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(54) Title: ELECTRIC MOTOR

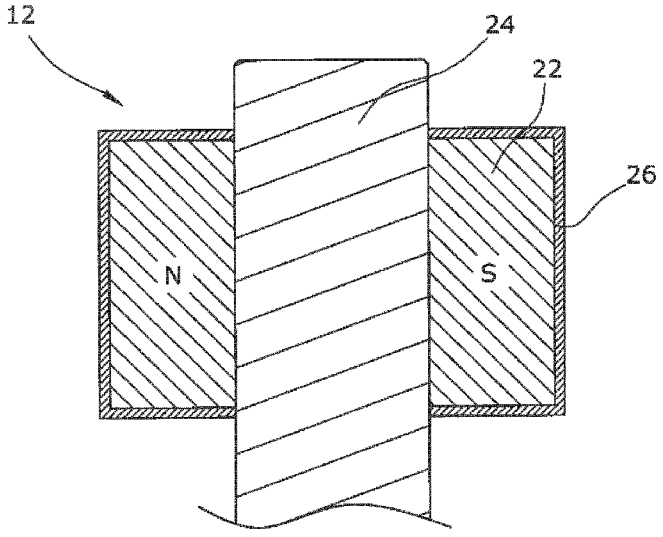

Fig.2

(57) Abstract: Electric motor (10) for a motor vehicle, comprising a permanently magnetized motor rotor (12) with a monolithic rotor body (22) being directly fixed to a rotor shaft (24), and a motor stator (14) with a stator body (16) and at least one stator coil (18) being electrically energized to provide a stator magnetic field for driving the motor rotor (12), wherein the monolithic rotor body (22) is only made of a sintered material.

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Electric motor

The invention is directed to an electric motor for a motor vehicle, preferably to an electric motor for a motor vehicle auxiliary unit.

Electric motors are provided with a rotatable motor rotor and with a static motor stator. Preferably, the motor rotor is provided permanently magnetized and the motor stator is provided electromagnetically magnetized so that no wear-prone sliding contacts are required for energizing the electromagnetic motor stator. The motor stator of this brushless electric motor comprises a stator body with at least one stator coil being electrically energized to provide a stator magnetic field for driving the motor rotor.

The permanently magnetized motor rotor can be provided with a monolithic rotor body made of a permanently magnetized resin bonded material, i.e. a permanent magnetic powder being embedded in a resin. The monolithic rotor body is typically directly fixed to a rotor shaft, which allows a compact realization of the motor rotor and, as a result, of the electric motor. However, the resin bonded material allows only a relatively low magnetic power density so that the electric motor can provide only a low mechanical performance.

Alternatively, the permanently magnetized motor rotor can be provided with permanent magnets, for example made of a sintered material, which are embedded into a preferably laminated rotor body. Sintered materials such as, for example, rare-earth containing alloys allow a significantly higher magnetic power density compared to resin bonded materials. As result, the motor rotor with sintered magnets being embedded into the

laminated rotor body allows a high-performance electric motor. However, the multi-piece motor rotor is relatively large.

It is an object of the invention to provide a compact and high-performance electric motor for a motor vehicle.

This object is achieved with an electric motor with the features of claim 1.

The electric motor according to the invention is provided with a permanently magnetized motor rotor defined by a permanently magnetized monolithic rotor body. The monolithic rotor body is directly fixed to a rotor shaft, i.e. the motor rotor is not provided with any supplemental magnet support body. In particular, the motor rotor does not comprise a laminated rotor core. This allows a very compact realization of the motor rotor and, as a result, of the electric motor. Preferably, the monolithic rotor body is directly cast or sintered onto the rotor shaft. This allows a very strong and reliable fixation of the rotor body at the rotor shaft.

The electric motor according to the invention is also provided with a motor stator with a stator body and at least one stator coil. The stator coil is electrically energized to provide a stator magnetic field for driving the motor rotor. The ferromagnetic stator body can be provided as laminated stator body to minimize eddy currents within the motor stator and, as a result, to allow a high motor efficiency and a high motor power.

