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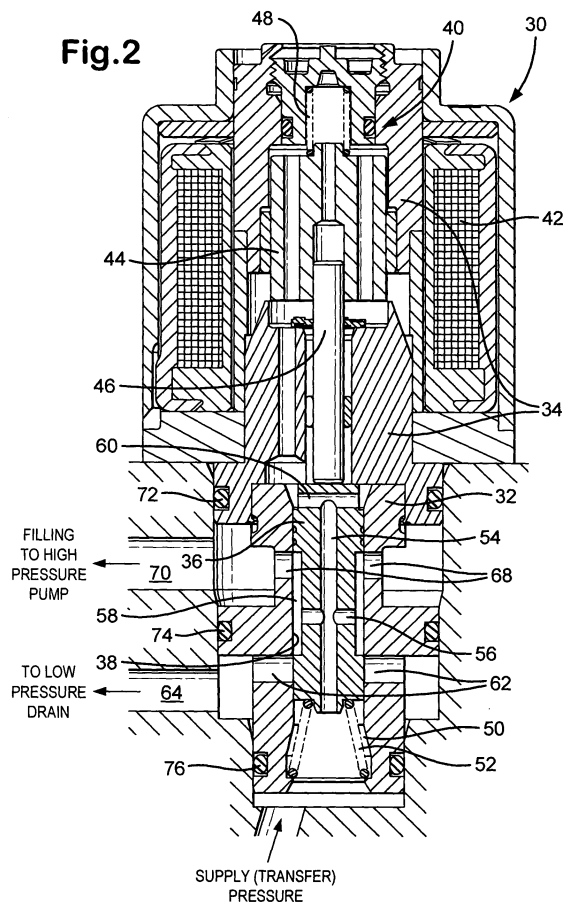
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(54) Metering device

(57) A metering device (30) for controlling the flow of fuel to a fuel pump includes metering valve means (36, 68), having a metering valve inlet (50; 150) and a metering valve outlet (68; 168), for controlling the rate of flow of fuel to the fuel pump, and regulator valve means (36, 62) operable to regulate the pressure of fuel at the metering valve inlet (50). A metering actuator (40) is operable to control the metering valve means (36, 68) and a regulator actuator (40) is operable to control the regulator valve means (36, 62). The metering actuator and the regulator actuator may be one and the same actuator, so that the metering and pressure regulating functions of the device are provided by a common valve member (36). In use, the valve member (36) co-operates with both the metering valve outlet (68; 168) and a pressure regulator valve outlet (62; 162) upon axial movement of the valve member (36) under the control of the actuator (40).

Fig.2



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Description

[0001] The invention relates to a metering device for use in a common rail fuel system. In particular, but not exclusively, the invention relates to a metering device for use in regulating the supply of relatively low pressure fuel to a high pressure fuel pump of the type intended to supply fuel to a common rail. The invention also relates to a high pressure fuel pump incorporating a metering device and, in addition, to a common rail fuel system incorporating the metering device.

[0002] Figure 1 illustrates a part of a common rail fuel system of the type including a supply pump 10 for delivering fuel to a high pressure common rail fuel pump (not shown). The high pressure pump is arranged to supply a common rail or other fuel accumulator volume with highly pressurised fuel. The supply pump 10 takes the form of a vane pump, often referred to as the 'transfer pump', having a pump inlet 12 and a pump outlet 14 across which a pressure regulating device 16 (the pressure regulator) is located to regulate fuel pressure at the pump outlet 14. The pressure regulator 16 takes the form of a hydraulically operable device having a spring-biased piston 18 which co-operates with a port 20 provided in a piston bore 22 so as to vary that quantity of fuel at the pump outlet 14 which is returned or recirculated to a low pressure drain (not shown), thus controlling the pressure of fuel at the pump outlet 14.

[0003] Fuel at the regulated output pressure is supplied from the transfer pump 10, through a separate metering valve device 24 to the inlet of the common rail fuel pump so as to regulate the quantity of fuel that is delivered to the pump for pressurisation. The metering valve device 24 is a variable-orifice device and has an associated actuator (not shown), typically in the form of an electromagnetic actuator, which is arranged to control movement of a metering valve member.

[0004] The metering valve member co-operates with the orifice of the device to control the degree to which it is obscured, thereby varying the restriction to fuel flow presented by the orifice and, hence, varying the flow rate of fuel to the high pressure pump.

[0005] The transfer pump 10 is operable to provide an output pressure at the pump outlet 14 which is dependent upon engine speed. When transfer pressure is high, so that pressure at the inlet of the metering valve device 24 is high, the sensitivity of the metering valve device 24 may be undesirably high as any slight change in the position of the metering valve member will have a relatively large effect on the flow rate through the device 24. Therefore, a particular problem occurs when low fuelling levels are required at high engine speed. In contrast, when transfer pressure is low there may be a lack of sensitivity of fuelling as the metering valve member must be moved through a much greater amount in order to have any significant effect on the flow rate through the device 24. Setting the metering valve device 24 and the regulator 16 so as to cope satisfactorily with the full range of engine

speed and load conditions can therefore be problematic.

[0006] It is an object of the present invention to provide a metering device for a fuel system which alleviates or removes this problem.

