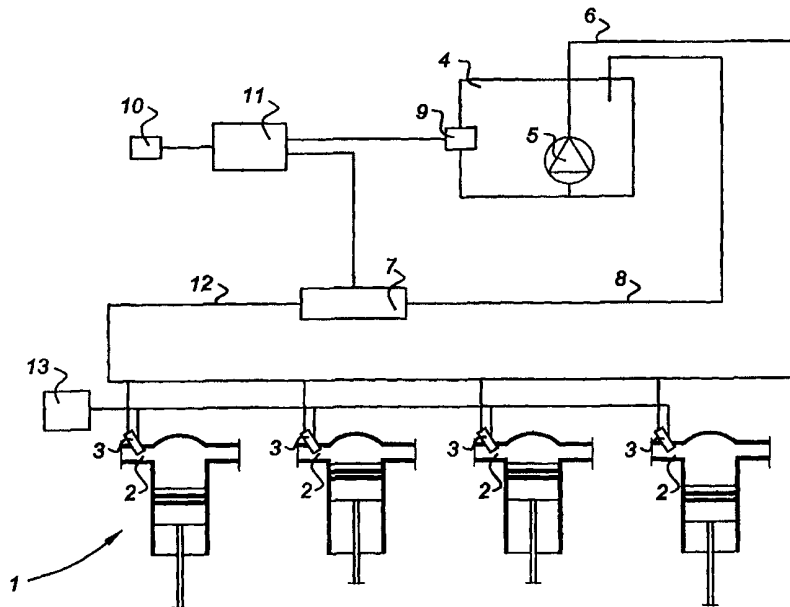




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| <p>(21) International Application Number: PCT/NL99/00404</p> <p>(22) International Filing Date: 30 June 1999 (30.06.99)</p> <p>(30) Priority Data: 1009528 30 June 1998 (30.06.98) NL</p> <p>(71) Applicant (for all designated States except US): VIALLE BEHEER B.V. [NL/NL]; P.O. Box 28060, NL-5602 JB Eindhoven (NL).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): JAASMA, Servatius, Alfons, Maria [NL/NL]; Finisterelaan 47, NL-5627 TE Eindhoven (NL).</p> <p>(74) Agent: DE BRUIJN, Leendert, C.; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL).</p> | <p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report. In English translation (filed in Dutch).</p> | |

(54) Title: FUEL SYSTEM FOR LIQUEFIED GAS



(57) Abstract

Fuel system for an internal combustion engine driven by liquefied gas. With the aid of a pump the pressure in the storage tank in which the fuel, such as LPG, is present is raised and fed via a supply line to one or more injectors. The injectors are connected to a return line in which pressure control means are present. Control of the pressure is performed in such a way that when the absolute pressure in the tank rises, for example as a result of a rise in temperature, the additional pressure contributed by the pump is reduced. Consequently, the pressure ratios over the injectors are restricted in the absolute sense in the supply line.

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Fuel system for liquefied gas

The present invention relates to a fuel system for an internal combustion engine driven by liquefied gas, comprising a storage tank for the liquefied gas, a pump in communication with the contents of said storage tank, to which pump a supply line is connected, which supply line is connected at the other end to at least one injector for injecting liquefied gas into said engine, pressure control means being present which control the rise in pressure provided by the pump in the supply line and comprise a control unit. (74)

A system of this type is disclosed in JP 60-222550A. In this known system the pressure in the supply line is raised by a constant value above the tank pressure. Raising the pressure with the aid of a pump is necessary in order to prevent premature vaporisation of the liquid gas, such as LPG. After all, vapour bubbles give rise to disruption of the operation of the engine because the amount of fuel introduced falls dramatically, as a result of which there is no longer an ignitable mixture present. At higher temperature the pressure in the tank increases and by controlling the fitted pressure controller as a function of this raised pressure, the added pressure remains constant. Another publication in which this is described is Japanese Patent Application 62-243956A.

Appreciable demands are imposed on the injectors used for injection in internal combustion engines. After all, the range over which such injectors have to function is becoming increasingly wider as the power of such engines becomes increasingly higher and the idling consumption of such engines becomes ever lower. This range is between idling and maximum power. This maximum power is achieved at relatively high revs, so that the time for injection is relatively short.

