(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 January 2017 (05.01.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/003359 A1

(51) International Patent Classification:
F02M 37/22 (2006.01) *B01D 35/147* (2006.01)
B01D 35/143 (2006.01)

(21) International Application Number:
PCT/SE2016/050649

(22) International Filing Date:
28 June 2016 (28.06.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1550935-9 2 July 2015 (02.07.2015) SE

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: FUEL SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

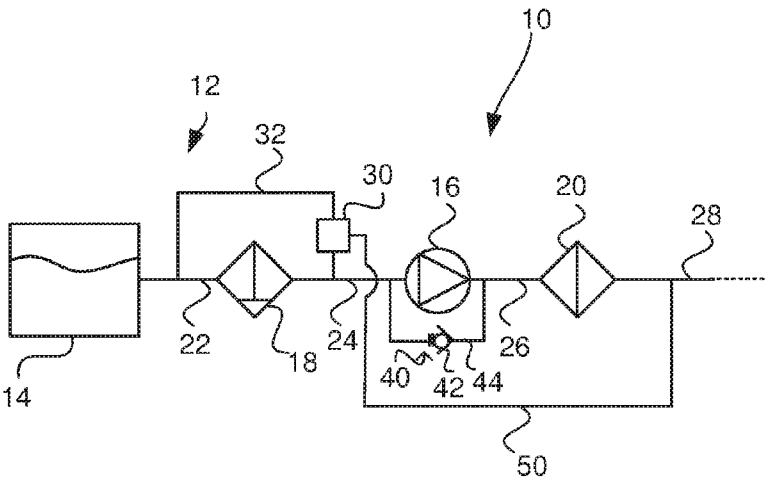


Fig. 2

(57) Abstract: The invention relates to a fuel system for an internal combustion engine (2), comprising a first fuel tank (14), a first fuel pump (16), a first fuel filter (18) and a second fuel filter (20). A first fuel pipe (22) is arranged in fluid connection with the first fuel tank (14) and the first fuel filter (18), a second fuel pipe (24) is arranged in fluid connection with the first fuel filter (18) and the first fuel pump (16), a third fuel pipe (26) is arranged in fluid connection with the first fuel pump (16) and the second fuel filter (20), and a fourth fuel pipe (28) is arranged in fluid connection with the second fuel filter (20) and a high-pressure circuit of the fuel system (10). A bypass valve (30) is arranged to allow fuel to bypass the first fuel filter (18) via a bypass pipe (32) arranged in fluid connection with the first fuel pipe (22) and the second fuel pipe (24), wherein the bypass valve (30) is adapted to be controlled based on the supply pressure downstream of the first fuel pump (16).

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Fuel system for an internal combustion engine

TECHNICAL FIELD

The present invention relates to a fuel system for a combustion engine, an internal combustion engine system comprising the fuel system and a vehicle comprising the fuel system.

BACKGROUND AND PRIOR ART

An internal combustion engine such as a diesel engine or an Otto engine is equipped with a fuel system to transport fuel from one or several fuel tanks to the internal combustion engine's injection system. The fuel system comprises one or several fuel pumps which may be mechanically driven by the internal combustion engine or may be electrically driven by an electric machine. The fuel system typically comprises a low pressure circuit with first low pressure fuel pump and a high pressure circuit with a high pressure fuel pump. The fuel pumps create a fuel flow and a pressure to transport the fuel to the internal combustion engine's injection system, which supplies the fuel to the combustion chamber of the internal combustion engine.

The fuel system also comprises one or several fuel filters, through which the fuel passes and is filtered on its way towards the internal combustion engine. Particles in the fuel will get stuck in the fuel filter during filtration and the fuel filter will gradually become clogged. When a fuel filter is clogged or partly clogged by particles, the transport of fuel from the fuel tanks to the internal combustion engine's injection system is hindered or made more difficult since it is difficult for the fuel to pass through the fuel filter. Different fuels are more or less prone to clog the fuel filters. When biodiesel fuels are used, such as FAME-fuels (fatty-acid methyl ester), the fuel filters tend to become clogged more rapidly than when an ordinary diesel fuel is used. Also, suction filters are likely to become clogged more rapidly than pressure filters. This is particularly a problem during cold start where a fuel pump driven by the starter motor is used to feed fuel through the suction filter. In such cases, the fuel pump may not be able to

force enough fuel through the suction filter and thus transfer enough fuel to start the combustion engine. Such disruptions of the combustion engine are disadvantageous.

Document JP2007278261 A describes a bypass path for a pressure filter pressurized between a feed pump and an injection pump in a low pressure circuit of a fuel system. However, said document does not deal with problems relating to suction filters, which are sensitive and more likely to be clogged than pressure filters. Despite known solutions in the field, there is still a need to develop a fuel system for a combustion engine, which reduces the risk of operational disruptions of the internal combustion engine.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a fuel system for an internal combustion engine, which reduces the risk of operational disruptions in the combustion engine.