5 **[0007]** According to a first aspect of the present invention, there is provided a metering device for controlling the flow of fuel to a fuel pump, the metering device including:

10 metering valve means, having a metering valve inlet and a metering valve outlet, for controlling the flow rate of fuel to the fuel pump,

15 regulator valve means operable to regulate the pressure of fuel at the metering valve inlet,

a metering actuator which is operable to control the metering valve means, and

20 a regulator actuator which is operable to control the pressure regulator means.

[0008] Conveniently, the metering device has application in a common rail fuel system in which the metering device is situated between a low pressure (e.g. transfer pressure) pump and a high pressure (e.g. common rail type) pump.

25 **[0009]** It is one benefit of the invention that the regulator valve means, which provides the pressure regulating function of the device, is positively actuated rather than being a hydraulically-operable device as in conventional systems. The pressure regulator of the arrangement can therefore be actuated to 'open', to reduce fuel pressure at the metering valve inlet, in circumstances in which only a low rate of flow of fuel through the metering valve outlet is required. This improves the sensitivity of fuel control when low pump filling rates are required for the high pressure pump. The invention differs from known systems, such as that shown in Figure 1, as the pressure regulating function is positively controlled through the regulator actuator, rather than relying on a hydraulically-operable pressure regulator.

30 **[0010]** In a preferred embodiment of the invention, the metering actuator and the regulator actuator are one and the same actuator. In other words, the metering valve means and the regulator valve means share a common actuator which controls both (i) co-operation between the metering valve means and the metering valve outlet and (ii) operation of the regulator valve means.

35 **[0011]** In a further preferred embodiment, the regulator valve means and the metering valve means are formed in a single, common unit. For example, the metering valve means includes a metering valve member which co-operates with the metering valve outlet to control the rate of flow of fuel to the high pressure pump, and wherein the regulator valve means is provided by the metering valve member co-operating with a pressure regulator outlet to a low pressure drain.

[0012] In one particularly preferred embodiment, the metering valve means includes a metering valve member which is axially movable within a guide or bore provided in a valve housing, wherein the bore is provided with a filling port to define the metering valve outlet so that axial movement of the metering valve member within the bore serves to control the degree of opening of the filling port, thereby to control the rate of flow of fuel through the filling port to the high pressure pump. Conveniently, the bore is provided with a return port to define the pressure regulator outlet, whereby axial movement of the metering valve member within the bore serves to control the degree of opening of the return port, thereby to control the rate of flow of fuel through the return port to the low pressure drain.

[0013] A preferred embodiment of the invention therefore includes a metering valve member which is co-operable with a filling port to control the flow of fuel to the high pressure pump and which is further co-operable with a return port to control the pressure of fuel at the metering valve inlet. This embodiment is particularly convenient as not only does it provide the aforementioned advantageous operating characteristic for low pump filling rates, but only a single valve member is needed to provide both the metering and pressure regulating functions, thus reducing the total part count.

[0014] As mentioned previously, it is beneficial for the pressure regulator device to be actuated to open (i.e. to reduce the pressure of fuel supplied to the metering valve inlet) in circumstances in which a low rate of flow of fuel through the metering valve outlet is required. In the single valve member embodiment, the device is thus configured so that movement of the valve member to open the filling port causes the return port to close, and vice versa. Thus, if it is determined that rail pressure is too high, the device can be actuated so as to open the return port to the low pressure drain, resulting in the filling port being closed to reduce the rate of flow of fuel to the high pressure pump. If it is determined that rail pressure is too low, the device can be actuated so as to close the return port to the low pressure drain, resulting in the filling port being opened further to increase the flow rate to the high pressure pump. The operations of the regulator valve means and the metering valve means therefore complement one another.

[0015] Conveniently, therefore, the metering device further includes control means for controlling the actuator in response to a pressure signal representative of fuel pressure within the common rail.

[0016] The return port and the filling port may be dimensioned so that each is of the same diameter and, thus, presents the same, maximum cross sectional flow area (i.e. the cross sectional flow area in circumstances in which it is fully opened). Alternatively, the return port and the filling port may be of different diameter. By sizing the ports differently, the operating characteristic of the device can be tuned to optimise the pump filling function.

[0017] In one embodiment, a set of at least two return

ports may be provided, each of which communicates with the low pressure drain. In addition, or alternatively, a set of at least two filling ports may be provided, each of which communicates with the high pressure pump. Each of the return ports of the set may be shaped so as to present a different cross sectional flow area in circumstances in which it is fully open. Alternatively, or in addition, each of the filling ports of the set may be shaped so as to present a different cross sectional flow area in circumstances in which it is fully open. This 'axial staggering' of like ones of the ports (i.e. sizing the return and filling ports so that they present different cross sectional flow areas) provides the benefit that the operating characteristic of the device can be optimised for different fuel pump applications.

[0018] In another embodiment, additional ports may be provided in the bore, for example to communicate with an engine cam box or other fuel chamber. The metering valve member may be operable to vary the degree of opening of the additional ports, depending upon its position. The provision of an additional port or ports to the engine cam box facilitates lubrication of bearings, for example.

[0019] In one embodiment the bore defines an inlet at one end of the bore. In another embodiment the inlet is defined in a wall of the bore, along the bore length, rather than at the end of the bore.

