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(71) Applicant: **Power Packer North America, Inc.**
Westfield WI 53964 (US)

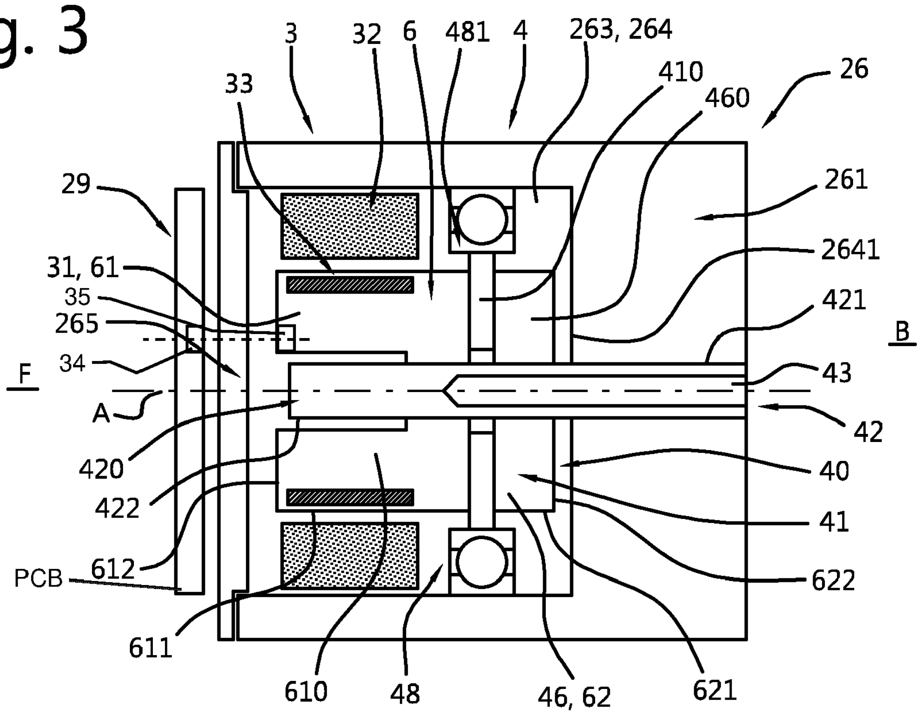
(72) Inventor: **NIEUWENHUIS, Marcel Gerardus Maria**
7544 SC Enschede (NL)

(74) Representative: **EP&C**
P.O. Box 3241
2280 GE Rijswijk (NL)

(54) **PUMP UNIT WITH PUMP AND ELECTRIC MOTOR**

(57) Pump unit 26 for pressurising a hydraulic actuating system 21 including a pump housing 261 with a pump chamber 264 for housing a pump and an electric motor 3 for driving the pump. The electric motor, a brushless DC motor, comprises a motor rotor 31 with several magnets 33 at an outer surface, and a field coil positioned opposite the magnets for rotationally driving the motor rotor. The pump unit further comprises a control unit 29 including a printed circuit board PCB for controlling the electric motor. The control unit and a closure 29, 265 form a subassembly which is mountable as a module to close the pump chamber. The control unit comprises at least one Hall sensor 34 to detect a rotational position of the motor rotor. The at least one Hall sensor is positioned on the printed circuit board being positioned opposite a motor rotor end face 612.

Fig. 3



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Description

[0001] The present invention relates to a pump unit for pressurising a hydraulic actuating system.

[0002] The pump unit comprises a pump housing including a pump chamber for housing a pump. It is desired to provide a pump unit design providing more compactness while maintaining a same pump capacity, or in other words to provide an increase in pump capacity while maintaining the same compactness. Such a compact pump unit will be beneficial in a plurality of applications which include a hydraulically actuated system for moving components.

[0003] A compact pump unit is in particular interesting for an automotive appliance, more in particular for actuating a convertible roof system or a vehicle wheel suspension, because of their narrow build-in spaces, and the required dynamic performance in an arbitrary orientation of the pump unit.

[0004] Besides automotive applications, such a compact pump unit will also be beneficial in other fields, e.g. in a marine, medical or civil field. For example, in the marine field, the compact pump unit may be beneficial in a hydraulic actuating system for operating a marine device, like a marine door, hatch, lift, balcony, bulwarks, mast, mooring gangway etc. For example, in the medical field, the compact pump unit may be beneficial in a hydraulic actuating system for operating a medical device, like a medical tool, lift, trolley, chair or stretcher, e.g. an ambulance stretcher or dental chair, or a medical table, e.g. an operating, treatment or scanning table. For example, in the civil field, the compact pump unit may be beneficial in a hydraulic actuating system for operating a buildings door or hatch, e.g. a sliding garage door, porthole, skylight or shutter.

[0005] EP2.662.568 discloses an electrical pump apparatus including a housing for integrally housing a pump that generates an oil pressure, a brushless motor that drives the pump and a control device that controls the operation of the motor. A cylindrical motor case is placed in rear of a pump case and a cover closes a rear opening end. The cover is fixed to the motor case by means of welding. A three-phase driving electric power is supplied from the control device. The control device includes a circuit board. The circuit board is mounted to an insulator. Motor coils of the motor are clampingly held between the circuit board and the insulator. Voltage sensors functioning as a voltage detecting means are connected to a microcomputer embedded on the circuit board. The microcomputer estimates a rotation position of a motor rotor based on induced voltages of the motor coils detected by the voltage sensors.

[0006] US6.168.393 in the name of Hoerbiger discloses a conventional motor-driven radial piston pump assembly. The pump assembly is configured for transportable purposes or for generating small forces, for example, for the hydraulic activation of motor vehicle folding canopy tops. The main requirement to this pump assembly is that the assembly is as small as possible, such that the pump assembly can be built into narrow mounting spaces, e.g. into a narrow chassis compartment of a vehicle.

[0007] The pump assembly includes a radial piston pump which is supported by a base section on one side thereof. The base section serves to mount the pump together with all its connection lines, a control element and an electric motor. The electric motor is operatively connected to the pump and is supported on the base section coaxially with respect to a central axis of a motor output shaft which lies along a pump propulsion axis.

[0008] The electric motor is typically a conventional DC motor which functions to operate the pump. The electric motor comprises a motor housing which can be closed by a cover. The motor housing houses the motor. The motor is supported at a pump end and an opposite end. The motor has an output motor shaft at its pump end. Electrical components are provided at the opposite end. The output motor shaft is connected by a coupling to a rotor of the pump. The coupling comprises a flange shaped body and a beam shaped the link.

[0009] The electric motor is connected to the base section by the motor housing, so that all supporting, bearing forces and moments are carried by the base section. The base section can be constructed for the attachment of the entire motor-driven radial piston pump assembly. The base section bears the reaction forces and the weight of the motor and transmits those forces directly on the base section which also supports the pump which effects in a compact construction.

[0010] A drawback to this known pump assembly is that its outer size is still not small enough. A pump assembly of this type having small outer dimensions is highly desired.

[0011] GB 812.812A discloses a pump which comprises a housing for a stator, a rotor with pistons and a movable track ring. The rotor and track ring are arranged in a cylindrical recess of the housing. The rotor has a rotor shaft which is received in bores which are provided with anti-friction bearings, for example of the needle roller type on which the rotor shaft revolves. At its outer end, the rotor shaft is further supported by an additional anti-friction bearing. The rotor can be driven by coupling a motor onto the outer end of the motor shaft.

[0012] A drawback of this pump is that the pump capacity is limited. Further, the pump requires too much build-in space for use in an automotive actuating system.

[0013] EP 0 544.856 discloses a pump unit including a hydraulic piston pump driven by an electric motor. The piston pump and electric motor are housed in a common cylindrical pump housing which is at both ends closed by lid shaped components. The electric motor and piston pump form a first and second module which are coupled to each other.

[0014] The electric motor comprises a motor rotor. The motor rotor supports several magnets at its outer circumference. At one side, the motor rotor is journaled by a ball bearing to a shaft and at an opposite side, the motor rotor is supported by the piston pump. The motor rotor is driveable by actuating radially positioned coils opposite the magnets. The motor rotor is rotationally connected to a pump rotor of the piston pump, such that the pump rotor rotates together with the motor rotor.

[0015] The piston pump has a pump rotor body which is supported by a pump stator. The pump stator as an elongated stator body which is at one end fixed to the pump housing. The pump rotor body has a protrusion which is received in a recess of the motor rotor body. The pump rotor body is rotationally fixed to the motor rotor.

[0016] A drawback of the disclosed pump unit is that its outer size is still not small enough. A more compact pump unit is desired.