Another object of the present invention is to provide a fuel system for an internal combustion engine, which is suitable for biodiesel fuels.

The objects are attained by a fuel system as defined in the appended claims which relate to a fuel system for an internal combustion engine comprising a low-pressure circuit with a first fuel tank, a first fuel pump, a first fuel filter arranged upstream of the first fuel pump and a second fuel filter arranged downstream of the first fuel pump. A first fuel pipe is arranged in fluid connection with the first fuel tank and the first fuel filter and a second fuel pipe is arranged in fluid connection with the first fuel filter and the first fuel pump. Further, a third fuel pipe is arranged in fluid connection with the first fuel pump and the second fuel filter, and a fourth fuel pipe is arranged in fluid connection with the second fuel filter and a high-pressure circuit of the fuel system. A bypass valve is arranged to allow fuel to bypass the first fuel filter via a bypass pipe arranged in fluid connection with the first fuel pipe and the second fuel pipe. The bypass valve is adapted to be controlled based on the supply pressure downstream of the first fuel pump.

By arranging a bypass valve such that fuel is allowed to bypass the first fuel filter based on the supply pressure downstream of the first fuel pump in the low-pressure circuit, it can be ensured that fuel with sufficient supply pressure is provided to the high-pressure circuit. In this way it can be assured that the internal combustion engine can receive sufficient amount

of fuel even when the first fuel filter is clogged. The risk for operational disruptions of the internal combustion engine is thereby reduced, especially in connection with the use of biodiesel fuels.

The herein mentioned objects are also attained by an internal combustion engine system and a vehicle comprising the fuel system as generally defined above and as defined in the appended claims.

Further features, advantages and objects will be described below with reference to the detailed description and the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

For the understanding of the present invention and further objects and advantages of it, the detailed description set out below can be read together with the accompanying drawings, in which the same reference notations denote similar items in the various diagrams, and in which:

Fig. 1 schematically illustrates a vehicle according to an embodiment of the invention;

Fig. 2 schematically illustrates a fuel system for an internal combustion engine according to an embodiment of the invention;

Fig. 3a schematically illustrates a bypass valve of a fuel system according to an embodiment of the invention; and

Fig. 3b schematically illustrates a bypass valve of a fuel system according to an embodiment of the invention.

DETAILED DESCRPTION OF THE INVENTION

As generally described above, the fuel system comprises a low-pressure circuit with a first fuel tank, a first fuel pump, a first fuel filter arranged upstream of the first fuel pump and a second fuel filter arranged downstream of the first fuel pump. A first fuel pipe is arranged in fluid connection with the first fuel tank and the first fuel filter and a second fuel pipe is arranged in fluid connection with the first fuel filter and the first fuel pump. Further, a third fuel pipe is arranged in fluid connection with the first fuel pump and the second fuel filter, and a fourth

fuel pipe is arranged in fluid connection with the second fuel filter and a high-pressure circuit of the fuel system. The bypass pipe in the fuel system is arranged in fluid connection with the first fuel pipe and the second fuel pipe and the bypass valve is arranged in fluid connection with the bypass pipe. Preferably, the bypass valve is directly connected to the bypass pipe. Further, the bypass valve is suitably arranged such that when the bypass valve is in an open position, fuel flows from the fuel tank through the first fuel pipe, the bypass pipe and the bypass valve to the second fuel pipe and further to the first fuel pump. When the bypass valve is in a closed position, fuel flows from the fuel tank through the first fuel pipe and the first fuel filter to the second fuel pipe and the first fuel pump. The bypass valve is thus arranged to fluidly connect or disconnect the first fuel pipe with the second fuel pipe via the bypass pipe.

The fuel system may comprise further components not mentioned herein according to common fuel systems. The low-pressure circuit may for example comprise more than one fuel tank and/or more than one fuel pump. With the first fuel pump in this connection is thus meant a fuel pump arranged to suck fuel through the first fuel filter, i.e. a suction filter as further described below. The fuel system may comprise a second fuel pump downstream of the first fuel pump. The high-pressure circuit typically comprises a high pressure pump and an injection system for the internal combustion engine.

Since the first fuel filter is arranged upstream of the first fuel pump the first fuel filter is a suction filter. The fuel pump is preferably a low pressure fuel pump. Suction filters are more likely to be clogged than pressure filters, since the first fuel pipe is not pressurized and the pressure of the fuel in the first pipe corresponds to the atmospheric pressure. Thus, the pressure drop through the suction filter corresponds to the atmospheric pressure. When the first fuel filter is clogged or partly clogged, the first fuel pump can have difficulties to suck fuel through the first fuel filter. Therefore, the first fuel pump may not be able to provide sufficient supply pressure downstream of the first fuel pump and further to the high-pressure circuit. By supply pressure is thus meant fuel pressure downstream of the first fuel pump. Therefore, the internal combustion engine will not receive sufficient amount of fuel.