This means that appreciable demands are imposed on the dynamic range of such injectors. This dynamic range is indicated by the so-called turn down ratio, which is the quotient of the maximum flow to be delivered and the minimum flow to be delivered. These demands can be met for injectors for petrol engines where the pressure on the fuel rail, that is to say the supply line, is essentially constant. When liquefied gas is injected this dynamic range is even further increased because the pressure in the supply line varies in the absolute sense. As described above, the pressure in the storage tank will vary as a function of the temperature, and as a result of the coupling of the absolute pressure in the supply system with the absolute pressure in the tank this pressure will also vary. As a result demands are imposed on the dynamic characteristics of the injector which are impossible to meet or virtually

impossible to meet. In the case of petrol engines, where there is individual injection for each cylinder, the length of the inlet pipes for the cylinder concerned is often chosen to be so long that injected petrol is never able to move to another inlet of another cylinder, as a result of which the injection cycle for a four-stroke engine can be 720° , that is to say virtually continuous. However, because of environmental considerations, in recent years there has been increasing use of sequential injection, with which injection takes place only during the actual movement of the column of air through the inlet line, that is to say the time during which the inlet valve is open. According to even more recent developments, this range is even further reduced in order to optimise combustion. The consequence of all of this is that the time available for injection is decreasing and increasingly more stringent demands are being imposed on injectors.

US Patent 5 479 906 discloses a fuel system for fuel in vapour form. With this system some of the fuel is introduced by injectors. This is effected via a pump, a return line being fitted. Fuel injection takes place with the fuel in the liquid phase. To prevent the temperature in the tank rising too much as a consequence of the work performed in the pump, it is proposed to make a bleed line on the top of the fuel tank, by means of which bleed line fuel in vapour form can be introduced into the inlet channel of the combustion engine. As a result of the transition from liquid to vapour in the tank, the temperature of the tank falls. It is stated that the pressure in the fuel supply rail for the injectors can be controlled as a function of the desired outlet pressure. If the pressure in the tank rises, liquid in the tank will vaporise, just as in the case when the temperature rises in the tank, and will be combusted via the separate circuit.

It is known from PCT application WO 92/08886 to keep the pressure difference between tank and injector line constant.

The aim of the present invention is to be able to implement modern systems of this type using existing injectors which are largely based on petrol/diesel engine technology, that is to say have a corresponding dynamic range. In other words, the aim is to use injectors of restricted dynamic range and still to inject liquefied fuel into internal combustion engines.

This aim is realised with a fuel system as described above in that the pressure control means are designed such that said pressure rise decreases as the absolute pressure in said tank increases.

By means of this measure the variation in the absolute pressure in the supply line is appreciably less, as a result of which a more restricted dynamic range of the injector or

injectors can suffice. In contrast to the prior art, where, for example, a constant pressure rise of, for example, 5 atmospheres, was generated by the pump, according to the invention said pressure rise will vary, for example as a function of the temperature. If the temperature is high, that is to say the pressure inside the storage tank is high, the absolute pressure rise will be relatively low, whilst at a lower temperature, that is to say lower pressure in the tank, the pressure rise will be greater. It will be understood that the various features are so implemented that there is no risk of vapour bubble formation in the supply line or injectors even at the highest temperature, that is to say the lowest pressure rise. This also applies in the case of special operating conditions, such as switching off a combustion engine, where switching off must be able to be achieved in a computer-controlled manner within a very short time.

In contrast to US Patent 5 479 906, according to the invention a pressure rise produced by the pump is reduced if the absolute pressure in the tank rises. In US Patent 5 479 906 an additional quantity of liquid is vaporised when the pressure is too high and, if necessary, correction of the operation of the fuel pump takes place in order to achieve a desired outlet pressure.

Furthermore, with the fuel system according to the invention it is possible to restrict or even to eliminate the temperature rise in the storage tank for liquid LPG. Such a temperature rise is caused by the heat introduced into the tank by pumping round the fluid from the tank. Moreover, the dynamic range is improved with the fuel system according to the invention described above.

It is possible to produce a variable pressure rise according to the invention in any way known from the prior art.

According to a first preferred embodiment of the invention, a pressure regulator that can be controlled externally is fitted in the return line downstream of the injectors. The basic setting of the pressure regulator is regulated as a function of the temperature detected in the fuel tank. It is, of course, also possible, to determine pressure differences by detecting the pressure in the tank as well as the ambient pressure.

According to a further variant, a permanently open restriction is incorporated in the return line or the latter itself has an appreciable resistance. The pressure in the supply line is then regulated by regulating the flow of the quantity of fuel. Optionally, the various features can be combined with a pressure regulator. Such a combination will frequently be encountered because a non-return valve is fitted in the opening from the return line to the

tank, which non-return valve acts as a restriction. According to a preferred embodiment this is possible by varying the output of the pump and more particularly by varying the speed of revolution of the fuel pump.