[0017] A further drawback is that the disclosed pump unit has a poor dynamic performance. Particularly, when driving such a pump unit at a high rotational speed and in an arbitrary orientation as it is desired in automotive appliances, such a pump unit will become unstable.

[0018] The general object of the present invention is to at least partially eliminate the above mentioned drawbacks and/or to provide a useable alternative. More specific, it is an object of the invention to provide a pump unit which has a compact configuration and additionally provides a stable dynamic behaviour when operating at a high rotational speed as it is for example required in an automotive appliances, like operating a convertible roof system.

[0019] More in particular, the invention aims to provide a hydraulic actuating system including a compact pump unit which can be build-in into narrow mounting spaces, like a chassis compartment of a vehicle. Additionally, it is a further object to provide a pump unit which has a high dynamic performance which allows a build-in of the pump unit in an arbitrary orientation.

[0020] According to the invention, this object is achieved by a pump unit according to claim 1. According to the invention, a pump unit is provided for pressurising a hydraulic actuating system, in particular for actuating a convertible roof system. The pump unit comprises a pump housing including a pump chamber for housing a pump. The pump unit further comprises an electric motor for driving the pump.

[0021] The electric motor comprises a motor rotor which has a longitudinal motor rotor body including several magnets. The motor rotor body defines an axial axis. The magnets are positioned at an outer surface of the motor rotor body. Further, the electric motor comprises a field coil which is positioned opposite the magnets of the motor rotor body for rotationally driving the motor rotor body.

[0022] In particular, the pump is a piston pump which comprises a pump stator which is stationary positioned inside the pump chamber. The pump stator has a longitudinal pump stator body which includes at least two channels respectively serving as an inlet or outlet channel. Further, the piston pump comprises a pump rotor which is positioned around the pump stator body. The pump rotor has a pump rotor body which is driveable in a rotational direction about the axial axis. The pump rotor body includes several cylinder holes for each receiving a piston which is slidable with respect to the pump rotor body in a radial direction. Further, the piston pump comprises an eccentric ring which is positioned around the pump rotor body. The eccentric ring is eccentrically positioned at an eccentricity with respect to the pump rotor body to provide a pump capacity.

[0023] The pump unit further comprises a control unit for controlling a pump capacity. The pump capacity may be controlled by controlling a rotational speed of the electric motor. However, preferably, in operation the motor rotor is driven at a constant rotational speed. A pump capacity of a pump can then be controlled by the control unit by adjusting an eccentricity of the eccentric ring of the piston pump.

[0024] The pump housing of the pump unit comprises a closure for closing of the pump chamber. In particular, the closure is a lid including a seal which is mountable to an opening of the pump chamber for sealing the pump chamber. In particular, the closure has an alignment member to rotationally position the closure with respect to the pump chamber.

[0025] The control unit of the pump unit includes a printed circuit board which is connected to the closure. The control unit forms a sub-assembly together with the closure. The sub-assembly of the control unit and closure form a module which is mountable as a separate item to the pump housing.

[0026] The control unit is configured to control the electric motor. In an embodiment, the control unit is further configured to control an actuator for actuating an eccentric ring of the pump. The electric motor of the pump unit is a brushless DC motor. The control unit comprises at least one Hall sensor for detecting an angular position of the motor rotor. The Hall sensor provides a sensor signal to determine an angular position of the motor rotor for accurately powering a field coil of the electric motor. Herewith, the Hall sensor can be used to optimise a control of the brushless DC motor of the pump unit.

[0027] An improvement is provided by positioning the at least one Hall sensor on the printed circuit board of the control unit. The at least one Hall sensor is positioned opposite the end face of the motor rotor for detecting an angular position of the motor rotor. The printed circuit board being mounted to the closure is positioned opposite an end face of the motor rotor to properly align the at least one Hall sensor with the motor rotor.

[0028] In particular, the printed circuit board of the control unit holding the at least one Hall sensor is aligned with a rotor marker of the motor rotor of the pump unit. In particular, the closure comprises a closure recess for receiving and positioning the printed circuit board. The printed circuit board is centred by the closure recess. In the assembly of the pump unit, the positioning of the printed circuit board in the closure recess aligns and positions the Hall sensor with respect to the rotor marker of the motor rotor. Preferably, the printed circuit board comprises two Hall sensors, more preferably three Hall sensors being equally circularly spaced on the printed circuit board opposite the motor rotor end face.

[0029] In an embodiment of the pump unit according to the invention, the printed circuit board is positioned external from the pump chamber at an outer surface of the closure. The printed circuit board is positioned outside the pump chamber. The closure is positioned in between the printed circuit board and the pump chamber. The closure may include a passageway for guiding an electrical wire from the printed circuit board to a field coil inside the pump chamber. The at least one Hall sensor is positioned outside the pump chamber, and the closure comprises a non-ferrite material to conduct a generated magnetic field enabling the at least one Hall sensor to detect an angular position of the motor rotor.

[0030] In a further embodiment, the module may hold the field coils of the electric motor. Preferably, the field coils are positioned in between the closure and the control unit. The field coils are connected at an outer front side to the closure. The closure comprises a non-ferrite material to conduct a generated magnetic field to the magnets on the motor rotor provided at a back of the closure. Advantageously, the pump unit has a modular structure which allows a reduction of an assembly time in producing the pump unit.

[0031] According to an embodiment of the invention an improvement is provided in that the motor rotor and the pump rotor are incorporated into a common rotor. The common rotor is a one piece item. The common rotor is positioned inside the pump chamber. The pump chamber houses the common rotor. The common rotor includes a motor and a pump rotor portion. Functionally seen, the common rotor serves both as a rotor for the electric motor and as a rotor for the pump. The improvement according to the first aspect provides that the common rotor is fully supported by the pump stator.

[0032] The pump unit according to this embodiment lacks a motor stator. No separate motor stator is provided to support the motor rotor. The motor rotor is incorporated with the pump rotor into a common rotor which is supported by the pump stator only. A separate motor stator is redundant, since the common rotor is fully supported by the pump stator.

[0033] In other words, it can also be said that according to the aspect, the motor stator is incorporated into the pump stator which has resulted in a common stator. Advantageously, the pump unit according to the first aspect may have a compact configuration. Additionally, the pump unit may have a stable dynamic performance which allows high rotational speeds and an installation of the pump unit in an arbitrary orientation.

[0034] In comparison with the prior art pump unit from EP 0.544.856, the pump unit according to the first aspect of the invention is supported by the pump stator only and not by a separate second shaft, a motor stator, positioned at an opposite side of the common rotor. According to the first aspect only one component, the pump stator, is provided to support the common rotor. Advantageously, a possible misalignment in between separate components is prevented which contributes to an improved dynamic performance of the pump unit according to the invention. Potential unbalances are minimised which allows a high rotational speed of the common rotor to achieve a relatively high pump capacity by a relatively small sized pump unit.

[0035] In an embodiment of the pump unit according to the invention, the pump stator is fixed to the pump housing as a cantilever. The pump stator has a proximal end which is fixed to the pump housing and a free distal end. The pump stator is connected at only one end to the pump housing. Herewith, instead of a support at both sides of the common rotor, the common rotor is supported at only one side to the pump housing, i.e. the proximal end of the pump stator. Advantageously, by providing a single sided support to the common rotor, the pump unit may have a further compact configuration in the axial direction.

[0036] In an embodiment of the pump unit according to the invention, the pump stator extends through the common rotor over at least a half length of the common rotor. The common rotor has a length in the axial direction which is at most twice a length of the pump stator. Advantageously, the length of the pump stator contributes to a stable dynamic performance. Especially at high speeds it provides a rigid support to the common rotor to counter occurring forces in operation.

[0037] In an embodiment of the pump unit according to the invention, the common rotor is a one piece item which is manufactured by a lathe operation from a solid part. The solid part may be a piece of rough rod material out of a single kind of material which is subsequently processed by a turning operation to obtain the one piece common rotor. Alternatively, the solid part may be provided by a moulding operation. The solid part may be a one piece pre-fabricated rod material. The solid part may be a so-called hybrid piece, including a combined first and second material, e.g. aluminium and steel, wherein - seen in a longitudinal direction - the first material is positioned adjacent to the second material. The common rotor made from a hybrid material includes the first material which forms the motor rotor portion which is different from the second material which forms the pump rotor portion. Starting with the hybrid piece as an input material, the one piece common rotor may be obtained after carrying out a turning operation. The common rotor formed out of the hybrid piece may comprise a motor rotor portion out of the first material, e.g. aluminium or plastic and a pump rotor portion out of the second material, e.g. steel. Advantageously, forming the common rotor out of a solid part by a turning operation may contribute to an accurately balanced common rotor which contributes to a stable dynamic behaviour.