Depending on the fuel type, the temperature of the fuel may also cause problems when sucking the fuel through the first fuel filter. The viscosity of biodiesel fuels, such as FAME-fuels, increases at relatively low temperatures (much more than petroleum diesel). The

resistance in the first fuel pipe between the fuel tank and the first fuel filter will thus increase at low temperatures, which will affect the ability of the fuel pump to provide sufficient supply pressure, which is needed to supply sufficiently fuel to the internal combustion engine.

By controlling the bypass valve based on the supply pressure downstream of the first fuel pump it can be ensured that the risk for operational disruptions of the internal combustion engine is reduced in a reliable and efficient way. Thus, when the first fuel filter is clogged or the first fuel pump is for any other reason hindered from providing sufficient supply pressure downstream of the first fuel pump, the bypass valve is adapted to be controlled or moved to an open position, such that fuel may bypass the first fuel filter. In this way, the fuel pump is able to provide fuel with sufficient supply pressure to the high-pressure circuit of the fuel system.

As soon as the supply pressure downstream of the fuel pump is high enough for the high-pressure circuit to function properly, the bypass valve is adapted to be controlled or moved to a closed position, such that fuel will be fed through the first fuel filter. In this way, it can be ensured that unfiltered fuel is not supplied to the fuel pump longer than necessary.

According to an aspect of the invention, the bypass valve is adapted to be controlled based on the supply pressure downstream of the second fuel filter in the fourth fuel pipe. The second fuel filter is also located downstream of the first fuel pump, whereby the definition of supply pressure applies, i.e. that the supply pressure is fuel pressure downstream of the first fuel pump. By using the supply pressure downstream of the second fuel filter it is the actual supply pressure, which is provided to the high-pressure circuit, that is controlling the bypass valve. In this way, it can be ensured that sufficient supply pressure can be provided for the high-pressure circuit so that the internal combustion engine can function properly. Alternatively, the bypass valve is controlled based on the supply pressure in the third fuel pipe, downstream of the fuel pump and upstream of the second fuel filter. The expected pressure drop over the second fuel filter is then considered to determine if the current supply pressure is sufficient for the high-pressure circuit.

According to an aspect of the invention, the bypass valve is adapted to be controlled to a closed position, such that the fuel flows through the first fuel filter, when the supply pressure exceeds a predetermined value. The predetermined value corresponds suitably to a minimum

supply pressure, which enables proper function of the high-pressure circuit and supply of sufficient amount of fuel to the internal combustion engine.

According to a further aspect of the invention, the bypass valve is adapted to be controlled to an open position, such that the fuel flows through the bypass pipe, when the supply pressure is below a predetermined value. The predetermined value is suitably a supply pressure, which corresponds to a value in which proper function of the high-pressure circuit, and supply of sufficient amount of fuel to the internal combustion engine are prevented. The value is suitable below the predetermined value corresponding to a minimum supply pressure which enables proper function of the high-pressure circuit.

According to another aspect of the invention, the bypass valve is a hydraulic valve. Different constructions of the hydraulic valve are possible, but when the bypass valve is a hydraulic valve, it is affected by the supply pressure downstream of the first fuel pump. The bypass valve is suitably self-adjusting and passive control of the bypass valve can thereby be achieved. In this way, no additional electronic control devices, pressure sensing devices and similar are needed to control the bypass valve and thus the bypass of the first fuel filter. A hydraulic bypass valve is robust and durable and thereby minimizes the risk for operational disruptions due to, for example, wear of the bypass valve.

According to a further aspect of the invention the bypass valve is a spring loaded valve connected to the bypass pipe and a fuel pipe downstream of the first fuel pump, wherein a body with a passage is arranged such that a spring device can act with a spring force on a first side of the body and a force associated with the supply pressure can act on a second side of the body. The first side of the body is opposite to the second side of the body.

The bypass valve is suitably connected to the fourth fuel pipe downstream of the first fuel pump. The bypass valve is preferably connected to the fuel pipe downstream of the first fuel pump via a control conduit arranged in fluid connection with the fuel pipe. The supply pressure in the control conduit is thus essentially the same as in the fuel pipe downstream of the first fuel pump. The pressure in the control conduit is suitably always higher than atmosphere.

According to one embodiment of the invention, the spring-loaded valve suitably comprises housing with an opening to the control conduit. The spring device and the body are arranged inside the housing. The spring device is arranged on a first side of the body inside the housing and the opening to the control conduit is on a second side of the body. The second side is opposite the first side. The spring force and the force associated with the supply pressure are thus acting on the body in opposing directions. The force acting on the second side of the body depends on the supply pressure and the area of the body on which the supply pressure acts. The force acting on the second side of the body thus depends on the area of the body, which is facing in the direction of the control conduit.

