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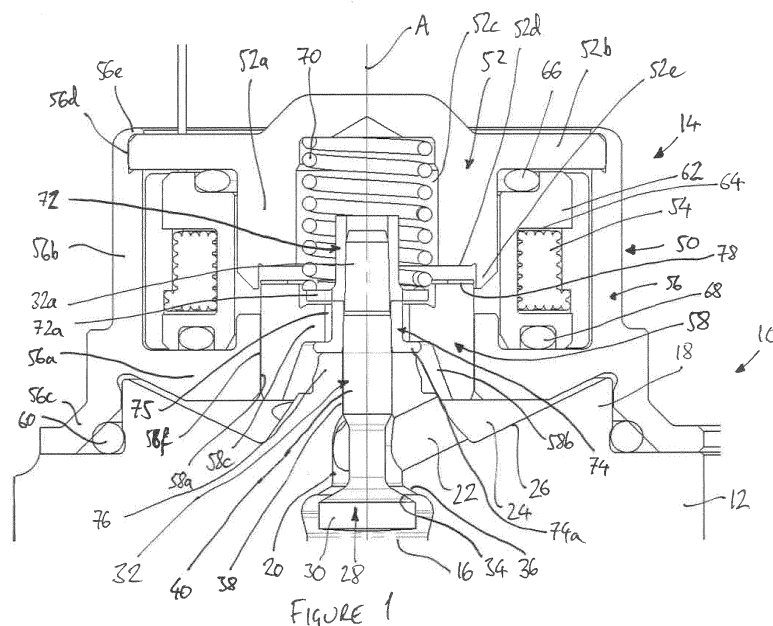
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• **Marechal, Michel****41150 Chouzy Sur Cisse (FR)**(54) **Valve assembly**

(57) An inlet valve assembly (14) for a high-pressure fuel pump is disclosed. The inlet valve assembly comprises an inlet valve member (28) moveable between open and closed positions to control the fuel flow from a source (24) of low-pressure fuel to a pumping chamber (16) of the fuel pump, and an electromagnetic actuator (50) comprising a core member (52), a solenoid coil (54), and an armature (58) moveable towards the core member (52) in response to energisation of the coil (54). In a first phase of operation, the armature (58) is decoupled

from the valve member (28) to allow movement of the armature (58) towards the core member (52) without movement of the valve member (28) and, in a second phase of operation, the armature (58) is coupled to the valve member (28) to carry the valve member (28) towards its closed position. Because the armature (58) is initially decoupled from the valve member (28), variations in concentricity and part dimensions due to manufacturing tolerances can be accommodated without affecting operation of the valve assembly.

**FIGURE 1****EP 2 687 712 A1**

Description

Field of the invention

[0001] The present invention relates to an inlet valve assembly suitable for use in a fuel pump. In particular, the invention relates to an inlet valve assembly for a pump head of a high-pressure fuel pump for use in a common rail fuel injection system.

Background to the invention

[0002] High-pressure fuel pumps for common rail fuel injection systems typically comprise one or more hydraulic pump heads in which fuel is pressurised in a pumping chamber of the pump head by the reciprocating movement of a plunger.

[0003] Typically, low-pressure fuel is delivered to the pump head by a low-pressure lift pump in the fuel tank and/or by a transfer pump built into the high-pressure fuel pump. The low-pressure fuel is drawn into the pumping chamber through an associated inlet valve on a filling or return stroke of the plunger, during which the volume of the pumping chamber increases. On a pumping or forward stroke of the plunger, the inlet valve closes and the volume of the pumping chamber decreases, resulting in an increase in the fuel pressure within the pumping chamber. At a pre-determined pressure, an outlet valve associated with the pumping chamber opens to allow the high-pressure fuel out of from the pumping chamber to the common rail for delivery to the fuel injectors.

[0004] The fuel pressure in the common rail, which determines the fuel injection pressure, may be varied from a moderate pressure of a few hundred bar at low engine loads and speeds to a very high pressure of up to 3000 bar or more at high engine loads and speeds.

[0005] To regulate the fuel pressure in the common rail, an additional control valve, known as an inlet metering valve, may be provided upstream of the inlet valve of the pumping chamber. The inlet metering valve is used to control the amount of fuel that enters the pumping chambers of the fuel pump, and consequently the quantity of fuel that is compressed and delivered to the common rail at high pressure with each plunger stroke. A conventional inlet metering valve is effectively a controllable orifice, which acts to throttle the flow of fuel to the inlet valve of the high-pressure pump. In this way, only the amount of fuel required by the engine is delivered to the rail, thereby saving both fuel and energy compared to the situation where fuel is fed by the lift or transfer pump at constant full delivery. The inlet metering valve is under the control of the engine control unit, which determines the desired rail pressure and the actual rail pressure and adjusts the inlet metering valve accordingly.