According to the invention, the monolithic rotor body of the motor rotor is only made of a sintered material. The sintered material can be, for example, a rare-earth containing alloy such as NdFeB. The sintered material can be directly cast onto the rotor body and can be easily permanently magnetized. The sintered material allows a high magnetic power density and, as a result, a high mechanical motor performance of

the electric motor. As a result, the motor rotor with the monolithic rotor body made of a sintered material allows a compact and high-power electric motor.

Preferably, the monolithic rotor body is a permanently and diametrically magnetized ring magnet with two magnetic poles. The sintered material can be easily manufactured anisotropic to define exactly two diametrical magnetic poles. Since the motor rotor has an annular shape and is diametrically magnetized, the rotating motor rotor generates a substantially sinusoidal local magnetic field profile, which is detectable at a suitable static sensor position. This allows a very exact detection of the rotor position so that the electric motor can be controlled very accurately and reliably.

In a preferred embodiment of the invention, the monolithic rotor body is coated with a corrosion protection film to avoid a corrosion of the motor rotor even if the motor rotor is in contact with a corrosive fluid. The monolithic rotor body can be, for example, coated with a nickel alloy such as Ni-Cu-Ni.

The electric motor according to the invention can be provided to drive an automotive liquid pump, wherein the motor rotor is in fluidic contact with a pump liquid, i.e. the motor rotor is not fluidically sealed against the pump liquid. The sintered monolithic rotor body according to the invention allows a very compact automotive fluid pump which can provide a high pump output pressure.

An embodiment of the invention is described with reference to the enclosed drawings, wherein

figure 1 shows a simplified illustration of an automotive liquid pump with an electric motor according to the invention, and

figure 2 shows a schematic sectional view of a motor rotor of the electric motor of figure 1.

Figure 1 shows an automotive liquid pump 8 with a brushless electric motor 10, wherein a motor rotor 12 of the electric motor 10 is co-rotatably connected with a pump wheel PW for driving the liquid pump 8. The motor rotor 12 is in fluidic contact with a pump liquid being pumped by the liquid pump 8. The motor rotor 12 is fluidically separated from a motor stator 14 by a separating can 15.

The motor stator 14 comprises a ferromagnetic stator body 16 and a single stator coil 18 which is arranged satellite-like. The stator coil 18 is electrically connected with a motor electronics 20 for energizing the stator coil 18 for driving the motor rotor 12.

The motor rotor 12 comprises a monolithic rotor body 22 being fixed at a rotor shaft 24. The monolithic rotor body 22 is made of a sintered material and is permanently magnetized. In the present embodiment of the invention the monolithic rotor body 22 is a ring magnet made of NdFeB which is permanently and diametrically magnetized to define exactly two permanent magnetic poles N,S. The monolithic rotor body 22 is directly cast onto the rotor shaft 24 so that the monolithic rotor body 22 is directly fixed to the rotor shaft 24. In the present embodiment of the invention, the monolithic rotor body 22 is coated with a corrosion protection film 26 made of a nickel alloy.

Reference list

8	automotive liquid pump
10	electric motor
12	motor rotor
14	motor stator
15	separating can
16	stator body
18	stator coil
20	motor electronics
22	monolithic rotor body
24	rotor shaft
26	corrosion protection film
PW	pump wheel

CLAIMS

1. Electric motor (10) for a motor vehicle, comprising
a permanently magnetized motor rotor (12) with a monolithic rotor body (22) being directly fixed to a rotor shaft (24), and
a motor stator (14) with a stator body (16) and at least one stator coil (18) being electrically energized to provide a stator magnetic field for driving the motor rotor (12),
wherein the monolithic rotor body (22) is only made of a sintered material.

2. Electric motor according (10) to claim 1, wherein the monolithic rotor body (22) is a permanently and diametrically magnetized ring magnet with two magnetic poles (N,S).

