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(54) **HIGH PRESSURE DIESEL FUEL PUMP**

HOCHDRUCKDIESELKRAFTSTOFFPUMPE

POMPE À CARBURANT DIESEL À HAUTE PRESSION

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Description

BACKGROUND

Technical Field

[0001] The present invention relates generally to the field of high pressure diesel fuel pumps. More particularly, but not exclusively, the present invention concerns a pressure limiting assembly for high pressure diesel fuel pumps.

Description of the Related Art

[0002] As it is well known in the art, diesel internal combustion engines comprise a low-pressure fuel pump in order to feed fuel from a fuel tank to a high pressure fuel pump, which in turn delivers high pressure fuel to the common rail connected to a set of fuel injectors as described in WO2009/065761 A1 and in DE 10 2013 201892 A1.

[0003] The high pressure fuel pump typically comprises one or a plurality of pumping units disposed about a rotating driveshaft with a cam. Each of the pumping units comprises a plunger and the cam drives the plungers along respective pumping axes. The driveshaft and cam are located within a cambox of a pump housing.

[0004] As shown in Figure 1A, a low pressure fuel pump (not shown) supplies fuel through a low pressure fuel line 2 at low pressure into the cambox 3 of a high pressure fuel pump 1. The fuel serves as a lubricant and essentially a cool flow of fuel for front and rear bearings 4, 5 of a rotating drive shaft, as well as supplying fuel to the pumping chambers (not shown) and pumping head 6. The pumping head 6 sends the fuel at high pressure down a high pressure fuel line 7 to the common rail and fuel injectors (not shown). The fuel pressure in the cambox 3 may be regulated by means of a low pressure limiter 9, typically arranged in a wall of the cambox 3. The low pressure limiter 9 allows flow of the fuel from the cambox 3 back to a fuel tank (not shown). A typical low pressure limiter 9 is shown in Figure 1B and comprises a housing 9a for mounting in a bore in said wall of a cambox 3. The housing 9a comprises an axially reciprocating plunger 9b located in an axial chamber 9c. The plunger 9b is biased towards an inlet 9d by a spring 9e thereby closing said inlet 9d. The housing 9a further comprises one or more standard outlets 9f arranged at a bottom end of the chamber 9c near the inlet 9d. When the pressure in the cambox 3 acting on the plunger 9b exceeds the force of the spring 9e, the exceeding pressure pushes the plunger 9b back from the inlet 9d, thereby opening the inlet 9d and allowing fuel to flow both (a) between the clearance between the plunger 9b and the chamber 9c to the spring 9e and (b) through to the outlets 9f to be returned to the fuel tank via a return fuel line 8.

[0005] Due to the pressure oscillations experience in low pressure limiters, they are prone to erratic movement. Accordingly, hydraulic damping is included as part of the design, which comprises at least one damping orifice 9g linking the spring-part of the chamber 9c with the return fuel line 8. The damping orifice(s) 9g is/are adapted to both evacuate exceeding fuel from the spring-part of the chamber 9c to the return fuel line 8 in addition to drawing in fuel into the spring-part of the chamber 9c from the return fuel line 8.

[0006] The disadvantage of such known low pressure limiters 9 is that, despite providing a hydraulic damping feature, small changes in operating temperatures of a high pressure fuel pump can have dramatic effects on the level of damping that is required in order to keep the low pressure limiter steady. Furthermore, when known low pressure limiters are forced to operate at high speeds, the high level of damping often results in the pressure in the spring-part of the chamber 9c behind the plunger massively overwhelming the pressure in front of the plunger, causing the plunger to lock in a shut position ('hardening' or 'high speed closure'). At this point, no increased return fuel flow is possible.

[0007] It is an object of the present invention to address one or more of the problems of known arrangements.

[0008] Therefore, it is now desired to provide an improved pressure limiting assembly that is capable of controlling the level of hydraulic damping therein.

SUMMARY OF THE INVENTION

[0009] In a first aspect of the present invention there is provided a high pressure diesel pump according to claim 1.