The body is suitably arranged inside the housing such that the first side of the body and the housing defines a cavity in which the spring device is arranged. The longitudinal extension of the body is preferably perpendicular to the extension of the passage through the body. The body suitably extends longitudinally between the first side and the second side. The body is suitably arranged to be moved in the longitudinal direction by means of the spring force and/or the force associated with the supply pressure. The body can thus act as a piston inside the housing. When the force associated with the supply pressure moves the body, the spring device is compressed. The cavity is thus decreased and the air inside the cavity may be vented through a venting arrangement arranged in fluid connection with the cavity. When the spring force moves the body, the spring device extracts and the cavity is expanded. The venting arrangement is suitably a venting conduit arranged in fluid connection with the cavity and the bypass pipe.

Suitable, the bypass valve is adapted to be in a closed position when the spring force is smaller than the force associated with the supply pressure, wherein the body is positioned such that the passage is not in fluid communication with the bypass pipe. When the provided supply pressure results in a force acting on the body which is larger than the spring force, the fluid thus flows from the fuel tank through the first fuel pipe, the first fuel filter, the second fuel pipe and on to the first fuel pump. The supply pressure provided by the first fuel pump is normally such that the force associated with the supply pressure is larger than the spring force. The spring device therefore preferably has a spring force that is smaller than the force obtained by the supply pressure provided during normal operating conditions. The supply pressure can be for example higher than 5 bar during normal operating conditions, but the

pressure may vary depending on the application, and the spring force should be adjusted accordingly. The spring force may be adapted to correspond to the predetermined value for supply pressure such that it is smaller than the force obtained by the supply pressure during normal operating conditions.

Further, the bypass valve is suitably adapted to be in an open position when the spring force is larger than the force associated with the supply pressure, wherein the body is positioned such that the passage is in fluid communication with the bypass pipe. When the provided supply pressure results in a force acting on the body which is smaller than the spring force, the fluid flows from the fuel tank through the first fuel pipe, the bypass pipe, the passage in the body, the second fuel pipe and on to the first fuel pump. The spring force is suitably larger than the force associated with the supply pressure when the supply pressure is lower than the supply pressure, which can be e.g. 5 bar, whereby the bypass valve is thus adapted to be in an open position when the supply pressure is below 5 bar. The predetermined value is thereby 5 bar. Of course, the supply pressure and thus the spring force can be lower or higher than 5 bar, and can be adjusted to be optimal to the vehicle or the fuel system in question.

According to a further aspect of the invention a supply pressure control device is arranged upstream of the second fuel filter. The supply pressure control device suitably comprises a check valve and a fifth fuel pipe arranged in fluid communication with the second fuel pipe and the third fuel pipe. The supply pressure control device is arranged to control the supply pressure upstream of the second filter by enabling excess fuel to flow from the third fuel pipe through the fifth fuel pipe back to the second fuel pipe.

Figure 1 schematically shows a side view of a vehicle 1 comprising a fuel system 10 according to an embodiment of the invention. The vehicle 1 comprises an internal combustion engine 2 connected to a gearbox 4. The gearbox 4 is also connected to the driving wheels 8 of the vehicle 1 through an output shaft of the gearbox (not shown). The vehicle also comprises a chassis 9. The vehicle 1 may be a heavy vehicle, e.g. a truck or a bus. The vehicle 1 may alternatively be a passenger car.

Figure 2 schematically shows a coupling diagram for a fuel system 10 for an internal combustion engine 2 according to an embodiment of the invention. The fuel system 10 comprises a low-pressure circuit 12 with a first fuel tank 14, a first fuel pump 16, a first fuel

filter 18 arranged upstream of the first fuel pump 16 and a second fuel filter 20 arranged downstream of the first fuel pump 16. A first fuel pipe 22 is arranged in fluid connection with the first fuel tank 14 and the first fuel filter 18. A second fuel pipe 24 is arranged in fluid connection with the first fuel filter 18 and the first fuel pump 16. A third fuel pipe 26 is arranged in fluid connection with the first fuel pump 16 and the second fuel filter 20. A fourth fuel pipe 28 is arranged in fluid connection with the second fuel filter 20 and a high-pressure circuit of the fuel system 10, which is not shown in detail. A bypass valve 30 is arranged to allow fuel to bypass the first fuel filter 18 via a bypass pipe 32 arranged in fluid connection with the first fuel pipe 22 and the second fuel pipe 24. The bypass valve 30 is adapted to be controlled based on the supply pressure downstream of the first fuel pump 16. In this way, it can be ensured that fuel with sufficient supply pressure is provided to the high-pressure circuit and the internal combustion engine 2 can receive sufficient amount of fuel even when the first fuel filter is clogged. The risk for operational disruptions of the internal combustion engine 2 is thereby reduced.

