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(11)

EP 1 091 119 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

11.04.2001 Bulletin 2001/15

(51) Int Cl.7: **F04B 1/16**

(21) Application number: **00308801.0**

(22) Date of filing: **05.10.2000**

(84) Designated Contracting States:

**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: **09.10.1999 GB 9923822**

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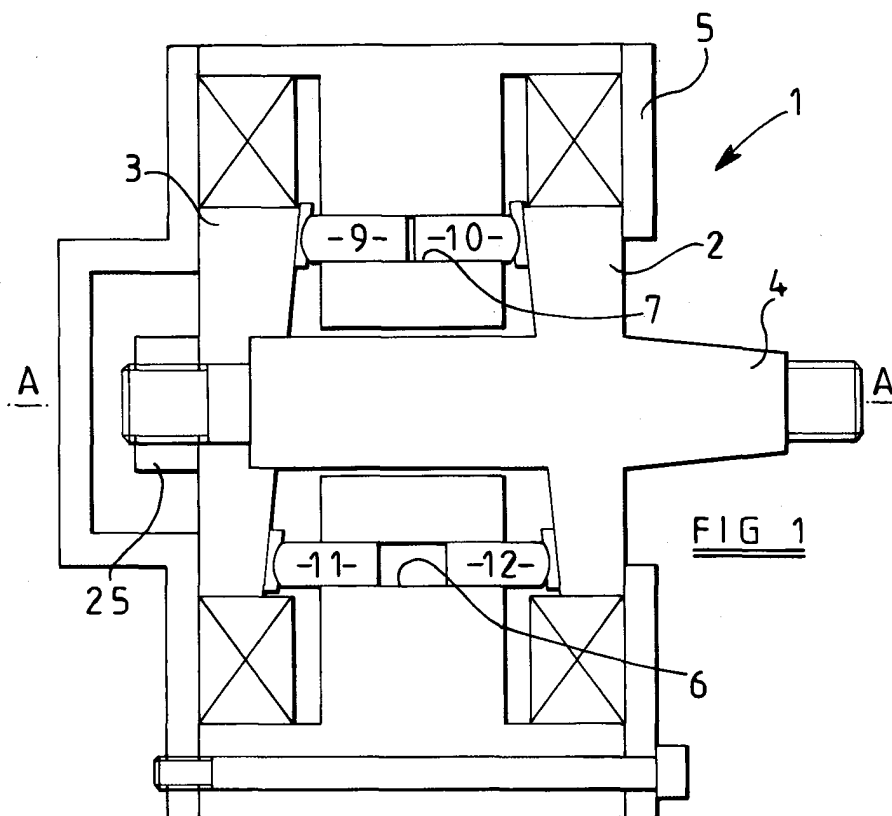
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(54) **Swash plate tyre pump**

(57) A pump comprises a shaft (4), two opposed swash plates (2,3) carried by the shaft (4), and at least one plunger (9, 10, 11, 12) disposed between the swash plates (2, 3). The swash plates (2, 3) are rotatable with the shaft (4) about a longitudinal axis of the shaft (4) for

driving the or each plunger (9, 10, 11, 12), the arrangement being such that forces exerted on the swash plates (2, 3) by the or each plunger (9, 10, 11, 12) during operation of the pump are mutually opposed so as to reduce the net axial force on the shaft (4).



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Description

[0001] This invention relates to a swash plate type pump.

[0002] Pumps are generally known comprising a shaft and a swash plate rotatable with the shaft about a longitudinal axis of the shaft. In a known type of arrangement, the swash plate drives two plungers, each in a respective bore. One problem with the known type of pump is the resultant axial load caused by reaction forces exerted by the plungers on the swash plate and transmitted through the shaft to its support structure. The resultant axial load is generally carried by a thrust bearing of the shaft support structure. This asymmetric loading results in more expensive and inevitably larger support bearings.

[0003] An object of the invention is to overcome or mitigate the above-mentioned problem.