[0038] The prior art pump unit from EP 0.544.856 discloses a common rotor as a one piece item which is manufactured by assembling two pre-manufactured parts. The two parts are welded together. In the embodiment according to the invention, the pump unit has a common rotor as a one piece item manufactured from a single solid part. Instead of an assembly of two separate pre-manufactured parts, the manufacturing out of a single solid part may provide an improved dynamic performance. The manufacturing of the common rotor by a turning operation may minimise any weight unbalances about a central axis of the common rotor. Minimising unbalances contributes advantageously to a more stable dynamic behaviour of the common rotor at a high rotational speed. A swivelling may be reduced. Additionally, minimising unbalances contributes to a more silent operation. Herewith, the pump unit is in particular suitable to be applied in an automotive hydraulic actuating system. For example, in a highly dynamic controlled vehicle wheel suspension, the pump unit is advantageous, because of its stable dynamic behaviour at high rotational speeds. For example, in a convertible roof system, the pump unit is advantageous, because of its silent operation.

[0039] In an embodiment of the pump unit according to the invention, the motor rotor contains magnets which are positioned at an outer circumferential motor rotor surface of the common rotor. Field coils to generate a magnetic field are positioned opposite the magnets. The field coils are radially spaced from the magnets. Preferably, the field coils are positioned inside the pump chamber of the pump housing. The field coils may be connected to an inner circumferential surface of the pump chamber.

[0040] In an embodiment of the pump unit according to the invention, the common rotor comprises a motor rotor recess which is open at a motor rotor end face. The motor rotor recess is adapted to receive the field coils of the electric motor. The motor rotor recess has an inner circumferential surface and an inner bottom surface, wherein the magnets of the motor rotor are positioned at the inner circumferential or bottom surface. Preferably, the magnets are positioned at the inner circumferential surface and the field coils are positioned inside the motor rotor recess at a position which is inwardly radially spaced from the magnets. The field coils are arranged to generate a fluctuating magnetic field in a radial direction to actuate the magnets to drive the motor rotor in a rotational direction.

[0041] In an embodiment of the pump unit according to the invention, the magnets of the motor rotor are positioned at the motor rotor end face of the common rotor. The field coils are positioned in an axial direction opposite the magnets of the motor rotor. Preferably, the field coils are positioned outside the pump chamber. The pump chamber may be closed by a closure, wherein the field coils are connected to the closure. Advantageously, the axial arrangement of the magnets and field coils may further contribute to a compact configuration of the common rotor. In comparison with a radial arrangement of the magnets and field coils, a total weight of the common rotor may be reduced and the common rotor may have an increased balance which may contribute to an improved dynamic performance.

[0042] According to another aspect of the invention, the reservoir of the pump unit is formed by the pump chamber in the pump housing. The pump stator of the piston pump has an inlet channel which is in fluid communication with the pump chamber. In comparison with a conventional configuration including a separate tank as a reservoir positioned at and outside of the pump housing, the reservoir formed by the pump chamber makes a seal positioned in between the tank and the pump chamber redundant. Advantageously, a risk on leakages which is especially present at high pressures of more than 100 bars is minimised.

[0043] Further, the invention relates to a hydraulic actuating system comprising a pump unit according to the invention. Advantageously, the hydraulic actuating system is suitable to be built-in into narrow spaces, like frame compartments. Additionally, the compact configuration of the integrated pump-motor pump unit allows the hydraulic actuating system to be installed invisible from the outside behind movable components, e.g. in medical devices behind furniture parts like hospital beds.

[0044] The pump unit according to the invention may be beneficial to be installed in a mobile hydraulic actuating system, because pump unit may have a very compact lightweight configuration.

[0045] The pump unit may beneficially be battery operated. The mobile hydraulic actuating system including a battery allows an operation of relatively heavy loads by at least one hydraulic actuator which is controlled by the electrically driven pump unit. Therefore, the pump unit according to the invention may be of great benefit in mobile applications which urge for a small and lightweight actuating system, but at the same time require serious loads to be moved. In particular, a pump unit for pressurising an automotive actuating system is provided, which automotive actuating system is for example configured as a convertible roof system, boot lid, hood cover system or wheel suspension of the vehicle. Typically, the pump unit is compactly sized to be installed at narrow mounting spaces, e.g. within a compartment of a vehicle chassis. Examples of such applications in the medical, marine and civil field are mentioned above. An actuating system of an ambulance stretcher is a striking example of such a mobile actuating system which should be lightweight and powerful at the same time. Lightweight, because the ambulance stretcher should be carried by personnel, and at the same time powerful because it should move the load of a patient on the stretcher.

[0046] The hydraulic actuating system is in particular an automotive hydraulic actuating system comprising a pump unit according to the invention. Advantageously, the pump unit includes a rotary piston pump which is suitable to operate silently and reliable at a high rotational speed. The pump unit is in particular an automotive pump unit configured for operating vehicle parts, like a convertible roof, sunroof, boot lid, hood lid, spoiler or vehicle wheel suspension linkage. Advantageously, the automotive pump unit has a compact configuration which allows an installation of the pump unit in a narrow vehicle compartment, like a chassis compartment which is positioned close to the movable vehicle part.

[0047] In an embodiment of the automotive actuating system, the automotive actuating system is a convertible roof system which comprises a convertible roof including a roof part which is movable with respect to a remaining roof part. The convertible roof to be operated serves to selectively cover or open a passenger space of a vehicle and may include several roof parts which are pivotally connected to each other. A first roof part is movable with respect to a second roof part to bring the convertible roof in respectively a closed or open state.
[0048] Further, the invention relates to a vehicle comprising such an automotive hydraulic actuating system, like a convertible roof system or vehicle wheel suspension.
[0049] Further embodiments are defined in the dependent claims.
[0050] The invention will be explained in more detail with reference to the appended drawings. The drawings show a practical embodiment according to the invention, which may not be interpreted as limiting the scope of the invention. Specific features may also be considered apart from the shown embodiment and may be taken into account in a broader context as a delimiting feature, not only for the shown embodiment but as a common feature for all embodiments falling within the scope of the appended claims, in which:

Fig. 1 shows a schematic side view of a vehicle provided with a convertible roof system;
Fig. 2 shows a schematic view of the convertible roof system out of a fig. 1 comprising a hydraulic actuating system which includes a pump unit for pressurising several cylinders;
Fig. 3 shows a first embodiment of a pump unit in a schematic sectional view about an axial axis, wherein the pump unit comprises an electric motor and a piston pump which are both received in a pump chamber of a pump housing and wherein the electric motor includes radially arranged magnets and field coils, wherein the field coils are outwardly positioned with respect to magnets;
Fig. 4 shows a second embodiment of a pump unit as in fig. 3, wherein the field coils are inwardly positioned with respect to the magnets;
Fig. 5 shows a third embodiment of a pump unit as in fig. 3, wherein the field coils of the electric motor are axially arranged with respect to the magnets.

[0051] In the figures, the same reference numbers are used to indicate identical or similar components.
[0052] Fig. 1 discloses in a schematic view a vehicle 1. The vehicle 1 comprises an automotive actuating system for hydraulically actuating movable vehicle parts, like a sunroof, hood lid, boot lid, spoiler, convertible roof or a wheel suspension. As illustrated here, the vehicle 1 is provided with a convertible roof system 2 for selectively opening or covering a passenger space. The convertible roof system 2 has a well known mechanical structure.
[0053] Here, the convertible roof system 2 has a convertible roof 20 which includes a front roof part 200. The roof part 200 is pivotally connected about a pivot axis to a remaining roof part 201 of the convertible roof 20. Here, the front roof part 200 is shown in released from a front window frame 11. In a closed configuration of the convertible roof, the front roof part 200 is connected to the front window frame 11 and locked by a locking member 12.
[0054] Fig. 2 shows an embodiment of a convertible roof system 2 in further detail. The general mechanical structure of such a convertible roof system is well known in the art. Fig. 2 further shows a hydraulic actuating system 21. The hydraulic actuating system 21 is arranged to actuate the convertible roof 20, locking member 12 and additionally a cover plate 202 . The cover plate 202 is provided to cover a compartment of the vehicle 1 which compartment is configured to receive the convertible roof 20 when transformed into an open configuration.
[0055] The hydraulic actuating system 21 comprises two pairs of hydraulic cylinders 23, 23'; 24, 24' for moving the roof parts 200, 201 of the convertible roof 2. A hydraulic cylinder 25 is provided to move the cover plate 202 and a hydraulic cylinder 22 is provided to actuate the locking member 12. The cylinders 22; 23, 23';25, 25' are hydraulically connected by hydraulic conduits to a hydraulic pump unit 26.
[0056] The pump unit 26 has a pump housing 261. The pump housing 261 is block shaped. A control unit 29 is provided to control the pump unit 26. The control unit 29 is electrically connected to an electric motor 3 for driving an internally positioned pump which is here a piston pump 4. The electric motor 3 is connected to a front side of the pump housing 261. The piston pump 4 is internally arranged inside the pump housing in a pump chamber 264. The pump chamber 264 is an inner space which is configured for housing the piston pump 4. The arrangement of the piston pump 4 in the pump chamber 264 is further illustrated by figures 3-5 which show a sectional view of the pump unit 26 about a longitudinal axis.
[0057] As shown in fig. 2, the pump unit 26 comprises a valve unit 28. The valve unit is mounted to a mounting face which is here positioned at a top side of the pump housing. Further, the pump unit 26 comprises a reservoir 263 for accumulating hydraulic liquid. The reservoir 263 is here positioned at a backside of the pump housing 261.
[0058] According to an aspect of the present invention, an improvement is provided by incorporating the electric motor 3 with the piston pump 4. Particularly, by incorporating a motor rotor 31 of the electric motor 3 with a pump rotor 46 of the piston pump up 4 into a common rotor 6 as shown in Fig. 3-5. The common rotor 6 is a one piece item. The common rotor 6 is a separately mountable component of an assembled pump unit 26. The common rotor 6 is mountable as a

