump portion 14. The rotation of the first pump outer rotor 32 causes the first pump inner rotor 34 to rotate and cause rotation of the common shaft 26. Rotation of the common shaft 26 causes rotation of the magnetic coupling 58 of the second pump portion 20'
through the connection between the magnetic coupling 58 and the common shaft 26. Rotation of the magnetic coupling 58 causes rotation of the magnetic rotor 54 by a magnetic connection through the wet sleeve 48 between magnets 56 and magnets 59. Rotation of the magnetic rotor 54 causes the second fluid to pump through the second pump chamber 36' defined by the wet sleeve 48 and the volute 50 so that the second fluid moves between the second pump inlet (not shown) and the second pump outlet 24'.

The second pump inlet (not shown) cannot be seen in Fig. 3 because it is formed in a portion of the volute 50 that is perpendicular to the plane of the cross-section view shown in Fig. 3. However, Fig. 4 shows a second pump inlet 22' in the volute 50, which is the same type of volute 50 and inlet 22' that is used in the embodiment shown in Fig. 3.

Referring now to Fig. 4, a cross-sectional of a third embodiment of a tandem pump 10" is shown. Similar reference numerals having the same or equivalent structures shown in the previous drawings are carried forward to Fig. 4. Fig. 4 shows an embodiment having the same first pump portion 14 as Figs. 1-3 and the same second pump portion 20' shown in Fig. 3, which is a gerotor pump. The main difference between the tandem pump 10' shown in Fig. 3 and the tandem pump 10" shown in Fig. 4 is that a stator 44' is positioned in an area of the pump housing 12 where the stator 44' circumscribes a magnetic coupling 58' of a second pump element 38". The second pump element 38" includes the magnetic coupling 58' and magnetic rotor 54. The magnetic coupling 58' has magnets 60 connected to the outside surface of the magnetic coupling 58' adjacent the stator 44'. The magnetic coupling 58' also has magnets 59 located on an inside surface of the magnetic coupling 58' which are coupled in a manner similar to Fig. 3. In the present embodiment of the invention shown in Fig. 4, energization of the stator 44' causes the magnetic coupling 58' to rotate, which in turn causes the magnetic rotor 54 of the second pump element 38" to rotate and pump fluid through the second pump chamber 36'. Rotation of the magnetic coupling 58' also causes rotation of the common shaft 26 because the magnetic coupling 58' is connected to the common shaft 26. Rotation of the common shaft 26 causes second pump portion 20' to operate in a slightly different manner than
the operation of second pump portion 20 in Figs. 1-3. In the present embodiment of the invention shown in Fig. 4, the rotation of the common shaft 26 causes an inner rotor 42' of the second pump chamber 36' to rotate which causes fluid to pump through the second pump chamber 36'.

In the embodiment shown in Fig. 4, a single electronics controller 46' is positioned between the first pump chamber 28' and second pump chamber 36'. This eliminates the presence of the electronics cover 19 shown in Figs. 1-2.

Referring now to Fig. 5a and 5b, a fourth and fifth embodiment of the present invention is shown. In the embodiments shown in Figs. 5a and 5b, the tandem pumps provide variable control of the two pump elements of the tandem pump using a single controller.

Fig. 5a shows a variable tandem pump 100 that includes a pump housing 112 containing a first pump portion 114 that is an engine oil pump and a second pump portion 120 that is a transmission oil pump.

The first pump portion 114 has a first pump inlet 116 and a first pump outlet 118. The second pump portion 120 has a second pump inlet (not shown) and a second pump outlet 124.

A first shaft 126 is rotatably positioned in the pump housing 112 in the first pump portion 114 and a second shaft 127 is rotatably positioned in the pump housing 112 and extends into the second pump portion 120. The first pump portion 114 includes a first pump chamber 128 and has a first pump element 130 that includes a first pump outer rotor 132 surrounding a first pump inner rotor 134. The first pump inner rotor is rotatably connected to a first end of the first shaft 126.

The second pump portion 120 has a second pump chamber 136 that contains a second pump element 138 having components connected to a second end of the second shaft 127. The second pump element 138 includes a second pump outer rotor 140 circumscribing a second pump inner rotor 142.