[0020] The metering valve member may be of the type which is axially movable within the bore or, alternatively, may be of the type which is angularly movable within the bore.

[0021] According to a second aspect of the invention, there is provided a high pressure (common rail) fuel pump including a metering device for controlling the rate of flow of fuel to the high pressure fuel pump, wherein the metering device is of the type defined in accordance with the first aspect of the invention. In a high pressure fuel pump, typically fuel is pressurised to a level in excess of around 1000 bar, or even 2000 bar.

[0022] According to a third aspect of the invention, there is provided a common rail fuel system having a common rail fuel pump which is supplied with fuel by a transfer pump and a metering device for controlling the rate of flow of fuel supplied between the transfer pump and the common rail fuel pump, wherein the metering device is of the type defined in accordance with the first aspect of the invention.

[0023] The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram to illustrate a known fuel metering arrangement for a high pressure fuel pump,

Figure 2 is a sectional view of a metering device of a first embodiment of the present invention,

Figure 3 is a schematic illustration of filling and return ports of the metering device in Figure 2, and

Figure 4 is a schematic illustration of a part of a metering device of a second embodiment of the present invention.

[0024] Referring to Figure 2, there is shown a metering device, referred to generally as 30, of a first embodiment of the invention which is suitable for use in a fuel system, such as a common rail fuel system, of an internal combustion engine. The fuel system includes a high pressure fuel pump (not shown), to which fuel is delivered from a low pressure transfer pump, via the metering device 30, as described previously. The pump delivers fuel to a common rail or accumulator volume of the system, from where fuel is delivered to a plurality of injectors. The metering device 30 includes a valve housing 32 and an actuator housing 34. A valve member 36 is movable within a bore 38 provided in the valve housing 32 under the control of an actuator, referred to generally as 40, located within the actuator housing 34. In practice the actuator 40 may take one of many forms, but that in the embodiment shown is in the form of an electro-magnetic actuator. The electromagnetic actuator 40 is of conventional type and so will not be described in great detail. The actuator 40 includes a winding 42 which is energisable to cause movement of an armature 44 coupled, through a press fit, with an actuator stem 46. The actuator stem 46 co-operates with an upper end of the valve member 36 such that movement of the armature 44, and hence of the stem 46, results in axial movement of the valve member 36 within the valve housing bore 38. A spring 48 serves to bias the actuator stem 46 against the valve member 36 so that the two parts remain coupled together at all times. The device 30 is also provided with a control means (not shown) for controlling operation of the actuator 40 in response to a pressure signal indicative of fuel pressure within the common rail.

[0025] A lower end of the valve housing bore 38 defines an inlet 50 for the device 30 which communicates with a low pressure pump of the system, for example the transfer pump. The inlet 50 houses a valve spring 52 which serves to urge the valve member 36 in an upwards direction, against any actuation force provided by the actuator 40. Upon energisation of the winding 42 to a suitably high level, a force is generated on the armature 44 causing the actuator stem 46 and the valve member 36 to be urged downwards, against the force of the valve spring 52. If the winding 42 is de-energised, the actuation force is removed and so the valve member 36 is urged in an upwards direction by means of the spring 52.

[0026] The valve member 36 is provided with an axially extending drilling or bore which defines an axial flow passage 54 for fuel through the valve member 36. One end of the axial flow passage 54 communicates with the inlet 50 so that fuel delivered to the device 30 from the transfer pump is able to flow into the axial flow passage 54 via

the inlet 50. Radially extending drillings or bores are also provided in the valve member 36. The metering valve member 36 is provided with a first radial bore 56 which communicates, in a mid-region thereof, with the axial flow passage 54. Outer ends of the first radial bore 56 communicate with an annular chamber 58 defined by an annular groove or recess provided in the outer surface of the valve member 36. The metering valve member 36 is also provided with a second radial bore 60, which is located at the end of the axial flow passage 54 remote from the inlet 50. The arrangement of the axial flow passage 54 and the first and second radial bores 56, 60 ensures the valve member 36 is hydraulically pressure balanced at all times. In this way the actuator 40 therefore only has to overcome the force of the inlet spring 52 in order to move the valve member 36 downwards within the valve bore 38, as described in further detail below.

[0027] Movement of the valve member 36 controls the degree of opening of various ports provided in the valve bore 38. The ports in the valve housing 32 are formed in two sets: a first set of ports 62 which open into a return path 64 to a low pressure drain and a second set of ports 68 which open into a filling path 70 to the high pressure pump (i.e. filling ports). The first set of ports 62 define 'regulator' outlets of the device 30, or return ports, and the second set of ports 68 define 'metering' outlets of the device 30, or filling ports. The axial position of the metering valve member 36 within the bore 38 will determine the extent to which the return and filling ports 62, 68 are open. It will be apparent from the following description, that co-operation between the outer surface of the valve member 36 and the return ports 62 defines a regulator valve means of the device and co-operation between the outer surface of the valve member 36 and the filling ports 68 defines a metering valve means of the device 30.

