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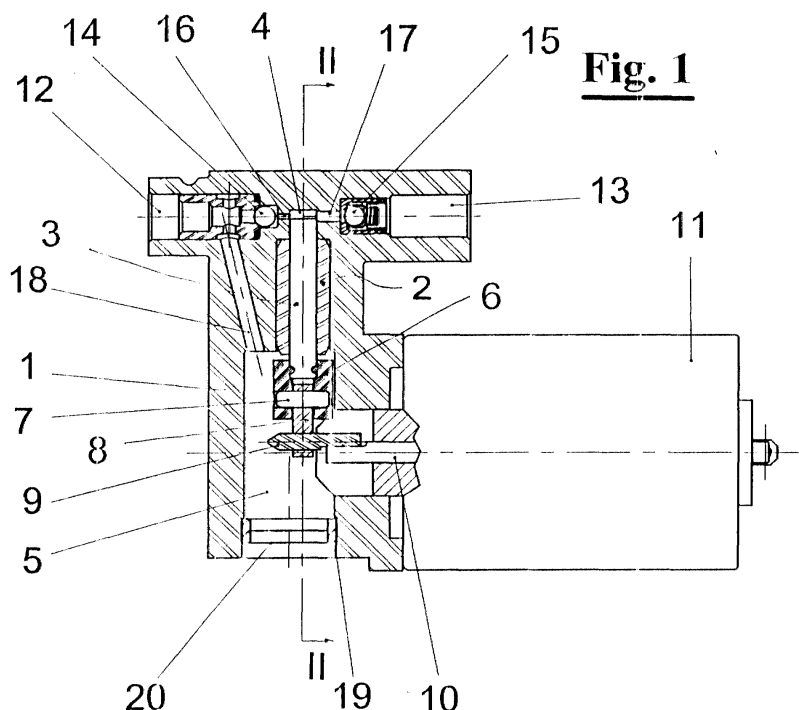
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(54) **Pump for feeding fuel to an internal combustion engine**

(57) A pump for feeding of fuel an injection system for an internal combustion engine comprising a body (1, 1'), a conduit (16,17) with single-acting valves (14, 15) that extends between a suction inlet (12) and a delivery outlet (13); at least one cylinder (2) made in the body (1, 1') wherein a piston (3) reciprocates capable of pumping fuel into the conduit (17) towards the delivery outlet (13). In the body a first (4) chamber crossed by the conduit (16, 17) and a second chamber (5, 5') are made both flooded by the fuel. The piston (3) reciprocates towards/

from the first and second chamber (4-5,5'). The inner diameter of the cylinder (2) exceeds the outer diameter of the pumping piston (3) according to a clearance sufficient to allow a minimum leakage of fuel from the first to the second chamber, whereby the leakage of fuel lubricates the coupling between the piston (3) and the cylinder (2). A channel of return (18) of the leaked fuel is provided between the second chamber and the conduit (16). For operating the piston (3) the second chamber (5) contains a cam mechanism (6,7,8,9) connected to a driven shaft (10).



Description

Field of the invention

[0001] The present invention relates to a pump for feeding of fuel a fuel injection system for internal combustion engines. In particular the pump is suitable for engines with small swept volume.

Background of the invention

[0002] The pumps for feeding a fuel injection system for internal combustion engines take the fuel from a tank located at a certain distance from the engine same. In the car manufacturing field many types of pumps for this purpose are operated by an electric motor.

[0003] In EP0222034, for example, a centrifugal pump is described for fuel feeding. The use of this type of pump is however limited to the cases wherein the necessary pressure of discharge is less than 1 bar. Furthermore the pump has not any self-priming capacity with the consequent need of locating it in the fuel tank or at a lower or equal level with respect to it.

[0004] Vane pumps are also known, such as for example described in GB2166802, which however have a substantial friction between blades and inner surface of the pump body and have, therefore, a considerable power consumption.