The tandem pump 100 further includes a stator 144 contained within the pump housing 112. The stator 144 has a first coil 146 and a second coil 148. The first coil 146 circumscribes and is magnetically coupled to the first pump outer rotor 132 and the second coil 148 circumscribes and is
magnetically coupled to a magnetic coupling element 150 formed on an end of the second shaft 127. When the first coil 146 is energized the first pump outer rotor 132 will rotate causing fluid to pump through the first pump chamber 130. The first pump outer rotor 132 and second pump inner rotor 134 are gears, which form a gerotor type pump.

When the second coil 148 is energized the magnetic coupling element 150 rotates, which causes the second shaft 127 to rotate. The second shaft 137 is connected to the second pump inner rotor 142, which causes fluid to pump through the second pump chamber 136. The second pump inner rotor 142 and the second pump outer rotor 140 are gears, which form a gerotor type pump.

The tandem pump 100 in accordance with the present invention further includes a single electronics controller 152 that independently controls the energization of the first coil 146 and second coil 148. The single electronics controller 152 includes one or more insulated-gate bipolar transistors which is capable of providing a rapid voltage signal to the stator 144 if required by a particular application. This allows for the first pump portion 114 and second pump portion 120 to be variable in that their output is independent of the other.

Fig. 5b shows a variable tandem pump 200 that includes a pump housing 212 containing a first pump portion 214 that is a water pump and a second pump portion 220 that is a transmission oil pump. However, as indicated above the pump portions are not limited to being a water pump and transmission pump but can be any type of pump for moving a fluid.

The first pump portion 214 has a wet sleeve 248 and a volute 250 that define a first pumping chamber 228. The volute 250 has a first pump inlet 216 and a first pump outlet 218. The first pump portion 214 contains a first pump element 230 that includes a first magnetic rotor 254 connected a first shaft 226, where the first magnetic rotor 254 and first shaft 226 are rotatably positioned in the wet sleeve 28 and extends into the first pump chamber 228 for moving a first fluid through the first pump chamber 228 between the first pump inlet 216 and the second pump outlet 218. The first magnetic rotor 225
has magnets 256 connected to a portion of the surface of the first magnetic rotor 225.

The first pump element 230 also includes first magnetic coupling element 258 that circumscribes and selectively rotates about a portion of the wet sleeve 248 and the magnets 256 of the first magnetic rotor 254, outside of the first pump chamber 228. The first magnetic coupling element 25 has outside magnets 260 on an outside surface and inside magnets 259 on an inside surface, which are magnetically coupled through the wet sleeve 248, to the magnets 256 of the first magnetic rotor 254.

A single stator 244 is positioned in the housing 212 and has a first coil 246 and a second coil 248. The first coil 246 circumscribes the first magnetic coupling element 258 and energization of the first coil 246 acts on the outside magnets 260 of the first magnetic coupling element 258, thereby causing the first magnetic coupling element 258 to rotate about a portion of the first magnetic rotor 254 where the magnets 256 are connected. The inside magnets 259 of the first magnetic coupling element 258 are magnetically through the wet sleeve 248 to the magnets 256 of the first magnetic rotor 254. This causes the first magnetic rotor 254 to rotate when the first coil 246 is energized and the first magnetic coupling 258 rotates. When the first magnetic rotor 254 rotates the first fluid begins pumping through the first pump portion 214.

The second pump portion 220 has a second pump chamber 236 that contains a second pump element 238 having components connected to an end of the second shaft 227. The second pump element 238 includes a second pump outer rotor 240 circumscribing a second pump inner rotor 242.

The second coil 248 of the stator 244 circumscribes and is magnetically coupled to a magnetic coupling element 250 formed on another end of the second shaft 227. When the second coil 248 is energized the magnetic coupling element 250 rotates, which causes the second shaft 227 to rotate. The second shaft 237 is connected to the second pump inner rotor 242, which causes fluid to pump through the second pump chamber 236. The second pump inner rotor 242 and the second pump outer rotor 240 are gears, which form a gerotor type pump.
The tandem pump 200 in accordance with the present invention further includes a single electronics controller 252 that independently controls the energization of the first coil 246 and second coil 248. The single electronics controller 252 includes one or more insulated-gate bipolar transistors which is capable of providing a rapid voltage signal to the stator 244 if required by a particular application. This allows for the first pump portion 214 and second pump portion 220 to be variable in that their output is independent of the other. In the present embodiment of the invention the single electronics controller 252 is positioned adjacent to and in heat sink contact with the wet sleeve 248 so that fluid flowing through the first pump chamber 228 will cool the single electronics controller 252 through the heat sink. It is also within the scope of this invention for the single electronics controller in the other water pump embodiments shown in Figs. 3 and 4 to be in positioned adjacent to and in heat sink contact with the wet sleeve.