[0010] By 'standard damping orifice' what is meant is a bore of fixed diameter/ width adapted to provide a first fixed rate of damping flow in and out of the spring chamber.

[0011] By 'variable damping orifice', what is meant is an arrangement of one or more bores and/or passages of fixed diameter/ width, with a means to reduce and/or block a bore or passage at at least one location in the arrangement, to provide a different rates of damping flow in and out of the spring chamber. With this arrangement, the pressure limiting assembly is able to adapt to provide different levels of hydraulic damping by controlling the rate of flow through the variable damping orifice. Where low levels of damping are required, the variable damping orifice is restricted or closed leaving the standard damping orifice to provide the damping required. Where a greater level of damping is required, the variable damping orifice may be opened at least partially to provide assistance to the standard damping orifice and a greater damping flow. Finally, where maximum levels of damping are required, the variable damping orifice may be fully opened, to provide the majority of the damping flow.

[0012] The variable damping orifice comprises a wide (relative to the standard damping orifice) bore. The variable damping orifice comprises a bore of between approximately 0.8 mm and approximately 1.5 mm in diameter/ width. Most preferably, the variable damping orifice comprises a bore of between approximately 1 mm and approximately 1.5 mm in diameter/ width.

[0013] Preferably, a diameter/width of the bore of the variable damping orifice is larger than a diameter/width of a bore of the standard damping orifice.

[0014] According to the invention, the variable damping orifice comprises a valve passage linking the bore to the spring chamber. Preferably, the bore of the variable damping orifice extends from the valve passage to the exterior of the housing.

[0015] Preferably, the valve passage opens to the exterior of the housing at the second (opposite) end.

[0016] Preferably, the variable damping orifice comprises a valve assembly adapted to control the rate of damping flow through the valve passage. Preferably, therefore, the valve assembly comprises a restriction means located within the valve passage to provide a restriction point within the valve passage.

[0017] Most preferably, the valve assembly and the valve passage comprise cooperating parts of said restriction means.

[0018] Preferably, the valve assembly is located at the second (opposite) end of the housing. The valve assembly preferably comprises a solenoid valve.

[0019] Preferably, the solenoid valve is digitally actuated.

[0020] Preferably, the restriction means comprises a spring-actuated piston moveably mounted within the valve passage. Preferably, the restriction means also comprises a piston seat forming part of the valve passage. Preferably, the restriction means is configured to provide at least a first closed configuration and a second open configuration for the spring-actuated piston.

[0021] Preferably, the valve passage comprises a wide portion disposed at the opening to the spring chamber and a narrow portion extending to the second (opposite) end of the housing with a piston seat therebetween.

[0022] Preferably, the bore of the variable damping orifice joins the narrow portion of the valve passage proximal to the seat ledge.

[0023] Between the piston seat may comprise a tapered ledge for the spring-actuated piston.

[0024] Preferably, the spring-actuated piston comprises a head. The head is preferably shallower and narrower than the wide portion of the valve passage. Preferably, the spring-actuated piston comprises a shaft. The shaft preferably comprises a clearance fit with the narrow portion of the valve passage. Preferably, the spring-actuated piston comprises a narrow neck significantly narrower than the narrow portion of the valve passage between the head and the shaft.

[0025] The head may gradually taper into the neck.

[0026] Preferably, in the first closed configuration the spring-actuated piston is pushed backwards from the spring chamber and the head is seated against the piston seat thereby closing the valve passage and the variable damping orifice.

[0027] Preferably, in the second open configuration the spring-actuated piston is pushed forwards towards the spring chamber, with the head at a maximum distance from the piston seat thereby fully opening the valve passage and the variable damping orifice.

[0028] Preferably, the valve passage and the spring-actuated piston comprise intermediate configurations in which the spring-actuated piston is disposed between the first configuration and the second configuration, thereby partially opening the valve passage and the variable damping orifice.

[0029] Preferably, the configuration of the valve assembly may be mapped to the operating temperature and/ or the speed of the high pressure fuel pump.

[0030] Preferably, the at least one standard damping orifice comprises a bore of between approximately 0.6 mm and approximately 1.0 mm in diameter/width. Preferably, the standard damping orifice extends from the spring chamber to an exterior of the housing approximately half way down thereof.