[0028] Appropriate seals are provided on the device to seal against fuel leakage between regions of different pressure. A first annular seal 72 is provided on the actuator housing 34 to seal against fuel leakage from the filling ports 68 and the filling path 70, a second annular seal 74 is provided on the valve housing 32 to seal against fuel leakage between the filling ports 68 and/or the filling path 70 and the return path 64 to drain, and a third annular seal 76 is provided on the valve housing 32 to seal against fuel leakage between supply pressure (transfer pressure) and the return path 64.

[0029] In use, fuel is delivered by the transfer pump to the inlet 50 of the device 30 and thus is allowed to flow into the axial flow passage 54 in the valve member 36 and into the annular chamber 58. In Figure 2, the metering valve member 36 is in the 'full filling' position, in which the filling ports 68 are fully open (i.e. fully uncovered) and the actuator 40 is de-energised. When the metering valve member 36 is in this position, the flow rate through the filling ports 68 is thus at its maximum value.

[0030] If the rail pressure sensor provides an indication to the controller that the fuel pressure in the rail is too high and it is required to reduce fuel delivery to the high

pressure pump, the actuator 40 receives a control signal from the controller to energise the winding 42. As a result of energisation of the winding 42, the actuator stem 46, and hence the valve member 36, will be urged in a downwards direction, against the force of the valve spring 52. As the valve member 36 starts to move downwards, the filling ports 68 will be partially covered by the outer surface of the metering valve member 36, thereby decreasing the flow rate through the filling ports 68 to the high pressure pump. In addition, as the metering valve member 36 starts to move downwards the return ports 62 will start to open so as to allow a proportion of fuel that flows into the annular chamber 58 to return to the return path 64. Fuel pressure at the inlet 50 therefore starts to reduce. A decrease in the fuel filling rate through the filling ports 68 is therefore accompanied by a decrease in fuel pressure at the inlet 50 to the device 24. This overcomes the problem described previously where a lack of control over filling is experienced at high supply pressures.

[0031] If the pressure sensor provides an indication that rail pressure is too low, the controller supplies a signal to the actuator 40 causing it to be de-energised. As a result, the valve member 36 is urged upwards by means of the valve spring 52 causing the return ports 62 to close and the filling ports 68 to open. Fuel pressure at the inlet 50 is therefore increased, as the return flow of fuel through the return ports 62 is reduced or ceases altogether. This is accompanied by an increased flow rate through the open filling ports 68.

[0032] The co-operable operations of the filling and return ports 68, 62 are illustrated in the representation shown in Figure 3, in which the stroke, S, of the metering valve member 36, represents the travel of the metering valve member 36 between a position in which the filling ports 68 are partially open (arbitrary position), to one in which the filling ports 68 are fully closed. Distance L1 represents the separation between the 'lower' control edge of a filling port 68 (referring to the orientation of Figure 2) and the 'upper' control edge of a return port 62.

[0033] It will be appreciated that it is an important difference between the known metering and pressure regulating system in Figure 1 and the metering device 30 of the present invention that transfer pressure is actively 'regulated', by actuating the metering valve member 36 in response to a feedback signal (rail pressure signal), rather than allowing simple hydraulic control of transfer pressure. In doing so, and by coupling actuation of the regulator function to actuation of the metering valve function in synergy, the problems experienced in known systems, particularly where improved control is required for lower pump filling rates, can be overcome.

[0034] In the embodiment illustrated in Figures 2 and 3, the filling ports 68 and the return ports 62 are of equal size (i.e. they have equal cross sectional flow areas) so that the opening of one set of ports by a certain amount is always accompanied by the closing of the other set of ports by the same amount, in a differential manner. For this particular embodiment, the relationship between fuel

delivery quantity through the filling ports 68 and engine speed (transfer pressure) will be independent of fuel demand. To optimise the filling function for the device 30, it may however be beneficial to select the size of the filling and return ports 68, 62 so that their cross sectional flow areas are different. Reference to the cross sectional flow areas being different refers to the cross sectional flow area presented by the port in circumstances in which the port is fully open.

[0035] In addition, or alternatively, each set of outlets 62, 68 may include several axially staggered ports formed in the wall of the valve housing bore 38, with each port in a set having a different diameter (i.e. cross sectional flow area) to other ports in the same set.

[0036] Figure 4 illustrates an alternative embodiment of the invention. Here also the metering device 30 includes a single metering valve member 36 which is axially movable within a bore 38 provided in a valve housing 32 to open and close, in a corresponding manner, filling and return ports 168, 162 spaced axially along a valve housing bore 38. In this embodiment, the regulator outlet of the device is defined by a single return port 162 which communicates with the low pressure drain and the metering outlet is defined by a single filling port 168. The inlet to the device 30 is defined by an inlet port 150 provided on the opposite side of the valve housing bore 38 to the filling and return ports 162, 168, rather than at the end of the bore 38 as in the previous embodiment. As the inlet 150 can communicate directly with the filling and/or return port 168, 162 (depending on the position of the valve member) directly through the annular chamber 58, there is no requirement for an axially extending flow passage in the valve member 36. The valve member 36 may also be provided with first and second balancing passages 80, 82 which serve to prevent the occurrence of a hydraulic lock. It will be appreciated to the skilled person the feature of the balancing passages is optional, rather than being essential.