Referring now to Figs. 6-7 a sixth embodiment of a tandem pump 300 is shown. The tandem pump 300 has a pump housing 312 defining a first pump portion 314 with a first pump inlet 316 and first pump outlet 318 disposed thought the pump housing 312. The tandem pump 300 also has a second pump portion 320 having a second pump inlet 322 and a second pump outlet 324 disposed through the pump housing 312.

Within the pump housing 312 is a first pump chamber 328 of the first pump portion 314. The first pump chamber 328 is in fluid connection to the first pump inlet 316 and the second pump inlet 318. The first pump portion 314 also includes a first pump element 330 that includes a first pump outer rotor 332 surrounding a first pump inner rotor 334. The first pump inner rotor is connected to a first end of a first shaft 326. The first shaft 326 is rotatably positioned in the pump housing 312.

Within the pump housing 312 is a second pump chamber 336 of said second pump portion 320. The second pump chamber 336 is in fluid connection with the second pump inlet 322 and the second pump outlet 324. The second pump portion 320 includes a second pump element 338 within the second pump chamber 336. The second pump element 338 has a second pump outer rotor 340 circumscribing a second pump inner rotor 342.
The second pump inner rotor 342 is connected to a second shaft 327 and rotatable within the second pump chamber 336.

Between the first pump portion 314 and second pump portion 320 is a single rotor 354 rotatably positioned inside of the pump housing 312. The single rotor 354 connects to the first shaft 326 and the second shaft 327. The single rotor 354 also has a magnetic coil 355 wound on its outside surface. Within the single rotor 354 is a first clutch member 356 coupled between the single rotor 354 and first shaft 326. There is also a second clutch member 358 coupled between the single rotor 354 and the second shaft 327. The first clutch member 356 and the second clutch member 358 are one way clutches with their outer housing mounted to the single rotor 354 and an inner sleeve connected to one of the first shaft 326 or second shaft 327 with a needle bearing positioned between the inner sleeve and outer housing. When the single rotor 354 is rotated in a clutch engaging direction torque from the single rotor 354 will be applied to the first shaft 326 or second shaft 327. When the single rotor 354 is rotated in clutch disengaging direction the first clutch member 356 or second clutch 358 member are disengaged and the first shaft 326 or second shaft 327 will rotate freely and not be driven by the rotation of the single rotor 354. While the present embodiment of the invention has needle bearing clutch members it is within the scope of this invention for virtually any other type of clutch mechanism to be used.

The tandem pump 300 also has a stator 344 with a stator coil 346 circumscribing the magnetic coil 355 of the single rotor 354. The stator coil 346 is energized in one of a first manner or a second manner where energization in said first manner causes the single rotor 354 to rotate in a first direction causing the second clutch element 358 to disengage and the first clutch element 356 to engage. When this occurs the first shaft 326 rotates the first pump member 330. Energization of the stator coil 346 in a second manner causes the single rotor 354 to rotate in a second direction causing the first clutch 356 to disengage and the second clutch 358 to engage and drive the second shaft 327 to rotate the second pump member 338.

The energization of the stator 344 is controlled by a single electronics controller 352 located in the pump housing 312 and is covered by a
removable pump cover 319, where the single electronics controller 352 is connected in contact with the pump cover 319 for better heat conductivity. The single electronics controller 352 also includes one or more insulated-gate bipolar transistors.

The tandem pump 300 of the present embodiment provides an advantage of being able to pump a single fluid over a wide range of flow and pressure requirements by using a single stator and two different sized pumping elements. In particular the tandem pump can use one side of the pump to provide high pressure and low flow based on the small displacement of the pump, while the second side can be used to provide high flow and low pressure under similar motor speeds and resultant torque with a larger displacement pump. It is also within the scope of this embodiment of the invention to be used to pump the same type of fluid or different fluids depending on the needs of a particular application.