[0031] In a second aspect of the present invention there is provided a pressure limiting assembly for a high pressure diesel fuel pump, comprising a housing with a plunger chamber at an open end with a plunger located therein, a spring chamber at a second (opposite) end with a spring disposed therein, the plunger being arranged for axially reciprocating movement along a plunger axis and being biased by the spring towards an inlet at the open end, the housing comprising at least one standard damping orifice linking the spring chamber with a return fuel line, and an outlet orifice linking the plunger chamber with the return fuel line, characterised in that the housing further comprises at least one variable damping orifice linking the spring chamber with the return fuel line.

[0032] It will be appreciated that the preferred features described in relation to the first aspect of the invention apply to the second aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] For a better understanding of the invention, and to show how exemplary embodiments may be carried into effect, reference will now be made to the accompanying drawings in which:

Figure 1A is a schematic view of a PRIOR ART high pressure fuel pump with a pressure limiting assembly;

Figure 1B is a schematic cross-sectional side view of a PRIOR ART pressure limiting assembly according to Figure 1A;

Figure 2 is a schematic view of a high pressure fuel pump according to a first embodiment of the invention comprising a pressure limiting assembly showing the fuel flow pathways;

Figure 3 is a schematic view of a high pressure fuel pump according to a second embodiment of the invention comprising a pressure limiting assembly showing the fuel flow pathways;

Figure 4 is a schematic cross-sectional view of a pressure limiting assembly for the high pressure fuel pump according to Figure 2 or Figure 3; and

Figure 5 is an expanded schematic cross-sectional view of a variable damping orifice of the pressure limiting assembly of Figure 4.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0034] As shown in the Figures, a high pressure diesel fuel pump 10 comprises a pressure limiting assembly 20, 30 communicable with a cambox 11, the pressure limiting assembly 20, 30 comprising a housing 21, 31 with a plunger chamber 22, 32 at an open end 21a, 31a with a plunger 23, 33 located therein, a spring chamber 24, 34 at a second (opposite) end 21b, 31b with a spring 25, 35 disposed therein, the plunger 23, 33 being arranged for axially reciprocating movement along a plunger axis A-A' and being biased, by the spring 25, 35 towards an inlet 26, 36 at the open end 21a, 31a, the housing 21, 31 comprising at least one standard damping orifice 27, 37 linking the spring chamber 24, 34 with a return fuel line 12, and an outlet 28, 38 linking the plunger chamber 22, 32 with the return fuel line 12, characterised in that the housing 21, 31 further comprises at least one variable damping orifice 40, 50 linking the spring chamber 24, 34 with the return fuel line 12.

[0035] A first embodiment of the pressure limiting assembly 20 is shown more clearly in Figure 4, although it is to be appreciated that many of the features are common to both first and second embodiments.

[0036] The housing 21 of the pressure limiting assembly 20 is substantially cylindrical in shape.

[0037] As can be seen in Figures 2 and 3, the pressure limiting assembly 20, 30 is adapted for installation in a bore (not shown) in a wall of a cambox 11 of a high pressure fuel pump 10 of a diesel internal combustion engine. The pressure limiting assembly 20, 30 can be arranged in any wall portion of the cambox 11. The bore is fluidly connected to both the cambox 11 via a fluid inlet port 15, and to a return fuel line 12 via a fluid outlet port 16.

[0038] The housing 21 is retained in the bore via o-ring seals 13, 14 located in peripheral annual grooves in an exterior thereof. The grooves and the o-rings 13, 14 are disposed approximately half way down the spring chamber 24 and at a top of the spring chamber 24 respectively.

[0039] Returning to the first embodiment shown in Figure 4, the plunger chamber 22 and the spring chamber 24 are substantially cylindrical in shape, of similar or identical diameter, and are arranged end-to-end with one another within the housing 21.