[0005] In the car field there is also a considerable use of so called roller pumps, like that described in EP0189639. This type has, however, a reduced compression ring area between the rollers and the cooperating surfaces of the channel and of the vanes of the rotor. Furthermore the rollers urge at the same time on the surfaces of the cylindrical guide channel and on the vanes of the rotor with the consequent sliding that causes friction and wear of the components. A similar friction is present between the two ends of the rollers and the flat surfaces of the side plates that define the rotor.

[0006] In some roller pumps, like that described in US4362480, friction and wear are reduced by means of the use of expensive wearproof material and hardened surfaces on which copper-nickel alloys or PTFE are deposited.

[0007] Similar drawbacks of relevant friction and wear are present in radial piston pumps like that described in FR2367196.

[0008] Furthermore, pumps for fuel are known that use balls as pumping elements. A pump of this type is described in FR2506854. These pumps are particularly expensive since they need a high coupling precision between ball and relative cylinder to limit the leakage caused by a very small sealing surface. Furthermore they require an expensive hemispherical channel for reducing the pressure of contact between balls and guiding channel.

[0009] Recently, in the car field, the use is common of pumps so called "gerotor". Such pumps, an example of

which is shown in US 4500270, have two gearings, one of which is internally toothed, that rotate about two different axes. The pumping action is caused by the variation of volume that occurs when a tooth of the inner rotor penetrates a corresponding vane of the outer rotor. Also the pumps of this type are relatively expensive owing to the high dimensional precision required to both gears for reducing the fuel leakage. In particular, adjustment steps are provided to limit the clearance between the teeth of the two gears below 0.02mm. These pumps have, furthermore, a loss of efficiency owing to the sliding friction between the inner gear and the stator housing. This friction is, moreover, increased by the radial thrust caused by the pressure of the fuel contained in the vanes of the teeth.

[0010] A further aspect is that almost all the pumps of the types above described are operated by electric motors crossed by the flow of the fuel that is fed to the motor.

[0011] A problem connected to this type of electric motor is that, owing to the radial channel, that is narrow with respect to its length, the armature of the motor causes in the fuel, turbulence and vorticity in radial direction that reduce the flow of the fuel same and increase its temperature, thus enhancing the production of vapour that is detrimental to the good operation of the injection system. The flow causes, furthermore, a decrease in the efficiency of the electric motor/pump system.

[0012] Other problems are often connected to the use of an electric motor. Such problems are the wear of the coupling joint pump-motor and the co-axial thrust of the pump on the supports of the motor shaft. In some pumps, see FR2510804 and US4500270, the problem of the axial thrust is worsened by the use of resilient elements urging on the side plates that house the rotating parts of the pump for reducing the side clearance and the leakage.

[0013] A further type of pump for feeding petrol, used for two- and four-cycle engines, is like that shown in US 4829967. This pump provides one or more pistons that reciprocate through a mechanism of "desmodromic" type.

[0014] This pump avoids some of the drawbacks previously described but, being provided for fuel pressures of about 300 bar, is particularly expensive for complexity of the structure and for precision of the piston/cylinder coupling; the radial allowance existing between these two elements is about 0.001mm. This pump, operated directly by the internal combustion engine in direct phase has, furthermore, the need of a separate lubrication system for feeding oil under pressure to a circular channel made in the middle of the cylinder of the pumping element, in order to avoid fuel leakage towards the lower chamber containing the cam shaft and the driving mechanism.

Summary of the invention

[0015] Object of the present invention is to provide a pump for feeding of fuel an internal combustion engine that can be easily manufactured, has a fairly small size, does not require expensive machining or complex assembling, fulfils the required performances and does not present the above described drawbacks with reference to the prior art.

[0016] These objects are achieved by the pump according to the invention for feeding of fuel an injection system for an internal combustion engine comprising:

- a body,
- a conduit associated to said body, with single-acting valves for leading the fuel from a suction inlet towards a delivery outlet;
- at least one cylinder made in the body;
- at least one piston reciprocating in the at least one cylinder and capable of pumping fuel into the conduit, towards the delivery outlet.