The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.
CLAIMS

1. A tandem pump comprising:
   a pump housing defining a first pump portion having a first pump inlet and first pump outlet, a second pump portion having a second pump inlet and a second pump outlet;
   a common shaft rotatably positioned in said pump housing and extending between said first pump portion and said second pump portion;
   a first pump chamber of said first pump portion having a first pump element with a first pump outer rotor surrounding a first pump inner rotor, wherein said first pump inner rotor is connected to a first end of said common shaft;
   a second pump chamber of said second pump portion having a second pump element operationally connected to a second end of the common shaft, opposite the first end of the common shaft; and
   a stator contained in said first pump portion of said pump housing circumscribing said first pump outer rotor, wherein said stator and said first pump outer rotor are magnetically coupled so that energization of said stator causes said first pump outer rotor to rotate and pump a first fluid through said first pump chamber between said first pump inlet and said first pump outlet, and rotation of said first pump outer rotor causes rotation of said first pump inner rotor that is translated to said second pump element through said common shaft, wherein said second pump element rotates causing a second fluid to pump through said second pump chamber between said second pump inlet and said second pump outlet.

2. The tandem pump of claim 1 wherein the second pump element includes a second pump outer rotor surrounding a second pump inner rotor, wherein said second pump inner rotor is connected to a second end of the common shaft, opposite the first end of the common shaft.

3. The tandem pump of claim 1 wherein the second pump chamber further comprises:
said second pump chamber defined by a wet sleeve and volute, wherein said volute is connected to the pump housing and defines a flow path between the second pump inlet and the second pump outlet and the wet sleeve prevents the second fluid from leaving the second pump chamber;

a magnetic rotor connected to the second pump element, wherein the magnetic rotor and the second pump element are rotatably positioned within the second fluid in said second pump chamber;

a magnetic coupling connected to the second end of the common shaft within the pump housing, wherein the magnetic coupling is outside of the second pump chamber and is magnetically coupled to the magnetic rotor through the wet sleeve wherein rotation of the magnetic coupling causes rotation of the magnetic rotor and rotation of the second pump element.

4. The tandem pump of claim 3 further comprising a single electronics controller contained within the pump housing for controlling the energization of the stator, wherein the single electronics controller is in heat sink contact with a dry side of the wet sleeve so that the second fluid pumping though the second pump chamber cools the single electronics controller.

5. The tandem pump of claim 4 wherein the single electronics controller includes one or more insulated-gate bipolar transistors.

6. The tandem pump of claim 1 further comprising a single electronics controller contained within the pump housing for controlling the energization of the stator.

7. The tandem pump of claim 6 wherein the single electronics controller includes one or more insulated-gate bipolar transistors.

8. The tandem pump of claim 7 wherein the pump housing includes a removable pump cover where the single electronics controller is connected in contact with the pump cover for better heat conductivity.
9. The tandem pump of claim 1 wherein the second pump portion is a water pump and the first pump portion is an oil pump.

10. The tandem pump of claim 1 wherein the second pump portion is a transmission oil pump and the first pump portion is an engine oil pump.

11. A tandem pump comprising:

   a pump housing defining a first pump portion having a first pump inlet and first pump outlet, a second pump portion having a second pump inlet and a second pump outlet;

   a first magnetic coupling element connected to a first end of a first shaft and a second end of said first shaft extends into said a first pump chamber of the first pump portion where a first pump element is rotatably connected to a second end of the first shaft;

   the second pump portion includes a second pump chamber defined by a wet sleeve and volute, wherein said volute is connected to the pump housing and defines a flow path between the second pump inlet and the second pump outlet;

   a second magnetic coupling element connected to a second shaft, wherein the second magnetic coupling and the second shaft are rotatably positioned in said wet sleeve;

   a second pump element coupled to an end of the second shaft positioned in said volute, said second pump element is configured to rotate with said second shaft;

   a stator contained in said pump housing having a first coil and a second coil with the first coil circumscribing the first magnetic coupling element of the first pump portion and the second coil circumscribes the second magnetic coupling element, wherein energization of said first coil causes said first shaft to rotate the first pump element and pump a first fluid through said first pump chamber between said first pump inlet and said first pump outlet and energization of said second coil acts on said second magnetic coupling element to cause rotation of said second shaft and rotate said second pump element which causes a second fluid to pump through said
second pump chamber between said second pump inlet and said second pump outlet.

12. The tandem pump of claim 11 further comprising a single electronics controller contained within the pump housing for controlling the energization first coil and second coil independently using the single electronics controller, wherein the single electronics controller is in heat sink contact with a dry side of the wet sleeve so that the second fluid pumping though the second pump chamber cools the single electronics controller.