[0006] There are several disadvantages in the use of conventional inlet metering valves. In particular, inlet metering valves can be expensive and add to the overall cost of the common rail injection system, which is unde-

sirable. Secondly, inlet metering valves are relatively large and space-consuming components. Thirdly, inlet metering valves can be vulnerable to wear and to damage due to low-quality fuels. Furthermore, in some arrangements, the use of a conventional inlet metering valve means that the metering/rail pressure control mechanism is relatively far from the pumping chamber of the high-pressure fuel pump, which leads to undesirable delays in rail pressure control.

[0007] In an alternative arrangement, the inlet valve for the pumping chamber is provided with an actuator arrangement which allows the inlet valve to be closed in response to a signal from the engine's electronic control unit. In this way, the quantity of fuel that enters the pumping chamber during the filling stroke of the plunger can be regulated without the need for an additional inlet metering valve. Such arrangements are described in DE 10 2008 018 018 and EP 1921307. EP 1921307 also describes the use of the inlet valve as a spill valve to return high-pressure fuel from the pumping chamber to the fuel rail during the pumping stroke of the plunger.

[0008] Typically, electronically-controllable or switchable inlet valves are actuated by a solenoid actuator arrangement operable to control the movement of a poppet-type inlet valve member that is received within a bore in the pump head. An armature is attached to a valve stem of the valve member, and a head portion of the valve member is engageable with an associated seating formed at the end of the bore. When the solenoid is energised, the armature is drawn towards a core of the solenoid against the force of a biasing spring, which biases the valve stem into a normally-open position.

[0009] In practice, the performance of such solenoid-actuated inlet valves can be compromised by several factors. For example, the inlet valve is in its fully-open position, it is desirable that the cross-sectional area available for fuel to flow between the valve head and the valve seat is as large as possible, to maximise the flow of fuel into the pumping chamber at high engine loads. For this reason, the stroke of the valve member between its fully-open position and its fully-closed position must be relatively long. This, in turn, means that the air gap between the armature and the core is relatively large when the valve is fully open. Since the force applied to the armature of a solenoid actuator decreases significantly as the air gap increases, a relatively large and expensive solenoid must be used to achieve the force necessary to close the valve.

[0010] Also, in such an arrangement, the armature is typically in the form of a collar that is press-fitted or otherwise attached to the valve stem. Any variation in concentricity between the armature and the valve stem, and between the armature and the core, can result in undesirable side-loads that can cause excessive wear of the valve member and the valve seat during the service life of the inlet valve. Because the inlet valve is subject to very high fuel pressures, such wear can seriously impair the performance and reliability of the valve. The inlet

valve must therefore be manufactured with very tightly-controlled tolerances in the dimensions and concentricity of the parts, which increase manufacturing complexity and cost.

[0011] Against this background, it would be desirable to provide an electronically-controllable inlet valve assembly for the pump head of a high-pressure fuel pump which substantially overcomes or mitigates at least some of the above-mentioned problems.

Summary of the invention

[0012] From one aspect, the present invention resides in an inlet valve assembly for a high-pressure fuel pump, comprising an inlet valve member moveable between open and closed positions to control the fuel flow from a source of low-pressure fuel to a pumping chamber of the fuel pump, and an electromagnetic actuator comprising a core member, a solenoid coil, and an armature moveable towards the core member in response to energisation of the coil. In a first phase of operation, the armature is decoupled from the valve member to allow movement of the armature towards the core member without movement of the valve member. In a second phase of operation, the armature is coupled to the valve member to carry the valve member towards its closed position.

[0013] Because the armature can move independently of the valve member in the first phase of operation, any variations in concentricity between the valve member, the armature, the core member and/or other components of the valve assembly can be accommodated more readily than if the armature were fixedly attached to the valve member. As a result, the dimensional tolerances of the components of the valve assembly are less critical, and so the cost and complexity of manufacturing the valve assembly can be reduced.

[0014] Preferably, an annular clearance is defined between the armature and the valve member. In this way, axial misalignment between the armature and the valve member, for example due to manufacturing tolerances, can be accommodated without giving rise to undesirable side loading and wear on the valve member. In one embodiment, the armature is generally tubular, and the annular clearance is defined, in part, by an internal collar of the armature.

[0015] The valve member may carry a lift collar, and the armature may be arranged to engage with the lift collar to couple the armature to the valve member in the second phase of operation. For example, when the armature is tubular and includes an internal collar, the internal collar of the armature may engage with the lift collar. The lift collar may include an outwardly-directed flange, and a part of the armature (for example the internal collar, when provided) may engage with the flange. The lift collar is preferably press-fitted or crimped onto the valve member.

[0016] The inlet valve assembly may further comprise a biasing spring to bias the valve member into its open

position. When provided, the lift collar may function as a spring seat for the biasing spring. For example, when the lift collar includes an outwardly-directed flange, the biasing spring may act on a first side of the flange, and the internal collar of the armature may act on a second, opposite side of the flange.