[0017] The characteristic of the pump is that in the body a first chamber crossed by the conduit and a second chamber are made, both flooded by the fuel, the piston reciprocating towards/from the first and second chamber and having a first end plunging in the fuel in the first chamber and a second end plunging in the fuel in the second chamber. Furthermore the inner diameter of the cylinder exceeds the outer diameter of the at least one pumping piston according to a clearance sufficient to allow a minimum leakage of fuel from the first to the second chamber, whereby the leakage of fuel lubricates the coupling between the piston and the cylinder.

[0018] A channel is advantageously provided of return of the leaked fuel from the second chamber to the conduit.

[0019] Preferably, the clearance between the inner diameter of the cylinder and the outer diameter of the at least one pumping piston is set between 0.010 and 0.030 mm.

[0020] In a preferred embodiment, the conduit comprises a portion, on the side of the suction inlet upstream of the first fuel chamber and hydraulically connected to the first chamber, formed by a plurality of holes arranged along a circumference concentrically to the axis of the suction inlet and with the interposition of a first single-acting valve for determining a one way flow from the suction inlet to the first chamber.

[0021] Preferably, when the piston is at the top dead center, the chamber and the conduit portion that is set between the single-acting valves, have an overall volume that is less than the swept volume of the piston. The reciprocation stroke of the piston is furthermore longer than four times the diameter of the piston.

[0022] For operating the piston the second chamber contains advantageously a cam mechanism connected to a driven shaft.

[0023] The single-acting valve located between the suction inlet and the first chamber is a free ball valve, the stroke of the ball being less than 1/5 of the diameter of the ball.

[0024] In the body of the pump a compensation channel of the peak pressure is advantageously provided that extends between the first chamber and the outlet mouth. In the compensation channel a pressure relief valve is present loaded to open at a predetermined value of the pressure of the fuel present in the delivery outlet so that, when a preset value is exceeded, a partial return flow of the fuel from the delivery outlet towards the second chamber is determined.

[0025] The second chamber can be hydraulically connected to a fuel tank through an opening containing a filter element.

[0026] In particular, the pump according to the invention:

- reaches a discharge pressure up to 10 bar;
- has fairly small size and low power consumption and can be used even for small two-cycle engines for motorcycles;
- is self-priming and can, therefore, be located also out of the fuel tank;
- it does not produce a thrust coaxial to the drive shaft of the electric motor of the pump;
- it has a flow of the fuel that does not cross the electric motor avoiding, thus, the formation of vapours detrimental to the fuel injection;
- it does not need strict coupling piston/cylinder and oil sealing systems either;
- complex connection joints electric motor/pump are not necessary and, then, wear and noise are fairly low;
- the need of cumbersome damping systems of the peak pressures in the portion of the fuel feeding conduit located between the pump and the internal combustion engine is not necessary; in fact, such a device is included in the pump body without increasing the encumbrance of the same.

Brief description of the drawings

[0027] Further characteristics and the advantages of the pump according to the invention will be made clearer with the following description of an embodiment thereof, exemplifying but not limitative, with reference to the attached drawings, wherein:

- figure 1 shows a longitudinal cross sectional view of a mono-cylindrical embodiment of the pump according to the invention provided for being accommodated in a fuel tank, in association to an electric motor;
- figure 2 shows a transversal view of the pump sectioned according to line II-II of figure 1;
- figure 3 shows a cross sectional longitudinal view

of a different embodiment of the pump to be located outside of the tank and comprising a damping system of the fuel feeding peak pressure.

Description of a preferred embodiment

[0028] According to the present invention, the pump comprises a body 1 having a cylinder 2 in which a pumping piston 3 reciprocates whose ends plunge in two chambers of different volume 4 and 5 contained in the same pump body 1. At the end on the same side of the chamber of major volume 5 piston 3 is integrally connected to a joint 6 that is connected, by means of a first pin 7 and a connecting rod 8, to a second pin 9 eccentrically integral to shaft 10 of an electric motor 11.

[0029] If the pump is used on engines with higher swept volume, connecting rod 8 and pins 7 and 9 may be coupled by needle bearings.