[0037] In use, the inlet port 150 delivers fuel at supply pressure (transfer pressure) to the annular chamber 58. If it is determined that rail pressure is too high, an actuator (not shown) for the valve member 36 is energised to cause the valve member 36 to move to the right in the illustration shown so that the filling port 168 starts to close and the return port starts to open. As a proportion of fuel delivered through the inlet 50 is thus able to flow to low pressure, the pressure of fuel at the inlet to the filling port 168 is reduced at the same time as the filling port is closed to reduce the flow rate through the port 168. Conversely, if it is determined that rail pressure is too low, the actuator for the valve member 36 is de-energised so that the valve member 36 is urged back to the left into a position in which the filling port 168 is fully opened (corresponding to maximum filling) and the return port 162 to low pressure is closed.

[0038] Other embodiments are envisaged in which additional ports are provided in the valve housing bore 38, for example to communicate with the cam box so as to

ensure there is lubrication for the bearings. The cambox port may be positioned so that it is open for all positions of the metering valve member 36 through its stroke. Alternatively, the cambox port may be positioned relative to the filling and return ports so that it can be shut-off altogether if necessary in certain circumstances.

[0039] Although the specific embodiments described previously include only a single actuator 40 for controlling the metering valve member 36, and hence both the metering and pressure regulating functions of the device 30, it is also envisaged that the metering and pressure regulating functions may be provided by separate parts and, hence, may have separate actuators. For example, a pressure regulator device may be provided having a pressure regulator valve member which co-operates with pressure regulator ports, wherein the pressure regulator valve member is separate and distinct from the metering valve member 36 and its co-operation with the filling ports 68. Although in this embodiment separate actuators may be provided for the pressure regulator valve member and the metering valve member, it is important that operation of the actuators are controlled in a complementary fashion so that operation of the metering valve member to reduce the flow rate through the filling port(s) is accompanied by a corresponding opening of the pressure regulator ports to increase fuel flow to low pressure, and vice versa.

[0040] Another embodiment of the device (not shown) may include an appropriately recessed valve member which is angularly movable within a metering valve bore so as to co-operate with return and filling ports provided in the bore. An actuator for the metering valve member controls the angular position of the metering valve member, with the return and filling ports sized and positioned so that an increase in flow through the filling port is accompanied by a reduction in flow through the return port to the low pressure drain, and vice versa.

Claims

1. A metering device (30) for controlling the flow of fuel to a fuel pump, the metering device (30) including:

metering valve means (36, 68) for controlling the rate of flow of fuel to the fuel pump, wherein the metering valve means has a metering valve inlet (50; 150) and a metering valve outlet (68; 168), pressure regulator means (36, 62) operable to regulate the pressure of fuel at the metering valve inlet (50),

a metering actuator (40) which is operable to control the metering valve means (36, 68), and a regulator actuator (40) which is operable to control the pressure regulator means (36, 62).

2. The metering device (30) as claimed in claim 1, wherein the metering valve means (36, 68) and the

pressure regulator means (36, 62) share a common actuator (40).

3. The metering device (30) as claimed in claim 2, wherein the metering valve means includes a metering valve member (36) which co-operates with the metering valve outlet (68) to control the rate of flow of fuel to the fuel pump, and wherein the pressure regulator means is provided by the metering valve member (36) in co-operation with a pressure regulator outlet (62) to a low pressure drain.
4. The metering device (30) as claimed in claim 3, wherein the metering valve member (36) is hydraulically pressure balanced.
5. The metering device (30) as claimed in claim 3 or claim 4, wherein the metering valve member (36) is movable within a bore (38) provided in a valve housing (32), wherein the metering valve outlet is defined by a filling port (68; 168) provided in the bore (38) so that movement of the metering valve member (36) within the bore (38) serves to control the degree of opening of the filling port (68; 168).
6. The metering device (30) as claimed in claim 5, wherein the pressure regulator outlet is defined by a return port (62; 162) provided in the bore (38) so that movement of the metering valve member (36) within the bore (38) serves to control the degree of opening of the return port (62; 162).
7. The metering device (30) as claimed in claim 5 or claim 6, wherein the bore (38) defines an inlet (50) at one end thereof.
8. The metering device (30) as claimed in claim 5 or claim 6, wherein the inlet (150) is defined in a wall of the bore (38).
9. The metering device (30) as claimed in any one of claims 5 to 8, wherein the filling port (68; 168) defines a maximum cross sectional flow area which is substantially the same as a maximum cross sectional flow area defined by the return port (62, 162).
10. The metering device (30) as claimed in any one of claims 5 to 8, wherein the filling port (68; 168) provides a maximum cross sectional flow area which is different to a maximum cross sectional flow area defined by the return port (62, 162).
11. The metering device (30) as claimed in any one of claims 5 to 10, wherein the bore (38) is provided with a set of at least two filling ports (68; 168) and a set of at least two return ports (62; 162).
12. The metering device (30) as claimed in claim 11,

wherein each of the filling ports (68; 168) of one of the sets has a different cross sectional flow area to the or each of the other filling ports of the set.