whole to remaining parts of the pump unit 26.

[0059] The common rotor 6 is positioned inside the pump chamber 264. The common rotor 6 defines an axial axis A. The axial axis A is an axis of rotation of the common rotor 6. The common rotor 6 includes a motor rotor portion 61 which serves as a motor rotor 31 and a pump rotor portion 62 which serves as a pump rotor 46.

[0060] The electric motor 3 is a brushless DC motor. The DC motor is advantageous, because of its relatively long lifetime without intervening servicing. The electric motor 3 has a motor rotor 31 which forms the motor portion 61 of the common rotor 6. The motor rotor 31 has a motor rotor body 610. The motor rotor body 610 is cylindrically shaped and elongated. The motor rotor body 610 has an outer circumferential surface 611 and a motor rotor end face 612.

[0061] Further, the electric motor 3 comprises several field coils 32. The field coils 32 are DC field coils which in operation generate a magnetic field. The field coils 32 are positioned opposite the magnets 33 at the motor rotor body 610. Several embodiments including a rotor with magnets and opposite positioned field coils are possible and further illustrated in figures 3-5.

[0062] According to an aspect of the invention, the motor rotor 31 and the pump rotor 46 are both supported by the pump stator 42. In contrast to conventional motors, the electric motor 3 according to the invention has no separate component serving as motor stator. The electric motor 3 has a motor rotor 31 which is supported by the pump stator 42 which makes a motor stator redundant.

[0063] The piston pump 4 is a rotary piston pump. Such a type of a piston pump is well known in the art. Such a rotary piston pump 40 includes pistons 41 which in operation rotate together with a pump rotor.

[0064] Such a rotary piston pump 40 has a pump rotor 46 and a pump stator 42. The pump stator 42 has an elongated stator body 420 which extends in an axial direction. The pump stator body 420 is beam shaped. The pump stator body 420 is stationary fixed to the pump housing 261. The pump stator body 420 is fixed as a cantilever. The pump stator body 420 has a proximal stator end 421 which is fixed to the bottom surface 2641 of the pump chamber 264. The pump stator body 420 extends along the axial axis of the pump unit 26. The pump stator body 420 has a free distal stator end 422 which is positioned in the inner space provided by the pump chamber 264. The pump stator body 420 includes at least two channels forming at least one inlet channel 43 and at least one outlet channel 44 for transferring hydraulic liquid.

[0065] The pump rotor 46 has a pump rotor body 460 which is rotationally connected to the pump stator body 420 of the pump stator 42. The pump rotor body 460 is co-axially positioned with respect to the pump stator 42. The pump stator 42 supports the pump rotor 46. The pump rotor 46 is supported from one side. The pump stator 42 provides a single sided support to the pump rotor 46 as the pump stator 42 is only fixed at the proximal stator end 421 to the pump housing.

[0066] The pump rotor body 460 comprises several cylinder holes for each receiving a piston 41. The piston 41 has a longitudinal piston body 410. The piston body 410 has a proximal piston end which is directed to stator body 420 and a distal piston end which is directed radially outwards to a ring-shaped element which surrounds the rotor body 460. The ring-shaped element is a so-called eccentric ring 48. The rotor body 460 is positioned inside the eccentric ring 48.

[0067] To reduce wear, the eccentric ring 48 is formed as a bearing. The bearing may be a plain bearing. Here, the eccentric ring 48 is formed by a ball bearing having an inner ring and an outer ring, wherein the inner ring is beared by ball bearings with respect to outer ring. The outer ring is stationary positioned and fixed to the pump housing 261 and the inner ring is rotatable positioned. The inner ring of the eccentric ring 48 is movable in rotation together with the inside positioned pump rotor 46.

[0068] The eccentric ring 48 comprises an inner bearing surface which serves as a running surface 481 for the distal ends of the pistons 41. The running surface 481 is positioned opposite an outer circumferential rotor surface 621 of the pump rotor body 460. The eccentric ring 48 is eccentrically positioned with respect to the pump rotor body 460. A ring-shaped intermediate space in between the outer circumferential rotor surface 461 and the inner running surface 481 is provided to allow in operation the pistons 41 holded by the pump rotor body 460 to move in a radial direction. Due to a present eccentricity E, a height of the intermediate space in between the outer circumferential rotor surface 621 and the running surface 481 is varying which will cause the pistons 41 to move in the radial direction when rotationally driving the pump rotor body 460. Radially inward moving pistons 41 will provide a pressure to the hydraulic liquid and will push hydraulic liquid through the outlet channel 44 and radially outward moving pistons 41 will provide an underpressure to the hydraulic liquid which will suck hydraulic liquid through the inlet channel 43. Herewith, the radially moving pistons 41 generate a pumping working to the hydraulic circuit.

[0069] Fig. 3-5 show schematic sectional views about a longitudinal axis of several embodiments of a pump unit in which several aspects of the invention are shown.

[0070] According to an aspect of the invention, the reservoir 263 is formed by the pump chamber 264. An inlet channel 43 of the pump stator 42 is in fluid communication with the pump chamber, such that hydraulic liquid can be transferred from the pump chamber 264 as a reservoir 263.

[0071] Fig. 3-5 schematically show three alternative embodiments of such improved pump units 26 including a common rotor 6 supporters by only one individual stator. The shown embodiments include the same or similar components, but these components are spatially different positioned.

[0072] The pump unit 26 comprises a pump housing 261 including a pump chamber 264 for housing the electric motor 3 and the piston pump 4 and a closure 265 to close the pump chamber 264. In fig. 3 and 4, the electric motor 3 and piston pump for are fully received in the pump chamber 264. In fig. 5, a part of the electric motor 3 is positioned outside the pump chamber 264.

[0073] The pump housing 261 has a compact configuration. Here, the pump housing 261 is cylindrically shaped. The pump housing 261 has at least one external mounting face at an outer surface for mounting e.g. a valve unit 28, a control unit 29, an electrical supply and/or a reservoir 263.

[0074] The pump chamber 264 inside the pump housing 261 defines the axial axis A which extends from a front side F to a backside B of the pump housing. The pump chamber 264 is open at the front side F of the pump housing 261. The pump chamber 264 is formed by an inner space which is cylindrically shaped. The pump chamber 264 has a bottom surface 2641 and an inner circumferential surface 2642. The pump chamber 264 is adapted for at least partially receiving both the electric motor 3 and the piston pump 4.

[0075] The closure 265 is provided for closing the pump chamber 264 in an assembled configuration of the pump unit 26. The closure 265 is plate shaped. Here, the closure 265 is a lid which fits to the pump chamber opening. The closure 265 is sealable connectable to the pump housing 261 for hydraulically sealing the pump chamber 264.

[0076] Further, the pump unit 26 comprises a control unit 29. The control unit 29 has a compact configuration. The control unit 29 includes a printed circuit board PCB which is designed for controlling the pump unit 26. A functional scheme of controllable movements of a particular hydraulic actuating system 21, which is in particular a convertible roof system 2, is embedded in the design of the printed circuit board of the control unit 29. The control unit 29 is plate shaped and connectable to an external surface of the closure 265. The control unit 29 is adapted to the closure 265 form a module of the pump unit. The control unit 29 is sized in correspondence with the diameter of the closure 265. According to an aspect of the invention, the control unit 29 and the closure 265 form a subassembly. The subassembly of the control unit 29 and the closure 265 form the separate mountable module of the pump unit 26.