[0030] The eccentricity of second pin 9 with respect to the axis of shaft 10 of electric motor 11 determines the reciprocation stroke of pumping piston 3. The constancy of said stroke in case of a mass production is assured by the easy structure of the cam system formed by a flattening machined on second pin 9 and on shaft 10 of the engine with the following union of said two parts by means of a strong welding, preferably a laser welding.

[0031] If the number of parts in a mass production must be reduced the step of welding can be avoided on the assembled electric motor, if eccentric pin 9 is formed in one piece with shaft 10 of electric motor 11.

[0032] Joint 6 that is integral to the pumping piston is, preferably, of plastics and its connection to piston 3 can be preferably done by means of direct injection moulding on it.

[0033] In pump body, furthermore, two conduits 12 and 13 are made that are, respectively, the inlet conduit 12 and the outlet conduit 13 of the fuel. Both conduits are hydraulically connected, with the interposition of two single-acting ball valves 14 and 15 and by means of a plurality of narrow ducts 16 and 17, to the chamber of minor volume 4 in which pumping piston 3 plunges.

[0034] The chamber of major volume 5, wherein the drive mechanism of pumping piston 3 is housed, is furthermore connected, by means of a further conduit 18 made in the body 1 of the pump, to the inlet conduit 12 of the fuel.

[0035] In case of arrangement of the pump/motor unit in the fuel tank, the chamber of major volume 5 provides an opening 19 of connection with the tank same. Preferably, in said opening a filter 20 is arranged.

[0036] The clearance existing between the reciprocating pumping piston 3 and the cooperating cylinder 2 is important for avoiding expensive machining, to limit the leakage, to keep a self-priming capacity and to contain the power consumption, by assuring the presence, between pumping piston and cylinder, of a hydrodynamic bearing determined by the fuel. In this case the sealing

area between the two chambers 4 and 5 is proportional to the length of cylinder 2.

[0037] According to the present invention, the above objects are achieved using a diametrical clearance between piston and cylinder set between 0.010 and 0.030 mm. This clearance allows to limit the costs of production avoiding the need of expensive couplings during production and long control steps when assembling.

[0038] With this clearance the leakage of fuel between pumping piston 3 and cylinder 2, not slight but in any case low, which occurs during the pumping step, is not detrimental to the pumping action since the chamber 5 containing the driving mechanism of the pump is flooded with fuel. The fuel leaked into chamber 5 is returned to the inlet conduit of the pump through the further conduit 18 made in the body of the pump same.

[0039] The amount of leaked fuel, and therefore the volumetric efficiency of the pump, are preferably controlled providing a length of cylinder 2, and then a sealing area between the two chambers 4 and 5, equal to at least four times the diameter of pumping piston 3.

[0040] Another parameter for improving the volumetric efficiency is the amount of fuel contained in the space formed by the chamber of minor volume 4 and the plurality of conduits 16 and 17 that connect said chamber to the two single-acting valves 14 and 15. Preferably, when pumping piston 3 is located in the position corresponding to the minimum volume of chamber 4, the volume of said amount of fuel must not exceed the swept volume of the pump, calculated as known by the transversal cross section of pumping piston 3 multiplied with the reciprocation stroke.

[0041] The volume of liquid contained in the space around the chamber of minor volume 4 is also limited by the use, at the suction inlet 12, of a free single-acting ball valve, that avoids the considerably more volume of liquid that would be contained in the space if a spring loaded ball valve were used.

[0042] Even without spring, the ball of said single-acting valve 14 is centred with respect to the relative recess by the flow of the fuel pushed towards the chamber of minor volume 4 by means of a plurality of conduits 16 arranged along a circumference concentrically to the axis of said recess.

[0043] For reducing further the volume of liquid around chamber 4, the ball of single-acting valve 14 located at suction inlet 12 is associated to a pawl that limits the stroke of the ball to less than 1/5 of the diameter of said ball.

[0044] In some pumps a dampening system of the peak pressure is provided, preferably made in the body, suitable for reducing the unevenness of the pressure of fuel fed to the internal combustion engine, as in particular in the case of pumps having a single piston.