[0017] Stop means may be provided for limiting the opening movement of the valve member. In one embodiment, the stop means comprises a stop member carried on the valve member. The stop member may be arranged to stop against a housing part of the fuel pump to limit the opening movement of the valve member. The stop member may be disposed between the armature and the valve member and, advantageously, the stop member may be made from a non-magnetic material. With this arrangement, the stop member helps to prevent the magnetic field circuit that arises upon energisation of the coil from entering the valve member, thereby increasing the efficiency of the actuator.

[0018] In one embodiment, the stop member comprises a tubular sleeve or collar. The stop member may include an outwardly-directed flange for engagement with a housing part of the fuel pump. In addition to limiting the opening movement of the valve member, the stop member may also limit movement of the armature away from the core. The stop member may be press-fitted or crimped onto the valve member.

[0019] A non-magnetic spacer member may be disposed between the armature and the core. The spacer member may, for example, comprise a non-magnetic washer affixed to the armature.

[0020] The core member may include an extended portion that overlaps with the armature during at least a part of the range of movement of the armature. In this way, the maximum gap between the core member and the armature can be larger, for a given core and armature size, than would be the case if no extended portion were present. Thus the range of movement of the valve member can be relatively large, maximising the rate at which fuel can flow through the inlet valve assembly to fill the pumping chamber. Said another way, for a given maximum gap between the armature and the core member, the presence of the extended portion of the core member allows a smaller coil to be used than would otherwise be the case. Thus the size of the valve assembly can be reduced.

[0021] The extended portion preferably overlaps with the armature along the axis of movement of the armature over the whole range of movement of the armature. The extended portion may, for example, comprise an annular projection that extends from a face of the core member. The extended portion preferably defines a recess that receives, in part, the armature.

[0022] The inlet valve assembly may include an outer pole. The outer pole may include an aperture for receiving the armature, and movement of the armature may be guided by the aperture. The outer pole may be arranged to retain the core member. For example, the core member

may comprise a flange, and the outer pole may include a slot to receive the flange. The outer pole may be generally cup-shaped. For example, in one embodiment, the outer pole includes a base, and the base includes the aperture through which the armature is received.

[0023] The inlet valve assembly of the present invention is preferably adapted for use with a pump head of a high-pressure fuel pump. To this end, the inlet valve assembly may be adapted to engage with a housing of a pump head. For example, when the inlet valve assembly includes an outer pole, the outer pole may comprise a mounting flange for mounting the inlet valve assembly to the pump head housing.

[0024] A pump head for a high pressure fuel pump, comprising an inlet valve assembly according to the above-described aspect of the invention may also be provided. Furthermore, a fuel pump having at least one such pump head can also be contemplated.

Brief description of the drawings

[0025] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which like reference numerals are used for like features, and in which:

Figure 1 is a cross-sectional view of part of a pump head having an inlet valve assembly according to an embodiment of the present invention, with the inlet valve assembly in an open position;

Figure 2(a) is a cross-sectional view of the pump head of Figure 1, with the inlet valve assembly in an intermediate position; and

Figure 2(b) is a cross-sectional view of the pump head of Figure 1, with the inlet valve assembly in a closed position.

[0026] Throughout this description, terms such as "upper" and "lower" will be used with reference to the position of the parts as shown in the accompanying drawings. It will be appreciated, however, that the parts could adopt different orientations in use.

Detailed description of embodiments of the invention

[0027] Figure 1 shows, in part, a pump head 10 comprising a head housing 12 and an inlet valve assembly 14 mounted on the head housing 12. Although not shown in Figure 1, the head housing 12 defines a plunger bore for receiving a plunger that reciprocates in use along a pumping axis A to cyclically increase and decrease the volume of a pumping chamber 16 (only the upper end of which can be seen in Figure 1).

[0028] The upper end of the head housing 12 comprises a generally cylindrical turret portion 18. As will be ex-

plained in more detail below, parts of the inlet valve assembly 14 cooperate with the turret to connect the inlet valve assembly 14 to the head housing 12.

[0029] The pumping chamber 16 is formed as a bore in the head housing 12. During a return stroke of the plunger, fuel can be drawn into the pumping chamber 16 by way of an inlet bore 20. The inlet bore 20 communicates, by way of a drilling 22, with an annular space 24 formed by an annular v-shaped groove 26 in the top of the turret portion 18. The annular space 24 receives fuel at low pressure by way of inlet passages (not shown).

[0030] The flow of fuel between the inlet bore 20 and the pumping chamber 16 is regulated by a poppet valve member 28 of the inlet valve assembly 14. At its lowest end, the valve member 28 is formed into a valve head 30 with a relatively large diameter. The remainder of the valve member 28 forms a valve stem 32. A frustoconical seating surface 34 extends from the valve head 30 to the valve stem 32, and the seating surface 34 is engageable with a frustoconical valve seat 36 formed in the head housing 12 where the pumping chamber 16 meets the inlet bore 20. In Figure 1, the valve member 28 is shown in its open position, with the seating surface 34 disengaged from the valve seat 36 to allow fuel to enter the pumping chamber 16.