13. The tandem pump of claim 12 wherein the single electronics controller includes one or more insulated-gate bipolar transistors.

14. The tandem pump of claim 11 wherein the pump housing includes a removable pump cover where the single electronics controller is connected in contact with the pump cover for better heat conductivity.

15. A tandem pump comprising:
   a pump housing defining a first pump portion having a first pump inlet and first pump outlet, a second pump portion having a second pump inlet and a second pump outlet;
   a first pump chamber of said first pump portion having a first pump element having a first pump outer rotor surrounding a first pump inner rotor, wherein said first pump inner rotor is connected to a first end of a first shaft, said first shaft being rotatably positioned in the pump housing;
   a second pump chamber of said second pump portion having a second pump element operationally connected to a first end of a second shaft, said second shaft being rotatably positioned in the pump housing;
   a first magnetic coupling element connected to the first pump outer rotor;
   a second magnetic coupling element coupled at the second end of the second shaft; and
a stator contained in said pump housing having a first coil and a second coil with the first coil circumscribing the first magnetic coupling element of the first pump portion and the second coil circumscribes the second magnetic coupling element, wherein energization of said first coil acts on the first magnetic coupling element to cause said first pump outer rotor to rotate and pump a first fluid through said first pump chamber between said first pump inlet and said first pump outlet and energization of the second coil acts on said second magnetic coupling to cause rotation of said second shaft which rotates said second pump element and causes a second fluid to pump through said second pump chamber between said second pump inlet and said second pump outlet.

16. The tandem pump of claim 15 further comprising a single electronics controller contained within the pump housing for independently energizing the first coil and the second coil.

17. The tandem pump of claim 16 wherein the single electronics controller includes one or more insulated-gate bipolar transistors.

18. The tandem pump of claim 17 wherein the pump housing includes a removable pump cover where the single electronics controller is connected in contact with the pump cover for better heat conductivity.

19. The tandem pump of claim 15 wherein the second pump portion is a transmission oil pump and the first pump portion is an engine oil pump.

20. A tandem pump comprising:

   a pump housing defining a first pump portion having a first pump inlet and first pump outlet, a second pump portion having a second pump inlet and a second pump outlet;

   a first pump chamber of said first pump portion having a first pump element having a first pump outer rotor surrounding a first pump inner rotor,
wherein said first pump inner rotor is connected to a first end of a first shaft, said first shaft being rotatably positioned in the pump housing;

a second pump chamber of said second pump portion having a second pump element operationally connected to a first end of a second shaft, said second shaft being rotatably positioned in the pump housing;

a single rotor rotatably positioned inside of said pump housing connected to the first shaft and the second shaft, said single rotor having a magnetic coil wound on its outside surface

a first clutch member coupled between the single rotor and said first shaft;

a second clutch member coupled between the single rotor and said second shaft; and

a stator contained in said pump housing having a stator coil circumscribing the magnetic coil of the single rotor, wherein said stator coil is energized in one of a first manner or a second manner where energization in said first manner causes the single rotor will rotate in a first direction causing said second clutch element to disengage and said first clutch element to engage and drive the first shaft to rotate the first pump member, and energization of said stator coil in a second manner causes said single rotor to rotate in a second direction causing said first clutch to disengage and said second clutch to engage and drive the second shaft to rotate the second pump member.

21. The tandem pump of claim 20 further comprising a single electronics controller contained within the pump housing for controlling the energization of the stator.

22. The tandem pump of claim 21 wherein the single electronics controller includes one or more insulated-gate bipolar transistors.

23. The tandem pump of claim 21 wherein the pump housing includes a removable pump cover where the single electronics controller is connected in contact with the pump cover for better heat conductivity.
24. The tandem pump of claim 21 wherein the second pump portion is a water pump and the first pump portion is an oil pump.

25. The tandem pump of claim 21 wherein the second pump portion is a transmission oil pump and the first pump portion is an engine oil pump.

26. The tandem pump of claim 21 wherein the first pump element includes a first pump outer rotor surrounding a first pump inner rotor, wherein said first pump inner rotor is connected to the first shaft and rotates with the first shaft to pump fluid through the first pump chamber.