[0077] As shown in fig. 3, the motor rotor body 610 comprises several magnets 33 which are positioned at the outer circumferential rotor surface 621. Field coils 32 are positioned opposite the magnets 33. The field coils 32 are radially positioned with respect to the magnets 33. The field coils 32 are positioned around the motor rotor 31. The field coils 32 are radially outwardly spaced from the magnets 33 which are supported by the motor rotor body 610. The field coils 32 are positioned inside the pump chamber 264 at the inner circumferential surface 2642 .

[0078] Fig. 3-5 show the subassembly of the closure 265 and the printed circuit board PCB of the control unit 29. The printed circuit board PCB holds at least one Hall sensor 34. The at least one Hall sensor 34 is positioned at a radius from the axial axis A. The Hall sensor 34 is embedded in the electronic circuit on the printed circuit board. The Hall sensor 34 cooperates with a rotor marker 35 positioned on a motor rotor end face 612 to detect an angular position of the motor rotor body 61. The rotor marker 35 may be formed by a magnet 33 of the rotor.

[0079] The printed circuit board is aligned with the closure 265, e.g. by receiving the printed circuit board in a closure recess, to obtain an alignment of the Hall sensor 34 with the rotor marker 35 of the motor rotor. Here, the at least one Hall sensor is situated outside the pump chamber 264. The closure 265 contains at least at a portion of a non-ferrite material for conducting a magnetic flux for detecting the rotor marker 35 by the Hall sensor 34. Embedding the at least one Hall sensor 34 on the printed circuit board is beneficial to obtain a more compact configuration of the pump unit.

[0080] Fig. 3 shows the pump stator 42 which extends through the rotor 6. Here, the pump stator 42 extends substantially until the motor rotor end face 612 of the rotor 6.

[0081] Fig. 4 shows a different spatial arrangement of the field coils 32 and the magnets 33. The field coils 32 are radially positioned with respect to the magnets 33. The motor rotor 31 comprises a rotor recess 613. The rotor recess 613 is open at the motor rotor end face 612 of the motor rotor portion 61. The rotor recess 613 is configured for receiving the field coils 32. The field coils 32 for generating a magnetic field are positioned opposite the magnets 33.

[0082] The magnets 33 are positioned at an inner surface, in particular an inner bottom or circumferential surface, of the rotor recess 613. Here, the magnets 33 are positioned at the inner circumferential surface of the rotor recess 613.

[0083] The field coils 32 are positioned inside the rotor recess 613. The field coils 32 are radially inwardly positioned with respect to the magnets 33 which are here positioned at the inner circumferential surface of the rotor recess 613. The field coils 32 are positioned inside the pump chamber 264. The field coils 32 are connected to the closure 265. The field coils 32 are centrally positioned and connected to an inner surface of the closure 265.

[0084] Fig. 4 shows the pump stator 42 which extends through the rotor 6. Here, the pump stator 42 extends substantially until the bottom surface of the rotor recess 613. The pump stator 42 extends about at least half a length of the common rotor 6.

[0085] Fig. 5 shows a further different spatial arrangement of the field coils 32 and the magnets 33. The magnets 33 are positioned at the motor rotor end face 612 of the rotor 6. Field coils 32 are positioned opposite the magnets 33. The field coils 32 are located outside the pump chamber 264. The field coils 32 are connected to be closure 265 which covers the pump chamber 264. The closure 265 is positioned in between the field coils 32 and the magnets 33 on the rotor 6. The control unit 29 is connected via the field coils to the closure 265. Advantageously, in comparison with the radially arranged field coils and magnets as shown in fig. 3 end 4, the rotor 6 of the pump unit in fig. 5 including the axial arranged field coils and magnets has a very compact configuration.

[0086] Fig. 5 shows the pump stator 42 which extends through the rotor 6. Here the pump stator 42 extends until the motor rotor end face 612 of the rotor 6.

[0087] Besides the illustrated embodiments of the pump unit according to the invention, several variants are possible without departing from the scope

[0088] Thus, the invention provides several aspects which allow a compact configuration of a pump unit. Such a compact pump unit is especially advantageous to be installed in a hydraulic actuating system for an automotive appliance, like a convertible roof system, in which the pump unit has to be build-in into narrow chassis compartments.

The above-mentioned aspects of the invention are to be considered independent from each other. In particular, the aspect regarding the arrangement of the field coils and magnets is considered to be technically independent from the aspect of the one piece common rotor supported by the pump stator only and from the aspect of the pump chamber which houses the piston pump and electric motor and which pump chamber serves as a reservoir of the pump unit.

[0089] Particular embodiments according to the invention are defined in the following clauses:

1. Pump unit (26) for pressurising a hydraulic actuating system (21), in particular for pressurising an automotive actuating system, like a convertible roof system (2), boot lid, hood cover system or wheel suspension of a vehicle (1), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a piston pump (4) and wherein the pump unit (26) further comprises an electric motor (3) for driving the piston pump , wherein the electric motor (3) comprises:

   - a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
   - a field coil (32) which is positioned opposite the magnets of the motor rotor body (610) for rotationally driving the motor rotor body (610);
     , wherein the piston pump (4) comprises:

     - a pump stator (42) which is stationary positioned inside the pump chamber (264), which pump stator has a longitudinal stator body (420), in which the pump stator body (420) includes at least two channels serving respectively as an inlet or outlet channel (43, 44);
     - a pump rotor (46) positioned around the pump stator body (420), which pump rotor has a pump rotor body (620) which is driveable in a rotational direction about the axial axis, wherein the pump rotor body (620) includes several cylinder holes for each receiving a piston (41) which is slidable with respect to the pump rotor body (620) in a radial direction;
     - an eccentric ring (48) positioned around the pump rotor body (620), in which the eccentric ring (48) is eccentrically positioned at an eccentricity E with respect to the pump rotor body (620) to provide a pump capacity;

   , wherein the motor rotor (31) and the pump rotor (46) are incorporated into a common rotor (6) which is a one piece item including a motor and a pump rotor portion (61,62) and wherein the common rotor (6) is only supported by the pump stator (42).

2. Pump unit (26) for pressurising a hydraulic actuating system (21), in particular for pressurising an automotive actuating system, like a convertible roof system (2), boot lid, hood cover system or wheel suspension of a vehicle (1), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a piston pump (4) and wherein the pump unit (26) further comprises an electric motor (3) for driving the piston pump , wherein the electric motor (3) comprises:

   - a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
   - a field coil (32) which is positioned opposite the magnets of the motor rotor body (610) for rotationally driving the motor rotor body (610);
     , wherein the piston pump (4) comprises:

     - a pump stator (42) which is stationary positioned inside the pump chamber (264), which pump stator has a longitudinal stator body (420), in which the pump stator body (420) includes at least two channels serving respectively as an inlet or outlet channel (43, 44);
     - a pump rotor (46) positioned around the pump stator body (420), which pump rotor has a pump rotor body

(620) which is driveable in a rotational direction about the axial axis, wherein the pump rotor body (620) includes several cylinder holes for each receiving a piston (41) which is slidable with respect to the pump rotor body (620) in a radial direction;
- an eccentric ring (48) positioned around the pump rotor body (620), in which the eccentric ring (48) is eccentrically positioned at an eccentricity E with respect to the pump rotor body (620) to provide a pump capacity;

, wherein the motor rotor (31) and the pump rotor (46) are incorporated into a common rotor (6) which is a one piece item including a motor and a pump rotor portion (61,62) and, wherein the magnets (33) of the motor rotor (31) are positioned at an outer circumferential motor rotor surface (611).

3. Pump unit (26) for pressurising a hydraulic actuating system (21), in particular for pressurising an automotive actuating system, like a convertible roof system (2), boot lid, hood cover system or wheel suspension of a vehicle (1), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a piston pump (4) and wherein the pump unit (26) further comprises an electric motor (3) for driving the piston pump
, wherein the electric motor (3) comprises:

- a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
- a field coil (32) which is positioned opposite the magnets of the motor rotor body (610) for rotationally driving the motor rotor body (610);
  , wherein the piston pump (4) comprises:
  - a pump stator (42) which is stationary positioned inside the pump chamber (264), which pump stator has a longitudinal stator body (420), in which the pump stator body (420) includes at least two channels serving respectively as an inlet or outlet channel (43, 44);
  - a pump rotor (46) positioned around the pump stator body (420), which pump rotor has a pump rotor body (620) which is driveable in a rotational direction about the axial axis, wherein the pump rotor body (620) includes several cylinder holes for each receiving a piston (41) which is slidable with respect to the pump rotor body (620) in a radial direction;
  - an eccentric ring (48) positioned around the pump rotor body (620), in which the eccentric ring (48) is eccentrically positioned at an eccentricity E with respect to the pump rotor body (620) to provide a pump capacity;

, wherein the motor rotor (31) and the pump rotor (46) are incorporated into a common rotor (6) which is a one piece item including a motor and a pump rotor portion (61,62) and wherein the common rotor (6) has a motor rotor recess (613) which is open at a motor rotor end face (612), wherein the motor rotor recess (613) has an inner circumferential surface (614) and an inner bottom surface (615), wherein the magnets are positioned at the inner circumferential or bottom surface.