[0031] The stem 32 of the valve member 28 extends upwardly from the valve head 30 through a guide bore 38 formed in the head housing 12. A guide portion 40 of the stem 32 has a suitable diameter to form a sliding fit in the guide bore 38, so that movement of the valve member 28 is guided in an axial direction. The guide bore 38, and hence the direction of movement of the valve member 28, is coaxial with the pumping axis A.

[0032] An upper portion of the stem 32 of the valve member 28 emerges from the head housing 12 and, as will now be described, engages with an actuator arrangement 50 of the valve assembly 14 that can be used to control movement of the valve member 28.

[0033] The actuator arrangement 50 generally comprises a core member 52, a solenoid coil 54, an outer pole 56, and a moveable armature 58. The outer pole 56 is mounted to the head housing 12 and is arranged to retain the core member 52 in a position spaced from the head housing 12, and the coil 54 and the armature 58 are disposed between the core member 52 and the head housing 12.

[0034] The outer pole 56 comprises a generally cup-shaped body having a base 56a and a generally cylindrical wall 56b extending upwardly from the base 56a. A mounting flange or lip 56c extends downwardly from the base 56a to embrace the turret portion 18 of the head housing 12. An o-ring 60 forms a seal between the turret portion 18 and a chamfered part of the lip 56c, to prevent fuel leakage from the valve assembly 14.

[0035] The core member 52 comprises a generally tubular central portion 52a, surrounded by an annular flange 52b. The flange 52b extends outwardly from the central portion 52a to mate with an annular slot 56d

formed in the inside surface of the wall 56b of the outer pole 56. The uppermost edge 56e of the wall 56b is crimped over the flange 52b to retain the flange 52b in the slot 56d.

[0036] The coil 54 is wound around a coil former 62, preferably of plastics material. The coil former 62 is ring-shaped, and the central portion 52a of the core member 52 is received in the centre of the ring. The coil former 62 therefore surrounds the central portion 52a of the core member 52, and is disposed between the flange 52b of the core member 52 and the base 56a of the outer pole 56. The coil 54 is received within an annular channel 64 formed in the outer face of the coil former 62.

[0037] The centre of the coil former 62 is in fluid communication with the annular space 24 through which low-pressure fuel is delivered to the pumping chamber 16. To prevent leakage of fuel, the coil former 62 forms a seal with the flange 52b of the core member 52 at its upper end and with the base 56a of the outer pole 56 at its lower end, with respective o-rings 66, 68 being provided to effect the seals. By virtue of these o-rings 66, 68, and the o-ring 60 that forms a seal between the outer pole 56 and the head housing 12, fuel cannot leak from the valve assembly 14.

[0038] The armature 58 is generally tubular, having an outer wall 58a and an inner bore 58b through which the stem 32 of the valve member 28 extends. The armature has an inwardly-extending collar 58c, provided at an intermediate position along the bore 58b, defining a restricted-diameter region within the bore 58b. The armature 58 is not fixedly connected to the valve member 28, but instead the collar 58c of the armature 58 cooperates with the valve member 28 to transfer movement of the armature 58 to the valve member 28 as will be explained below.

[0039] The base 56a of the outer pole 56 includes a central aperture 56f for receiving the armature 58. The outer wall 58a of the armature 58 is in sliding contact with the wall of the aperture 56f, so that the outer pole 56 guides axial movement of the armature 58 in use.

[0040] The tubular central portion 52a of the core member 52 extends downwardly, towards the armature 58. At its upper end, the tube that forms the central portion 52a is closed, so that the core member 52 acts as a cap for the valve assembly 14, and defines a cavity 52c within the central portion 52a for receiving a biasing spring 70 for the valve member 28. An upper end of the spring 70 bears against the closed end of the cavity 52c, whilst an opposite, lower end of the spring 70 acts against a spring collar 72 mounted on an upper part 32a of the stem 32 of the valve member 28. In this way, the spring 70 biases the valve member 28 into its open position.

[0041] The spring collar 72 comprises a tubular sleeve which is press-fitted onto the upper part 32a of the stem 32. At its lowermost end, the spring collar 72 is flared outwardly to define a spring flange 72a. The spring 70 bears on the upper surface of the spring flange 72a to apply a biasing force to the valve member 28 in its open-

ing direction.

