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(54) Title: VANE PUMP ASSEMBLY WITH INTEGRAL MOTOR

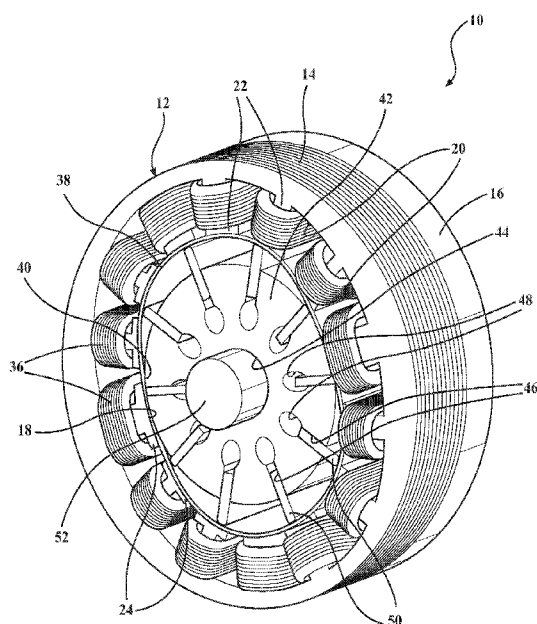


FIG. 3

(57) Abstract: A vane pump assembly (10) includes a housing (12) having at least one fluid inlet (32) and at least one fluid outlet (34) and a plurality of windings (36) disposed in the housing (12). The vane pump assembly (10) also includes a rotor (42) disposed in the housing (12) and rotatable relative to the windings (36), and a plurality of vanes (50) coupled to the rotor (42) and being made of a magnetic material to act as both pump vanes and motor magnet poles such that the rotor (42) acts as both a pump rotor and a motor rotor.

VANE PUMP ASSEMBLY WITH INTEGRAL MOTOR

BACKGROUND OF INVENTION

1. Field of Invention

[0001] The present invention relates generally to vane pumps and, more specifically, to a vane pump assembly with an integral motor.

2. Description of the Related Art

[0002] Traditional electrically driven vane pumps include an electric motor connected axially with the vane pump via a shaft. The electric motor typically powers the shaft or other component which is connected to a rotor of the vane pump. Often times, the package for such a configuration exceeds an available space in an intended environment such as a powertrain of a vehicle.

[0003] While electrically driven vane pumps known in the related art have generally performed well for their intended purpose, there remains a need in the art for a vane pump that combines a motor with the vane pump to fit within the available space in the intended environment.

SUMMARY OF THE INVENTION

[0004] The present invention provides a vane pump assembly including a housing having at least one fluid inlet and at least one fluid outlet and a plurality of windings disposed in the housing. The vane pump assembly also includes a rotor disposed in the housing and rotatable relative to the windings, and a plurality of vanes coupled to the rotor and being made of a magnetic material to act as both pump vanes and motor magnet poles such that the rotor acts as both a pump rotor and a motor rotor.

[0005] One characteristic of the present invention is that the vane pump assembly combines a motor with a vane pump radially without the use of a connective component such as a shaft. Another characteristic of the present invention is that the vane pump assembly yields a compact package with a minimal number of components that fits within a package space that is more compact than a traditional motor pump combination.

[0006] Other objects, features, and advantages of the present invention will be readily appreciated as the same becomes better understood after reading the subsequent description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a perspective view of a vane pump assembly, according to one embodiment of the present invention.

[0008] Figure 2 is an exploded perspective view of the vane pump assembly of Figure 1.

[0009] Figure 3 is an enlarged perspective view of the vane pump assembly of Figures 1 and 2 illustrating one end plate removed.