According to a further advantageous embodiment of the invention, the injector is an
5 injector controlled by pulse width.

The invention will be explained in more detail below with reference to illustrative embodiments shown in the drawing. In the drawing:

Fig. 1 shows, diagrammatically, a first embodiment of the fuel system according to the invention;

10 Fig. 2 shows in detail the regulator shown diagrammatically in Fig. 1; and

Fig. 3 shows a further variant, shown highly diagrammatically, of the fuel system according to the invention.

In Fig. 1 an internal combustion engine is indicated in its entirety by 1. The inlet pipes 2 of the engine are shown, in which injectors 3 for sequential injection are shown. These
15 injectors are controlled by a control unit 13, to which information with regard to the power demand is provided in a manner which is not shown and to which engine parameters such as temperature and the like are also fed. Such a control unit is generally known in the prior art in combination with injectors 3. Injectors 3 are provided via supply line 6 with LPG from storage tank 4, in which a pump 5 is fitted. A return line 8, in which a pressure regulator 7 is
20 accommodated, is connected to the injectors. This pressure regulator 7 is connected via an electric lead 12 to a control unit 11. Signals relating to the absolute pressure originating from sensor 9 in tank 4 and the ambient pressure 10 are fed to control unit 11.

With this arrangement, according to the invention control unit 11 is so constructed that if the pressure detected by sensor 9 rises with a constant take-off by injectors 13, pressure
25 regulator 7 allows more fuel to pass through. That is to say the absolute pressure rise caused by pump 5 is partly negated by the rise in the pressure inside the tank 4. An example of such a pressure regulator is shown in Fig. 2. The inlet is indicated by 15 and the outlet by 16. Inside housing 18 there is a displaceable piston 17 which controls communication between inlet 15 and outlet 16. Piston 17 is under the pressure of spring 19, one end of which bears on cup 20.
30 The position of cup 20 is variable in the direction of arrow 23 by means of a threaded rod 21 which is coupled to a rotary motor 22 which is connected to lead 12. By moving cup 20 upwards the rise in pressure between inlet 15 and outlet 16 will increase. Such a pressure regulator can either have been incorporated in the return line 8 or have been incorporated at

the end thereof in tank 4. Furthermore, special measures can have been taken in order as far as possible to limit the noise that is produced when LPG escapes in the tank.

A further variant of the invention is shown in Fig. 3. In this figure the components which correspond to those shown in Figs 1 and 2 have been provided with the same reference numerals. The internal combustion engine is also not shown. The pump fitted in the tank 4 is now indicated by 25. The speed of revolution of said pump is adjustable, this being controlled by control unit 29 which is connected to said pump via line 30. The speed of revolution is dependent on the signal that is produced by temperature sensor 26, which is fitted in the tank. After all, it has been found that the pressure inside the tank can be determined accurately from the temperature therein. A pressure regulator 27, which has only one restriction 28, is now incorporated in the return line 8. In fact, the pressure regulation is determined by the output of motor 25 in interaction with opening 28 (and, of course, the take-off via injectors 3). With this arrangement the control unit is designed such that on raising the temperature in the tank, that is to say on raising the pressure thereof, the pump has a lower output, as a result of which although the absolute pressure in line 6 increases, the difference between the pressure in line 6 and tank 4 falls.

An example of the absolute pressure in the supply line 6 as a function of the absolute pressure in the tank will be given below.

20 Table 1

| Pressure in tank bar | Pressure at injector bar | Increase in pressure bar |
|-------------------------|-----------------------------|-----------------------------|
| 2 | 10 | 8 |
| 10 | 16 | 6 |
| 25 | 29 | 4 |

It can be seen from the above table that when the pressure in the tank increases the pressure difference between line 6 and storage tank 4 decreases.

Of course, the various aspects are so chosen that no vapour formation can take place in the supply line or injectors even under the most adverse conditions.

It will be understood from the above that the inventive concept can be implemented in a wide variety of ways. For instance, it is possible to work with more than one pump. Moreover, correction means can be present to provide for correction of the reduced pressure

that is present in the suction pipes. It is also possible to construct the pressure regulator from a series circuit of a controller with a fixed setting, over which, for example, a pressure difference of 4 bar is achieved, and a fixed restriction, over which a pressure difference of 0 to 5 bar is achieved. Such systems fall within the scope of the appended claims.