[0042] The stem 32 of the valve member 28 also carries a stop collar 74. The stop collar 74 is press-fitted onto the stem 32 between the spring collar 72 and the guide portion 40 of the stem 32. Like the spring collar 72, the stop collar 74 comprises a tubular sleeve with an outwardly-flared lowermost end, to define a stop flange 74a. The stop flange 74a abuts a raised, central portion 76 of the turret 18 of the head housing 12 when the valve member 28 is in its open position, as shown in Figure 1. In this way, the stop flange 74a acts as a stop member for limiting the opening movement of the valve member 28.

[0043] As will be appreciated from Figure 1, the spring flange 72a and the stop flange 74a are spaced apart along the axis of the valve member 28. The internal collar 58c of the armature 58 extends into the gap between the spring flange 72a and the stop flange 74a. The thickness of the internal collar 58c, in the direction of the pumping axis A, is less than the gap between the spring flange 72a and the stop flange 74a, so that the collar 58c is a clearance fit between the respective flanges 72a, 74a. This allows the armature 58 to move in the axial direction independently of the valve member 28 over a short distance corresponding to the total axial clearance between the collar 58c and the flanges 72a, 74a.

[0044] As will also be appreciated from Figure 1, the internal diameter of the collar 58c of the armature 58 is larger than the external diameter of the tubular part of the stop collar 74, thereby to define an annular clearance 75 between the stop collar 74 and the collar 58c of the armature 58. The collar 58c of the armature 58 does not therefore constrain the valve member 28 in the radial direction.

[0045] With the valve member 28 in its fully-open position, as shown in Figure 1, the collar 58c rests on the stop flange 74a, which in turn abuts the raised portion 76 of the turret 18 of the head housing 12. Therefore the stop flange 74a also limits movement of the armature 58 away from the core member 52.

[0046] To accommodate axial movement of the armature 58 towards the core member 52 (upwards in Figure 1), the lowermost face of the central portion 52a of the core member 52 includes a recess 52d. The outer edge of the recess 52d is defined by a downwardly-extended portion 52e of the core member 52, in the form of an annular ridge or horn.

[0047] When the armature 58 is in its lowest position with the collar 58c resting on the stop flange 74a, as shown in Figure 1, the lowermost tip of the downwardly-extended portion 52e overlaps with the top of the armature 58 over a relatively short distance. When the coil 54 is energised to move the armature 58 upwardly towards the core member 52, as will be explained in more detail below, the recess 52d receives the top end of the armature 58 and the extended portion 52e overlaps with the armature 58 over a longer distance.

[0048] The inside diameter of the recess 52d is larger than the outside diameter of the armature 58, so that

there is no radial contact between the armature 58 and the core member 52. Furthermore, a washer or spacer 78 of non-magnetic material is provided on the top face of the armature 58, to prevent direct contact between the armature 58 and the core member 52 and to guide the magnetic flux to enter the armature 58 radially, rather than axially.

[0049] The core member 52, the outer pole 56 and the armature 58 are preferably formed from a ferromagnetic material, such as mild steel. In this way, when the coil 54 is energised, the resulting magnetic flux is contained within a magnetic circuit defined by these ferromagnetic components. The spring collar 72 and the stop collar 74 are made from a non-magnetic material, such as an austenitic stainless steel, which helps to stop the magnetic circuit from straying out of the armature 58 and into the valve member 28.

[0050] Referring additionally to Figures 2(a) and 2(b), operation of the inlet valve assembly 14 will now be described.

[0051] When the coil 54 is energised, the armature 58 moves towards the core member 52. Initially, the armature 58 is decoupled from the valve member 28 so that, in a first phase of movement of the armature 58, the valve member 28 remains stationary in its fully open position under the influence of the biasing spring 70.

[0052] As the armature 58 continues to move towards the core member 52, the collar 58c of the armature 58 rises to meet the spring flange 72a, as shown in Figure 2(a). In this way, the armature 58 couples to the valve member 28. Once the collar 58c is engaged with the spring flange 72a, in a second phase of movement of the armature 58, the armature 58 carries the valve member 28 towards its closed position. The spring collar 72 therefore acts as a lift collar for the valve member 28.

[0053] As shown in Figure 2(b), closing movement of the valve member 28 stops when the seating surface 34 of the valve member 28 meets the valve seat 36. Once the valve member 28 is seated, further upward movement of the armature 58 is blocked by the spring flange 72a, leaving a relatively small clearance between the top of the armature 58 and the core member 52 in the axial direction.

[0054] Advantageously, because the armature 58 is initially decoupled from the valve member 28, and because there is an annular clearance 75 between the valve member 28 and the armature 58, movement of the armature 58 can occur without being constrained by the valve member 28. Consequently, any variations in concentricity and/or alignment between the valve member 28 and the armature 58 can be accommodated without any adverse effect on the operation of the valve assembly 14. Said another way, because the armature 58 is decoupled from the valve member 28 during a first phase of operation of the valve assembly, additional axial and

radial degrees of freedom allow compensation for misalignment and dimensional variations due to manufacturing tolerances.