4. Pump unit (26) for pressurising a hydraulic actuating system (21), in particular for pressurising an automotive actuating system, like a convertible roof system (2), boot lid, hood cover system or wheel suspension of a vehicle (1), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a piston pump (4) and wherein the pump unit (26) further comprises an electric motor (3) for driving the piston pump
, wherein the electric motor (3) comprises:

- a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
- a field coil (32) which is positioned opposite the magnets of the motor rotor body (610) for rotationally driving the motor rotor body (610);
  , wherein the piston pump (4) comprises:
  - a pump stator (42) which is stationary positioned inside the pump chamber (264), which pump stator has a longitudinal stator body (420), in which the pump stator body (420) includes at least two channels serving respectively as an inlet or outlet channel (43, 44);
  - a pump rotor (46) positioned around the pump stator body (420), which pump rotor has a pump rotor body (620) which is driveable in a rotational direction about the axial axis, wherein the pump rotor body (620) includes several cylinder holes for each receiving a piston (41) which is slidable with respect to the pump

rotor body (620) in a radial direction;
- an eccentric ring (48) positioned around the pump rotor body (620), in which the eccentric ring (48) is eccentrically positioned at an eccentricity E with respect to the pump rotor body (620) to provide a pump capacity;

, wherein the motor rotor (31) and the pump rotor (46) are incorporated into a common rotor (6) which is a one piece item including a motor and a pump rotor portion (61,62) and wherein the magnets (33) of the motor rotor (31) are positioned at the motor rotor end face (612) of the common rotor (6).

5. Pump unit (26) for pressurising a hydraulic actuating system (21), in particular for pressurising an automotive actuating system, like a convertible roof system (2), boot lid, hood cover system or wheel suspension of a vehicle (1), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a piston pump (4) and wherein the pump unit (26) further comprises an electric motor (3) for driving the piston pump
, wherein the electric motor (3) comprises:

- a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
- a field coil (32) which is positioned opposite the magnets of the motor rotor body (610) for rotationally driving the motor rotor body (610);
  , wherein the piston pump (4) comprises:

  - a pump stator (42) which is stationary positioned inside the pump chamber (264), which pump stator has a longitudinal stator body (420), in which the pump stator body (420) includes at least two channels serving respectively as an inlet or outlet channel (43, 44);
  - a pump rotor (46) positioned around the pump stator body (420), which pump rotor has a pump rotor body (620) which is driveable in a rotational direction about the axial axis, wherein the pump rotor body (620) includes several cylinder holes for each receiving a piston (41) which is slidable with respect to the pump rotor body (620) in a radial direction;
  - an eccentric ring (48) positioned around the pump rotor body (620), in which the eccentric ring (48) is eccentrically positioned at an eccentricity E with respect to the pump rotor body (620) to provide a pump capacity;

, wherein the motor rotor (31) and the pump rotor (46) are incorporated into a common rotor (6) which is a one piece item including a motor and a pump rotor portion (61,62) and wherein the pump unit (26) further comprises a control unit (29) for controlling the pump capacity, wherein the control unit (29) is connectable to a closure (265) of the pump housing (261) for closing a pump chamber (264), wherein the control unit (29) and the closure (265) form a subassembly which is mountable as a module to the pump housing.

6. Pump unit (26) for pressurising a hydraulic actuating system (21), in particular for pressurising an automotive actuating system, like a convertible roof system (2), boot lid, hood cover system or wheel suspension of a vehicle (1), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a piston pump (4) and wherein the pump unit (26) further comprises an electric motor (3) for driving the piston pump
, wherein the electric motor (3) comprises:

- a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
- a field coil (32) which is positioned opposite the magnets of the motor rotor body (610) for rotationally driving the motor rotor body (610);
  , wherein the piston pump (4) comprises:

  - a pump stator (42) which is stationary positioned inside the pump chamber (264), which pump stator has a longitudinal stator body (420), in which the pump stator body (420) includes at least two channels serving respectively as an inlet or outlet channel (43, 44);
  - a pump rotor (46) positioned around the pump stator body (420), which pump rotor has a pump rotor body (620) which is driveable in a rotational direction about the axial axis, wherein the pump rotor body (620) includes several cylinder holes for each receiving a piston (41) which is slidable with respect to the pump rotor body (620) in a radial direction;
  - an eccentric ring (48) positioned around the pump rotor body (620), in which the eccentric ring (48) is

eccentrically positioned at an eccentricity E with respect to the pump rotor body (620) to provide a pump capacity;

, wherein the motor rotor (31) and the pump rotor (46) are incorporated into a common rotor (6) which is a one piece item including a motor and a pump rotor portion (61,62) and wherein the reservoir (263) is formed by the pump chamber in the pump housing.

[0090] Thus, a pump unit for pressurising a hydraulic actuating system including a pump housing 261 with a pump chamber for housing a pump and an electric motor for driving the pump. The electric motor, a brushless DC motor, comprises a motor rotor with several magnets at an outer surface, and a field coil positioned opposite the magnets for rotationally driving the motor rotor. The pump unit further comprises a control unit including a printed circuit board for controlling the electric motor. The control unit and a closure form a subassembly which is mountable as a module to close the pump chamber. The control unit comprises at least one Hall sensor to detect a rotational position of the motor rotor. The at least one Hall sensor is positioned on the printed circuit board being positioned opposite a motor rotor end face.

Legend to the figures:

1 vehicle
11 front window frame
12 locking member

2 convertible roof system
20 convertible roof
200 roof part
201 remaining roof part
202 cover plate

21 hydraulic actuating system
23, 23' hydraulic cylinder
28 valve unit
29 control unit

3 electric motor
31 motor rotor
32 field coil
33 magnet
34 Hall sensor
35 rotor marker

4 piston pump
40 rotary piston pump
41 piston
410 piston body 42 pump stator
420 pump stator body
421 pump stator proximal end
422 pump stator distal end
43 inlet channel
44 outlet channel
46 pump rotor

48 eccentric ring
481 running surface
482 outer circumferential ring surface

24, 24' hydraulic cylinder
25 hydraulic cylinder
22 hydraulic cylinder

26 pump unit
261 pump housing
263 reservoir
264 pump chamber
2641 bottom surface
2642 circumferential surface
265 closure

613 motor rotor recess
614 motor rotor inner circumferential surface
615 motor rotor inner bottom surface

62 pump rotor portion
620 pump rotor body
621 outer circumferential rotor surface
622 pump rotor end face

(continued)

484 motor end face
49 link
E eccentricity

5 ring actuator
53 lever

6 common rotor
61 motor rotor portion
610 motor rotor body
611 motor rotor outer circumferential surface
612 motor rotor end face

Claims

1. Pump unit (26) for pressurising a hydraulic actuating system (21), wherein the pump unit comprises a pump housing (261) including a pump chamber (264) for housing a pump and wherein the pump unit further comprises an electric motor (3) for driving the pump,
wherein the electric motor (3) comprises

- a motor rotor (31), wherein the motor rotor comprises a longitudinal motor rotor body (610) including several magnets (33) at an outer surface, wherein the motor rotor body (610) defines an axial axis;
- a field coil (32) which is positioned opposite the magnets (33) of the motor rotor body (610) for rotationally driving the motor rotor body;

wherein the pump unit (26) further comprises a control unit (29) for controlling the electric motor (3) of the pump unit, wherein the control unit (29) includes a printed circuit board (PCB) which is connected to a closure (265) of the pump housing, wherein the control unit and the closure (29, 265) form a subassembly which is mountable as a module to the pump housing (261) to close the pump chamber (264), wherein the electric motor (3) is a brushless DC motor in which the control unit (29) comprises at least one Hall sensor (34) to detect a rotational position of the motor rotor (31), wherein the at least one Hall sensor (34) is positioned on the printed circuit board (PCM) of the control unit (29) being positioned opposite a motor rotor end face (612).