13. The metering device (30) as claimed in claim 11 or claim 12, wherein each of the return ports (62; 162) of one of the sets has a different cross sectional flow area to the or each of the other return ports of the set. 5
14. The metering device (30) as claimed in claim 13, further comprising additional ports provided in the bore (38) which communicate with an engine cam box or other fuel chamber, whereby the metering valve member (36) is operable to vary the degree of opening of the additional ports. 10 15
15. The metering device (30) as claimed in any one of claims 5 to 14, wherein the metering valve member (36) is axially movable within the bore (38). 20
16. The metering device (30) as claimed in any one of claims 1 to 15, further comprising control means for controlling operation of the metering actuator (40) and the regulator actuator (40) in response to a pressure signal representative of fuel pressure downstream of the metering valve outlet (68). 25
17. A common rail fuel pump including a metering device (30) for controlling the rate of flow of fuel to the common rail fuel pump, wherein the metering device (30) is as claimed in any one of claims 1 to 16. 30
18. A common rail fuel system having a common rail pump which is supplied with fuel by a transfer pump, the fuel system further comprising a metering device (30) as claimed in any one of claims 1 to 16 for controlling the rate of flow of fuel supplied from the transfer pump to the common rail pump. 35 40

Amended claims in accordance with Rule 86(2) EPC.

1. A metering device (30) for controlling the flow of fuel to a fuel pump, the metering device (30) including: 45

metering valve means (36, 68) for controlling the rate of flow of fuel to the fuel pump, wherein the metering valve means has a metering valve inlet (50; 150) and a metering valve outlet (68; 168), pressure regulator means (36, 62) operable to regulate the pressure of fuel at the metering valve inlet (50), 50

a metering actuator (40) which is operable to control the metering valve means (36, 68), and 55

a regulator actuator (40) which is operable to control the pressure regulator means (36, 62), characterised in that

the metering valve means (36, 68) and the pressure regulator means (36, 62) share a common actuator (40).

2. The metering device (30) as claimed in claim 1, wherein the metering valve means includes a metering valve member (36) which co-operates with the metering valve outlet (68) to control the rate of flow of fuel to the fuel pump, and wherein the pressure regulator means is provided by the metering valve member (36) in co-operation with a pressure regulator outlet (62) to a low pressure drain.
3. The metering device (30) as claimed in claim 2, wherein the metering valve member (36) is hydraulically pressure balanced.
4. The metering device (30) as claimed in claim 2 or claim 3, wherein the metering valve member (36) is movable within a bore (38) provided in a valve housing (32), wherein the metering valve outlet is defined by a filling port (68; 168) provided in the bore (38) so that movement of the metering valve member (36) within the bore (38) serves to control the degree of opening of the filling port (68; 168).
5. The metering device (30) as claimed in claim 4, wherein the pressure regulator outlet is defined by a return port (62; 162) provided in the bore (38) so that movement of the metering valve member (36) within the bore (38) serves to control the degree of opening of the return port (62; 162).
6. The metering device (30) as claimed in claim 4 or claim 5, wherein the bore (38) defines an inlet (50) at one end thereof.
7. The metering device (30) as claimed in claim 4 or claim 5, wherein the inlet (150) is defined in a wall of the bore (38).
8. The metering device (30) as claimed in any one of claims 4 to 7, wherein the filling port (68; 168) defines a maximum cross sectional flow area which is substantially the same as a maximum cross sectional flow area defined by the return port (62, 162).
9. The metering device (30) as claimed in any one of claims 4 to 7, wherein the filling port (68; 168) provides a maximum cross sectional flow area which is different to a maximum cross sectional flow area defined by the return port (62, 162).
10. The metering device (30) as claimed in any one of claims 4 to 9, wherein the bore (38) is provided with a set of at least two filling ports (68; 168) and a set of at least two return ports (62; 162).

11. The metering device (30) as claimed in claim 10, wherein each of the filling ports (68; 168) of one of the sets has a different cross sectional flow area to the or each of the other filling ports of the set.

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12. The metering device (30) as claimed in claim 10 or claim 11, wherein each of the return ports (62; 162) of one of the sets has a different cross sectional flow area to the or each of the other return ports of the set.

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13. The metering device (30) as claimed in claim 12, further comprising additional ports provided in the bore (38) which communicate with an engine cam box or other fuel chamber, whereby the metering valve member (36) is operable to vary the degree of opening of the additional ports.

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14. The metering device (30) as claimed in any one of claims 4 to 13, wherein the metering valve member (36) is axially movable within the bore (38).

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15. The metering device (30) as claimed in any one of claims 1 to 14, further comprising control means for controlling operation of the metering actuator (40) and the regulator actuator (40) in response to a pressure signal representative of fuel pressure downstream of the metering valve outlet (68).

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16. A common rail fuel pump including a metering device (30) for controlling the rate of flow of fuel to the common rail fuel pump, wherein the metering device (30) is as claimed in any one of claims 1 to 15.

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17. A common rail fuel system having a common rail pump which is supplied with fuel by a transfer pump, the fuel system further comprising a metering device (30) as claimed in any one of claims 1 to 15 for controlling the rate of flow of fuel supplied from the transfer pump to the common rail pump.