[0045] Usually, the unevenness is minimised by means of resilient dampeners located between the feeding pump and the fuel injection system. These dampeners are efficient but their encumbrance creates prob-

lems of installation on the vehicle, particularly on motor-cycles and mopeds.

[0046] As shown in figure 3, in order to avoid the above described problems of encumbrance, an embodiment of the pump according to the present invention provides the presence of a conduit 21 made in the body 1' of the pump and hydraulically connecting the zone of the delivery outlet 13' located downstream the relative single-acting valve 15 with the chamber of major volume 5' containing the "desmodromic" cam drive mechanism.

[0047] In said connection conduit 21 a spring loaded pressure relief valve 22 is arranged that opens the flow at a pressure slightly higher than the pressure set by a pressure adjusting device, not shown, that is located on the conduit that connects the pump to the injection system of the internal combustion engine. Valve 22 allows, when a preset value is exceeded, a partial return flow of the fuel from delivery outlet 13' towards the chamber of major volume 5'.

[0048] The pressure relief valve provides, thus, to cut the significant part of the peak pressure that occurs at every stroke of the pumping piston and makes easier the equalisation of pressure.

[0049] The operation of the fuel feeding pump is fairly easy owing to its simple structure. To operate the pump, second pin 9 eccentrically connected to shaft 10 of the motor rotates about the axis of the shaft same. This movement causes, through connecting rod 8, first pin 7 and joint 6, the reciprocation of pumping piston 3. Owing to said movement of the piston and to the presence of single-acting valves 14 and 15 that allow a one way flow from the suction inlet to the delivery outlet, in the chamber of minor volume 4 fuel comes from said suction inlet 12 and, then, is compressed towards the delivery outlet 13 hydraulically connected to a pressure relief valve and to the injectors, not shown, of the injection system.

[0050] The foregoing description of a specific embodiment will so fully reveal the invention according to the conceptual point of view, so that others, by applying current knowledge, will be able to modify and/or adapt for various applications such an embodiment without further research and without parting from the invention, and it is therefore to be understood that such adaptations and modifications will have to be considered as equivalent to the specific embodiment. The means and the materials to realise the different functions described herein could have a different nature without, for this reason, departing from the field of the invention. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Claims

1. Pump for feeding of fuel the injection system of an internal combustion engine comprising:

- a body (1, 1');
- a conduit (16,17), associated to said body, having single-acting valves (14, 15) for leading said fuel from a suction inlet (12) towards a delivery outlet (13);
- at least one cylinder (2) made in said body (1, 1');
- at least one piston (3) reciprocating in said at least one cylinder (2) and capable of pumping fuel along said conduit (16,17) towards said delivery outlet (13),

characterised in that

- in said body a first (4) chamber crossed by said conduit (16, 17) and a second chamber (5, 5') are made both flooded by said fuel, said piston (3) reciprocating towards/from said first and second chamber (4-5,5') and having a first end plunging in fuel in said first chamber (4) and a second end plunging in fuel in said second chamber (5, 5'); and that
 - the inner diameter of said cylinder (2) exceeds the outer diameter of said at least one pumping piston (3) according to a clearance sufficient to allow a minimum leakage of fuel from said first to said second chamber, whereby said leakage of fuel lubricates the coupling between said piston (3) and said cylinder (2).
2. Pump according to claim 1, wherein said clearance between the inner diameter of said cylinder (2) and the outer diameter of said at least one pumping piston (3) is set between 0.010 and 0.030 mm.
 3. Pump according to claim 1, wherein a return channel (18) of said leaked fuel is provided that extends from said second chamber to said conduit (16).
 4. Pump according to claim 1, wherein said conduit (16,17) comprises a portion (16) on the side of the suction inlet (12) upstream of said first chamber (4) hydraulically connected to said first chamber (4), said portion being formed by a plurality of ducts arranged along a circumference concentrically to the axis of said suction inlet (12) and with the interposition of a first single-acting valve (14) for determining a one way flow from the suction inlet (12) to the first chamber (4).
 5. Pump according to claim 1, wherein when said piston (3) is at the top dead center said chamber (4) and the branch of said conduit (16,17) set between said single-acting valves (14, 15) have an overall volume less than the swept volume of said piston (3).
 6. Pump according to claim 1, wherein the reciproca-

tion stroke of said cylinder (2) is longer than four times the diameter of said piston (3).