[0055] Furthermore, because the extended portion 52e of the core member 52 (see Figure 1), overlaps with the armature 58, the magnetic flux is guided into the armature 58 in a more efficient manner than would be the case if the extended portion 52e were not present (i.e. if the lower face of the central portion 52a of the core member 52 were planar). Therefore the actuator arrangement of the embodiment of Figure 1 is effective even when the air gap between the armature 58 and the core member 52 is relatively large when the valve member 28 is fully open. Advantageously, this allows the clearance between the seating surface 34 of the valve member 28 and the valve seat 36 to be maximised for a given actuator size, so as to provide a high flow rate of fuel into the pumping chamber 16 during the filling stroke of the pumping element.

[0056] In use, the inlet valve assembly may be operated as follows. To fill the pumping chamber 16 during the filling stroke of the plunger, in which the plunger moves to increase the volume of the pumping chamber 16, the coil 54 is de-energised and the valve member 28 is held in its open position by the biasing spring 70 as shown in Figure 1. Fuel is drawn into the pumping chamber 16 past the open valve member 28 as a result of the increase in volume of the pumping chamber 16.

[0057] An electronic control unit of the engine calculates the quantity of fuel that should be permitted to enter the pumping chamber 16 during each filling stroke, according to the current rail pressure and the demand for fuel based on the prevailing engine operating conditions. Once the valve member 28 has been in its open position for a sufficient portion of the filling stroke to admit the desired quantity of fuel, the coil 54 is energised in response to a signal from the electronic control unit. After the initial phase of movement of the armature 58, during which the armature 58 is decoupled from the valve member 28, the armature 58 then couples to the valve member 28 as shown in Figure 2(a) and carries the valve member 28 to its closed position against the force of the biasing spring 70, as shown in Figure 2(b). Further filling of the pumping chamber 16 is thus prevented.

[0058] Once the plunger has completed its filling stroke, the pumping stroke of the plunger begins to decrease the volume of the pumping chamber 16, thereby to increase the pressure of fuel in the pumping chamber 16. Flow of fuel out of the pumping chamber 16 through the inlet valve is prevented by the seated valve member 28. The fuel pressure in the pumping chamber 16 applies a force to the valve member 28 in the closing direction, which becomes sufficient to overcome the opening force applied to the valve member 28 by the spring 70. At this point, the coil 54 can be de-energised to save energy: the valve member 28 remains in its closed position as a result of the fuel pressure in the pumping chamber 16.

[0059] The high-pressure fuel in the pumping chamber

16 is expelled through an outlet valve (not shown) of the pump head, which opens at a pre-determined pressure. As the pumping stroke ends and the filling stroke begins, the fuel pressure acting on the valve member 28 drops and the biasing spring 70 causes the valve member 28 to move back into its open position, as shown in Figure 1, to admit fuel into the pumping chamber 16 once more.

[0060] In the illustrated embodiment of the invention, the spring collar functions as a lift collar with which the armature engages to carry the valve member into its closed position. However, in other embodiments of the invention, separate spring and lift collars may be provided.

[0061] Whilst the inlet valve assemblies described above are of the normally-open type, it would also be conceivable to provide an inlet valve assembly of the normally-closed type, in which the actuator is energised to open the valve, and the armature couples to the valve member to carry the valve member to its open position. In general terms, an inlet valve assembly for a high-pressure fuel pump may comprise an inlet valve member moveable between open and closed positions to control the fuel flow from a source of low-pressure fuel to a pumping chamber of the fuel pump, and an electromagnetic actuator comprising a core member, a solenoid coil, and an armature moveable towards the core member in response to energisation of the coil. In a first phase of operation, the armature is decoupled from the valve member to allow movement of the armature towards the core member without movement of the valve member, and in a second phase of operation, the armature is coupled to the valve member to carry the valve member towards either its open position or its closed position.

[0062] It will be appreciated that further modifications and variations not explicitly described above are also possible without departing from the scope of the invention as defined in the appended claims.

Claims

1. An inlet valve assembly (14) for a high-pressure fuel pump, comprising:

an inlet valve member (28) moveable between open and closed positions to control the fuel flow from a source (24) of low-pressure fuel to a pumping chamber (16) of the fuel pump; and an electromagnetic actuator (50) comprising a core member (52), a solenoid coil (54), and an armature (58) moveable towards the core member (52) in response to energisation of the coil (54);

wherein, in a first phase of operation, the armature (58) is decoupled from the valve member (28) to allow movement of the armature (58) towards the core member (52) without movement of the valve member (28), and wherein, in a sec-

ond phase of operation, the armature (58) is coupled to the valve member (28) to carry the valve member (28) towards its closed position.