2. Pump unit (26) according to claim 1, wherein the closure (265) is plate-shaped, in particular formed as a lid, which fits to a pump chamber opening, wherein the printed circuit board (PCB) is sized to fit in a closure recess to align the at least one Hall sensor (34) with a rotor marker (35) of the motor rotor (31).

3. Pump unit (26) according to claim 1 or 2, wherein the printed circuit board (PCB) of the control unit (29) is positioned external from the pump chamber (264) at an outer surface of the closure (265).

4. Pump unit (26) according to any of the preceding claims, wherein the magnets (33) of the motor rotor (31) are positioned at the motor rotor end face (612) of the motor rotor (6).

5. Pump unit (26) according to claim 4, wherein the field coils (32) are positioned outside the pump chamber (264) of the pump housing (261).

6. Pump unit (26) according to any of the preceding claims, wherein the module of the control unit (29) and the closure (265) further comprises at least one field coil (32) of the electric motor.

7. Pump unit according to any of the claims 3 - 6, wherein the closure (265) comprises a non-ferrite material to conduct a generated magnetic field.

8. Pump unit (26) according to any of the preceding claims, wherein the motor rotor (6) has a motor rotor recess (613) which is open at a motor rotor end face (612), wherein the motor rotor recess (613) has an inner circumferential

surface (614) and an inner bottom surface (615), wherein the magnets (33) are positioned at the inner circumferential surface or at the inner bottom surface.

9. Pump unit (26) according to any of the claims 1-7, wherein the magnets (33) of the motor rotor (31) are positioned at an outer circumferential motor rotor surface (611).

10. Pump unit (26) according to any of the preceding claims, wherein a reservoir (263) is formed by the pump chamber in the pump housing.

11. Hydraulic actuating system (21) comprising a pump unit (26) according to any of the preceding claims.

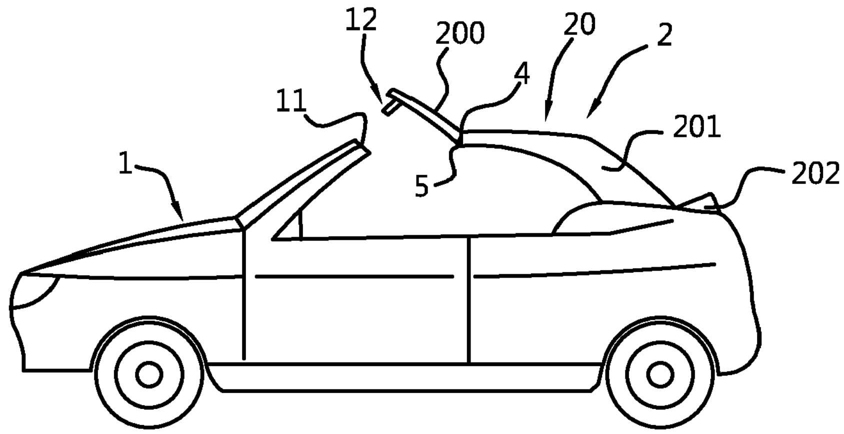
12. Vehicle suspension comprising a hydraulic actuating system (29) according to claim 11, wherein the vehicle suspension comprises a linkage and at least one hydraulic cylinder for actuating a link of the linkage to allow an active control of the vehicle wheel suspension.

13. Convertible roof system (2) comprising a hydraulic actuating system (21) according to claim 11, wherein the convertible roof system (2) comprises a convertible roof (20) including a roof part (3) which is movable with respect to a remaining roof part (6).

14. Vehicle (1) comprising a hydraulic actuating system (2) according to claim 11.

15. Use of the pump unit (26) according to any of the claims 1-10 in a marine, medical or civil field, e.g. in a marine device, like a marine door, hatch, lift, balcony, bulwarks, mast, mooring gangway etc., in the medical field, e.g.a medical tool, lift, trolley, chair or stretcher, e.g. an ambulance stretcher or dental chair, or a medical table, e.g. an operating, treatment or scanning table, in the civil field, e.g. for operating a buildings door or a hatch, e.g. a sliding garage door, porthole, skylight or shutter.

Fig. 1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200
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11
201
1
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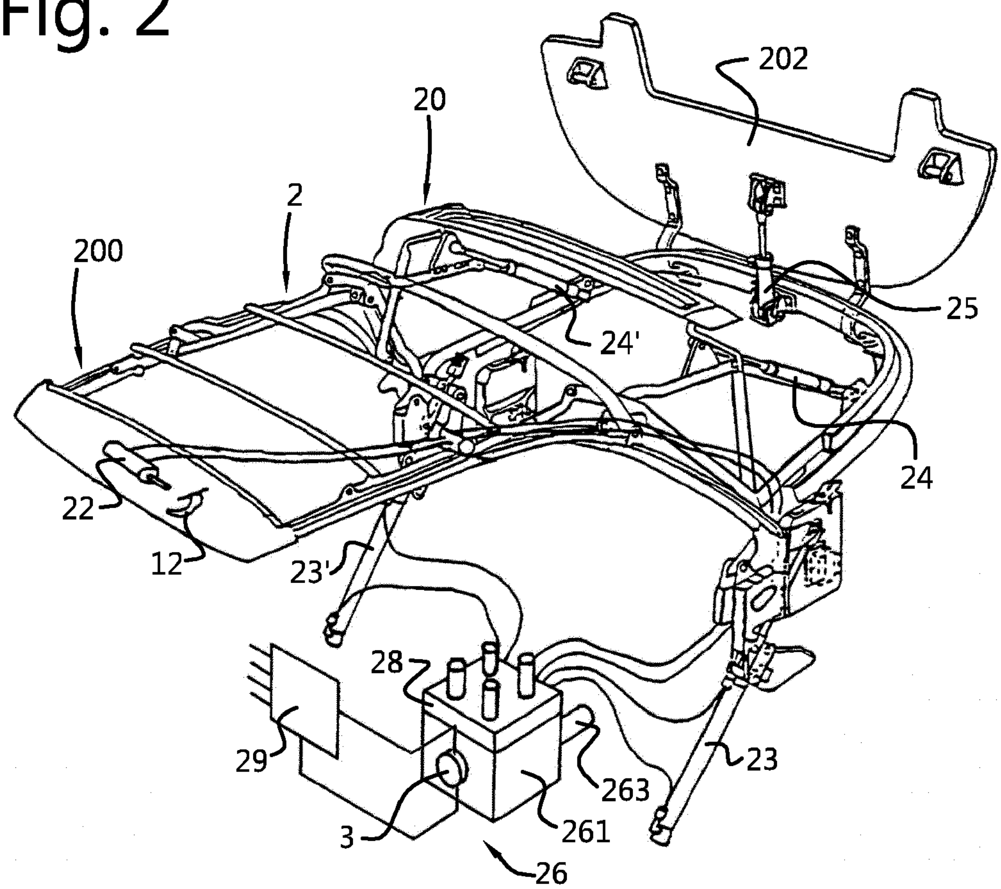
202

Fig. 2


202
20
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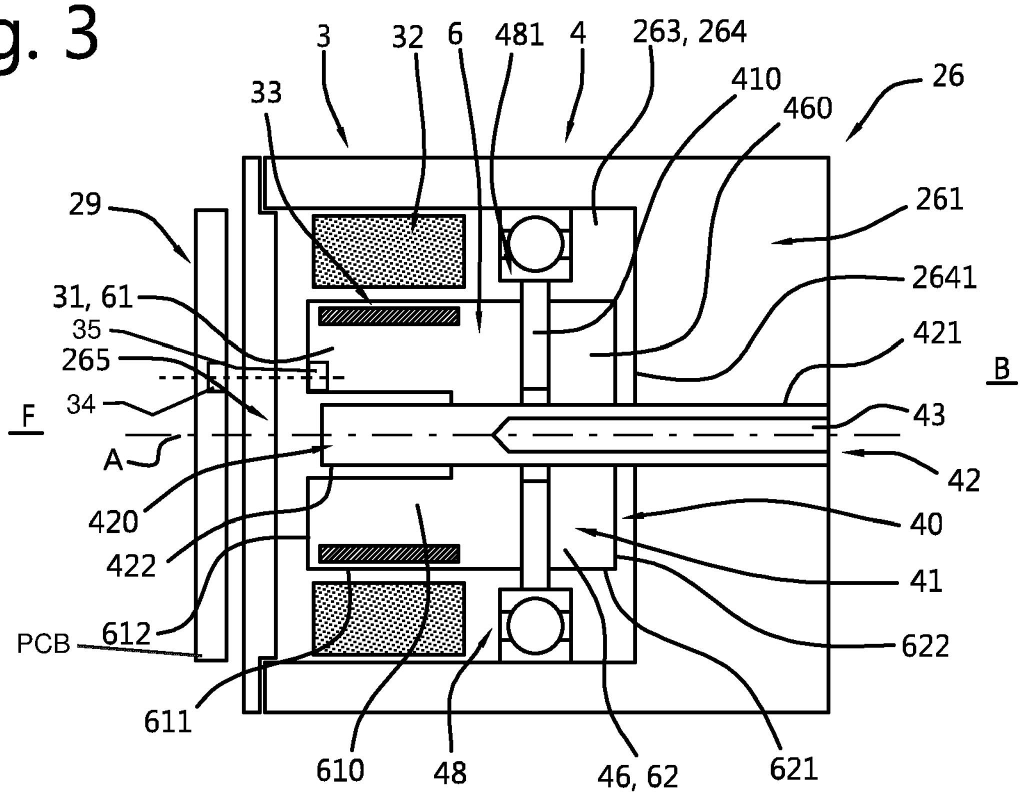
25
24'
24
22
12
23'
28
29
23
263
3
261
26