[0004] In accordance with the invention, a pump is provided comprising a shaft, two opposed swash plates carried by the shaft, and at least one plunger disposed between the swash plates, the swash plates being rotatable with the shaft about a longitudinal axis of the shaft for driving the or each plunger, the arrangement being such that forces exerted on the swash plates by the or each plunger during operation of the pump are mutually opposed so as to reduce the net axial force on the shaft.

[0005] This is advantageous in that there is a less stringent design requirement for the support structure supporting the pump, and in particular the support structure for the shaft. The absorption of axial forces within the shaft also facilitates the reduction of wear and tear in the support structure.

[0006] The term axial in this specification refers to the longitudinal axis of the shaft.

[0007] The plungers may be provided in a pair or in pairs, the plungers in the or each pair being arranged to move in mutually opposite directions throughout their respective strokes.

[0008] The stroke of the plungers in the or each pair may be substantially equal. Alternatively, one of the swash plates may be arranged to provide no plunger stroke or a reduced plunger stroke.

[0009] At least one of the swash plates is conveniently operable to vary the swept volume of the pump. This may be achieved, for example, by rotating the or each swash plate about a diametrically arranged axis, or alternatively by using a control arrangement as described in British Patent Application No. GB 2342701A.

[0010] The invention is particularly suitable for use in supplying fuel to a common rail of the fuel system of a compression ignition internal combustion engine, but it will be understood that the invention is also suitable for use in other applications where fluid must be pressurised to a high level.

[0011] In order that the invention may be better understood, an embodiment thereof will now be described,

by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal cross-sectional view of a pump embodying the invention; and

Figure 2 is a cross-sectional end view of the pump in Figure 1.

[0012] Referring to the drawings, a pump shown generally as 1 comprises two swash plates 2, 3 rotatable with a shaft 4 about its longitudinal axis A-A. The exemplary pump 1 is a high pressure pump particularly suited for use in supplying fuel to a common rail of a fuel system of a compression ignition internal combustion engine. The swash plates 2, 3 and shaft 4 are contained in a housing 5 defining two bores 6, 7 (shown in Figure 1). Each bore 6, 7 contains a pair of opposed plungers 9, 10 and 11, 12 respectively. The housing defines two further bores 13, 14 (shown in Figure 2), each containing a further respective pair of plungers (not shown). A respective slipper member 30a-30d (only four of which are shown in Figure 1) is located at one end of each of the plungers 9, 10, 11, 12, the slipper members 30a-30d co-operating with the respective swash plate 2, 3. Alternatively, the slipper members may be replaced with appropriate roller members.

[0013] In use, fuel is drawn by the reciprocating plungers through a pump inlet 15 and into each of the bores 6, 7, 13, 14 through respective inlet plate valves 16a, 17a, 18a, 19a in sequence during the respective suction phase in each of the bores 6, 7, 13, 14. Fuel at high pressure is expelled from the bores 6, 7, 13, 14 through outlet ball valves 16b, 17b, 18b, 19b during the compression phase for each of the bores, and is discharged through each of pump outlets 20, 21, 22, 23. The outlets 20, 21, 22, 23 may be in fluid communication with fuel supply passages in respective fuel injectors (not shown).

[0014] One end of the shaft (the left hand end as shown in Figure 1) is fitted with a nut 25 which retains the swash plate 3 in position on the shaft. The opposite end of the shaft 4 (the right hand end as shown in Figure 1) is connectable in use to drive gear (not shown) for driving the pump. The shaft 4 may be driven by any convenient means, for example through a taper, splines or a square. During the compression phase in each of the bores 6, 7, 13, 14, that is, as the plungers move together from the position shown in bore 6 in Figure 1 to the position shown in bore 7 in Figure 1, equal and opposite outward reaction forces are exerted on the swash plates 2, 3 and transmitted into the shaft 4. These axial forces are absorbed as stress within the shaft 4. At the high pressures involved, the axial forces can be very significant, and the fact that the axial forces are absorbed in the shaft 4 means that the housing 5 need not be provided with such a robust support structure for absorbing the net axial force transmitted by the shaft 4 to the sup-

port structure. It should be pointed out that some axial loading will still be applied by the helical external drive gear (not shown), and that some lateral loading will be applied by the external drive gear and the plungers.