27. The tandem pump of claim 21 wherein the second pump element includes a second pump outer rotor surrounding a second pump inner rotor, wherein said second pump inner rotor is connected to the second shaft and rotates with the second shaft to pump fluid through the second pump chamber.
**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/IB2014/060013  

A.  **CLASSIFICATION OF SUBJECT MATTER**  
IPC: F04D 13/12 (2006.01) .  F04C 11/00 (2006.01)  

According to International Patent Classification (IPC) or to both national classification and IPC  

B.  **FIELDS SEARCHED**  

Minimim documentation searched (classification system followed by classification symbols)  
IPC: F04D 13/12,  F04C 11/00  

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

Electronic database(s) consulted during the international search (name of databases) and, where practicable, search terms used  
Canadian Patent Data Base, Epodoc, Questel Orbit  
Keywords: two, magnet, common, Tandem, volute  

C.  **DOCUMENTS CONSIDERED TO BE RELEVANT**  

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DE 20005017787 U1 (LULIC, F. R.) A translation of the entire document or US 7582997B2</td>
<td>1 to 27</td>
</tr>
<tr>
<td>A</td>
<td>DE 20005013923 U1 (LAUFER, W. et al.) A translation of the entire document or US 8241016 B2</td>
<td>1 to 27</td>
</tr>
<tr>
<td>A</td>
<td>US 5540569 A (ALTHAM, T. J. et al.) The entire document</td>
<td>1 to 27</td>
</tr>
<tr>
<td>A</td>
<td>US 2012/0269653 A1 (LUTOSLAWSKI, J. et al.) The entire document</td>
<td>1 to 27</td>
</tr>
</tbody>
</table>

Other documents are listed in the continuation of Box C.  

Date of the actual completion of the international search  
25 June 2014 (25-06-2014)  
Date of mailing of the international search report  
15 July 2014 (15-07-2014)  

**Name and mailing address of the ISA/CA**  
Canadian Intellectual Property Office  
Place du Portage 1, C1 14 - 1st Floor, Box PCT  
50 Victoria Street  
Gatineau, Quebec K1A 0C9  
Facsimile No.: 001-819-953-2476

Authorized officer  
Malgorzata Samborski (819) 956-0759
### Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)

This international search report has not been established in respect of certain claims under Article 17(2Xa) for the following reasons:

1. Claim Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. Claim Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claim Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The claims are directed to a plurality of inventive concepts as follows:

**Group A - Claims 1 to 10 are directed to a tandem pump comprising: a common shaft, a stator and an outer rotor coupled magnetically with said stator;**

Continuation on page 5

1. ✔ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ✔ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ✔ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos.:

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicants protest and, where applicable, the payment of a protest fee.

- ☐ The additional search fees were accompanied by the applicants protest but the applicable protest fee was not paid within the time limit specified in the invitation.

- ☑ No protest accompanied the payment of additional search fees.
Continuation of: BOX ΙΠ

Group B - Claims 11 to 14 are directed to a tandem pump comprising: a wet sleeve, a volute, a first magnetic coupling element connected to a first shaft and a second magnetic coupling element connected to a second shaft;

Group C - Claims 15 to 19 are directed to a tandem pump comprising: a first magnetic coupling connected to a first outer rotor, a second magnetic coupling element connected to a second shaft, a stator having a first coil and a second coil; and

Group D - Claims 20 to 27 are directed to a tandem pump comprising: a first clutch member and a second clutch member

The claims must be limited to one inventive concept as set out in Rule 13 the PCT.
<table>
<thead>
<tr>
<th>Patent Document</th>
<th>Publication Date</th>
<th>Patent Family Member(s)</th>
<th>Publication Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP2009-293399 A</td>
<td>17 December 2009</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>DE 202005017787 U1</td>
<td>15 November 2005</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>DE 202005013923 U1</td>
<td>3 September 2005</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(30-07-1996)</td>
<td>DE69533829D1</td>
<td>05 January 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE69533829T2</td>
<td>15 December 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP0787260A1</td>
<td>06 August 1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP0787260A4</td>
<td>06 August 1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP0787260B1</td>
<td>01 December 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JPH09507281A</td>
<td>22 July 1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W09525891A1</td>
<td>28 September 1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US5466131A</td>
<td>14 November 1995</td>
</tr>
<tr>
<td></td>
<td>(25-10-2012)</td>
<td>US8714942B2</td>
<td>06 May 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA2766452A1</td>
<td>16 December 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO2010142042A1</td>
<td>16 December 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN102459844A</td>
<td>16 May 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP24407862A1</td>
<td>18 April 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KR20120043735A</td>
<td>04 May 2012</td>
</tr>
</tbody>
</table>