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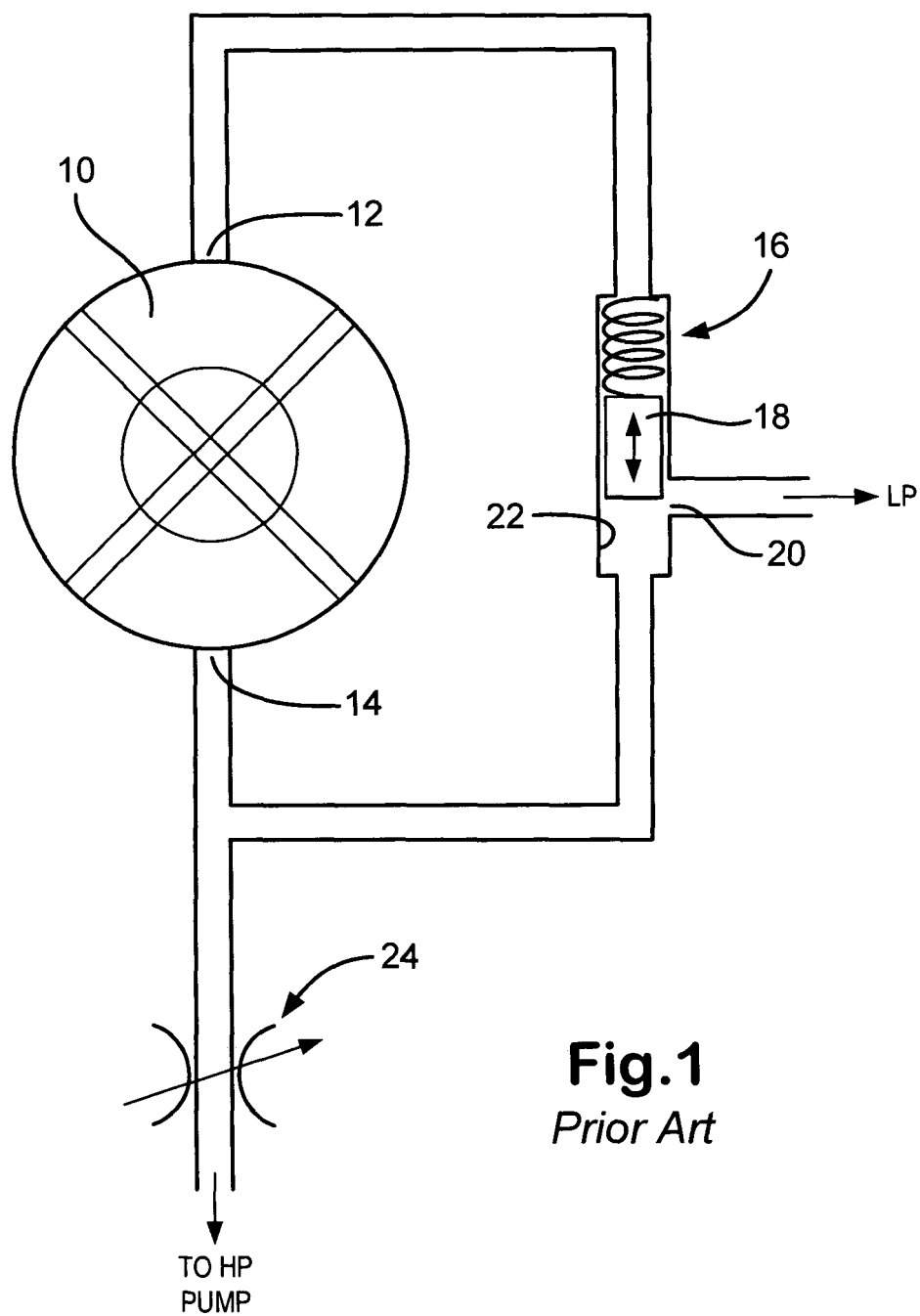
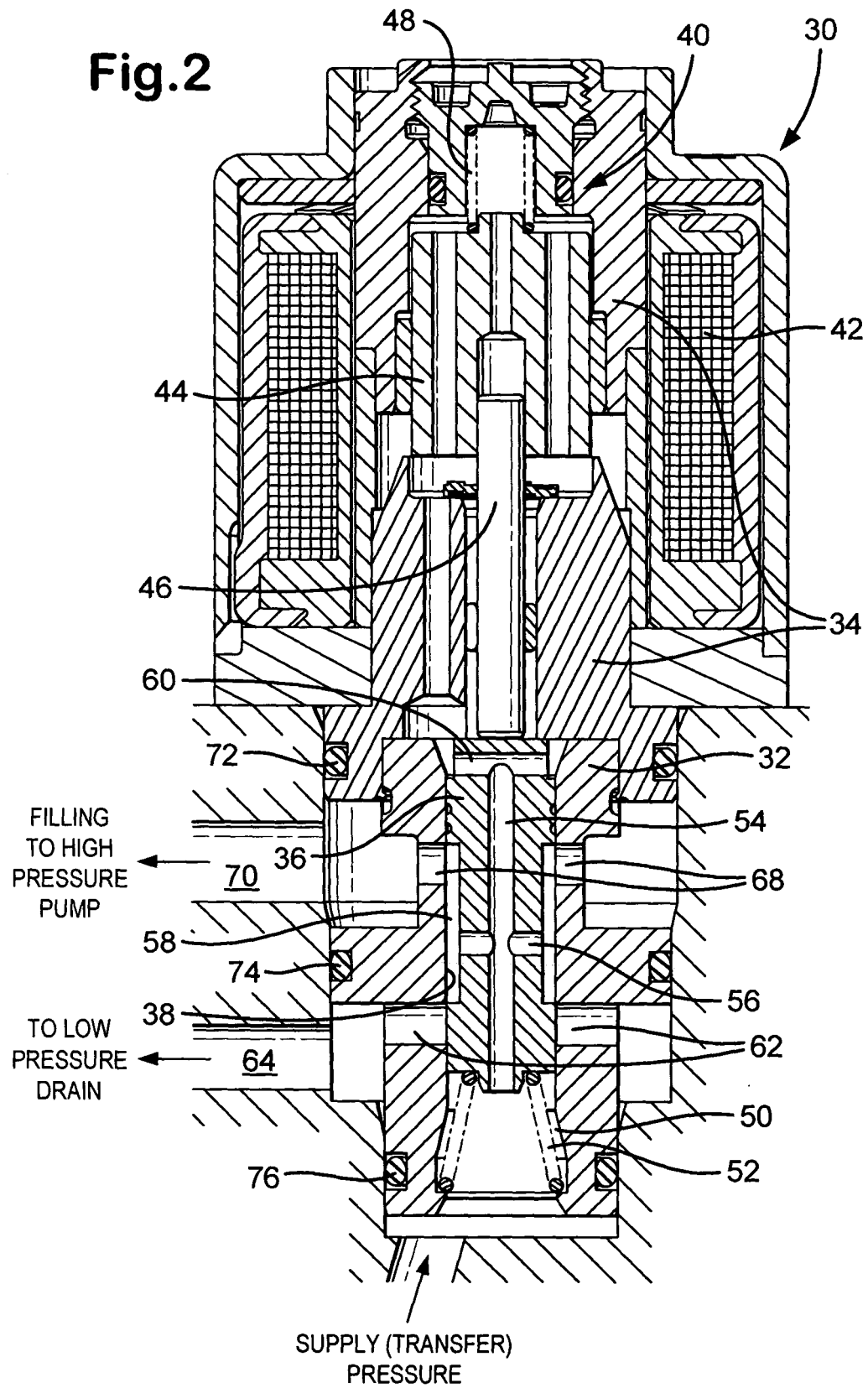