Claims

1. Fuel system for an internal combustion engine (1) driven by liquefied gas, comprising a storage tank (4) for the liquefied gas, a pump (5, 25) in communication with the contents of said storage tank, to which pump a supply line (6) is connected, which supply line is connected at the other end to at least one injector (3) for injecting liquefied gas into said engine, pressure control means (7, 11; 27, 29) being present which control the rise in pressure provided by the pump in the supply line and comprise a control unit, characterised in that the pressure control means are designed such that said pressure rise decreases as the absolute pressure in said tank increases.
2. Fuel system according to Claim 1, wherein said injector (3) is provided with a return line (8) to said tank and said pressure control means (7, 27) are arranged in said return line.
3. Fuel system according to Claim 2, wherein said pressure control means comprise a fixed restriction (28) in said return line (8) as well as a control unit (29) which influences the output of said pump (25).
4. Fuel system according to Claim 3, wherein the speed of revolution of said pump (25) is controllable.
5. Fuel system according to one of the preceding claims, wherein said rise in pressure is at least 8 bar when the pressure in the tank is ~ 1 to 2 atmospheres and said rise in pressure is at most 4 bar when the pressure in the tank is 25 atmospheres.
6. Fuel system according to one of the preceding claims, wherein said rise in pressure is derived from a signal originating from a temperature sensor (9) fitted in said tank.
7. Fuel system according to one of the preceding claims, wherein said injector comprises an injector controlled by pulse width.
8. Fuel system according to one of the preceding claims, wherein the pressure control means comprise a series circuit of a regulator having a fixed setting plus a fixed restriction.