[0015] In an alternative pump embodying the invention (not shown) one of the swash plates 2, 3 may present an operating face which is perpendicular or almost perpendicular to the longitudinal axis A-A of the shaft 4. The slight angle provided where the face is almost perpendicular facilitates sufficient movement to lubricate the plungers and followers associated with the swash plate. This arrangement is particularly suitable for smaller swept volumes.

[0016] In a further alternative pump embodying the invention (not shown) at least one of the swash plates 2, 3 may be movable relative to the shaft to vary the swept volume in each of the bores. Alternatively, the swash plates 2, 3 may be rotated relative to one another to vary the swept volume in each of the bores. This may be achieved by rotating a swash plate about a diametrical axis in a known manner, or in the manner disclosed in British Patent Application No. GB 2342701A. For example, it would be possible to control the displacement of the high pressure pump by means of a balancing piston which opposes the torque applied to the swash plate by the plungers and a control piston which is movable under the action of fluid within a control chamber to control the pivot angle of the swash plate. Electromagnetically controlled inlet and outlet valves may be used to control communication between the control chamber and a high pressure outlet of the pump and a low pressure drain respectively.

[0017] It will be appreciated that a different number of plunger bores to that shown in the accompanying drawings may be included in the pump of the present invention, each plunger bore having a plunger or a pair of plungers being reciprocable within the respective bore. It will also be appreciated that the housing 5 may be an integrally formed housing, or may be formed from separate housing parts.

Claims

1. A pump is provided comprising a shaft (4), two opposed swash plates (2,3) carried by the shaft (4), and at least one plunger (9, 10, 11, 12) disposed between the swash plates (2, 3), the swash plates (2, 3) being rotatable with the shaft (4) about a longitudinal axis of the shaft (4) for driving the or each plunger (9, 10, 11, 12), the arrangement being such that forces exerted on the swash plates (2, 3) by the or each plunger (9, 10, 11, 12) during operation of the pump are mutually opposed so as to reduce the net axial force on the shaft (4).
2. The pump as claimed in Claim 1, wherein the swash plates (2, 3) are contained within a housing (5) de-

fining a first bore (6), wherein a plunger (11, 12) is reciprocable within the first bore (6).

3. The pump as claimed in Claim 2, wherein the first bore (6) receives a first pair of opposed plungers (11, 12), each plunger (11, 12) having a plunger stroke within the first bore (6), the plungers being arranged to move in mutually opposite directions throughout their respective plunger strokes.
4. The pump as claimed in Claim 3, wherein the housing (5) defines a second bore (7), wherein the second bore (7) receives a second pair of opposed plungers (9, 10), each plunger having a plunger stroke within the second bore (7), wherein the opposed plungers (9, 10) within the second bore (7) are arranged to move in mutually opposite directions throughout their respective plunger strokes.
5. The pump as claimed in Claim 3 or Claim 4, wherein the plunger stroke of the plungers (11, 12, 9, 10) in one or both of the first or second pair is substantially equal.
6. The pump as claimed in Claim 3 or Claim 4, wherein one of the swash plates (2, 3) is arranged to provide no plunger stroke or a plunger stroke of reduced extent.
7. The pump as claimed in any of Claims 4 to 6, wherein at least one of the swash plates (2, 3) is operable to vary the volume of one or more of the first and second bores (6, 7) which is swept by the stroke of the associated plungers (11, 12, 9, 10).
8. The pump as claimed in Claim 7, wherein at least one of the swash plates (2, 3) is arranged such that it is rotatable about a diametrically arranged axis.
9. The pump as claimed in any of Claims 1 to 8, for use in supplying fuel to a common rail of the fuel system of a compression ignition internal combustion engine.