Fig. 3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B
34
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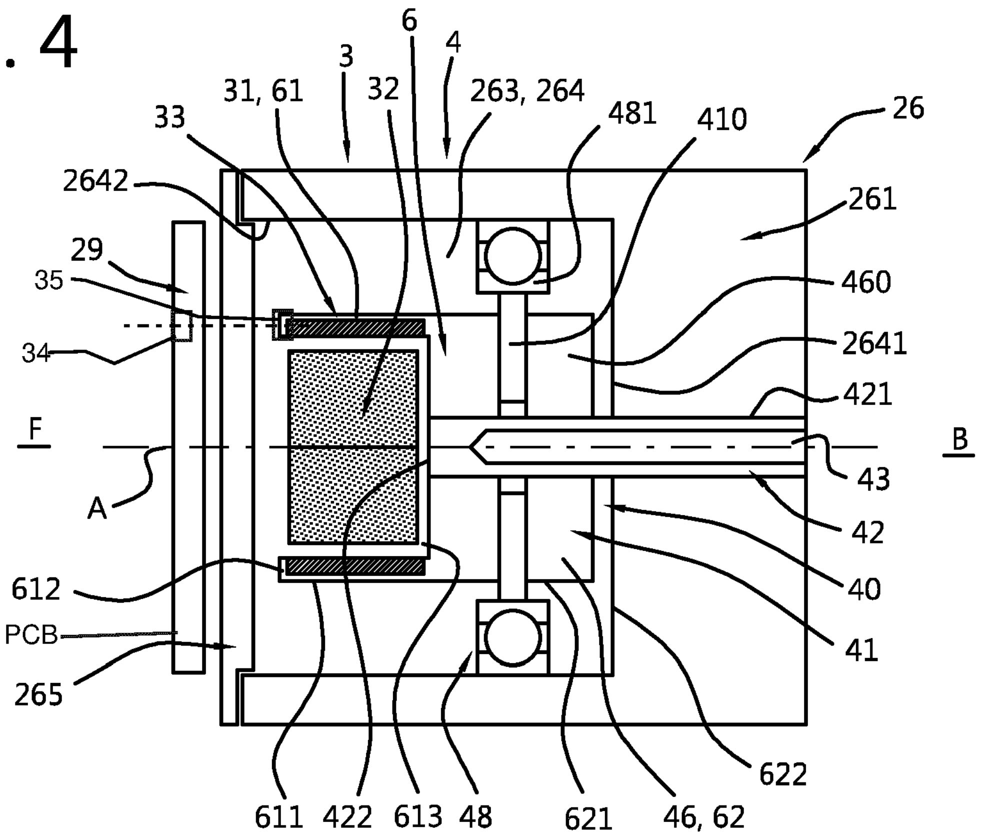
41
612
622
PCB
611
610
48
46, 62
621

Fig. 4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PCB
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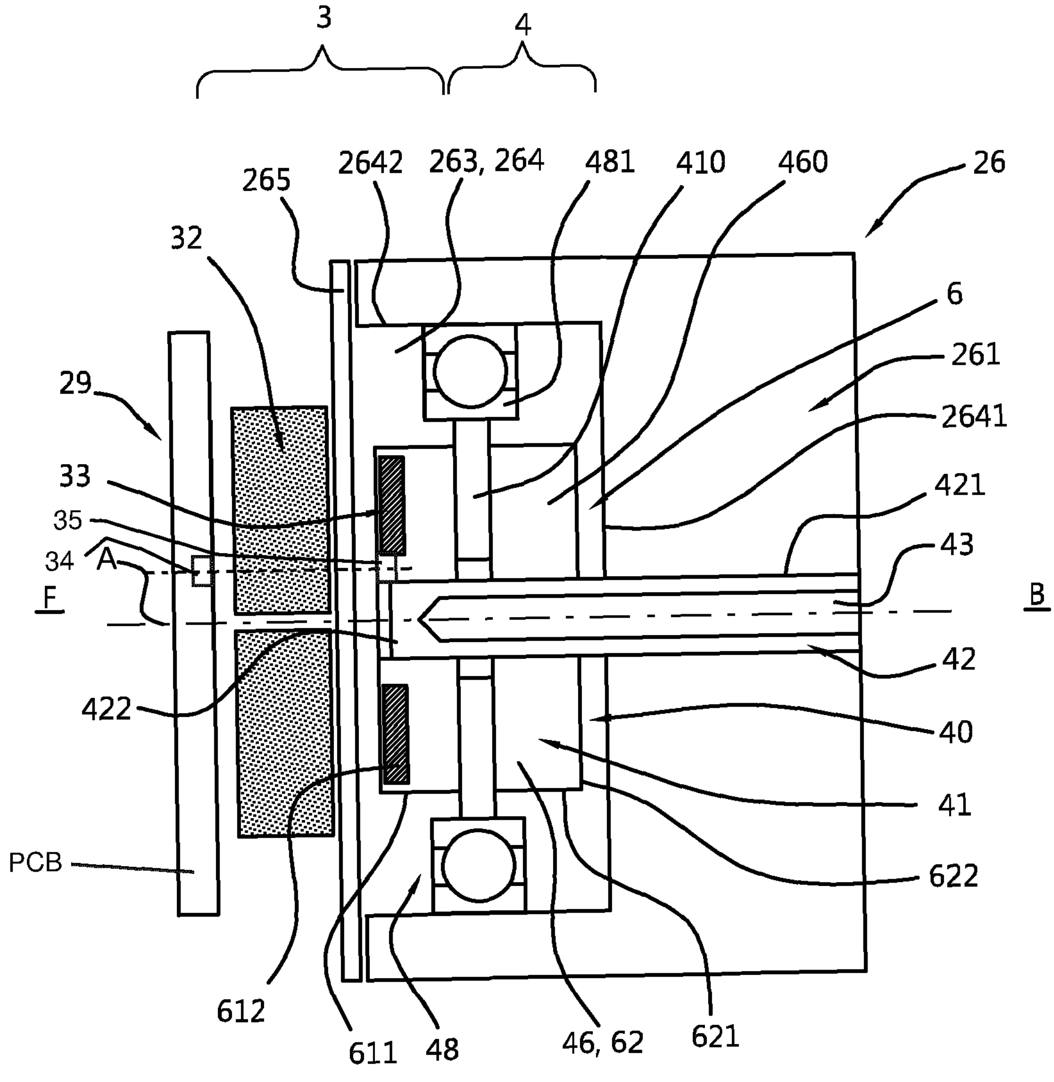
621
46, 62

Fig. 5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F
B
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42
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PCB
622
612
611
48
46, 62
621

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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 7945

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2019/154036 A1 (NIEUWENHUIS MARCEL GERARDUS MARIA [NL]) 23 May 2019 (2019-05-23) * figures 3-5 * * paragraph [0053] - paragraph [0084] * -----	1-15	INV. F04B1/047 F04B1/1071 F04B17/03 F04B49/06
Y	WO 2019/081011 A1 (PIERBURG PUMP TECHNOLOGY GMBH [DE]) 2 May 2019 (2019-05-02) * figures 1-3 * * page 5, line 13 - page 7, line 17 * -----	1-15	
A	WO 2018/091101 A1 (PIERBURG PUMP TECHNOLOGY GMBH [DE]) 24 May 2018 (2018-05-24) * figures 1-2 * * page 5, line 11 - page 7, line 17 * -----	1-15	
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			TECHNICAL FIELDS SEARCHED (IPC)
			F04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	7 April 2021	Ricci, Saverio

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons
& : member of the same patent family, corresponding document

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07-04-2021

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REFERENCES CITED IN THE DESCRIPTION

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