The first fuel filter 18 is suitably a water separating fuel filter. Since the first fuel filter 18 is arranged upstream of the first fuel pump 16, the first fuel filter 18 constitutes a suction filter.

The fourth fuel pipe 28 is in fluid connection with the high-pressure circuit of the fuel system 10. This is symbolised by the dotted line in the figure. The fuel system 10 may comprise components not shown in this figure according to common fuel systems. For example, the low-pressure circuit 12 may comprise more than one fuel tank 14 and/or more than one fuel pump 16.

A supply pressure control device 40 is arranged upstream of the second fuel filter 20. The supply pressure control device 40 comprises a check valve 42 and a fifth fuel pipe 44 arranged in fluid communication with the second fuel pipe 24 and the third fuel pipe 26. The supply pressure control device 40 is arranged to control the supply pressure upstream of the second fuel filter 20 by enabling excess fuel to flow from the third fuel pipe 26 through the fifth fuel pipe 44 back to the second fuel pipe 24.

The bypass valve 30 is arranged such that when the bypass valve 30 is in an open position the fuel flows from the fuel tank 14 through the first fuel pipe 22, the bypass pipe 32 and the bypass valve 30 to the second fuel pipe 24 and on to the first fuel pump 16. When the bypass

valve 30 is in a closed position the fuel suitably flows from the fuel tank 14 through the first fuel pipe 22 and the first fuel filter 18 to the second fuel pipe 24 and the first fuel pump 16. The bypass valve 30 is thus arranged to fluidly connect or disconnect the first fuel pipe 22 with the second fuel pipe 24 via the bypass pipe 32.

The bypass valve 30 according to one embodiment of the invention is shown in more detail in Fig. 3a and 3b. Other constructions would of course be possible. The bypass valve is a hydraulic valve affected by the supply pressure downstream of the first fuel pump 16. The bypass valve 30 is self-adjusting and a passive control of the bypass valve 30 is thereby achieved. The bypass valve 30 is a spring-loaded valve connected to the bypass pipe 32, the second fuel pipe 24 and the fourth fuel pipe 28 downstream of the first fuel pump 16. The bypass valve 30 is connected to the fourth fuel pipe 28 via a control conduit 50 arranged in fluid connection with the fuel pipe 28. The supply pressure in the control conduit 50 is thus essentially the same as in the fourth fuel pipe 28. The bypass valve 30 is adapted to be controlled based on the supply pressure downstream of the second fuel filter 20. By using the supply pressure downstream of the second fuel filter 20 it is the actual supply pressure, which is provided to the high-pressure circuit that is controlling the bypass valve 30.

As mentioned above, and as shown by Fig. 3a and 3b, the bypass valve 30 is a spring-loaded hydraulic valve arranged in fluid communication with the bypass pipe 32, the second fuel pipe 24 and the control conduit 50. The bypass valve 30 comprises a housing 60 and inside the housing 60 a spring device 62 and a body 64 are arranged. The spring device 62 is arranged on a first side of the body 64 inside the housing 60 and an opening 66 in the housing facing the control conduit 50 is on a second side of the body 64. The spring device 62 is thus acting with a spring force F_s on a first side 68' of the body 64 and a force associated with the supply pressure F_p is acting on a second side 68'' of the body 64. This is illustrated by arrows in Fig. 3a and 3b. The second side 68'' is opposite to the first side 68'. The spring force F_s and the force associated with the supply pressure F_p are thus acting on the body 64 in opposing directions. The force associated with the supply pressure F_p acting on the second side 68'' of the body 64 depends on the supply pressure and the area A of the second side 68'' of the body 64.

The body 64 is arranged inside the housing 60 such that the first side 68' of the body 64 and the housing 60 define a cavity 70 in which the spring device 62 is arranged. The body 64

suitably extends longitudinally between the first side 68' and the second side 68''. The body 64 is arranged to be moved in the longitudinal direction by means of the spring force F_s and/or the force associated with the supply pressure F_p. The body 64 thus acts as a piston inside the housing 60. When the force associated with the supply pressure F_p moves the body 64, the spring device 62 is compressed and the cavity 70 is decreased. When the spring force F_s moves the body 64, the spring device 62 extracts and the cavity 70 is expanded. A venting arrangement 72 is arranged in fluid connection with the cavity 70. The air inside the cavity 70 may thereby be vented and enable movement of the body 64. The venting arrangement 72 is suitably a venting conduit arranged in fluid connection with the cavity 70 and the bypass pipe 32.

The body comprises a passage 74 and the passage 74 extends perpendicularly to the longitudinal extension of the body 64. The passage 74 is a through hole.