Fig.1
Prior Art

Fig.2



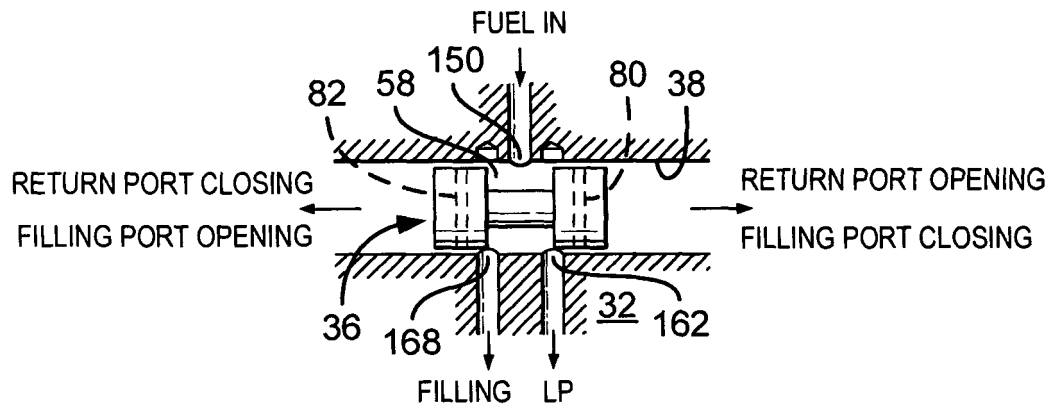
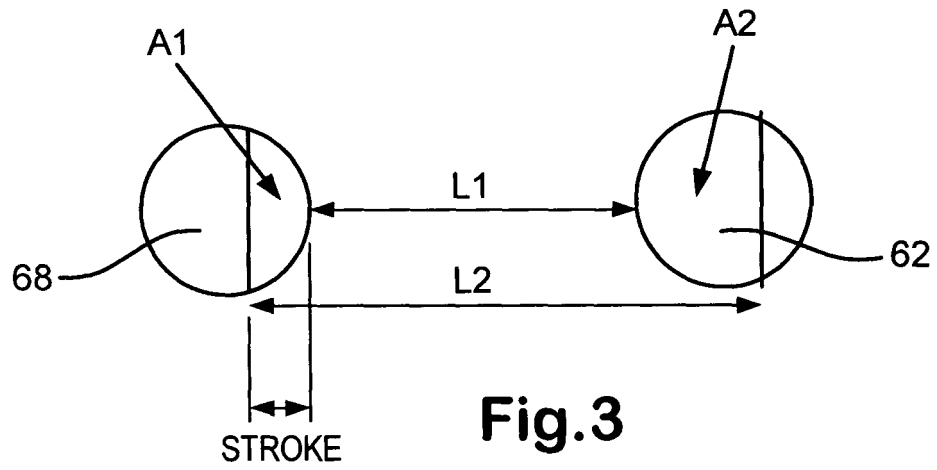


Fig.4



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 04 25 4617

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Place of search Munich		Date of completion of the search 30 September 2004	Examiner Etschmann, G
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			

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