3. Electric motor according (10) to any preceding claim, wherein the monolithic rotor body (22) is coated with a corrosion protection film (26).

4. Automotive liquid pump (8) with an electric motor (10) according to any preceding claim, wherein the motor rotor (12) is in fluidic contact with a pump liquid.

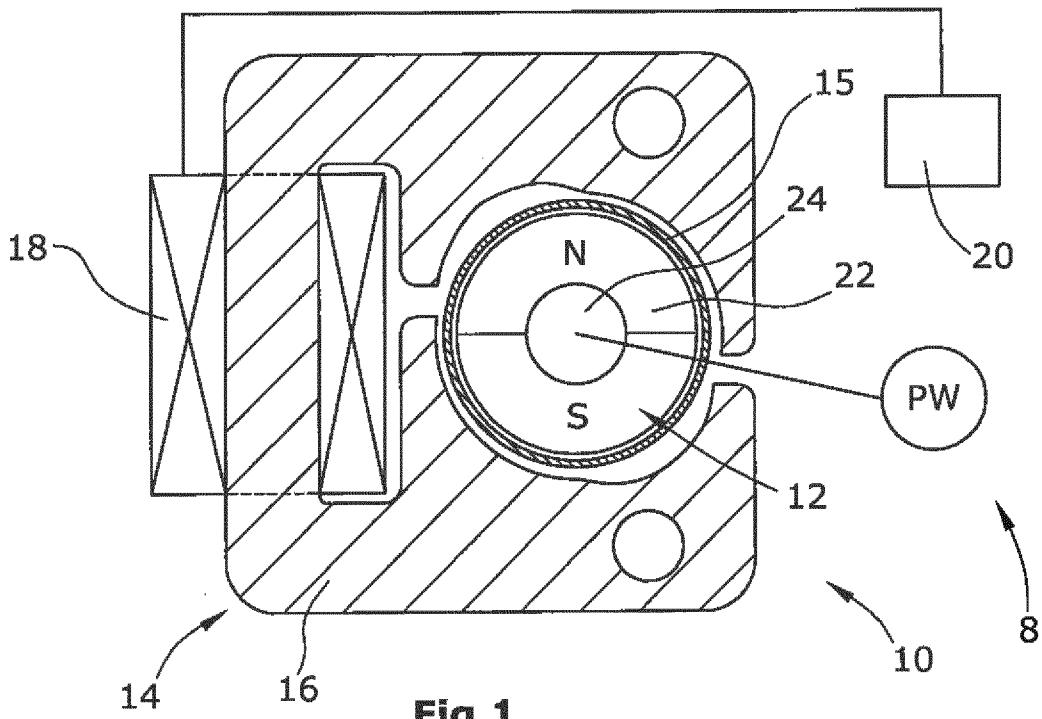

Fig.1

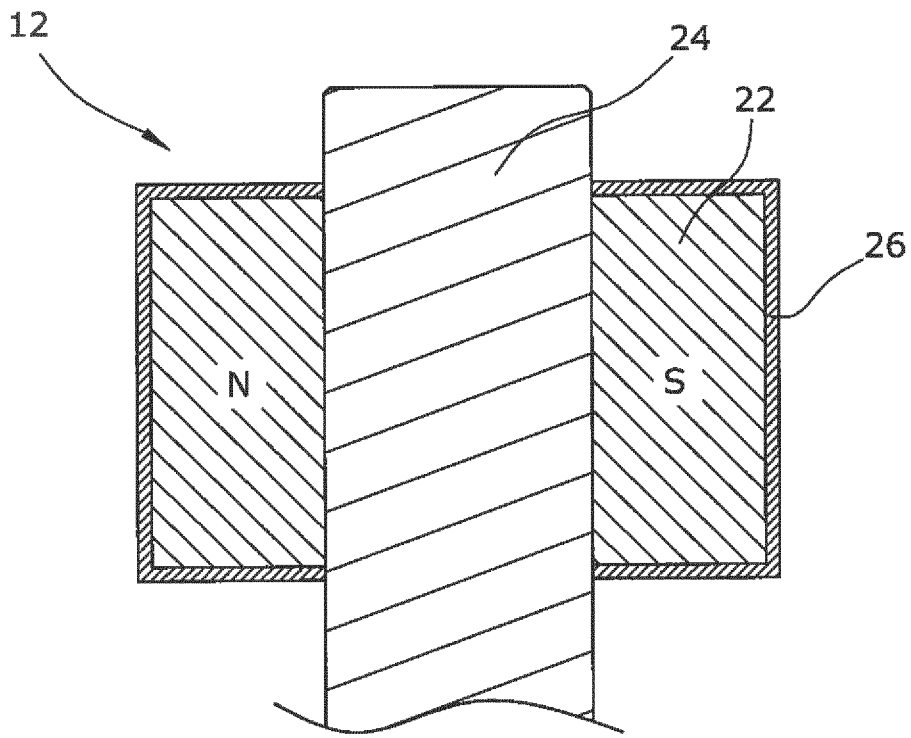

Fig.2

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
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ADD.

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)
H02K

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)
EPO-Internal, WPI Data

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 4 948 999 A (BERTRAM LEO [DE] ET AL) 14 August 1990 (1990-08-14) column 3, lines 11-66; figures 1, 2	1,2 3,4
X	DE 41 11 411 A1 (PAPST MOTOREN GMBH & CO KG [DE]) 15 October 1992 (1992-10-15) column 2, line 64 - column 3, line 3	1
X	US 3 858 308 A (PETERSON A DUANE) 7 January 1975 (1975-01-07) column 2, lines 6-15	1
X	US 2009/001826 A1 (SUZUKI YUZURU [JP] ET AL) 1 January 2009 (2009-01-01) paragraphs [0005], [0051]	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 611 679 A (GHOSH SYAMAL K [US] ET AL) 18 March 1997 (1997-03-18) column 1, lines 34-38	3