[0010] Figure 4 is an enlarged perspective view of another embodiment, according to the present invention, of the vane pump assembly of Figures 1-3 illustrating one end plate removed.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Referring now to the figures, where like numerals are used to designate like structure, one embodiment of a vane pump assembly 10, according to the present invention, is used to pump fluid for a powertrain system (not shown) of a vehicle (not shown) such as an automotive vehicle. The vane pump assembly 10 includes a housing, generally indicated at

12. The housing 12 includes a main housing 14 and a pair of end caps 16 disposed at the axial ends of the main housing 14. The main housing 14 is generally cylindrical in shape with a circular cross-section. The main housing 14 extends axially and includes an aperture 18 extending axially therethrough. The main housing 14 also includes a plurality of slots 20 spaced circumferentially and extending axially therethrough. In one embodiment, the slots 20 are generally rectangular in shape. The main housing 14 further includes a first support portion 22 extending axially and radially between a pair of the slots 20 and a second support portion 24 extending axially and circumferentially for each pair of the slots 20. The main housing 14 is made of a metal material. It should be appreciated that the main housing 14 may be integral, unitary, and one-piece.

[0012] Each end cap 16 is generally circular in shape. Each end cap 16 includes a central aperture 26 extending axially therethrough. The central aperture 26 is generally circular in shape. Each end cap 16 includes a groove or recess 28 extending circumferentially thereabout and axially therein to form a central portion 30. The central portion 30 is disposed within the aperture 18 of the main housing 14. Each end cap 16 includes least one fluid inlet 32 and at least one fluid outlet 34 extending circumferentially and axially therethrough. In one embodiment, each end cap 16 includes two fluid inlets 32 and two fluid outlets 34. In one embodiment, the fluid inlets 32 and the fluid outlets 34 extend axially through the central portion 30 and are spaced radially from the central aperture 26 to fluidly communicate with the aperture 18 of the main housing 14. It should be appreciated that fluid flows through the fluid inlets 32 and is pumped out through the fluid outlets 34. It should be appreciated that the groove 28 allows the fluid into the vane pump. It should further be appreciated that the housing 12 acts as both a housing and a stator of a motor.

[0013] The vane pump assembly 10 also includes a plurality of motor windings 36 disposed within the main housing 14 of the housing 12. In one embodiment, fourteen (14)

motor windings 36 are disposed within the main housing 14. Each of the motor windings 36 is generally wound in a closed shape that extends axially. Each of the moto windings 36 are made of wire such as copper wire. The motor windings 36 are wound around the first support portion 22 and disposed in a pair of adjacent slots 20 of the main housing 14. It should be appreciated that the motor windings 36 are connected to a source of electrical power (not shown).

[0014] The vane pump assembly 10 includes a cam 38 disposed in the aperture 18 of the main housing 14 and spaced radially from the motor windings 26. In one embodiment, the cam 38 is formed as a ring having a generally circular shape with a plurality of cam surfaces 40 on an interior thereof. The cam 38 is made of a non-magnetic material such as stainless steel. It should be appreciated that the cam 38 acts as a typical vane pump cam as well as maintaining a consistent or constant gap for magnets to be described.

[0015] The vane pump assembly 10 further includes a rotor 42 disposed within the cam 38. In one embodiment, the rotor 42 is generally cylindrical in shape with a circular cross-section. The rotor 42 extends axially and has a central aperture 44 extending axially therethrough. The rotor 42 has a plurality of slots 46 spaced circumferentially and extending axially therethrough and radially inward. The slots 46 are spaced from the central aperture 44. Each of the slots 46 has an arcuate portion 48 at an inner radial end thereof and extending axially through the rotor 42. The rotor 42 is made of a non-magnetic material. In one embodiment, the rotor 42 may be made as a laminated stack of steel, which is not magnetized. It should be appreciated that the slots 46 are for vanes 50 to be described as a typical vane pump would have.

[0016] The vane pump assembly 10 includes a plurality of vanes 50 cooperating with the rotor 42 and the cam 38. In one embodiment, each of the vanes 50 is generally rectangular in shape. The vanes 50 are disposed in the slots 46 of the rotor 42. The vanes 50

are made of a magnetic material. It should be appreciated that the vanes 50 act as pump vanes as well as motor magnet poles, thus turning the rotor 42 into both a pump rotor as well as a motor rotor.