2. An inlet valve assembly according to Claim 1, wherein an annular clearance (75) is defined between the armature (58) and the valve member (28).
3. An inlet valve assembly according to Claim 2, wherein the armature (58) is generally tubular, and wherein the annular clearance (75) is defined, in part, by an internal collar (58c) of the armature (58).
4. An inlet valve assembly according to any of Claims 1 to 3, wherein the valve member (28) carries a lift collar (72), and wherein the armature (58) is arranged to engage with the lift collar (72) to couple the armature (58) to the valve member (28) in the second phase of operation.
5. An inlet valve assembly according to Claim 4, further comprising a biasing spring (70) to bias the valve member (28) into its open position, and wherein the lift collar (72) comprises a spring seat for the biasing spring (72a).
6. An inlet valve assembly according to Claim 5, wherein the lift collar (72) is press-fitted or crimped onto the valve member (28).
7. An inlet valve assembly according to any preceding Claim, further comprising stop means (74, 76) for limiting the opening movement of the valve member (28).
8. An inlet valve assembly according to Claim 7, wherein the stop means comprises a stop member (74) carried on the valve member (28) and arranged to stop against a housing part (76) of the fuel pump to limit the opening movement of the valve member (28).
9. An inlet valve assembly according to Claim 8, wherein the stop member (74) is disposed between the armature (58) and the valve member (28), and wherein the stop member (74) is made from a non-magnetic material.
10. An inlet valve assembly according to Claim 8 or Claim 9, wherein the stop member (74) comprises a tubular sleeve.
11. An inlet valve assembly according to any of Claims 7 to 10, wherein the stop member (74) limits movement of the armature (58) away from the core member (52).
12. An inlet valve assembly according to any preceding

claim, further comprising a non-magnetic spacer member (78) disposed between the armature (58) and the core member (52).

13. An inlet valve assembly according to any preceding Claim, wherein the core member (52) includes an extended portion (52e) that overlaps with the armature (58) along the axis of movement of the armature (52) over at least a part of the range of movement of the armature (52). 5 10
14. An inlet valve assembly according to Claim 13, wherein the extended portion (52e) overlaps with the armature (58) along the axis of movement of the armature (52) over the whole range of movement of the armature (52). 15
15. An inlet valve assembly according to Claim 13 or Claim 14, wherein the extended portion (52e) defines a recess (52d) that receives, in part, the armature (52). 20