7. Pump according to claim 1, wherein for driving the reciprocation of said piston (3) said second chamber (5-5') contains a cam mechanism (6,7,8,9) connected to a driven shaft (10). 5
8. Pump according to claim 1, wherein the single-acting valve (14) arranged between said suction inlet (12) and said first chamber (4) is a free ball valve, the stroke of the ball being less than 1/5 of the diameter of said ball. 10
9. Pump according to claim 1, wherein in the body of the pump (1') a channel (21) is provided for compensation of the peak pressure that extends between said delivery outlet (13') and said second chamber (5'), in said compensation channel a spring loaded pressure relief valve (22) being present to open at a predetermined value of the pressure of the fuel present in the delivery outlet (13') allowing, when a preset value is exceeded, a partial return flow of the fuel from the delivery outlet (13') towards the second chamber (5'). 15 20 25
10. Pump according to claim 6, wherein said second chamber (5) is hydraulically connected to a fuel tank through an opening (19) containing a filter element (20). 30

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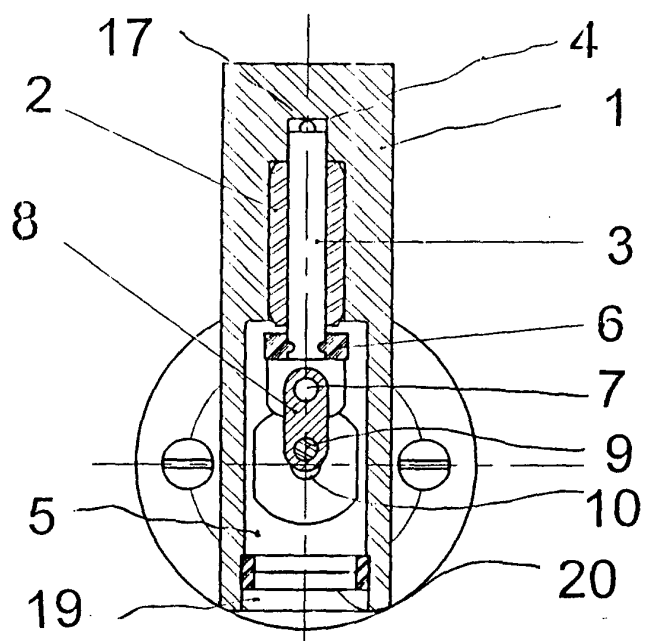
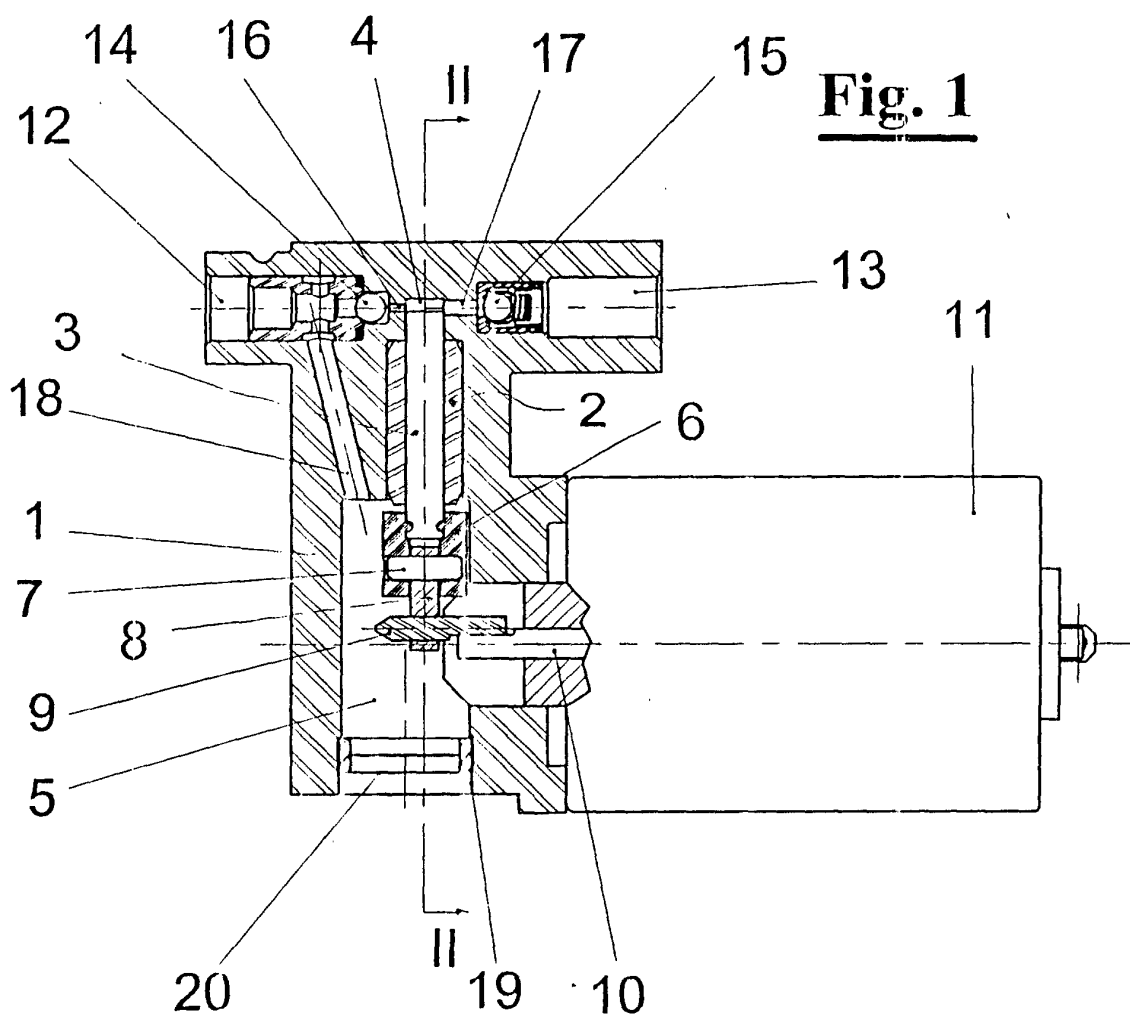
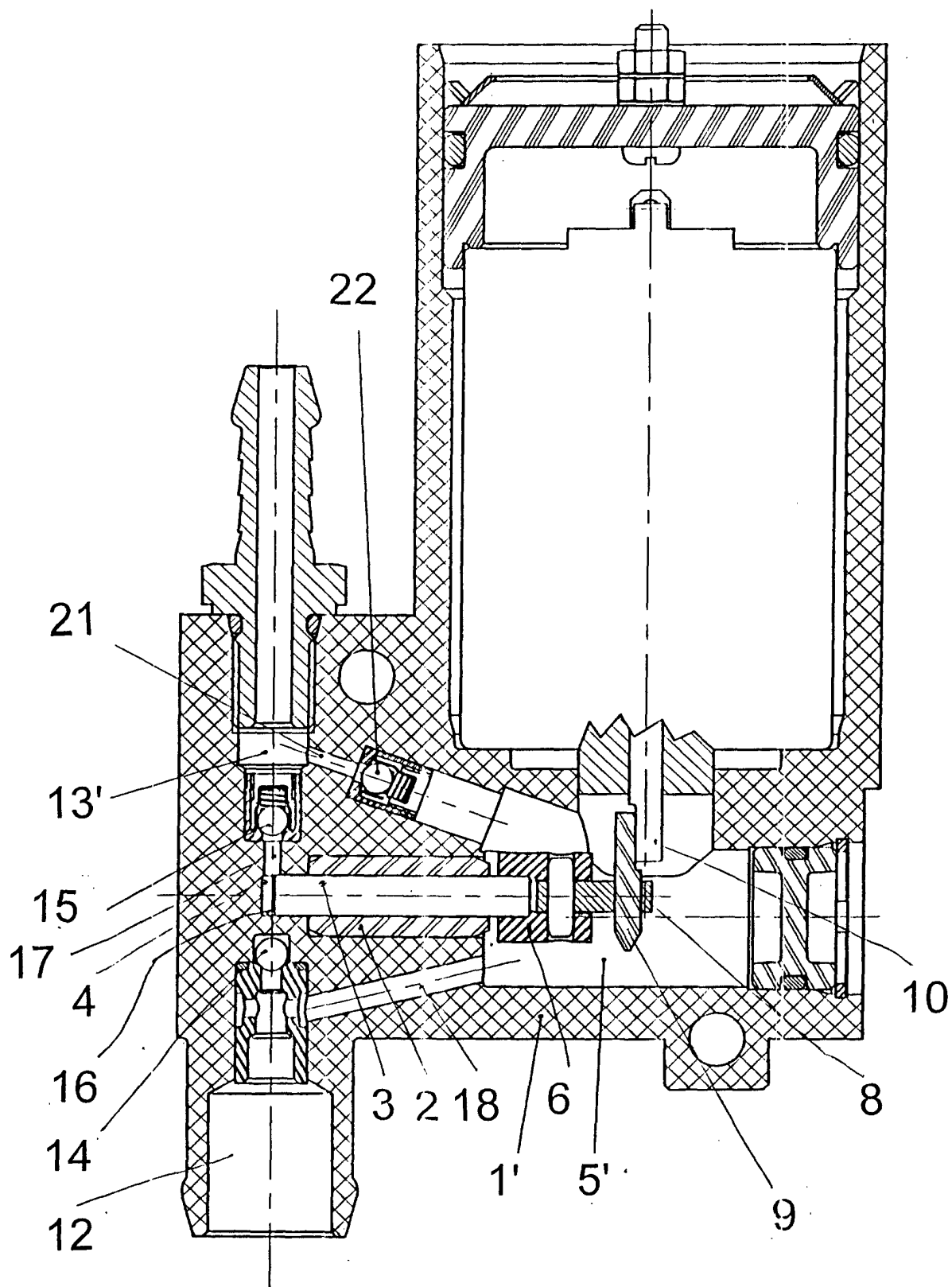