[0017] The vane pump assembly 10 also includes a rotor shaft 52. In one embodiment, the rotor shaft 52 is generally cylindrical in shape with a circular cross-section. The rotor shaft 52 extends axially and through the central apertures 26 and 44 of the end plates 16 and rotor 42, respectively. The rotor shaft 52 is made of a metal material. In one embodiment the rotor shaft 52 and the rotor 42 may be integral. It should be appreciated that the rotor shaft 52 acts as a bearing surface for the rotor 42. It should also be appreciated that the vane pump assembly 10 includes ancillary components such as bearings (not shown).

[0018] In operation, the vane pump assembly 10 includes an integral motor that operates as a brushless direct current (BLDC) motor. The vanes 50 act as magnets of the rotor 42 and the motor windings 36 are within the housing 12 which act as a stator of the motor. The end caps 16 provide journal bearings for the rotor shaft 52. The vanes 50 also act as pump vanes for a vane style pump and follow the cam surface 40 of the cam 38. It should be appreciated that the cam 38 occupies what would normally be an air gap of a motor.

[0019] As illustrated in Figure 4, in another embodiment, according to the present invention, of the vane pump assembly 10, separate magnets 54 and vanes 50 may be contained within the rotor 42. The magnets 54 are disposed in some of the slots 46 and fixed to the rotor 42 and the vanes 50 are able to move radially within the other slots 46 of the rotor 42 in a traditional manner. In one embodiment, one magnet 54 is disposed in one slot 46 between a pair of the vanes 50. In this embodiment, the motor windings 36 may only be needed at areas where the rotor 42 is near the main housing 14 with a small gap. It should be appreciated that the operation of the vane pump assembly 10 of Figure 4 is similar to the

operation of the vane pump assembly 10 of Figure 1 without departing from the scope of the present invention.

[0020] The vane pump assembly 10 of the present invention combines a vane pump and a motor. The vane pump assembly 10 of the present invention includes an integral motor that yields a compact package with a minimal number of components that fits within a package space that is more compact than a traditional motor pump combination.

[0021] The present invention has been described in an illustrative manner. It is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

[0022] Many modifications and variations of the invention are possible in light of the above teachings. Therefore, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed is:

1. A vane pump assembly (10) comprising:
a housing (12) having at least one fluid inlet (32) and at least one fluid outlet (34);
a plurality of windings (36) disposed in said housing (12);
a rotor (42) disposed in said housing (12) and rotatable relative to said windings (36);
and
a plurality of vanes (50) coupled to said rotor (42) and being made of a magnetic material to act as both pump vanes and motor magnet poles such that said rotor (42) acts as both a pump rotor and a motor rotor.
2. A vane pump assembly (10) as set forth in claim 1 wherein said housing (12) includes a plurality of slots (20) spaced circumferentially therein.
3. A vane pump assembly (10) as set forth in claim 2 wherein said windings (36) are wound around said slots (20) in said housing (12).
4. A vane pump assembly (10) as set forth in any one of claims 1-3 including a cam (38) disposed between said housing (12) and said rotor (42) to maintain a constant gap.
5. A vane pump assembly (10) as set forth in claim 4 wherein said cam (38) is made of a non-magnetic material.
6. A vane pump assembly (10) as set forth in any one of claims 1-3 wherein said housing (12) includes a main housing (14) extending axially and an end cap (16) at each axial

end of said main housing (14), said end cap (16) having at least one of said at least one fluid inlet (32) and said at least one fluid outlet (34).

7. A vane pump assembly (10) as set forth in claim 6 wherein said rotor (42) includes a plurality of slots (46) spaced circumferentially thereabout.

8. A vane pump assembly (10) as set forth in claim 7 wherein said vanes (50) are disposed in said slots (46) and movable in said slots (46) relative to said rotor (42).

9. A vane pump assembly (10) as set forth in any one of claims 7 and 8 including a plurality of magnets (54) disposed in said slots (46) and fixed relative to said rotor (42).

10. A vane pump assembly (10) as set forth in any one of claims 1-9 including a shaft (52) disposed in said housing (12) and coupled to said rotor (42).