A	US 2017/305676 A1 (RAMEZANI KAMRAN [US]) 26 October 2017 (2017-10-26) paragraph [0061]	3
Y	WO 2015/131948 A1 (PIERBURG PUMP TECHNOLOGY GMBH [DE]) 11 September 2015 (2015-09-11) page 1, lines 18-24	4

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/065162

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4948999 A	14-08-1990	AT 373743 B	10-02-1984
		AU 550417 B2	20-03-1986
		CA 1169462 A	19-06-1984
		CH 663299 A5	30-11-1987
		DE 3215376 A1	09-12-1982
		ES 8304380 A1	16-02-1983
		FR 2506534 A1	26-11-1982
		GB 2099234 A	01-12-1982
		HK 2486 A	24-01-1986
		IT 1151760 B	24-12-1986
		JP H02103770 U	17-08-1990
		JP S57199463 A	07-12-1982
		KR 890000029 B1	06-03-1989
		SE 454636 B	16-05-1988
		US 4948999 A	14-08-1990
DE 4111411 A1	15-10-1992	NONE	
US 3858308 A	07-01-1975	CA 1020323 A	08-11-1977
		US 3858308 A	07-01-1975
US 2009001826 A1	01-01-2009	JP 2009011019 A	15-01-2009
		US 2009001826 A1	01-01-2009
US 5611679 A	18-03-1997	NONE	
US 2017305676 A1	26-10-2017	DE 202017102415 U1	07-07-2017
		US 2017305676 A1	26-10-2017
WO 2015131948 A1	11-09-2015	CN 106062372 A	26-10-2016
		EP 3114351 A1	11-01-2017
		JP 6306734 B2	04-04-2018
		JP 2017510744 A	13-04-2017
		US 2017067469 A1	09-03-2017
		WO 2015131948 A1	11-09-2015