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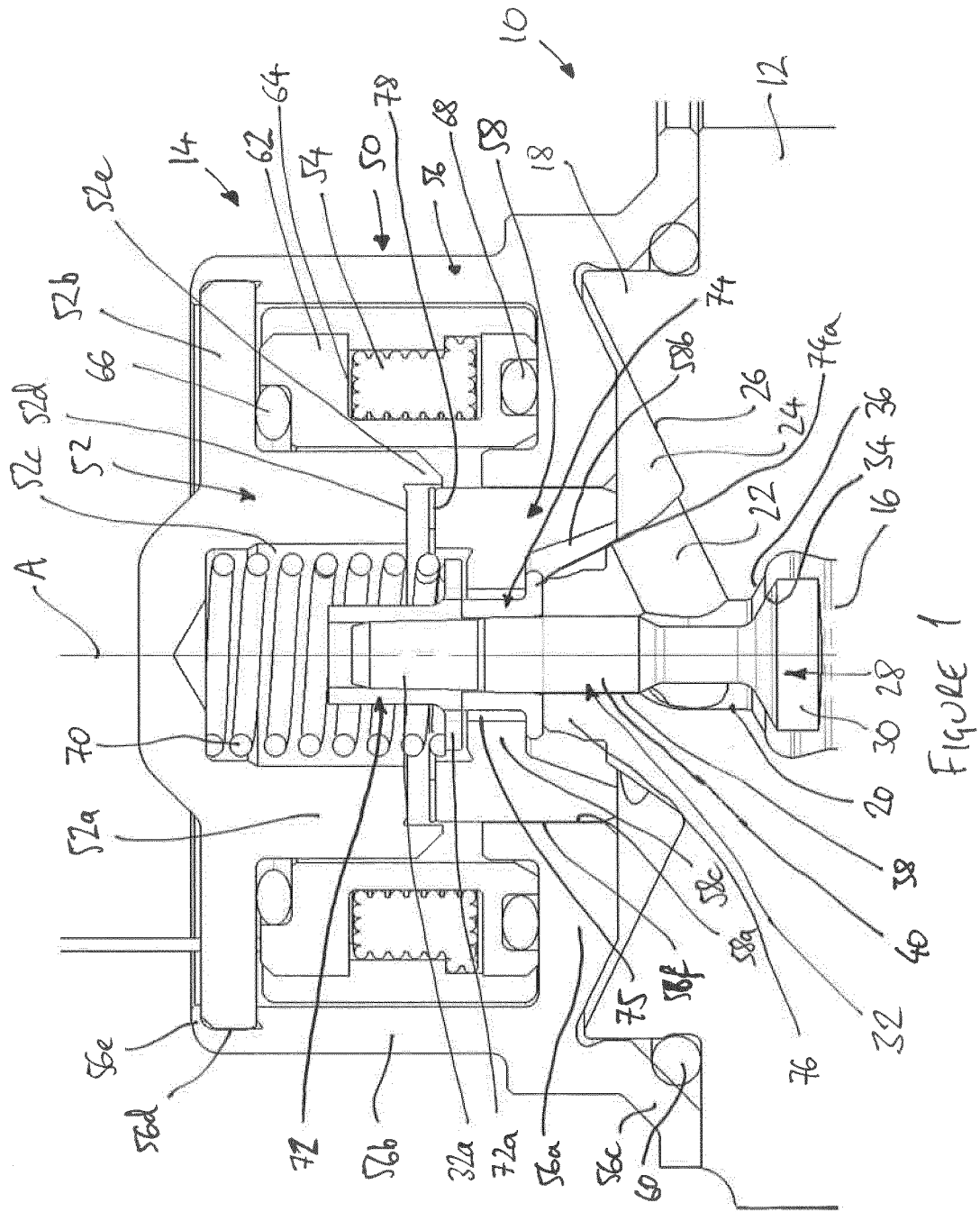
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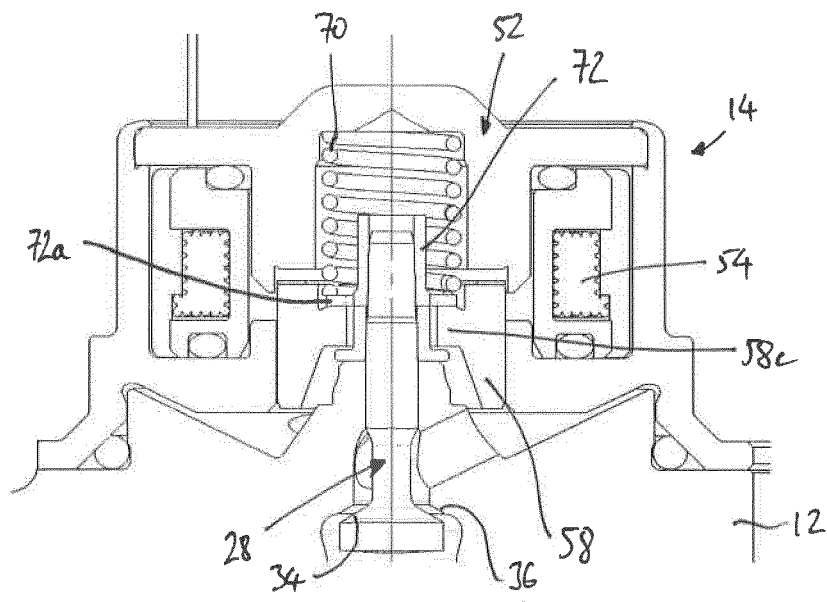


FIGURE 2(a)

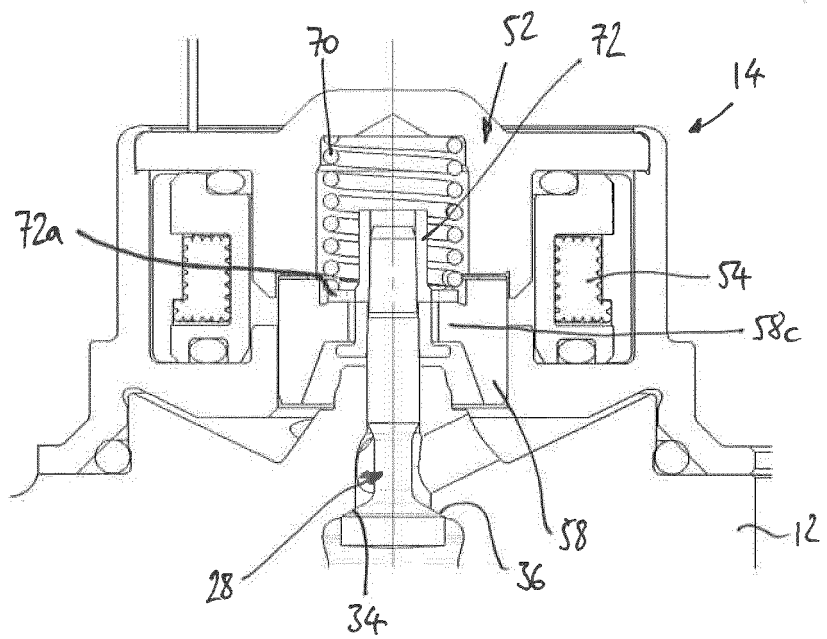


FIGURE 2(b)



EUROPEAN SEARCH REPORT

Application Number
EP 12 17 7133

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Place of search The Hague		Date of completion of the search 21 January 2013	Examiner Nobre Correia, S
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