11. A vane pump assembly (10) comprising:
a housing (12) having at least one fluid inlet (32) and at least one fluid outlet (34),
said housing (12) including a plurality of first slots (20) spaced circumferentially therein;
a plurality of windings (36) wound around said first slots (20) in said housing (12);
a rotor (42) having a plurality of second slots (46) disposed circumferentially thereabout disposed in said housing (12) and rotatable relative to said windings (36);
a cam (38) disposed between said housing (12) and said rotor (42) to maintain a constant gap; and
a plurality of vanes (50) disposed in said second slots (46) of said rotor (42) and being made of a magnetic material to act as both pump vanes and motor magnet poles such that said rotor (42) acts as both a pump rotor and a motor rotor.

12. A vane pump assembly (10) as set forth in claim 11, wherein said vanes (50) are movable radially in said second slots (46) relative to said rotor (42).

13. A vane pump assembly (10) as set forth in claim 11, including a plurality of magnets (54) disposed in said second slots (46) and fixed relative to said rotor (42).

14. A vane pump assembly (10) as set forth in any one of claims 11-14, wherein said cam (38) is made of a non-magnetic material.

15. A vane pump assembly (10) comprising:

a housing (12) including a main housing (14) extending axially and an end cap (16) at each axial end of said main housing (14), said end cap (16) having at least one fluid inlet (32) and at least one fluid outlet (34), said main housing (14) including a plurality of first slots (20) spaced circumferentially therein;

a plurality of windings (36) wound around said first slots (20) in said main housing (14);

a rotor (42) having a plurality of second slots (46) disposed circumferentially thereabout and disposed in said main housing (14) and rotatable relative to said windings (36);

a cam (38) disposed between said main housing (14) and said rotor (42) to maintain a constant gap;

a plurality of vanes (50) disposed in said second slots (46) of said rotor (42) and being made of a magnetic material to act as both pump vanes and motor magnet poles such that said rotor (42) acts as both a pump rotor and a motor rotor; and

a shaft (52) disposed in said housing (12) and coupled to said rotor (42).