Figure 3a shows the bypass valve 30 in an open position. The body 64 is thus positioned such that the passage 74 is in fluid communication with the bypass pipe 32. The bypass valve 30 is in the open position when the spring force F_s is larger than the force associated with the supply pressure F_p and the spring device 62 is thus in an extracted state. When the provided supply pressure results in a force F_p acting on the body 64 which is smaller than the spring force F_s, the fluid flows from the fuel tank 14 through the first fuel pipe 22, the bypass pipe 32, the passage 74 in the body 64, the second fuel pipe 24 and on to the first fuel pump 16. This is illustrated with arrows. The spring force F_s is larger than the force associated with the supply pressure F_p when the first fuel filter 18 is clogged. The spring force F_s is suitably larger than the force associated with the supply pressure F_p when the supply pressure is below a predetermined value, which can for example be 5 bar.

Figure 3b shows the bypass valve 30 in a closed position. The body 64 is thereby positioned such that the passage 74 is not in fluid communication with the bypass pipe 32. The passage 74 is thus displaced relative to the bypass pipe 32. The bypass valve 30 is in the closed position when the spring force F_s is smaller than the force associated with the supply pressure F_p and the spring device 62 is thus in a compressed state. When the provided supply pressure results in a force F_p acting on the body 64 which is larger than the spring force F_s, the fluid flows from the fuel tank 14 through the first fuel pipe 22, the first fuel filter 18, the second fuel pipe 24

and on to the first fuel pump 16. The supply pressure provided by the first fuel pump 16 is normally such that the force associated with the supply pressure F_p is larger than the spring force F_s. The spring device 62 therefore preferably includes a spring force F_s, which is smaller than the force obtained by the supply pressure F_p provided during normal operating conditions.

Further variations of the invention are possible within the scope defined in the appended claims.

Claims

1. A fuel system for an internal combustion engine (2) comprising a low-pressure circuit (12) with a first fuel tank (14), a first fuel pump (16), a first fuel filter (18) arranged upstream of the first fuel pump (16) and a second fuel filter (20) arranged downstream of the first fuel pump (16), wherein a first fuel pipe (22) is arranged in fluid connection with the first fuel tank (14) and the first fuel filter (18), a second fuel pipe (24) is arranged in with the first fuel filter (18) and the first fuel pump (16), a third fuel pipe (26) is arranged in fluid connection with the first fuel pump (16) and the second fuel filter (20), and a fourth fuel pipe (28) is arranged in fluid connection with the second fuel filter (20) and a high-pressure circuit of the fuel system (10), **characterized in that** a bypass valve (30) is arranged to allow fuel to bypass the first fuel filter (18) via a bypass pipe (32) arranged in fluid connection with the first fuel pipe (22) and the second fuel pipe (24), wherein the bypass valve (30) is adapted to be controlled based on the supply pressure downstream of the first fuel pump (16).

2. A fuel system according to claim 1, **characterized in that** the bypass valve (30) is adapted to be controlled based on the supply pressure downstream of the second fuel filter (20) in the fourth fuel pipe (28).

3. A fuel system according to claim 1 or 2, **characterized in that** the bypass valve (30) is adapted to be controlled to a closed position, such that the fuel flows through the first fuel filter (18), when the supply pressure is above a predetermined value.

4. A fuel system according to any of the preceding claims, **characterized in that** the bypass valve (30) is adapted to be controlled to an open position, such that the fuel flows through the bypass pipe (32), when the supply pressure is below a predetermined value.

5. A fuel system according to any of the preceding claims, **characterized in that** the bypass valve (30) is a hydraulic valve.

6. A fuel system according to claim 5, **characterized in that** the bypass valve (30) is a spring loaded valve connected to the bypass pipe (32) and a fuel pipe (26; 28) downstream of the first fuel pump (16), wherein a body (64) with a passage (74) is arranged such that a spring device (62) is acting with a spring force (F_s) on a first side (68') of the body (64) and a force associated with the supply pressure (F_p) is acting on a second side (68'') of the body (64).

7. A fuel system according to claim 6, **characterized in that** the bypass valve (30) is in a closed position when the spring force (F_s) is smaller than the force associated with the supply pressure (F_p), wherein the body is positioned such that the passage (74) is not in fluid communication with the bypass pipe (32).

8. A fuel system according to claim 6 or 7, **characterized in that** the bypass valve (30) is in an open position when the spring force (F_s) is larger than the force associated with the supply pressure (F_p), wherein the body (64) is positioned such that the passage (74) is in fluid communication with the bypass pipe (32).

9. An internal combustion engine system **characterized in** that it comprises a fuel system (10) according to any of the claims 1-8.