Fig. 3





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 83 0365

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 3 157 221 A (KEIL) 17 November 1964 (1964-11-17) * column 2, line 12 - line 32 * * column 2, line 72 - column 3, line 39; figures 1-3 *	1,3,7,9	F02M37/04 F04B53/04
X	US 2 183 510 A (THOMAS) 12 December 1939 (1939-12-12) * page 1, column 1, line 28 - column 2, line 43 * * page 2, column 1, line 29 - line 56 * * page 2, column 2, line 4 - line 26; figures 1-3 *	1,3,4,7	
X	US 2 365 237 A (ALLEN) 19 December 1944 (1944-12-19) * page 1, column 1, line 28 - page 2, column 1, line 6; figure 1 *	1,8 3,10	
A	DE 12 80 006 B (BORG-WARNER CORP.) * column 2, line 24 - column 3, line 12; figures 1-3 *	1,7	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	US 5 899 136 A (TARR ET AL) 4 May 1999 (1999-05-04)		F02M F04B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 20 October 2000	Examiner Van Zoest, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P4/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 83 0365

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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20-10-2000

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3157221	A	17-11-1964	NONE	
US 2183510	A	12-12-1939	NONE	
US 2365237	A	19-12-1944	NONE	
DE 1280006	B		NONE	
US 5899136	A	04-05-1999	WO 9945299 A	10-09-1999
			AU 6179198 A	20-09-1999
			DE 19880471 T	13-01-2000
			GB 2340191 A	16-02-2000