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Fig 1

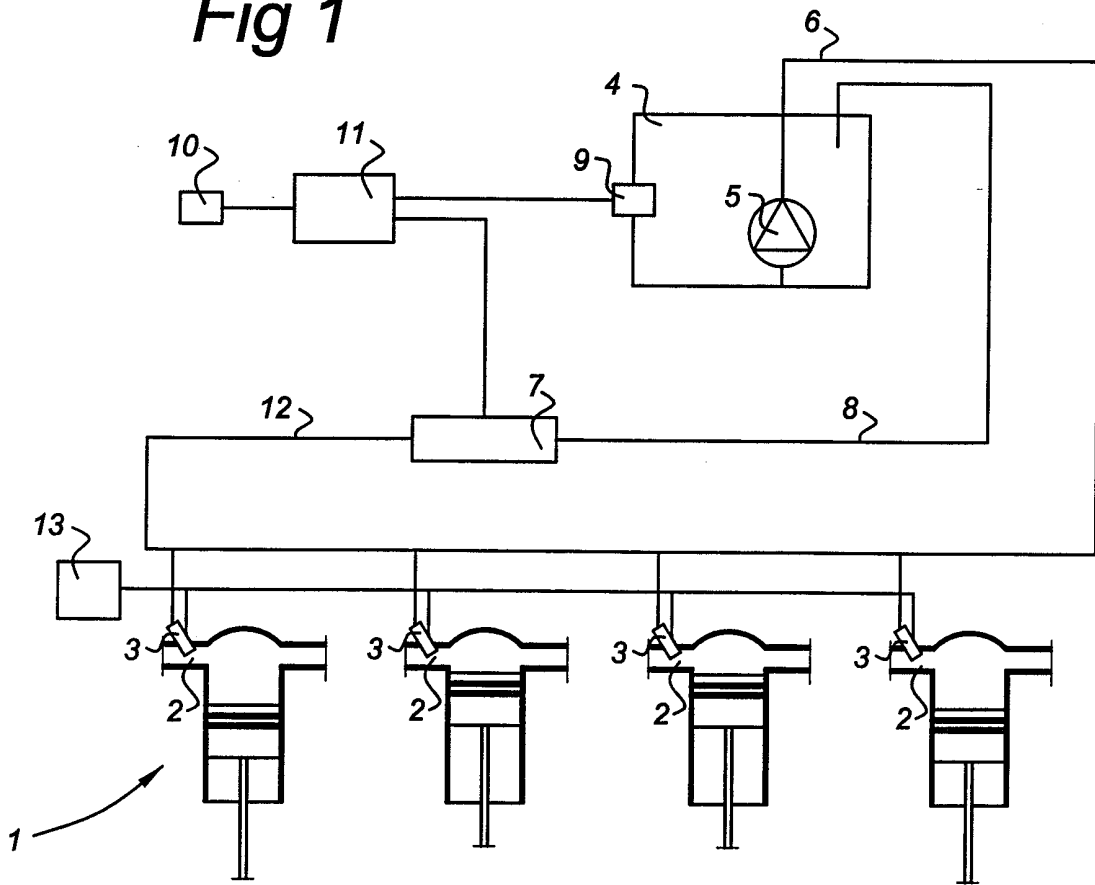


Fig 2

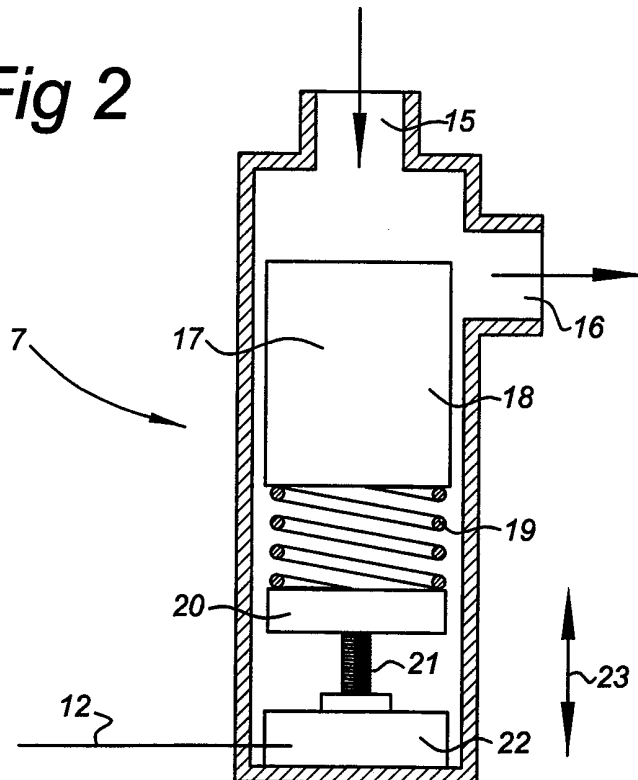
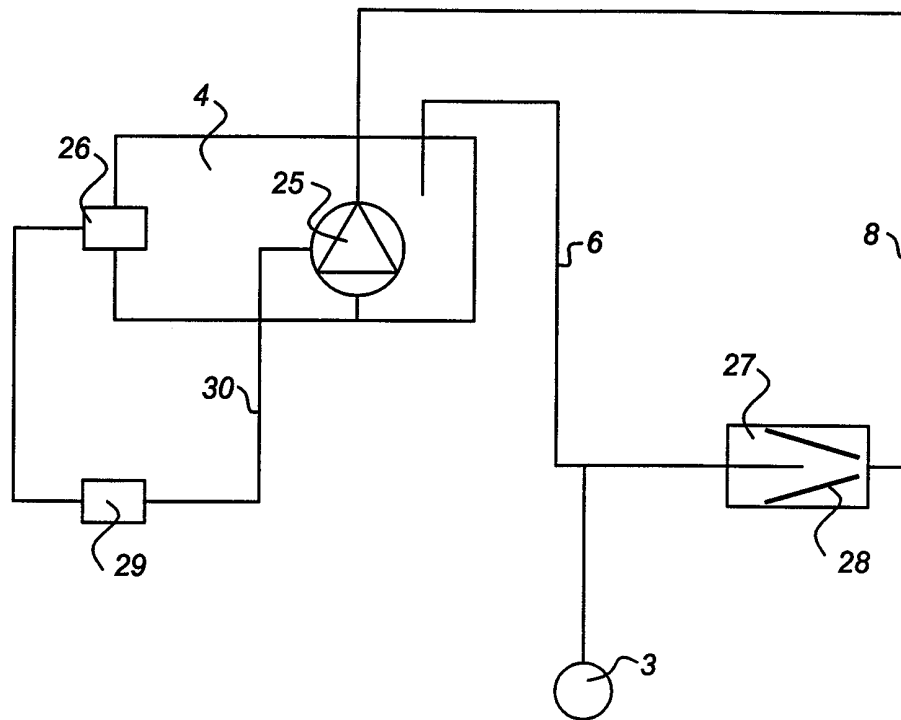


Fig 3



INTERNATIONAL SEARCH REPORT

Int. Application No
PCT/NL 99/00404

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| A. CLASSIFICATION OF SUBJECT MATTER IPC 7 F02M21/02 F02D19/02 | | | | |
| According to International Patent Classification (IPC) or to both national classification and IPC | | | | |
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| Date of the actual completion of the international search <h2 style="text-align: center;">5 October 1999</h2> | | Date of mailing of the international search report <h2 style="text-align: center;">11/10/1999</h2> | | |
| Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | | Authorized officer <h2 style="text-align: center;">Van Zoest, A</h2> | | |

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 99/00404

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