10. A vehicle **characterized in** that it comprises a fuel system (10) according to any of the claims 1-8.

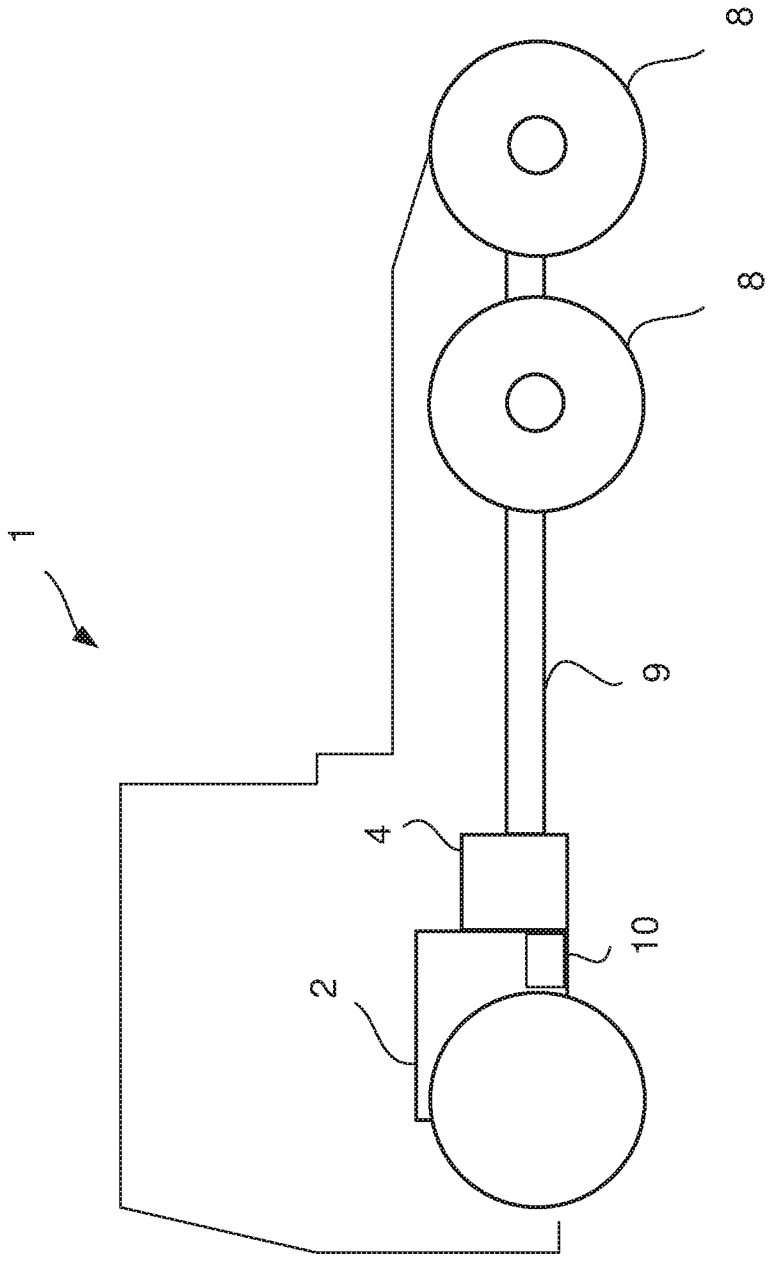


Fig. 1

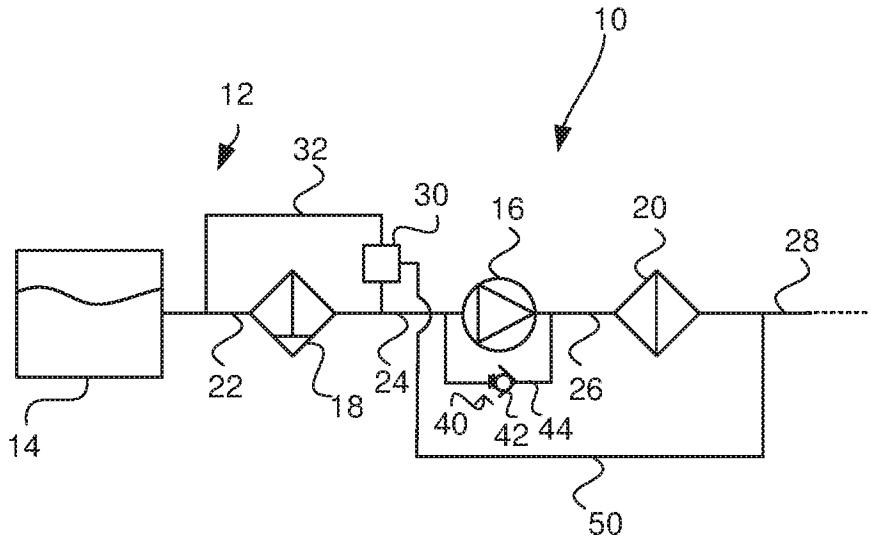


Fig. 2

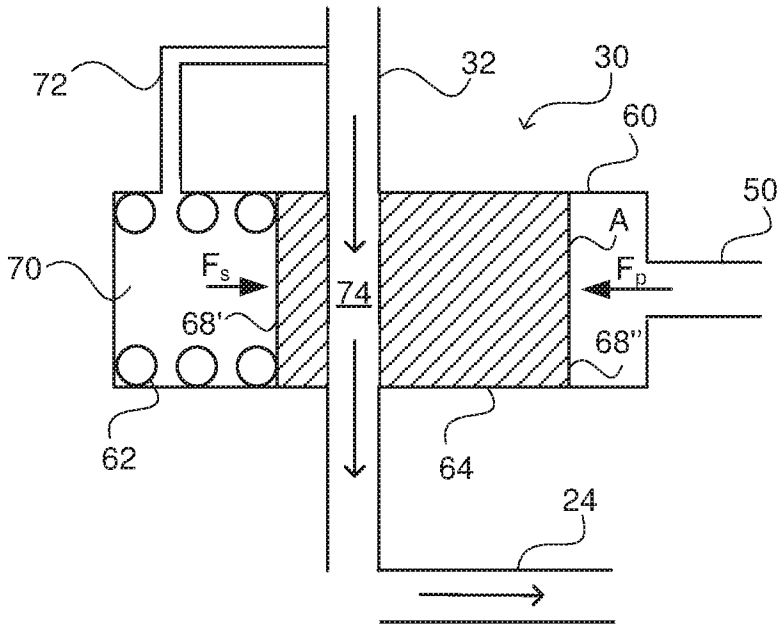

72
32
30
60
50
A
70
F_s
F_p
74
68'
68"
62
64
24

Fig. 3a

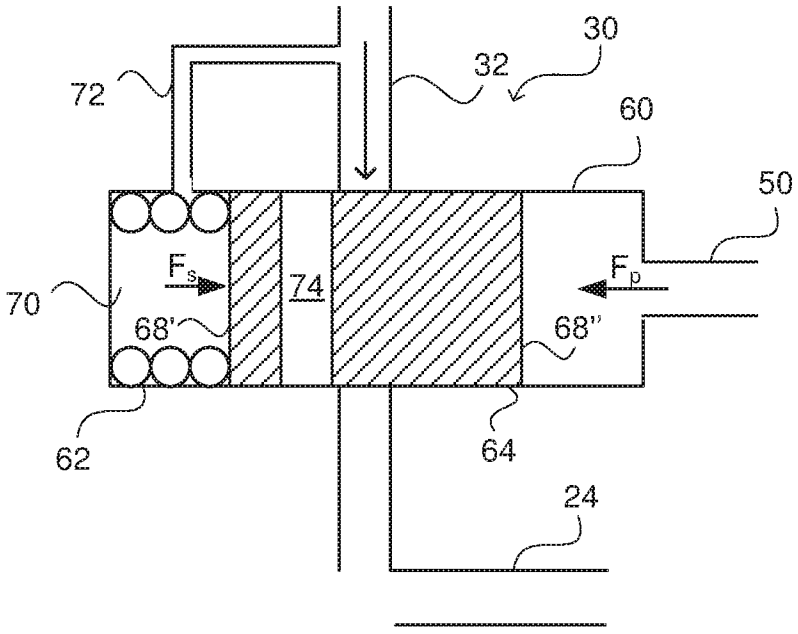

30
72
32
60
50
F_s
F_p
70
74
68'
68"
62
64
24

Fig. 3b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050649

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B01D, F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20100193415 A1 (NAGAI KOICHI), 5 August 2010 (2010-08-05); abstract; figure 1	1-10
	--	
A	US 20010027781 A1 (RUMPF BERND ET AL), 11 October 2001 (2001-10-11); abstract; figure 1	1-10
	--	
A	US 4346689 A (NEELY NOAH A), 31 August 1982 (1982-08-31); abstract; figures 1-3	1-10
	--	

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21-10-2016	21-10-2016

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Lars Jakobsson Telephone No. + 46 8 782 28 00

International application No.
PCT/SE2016/050649

Continuation of: second sheet

International Patent Classification (IPC)

F02M 37/22 (2006.01)
B01D 35/143 (2006.01)
B01D 35/147 (2006.01)

US	20100193415	A1	05/08/2010	JP	2010180733	A	19/08/2010
				JP	4821860	B2	24/11/2011
US	20010027781	A1	11/10/2001	AU	2327201	A	27/09/2001
				BR	0101097	A	06/11/2001
				DE	10013905	A1	27/09/2001
				EP	1136689	A2	26/09/2001
				US	6422213	B2	23/07/2002
US	4346689	A	31/08/1982	NONE			