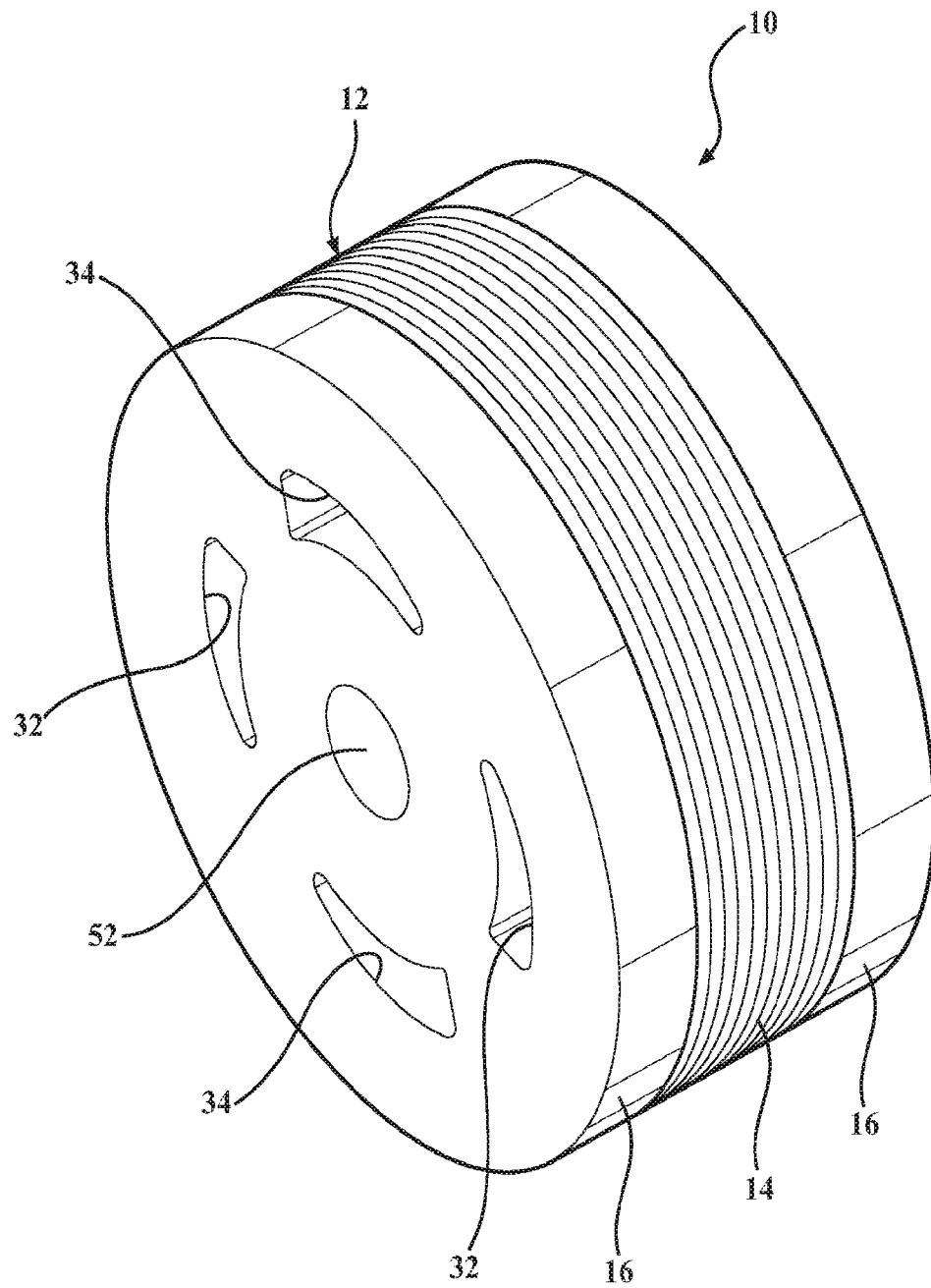


FIG. 1

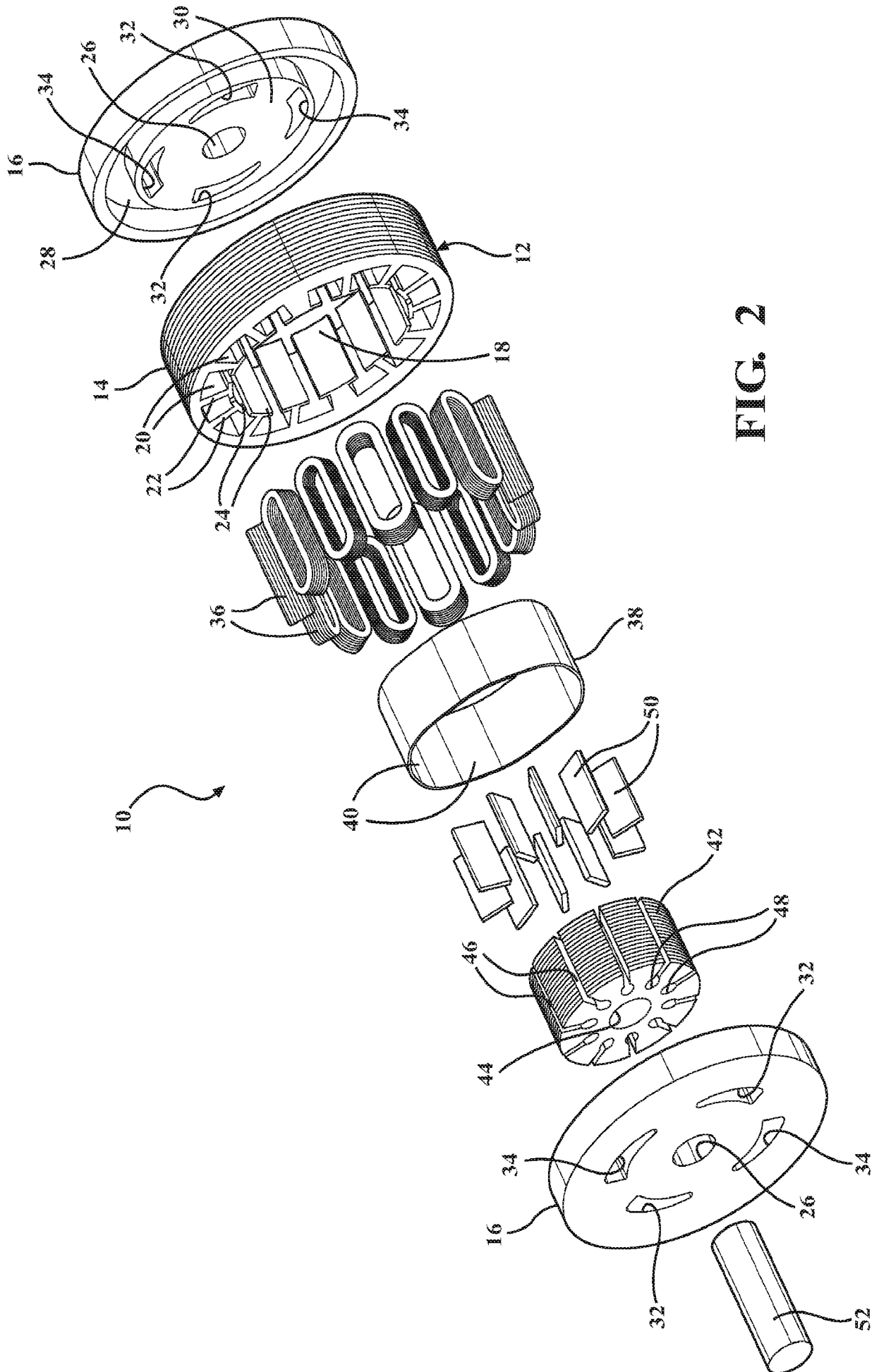


FIG. 2

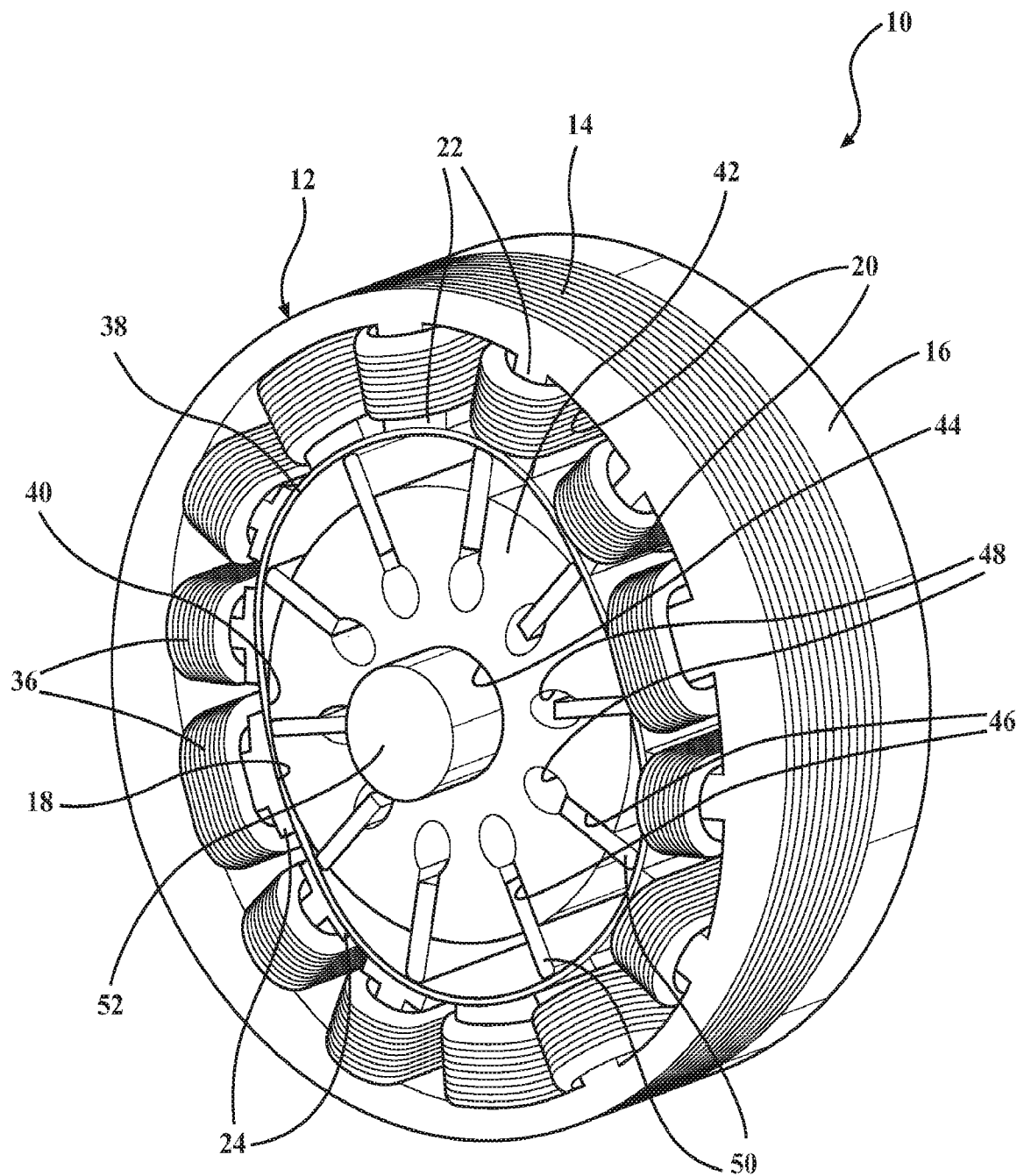


FIG. 3

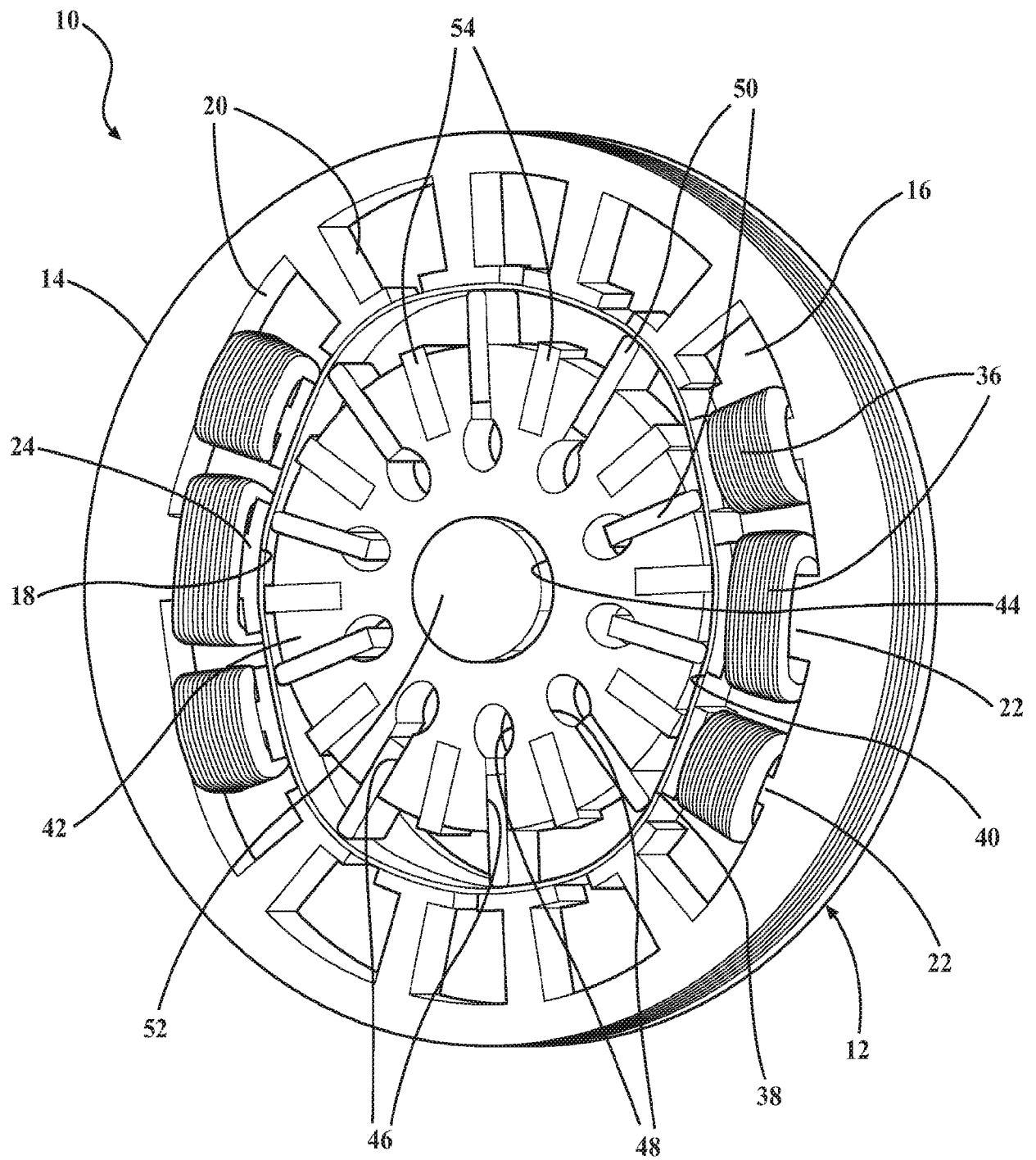


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/026316**A. CLASSIFICATION OF SUBJECT MATTER****F01C 21/08(2006.01)i, F04C 14/22(2006.01)i, F04C 2/344(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
F01C 21/08; F04B 35/04; F04C 2/356; F04C 2/344; F04B 17/03; F04C 15/00; F04C 14/22Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: vane, pump, inlet, outlet, winding, rotor, motor, magnet, slot, winding, housing, pole**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010-0047088 A1 (MARTIN, JERRY L.) 25 February 2010 See paragraphs [0015]-[0029]; and figures 1-2.	1-15
Y	JP 2011-117391 A (KYB CO., LTD.) 16 June 2011 See paragraph [0034]; and figure 2.	1-15
Y	JP 2000-104669 A (TOYODA MACHINE WORKS LTD.) 11 April 2000 See abstract, claim 1; and figures 1, 3.	1-15
A	US 2013-0183171 A1 (RICHSTONE LIMITED et al.) 18 July 2013 See paragraphs [0034]-[0041]; and figures 1-8.	1-15
A	US 2012-0051955 A1 (HADAR, GIL) 01 March 2012 See paragraphs [0024]-[0033]; and figures 1-3.	1-15
A	US 2015-0204327 A1 (CLARCOR ENGINE MOBILE SOLUTIONS, LLC.) 23 July 2015 See paragraphs [0024]-[0031]; and figures 1-4.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/026316

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0047088 A1	25/02/2010	None	
JP 2011-117391 A	16/06/2011	JP 5479869 B2	23/04/2014
JP 2000-104669 A	11/04/2000	None	
US 2013-0183171 A1	18/07/2013	CN 103233891 A CN 103233891 B DE 102012023000 A1 GB 2497840 A GB 2497840 B JP 2013-130132 A JP 5643923 B2 KR 10-1517483 B1 KR 10-2013-0073015 A US 8784084 B2	07/08/2013 28/10/2015 27/06/2013 26/06/2013 24/09/2014 04/07/2013 24/12/2014 07/05/2015 02/07/2013 22/07/2014
US 2012-0051955 A1	01/03/2012	CA 2753510 A1 CA 2753510 C CN 102333955 A CN 102333955 B DE 10745775 T1 DE 10745775 T8 EP 2401503 A1 EP 2401503 A4 JP 2012-518745 A JP 5523481 B2 KR 10-1701530 B1 KR 10-2011-0122178 A US 9163630 B2 WO 2010-096924 A1	02/09/2010 30/05/2017 25/01/2012 13/08/2014 06/12/2012 25/04/2013 04/01/2012 30/03/2016 16/08/2012 18/06/2014 01/02/2017 09/11/2011 20/10/2015 02/09/2010
US 2015-0204327 A1	23/07/2015	EP 2888483 A1 EP 2888483 A4 WO 2014-031400 A1	01/07/2015 17/08/2016 27/02/2014