[0040] The plunger 23 comprises a body shaped for a clearance fit with the plunger chamber 22. Accordingly, the plunger 23 comprises a substantially cylindrical body to fit within the plunger chamber 22. The plunger 23 comprises a substantially flat driven end 23a adapted to sit flush within the open end 21a of the housing 21, and a seating end 23b with a raised central portion adapted to seat the spring 25. The plunger 23 comprises two axial bores 23c/ 23d, which approach one another from the open end 21a and the seating end 23b, respectively. A narrow bore 23e links the two axial bores 23c, 23d to provide fluid flow therethrough from the inlet 26 to the spring chamber 24 at any time.

[0041] The spring 25 is fixedly attached to the second (opposite) end 21b of the housing 21 at one end (fixed end), and is seated over the raised central portion of the seating end 23b of the plunger 23 at an opposite end (seated end). The spring 25 is a is configured to yield under a predetermined pressure exerted thereon by the plunger 23, which in turn is subjected to pressure from the cambox 11 via the inlet 26.

[0042] The outlet 28 shown comprises a narrow radial bore extending between the plunger chamber 22 and an exterior of the housing 21 for connection with the return fuel line 12. The outlet 28 is disposed proximal to the open end 21a of the housing 21 approximately 2 mm to approximately 4 mm from the open end 21a, although the skilled person will appreciate that this is dependent upon the pressure that the plunger 23 should be subjected to in order to open up the outlet 28, which in turn is dependent upon the cling requirements of the specific pump 10. The outlet 28 is approximately 2.0 mm to approximately 11.0 mm in diameter However, in an alternative embodiment, the outlet 28 comprises a plurality of holes and an example of four 2.6 mm holes is envisaged as a potential option.

[0043] The at least one standard damping orifice 27 comprises a bore of approximately between 0.6 mm and approximately 1.0 mm in fixed diameter extending from the spring chamber 24 to an exterior of the housing 21 and adapted to connect with the return fuel line 12. The standard damping orifice 27 exits the spring chamber 24 via the cylindrical wall approximately half way down thereof. The standard damping orifice 27 exits the housing 21 on the plunger-side of the o-ring seal 13.

[0044] The variable damping orifice 40 comprises a wide (relative to the standard damping orifice 27) radial bore 41 of approximately between 0.8 mm and approximately 1.5 mm in diameter, a valve passage 29 and a digitally controlled valve assembly 45. However, the diameter of the bore 41 of the variable damping orifice 40 is always larger than the diameter of the bore of the standard damping orifice 27 to ensure a greater maximum rate of flow of fluid therethrough, if required.

[0045] The bore 41 extends from the second (opposite) end 21b of the housing 21 to the exterior of the housing 21 and exits the housing 21 between the two o-ring seals 13, 14. The bore 41 communicates with the spring chamber 24 via the valve passage 29 that exits the spring chamber 24 at the second (opposite) end 21b and extends coaxially with the spring chamber 24 and plunger chamber 22 within the second (opposite) end 21b of the housing 21. The valve passage 29 opens to the exterior of the housing at the second (opposite) end 21b. The digitally-controlled valve assembly 45 is mounted at the second (opposite) end 21b of the housing 21. The digitally controlled valve assembly 45 is adapted to vary the rate of flow of fluid provided through the valve passage 29, by restricting and enlarging a flow pathway of the valve passage 29 at a restriction point (see description hereafter). However, the maximum diameter of the variable damping orifice 40, namely the radial bore 41 is always larger than the fixed diameter of the standard damping orifice 27.

[0046] The valve assembly 45 comprises a spring-actuated piston 46 which is moveably mounted within the valve passage 29 and controlled by a spring 47 mounted therebehind, and a solenoid arrangement 48 to control the spring 47.

[0047] The valve passage 29 is profiled to seat the spring-actuated piston 46 in a first closed position and in a second open position.

[0048] Accordingly, as shown more clearly in Figure 5, the valve passage 29 comprises a first wide portion 29a at the entrance to the spring chamber 24 and a second narrow portion 29b extending to the second (opposite) end 21b of the housing 21. Between the first and second portions 29a, 29b the valve passage 29 comprises a tapered ledge 29c.

[0049] The bore 41 joins the narrow portion 29b of the valve passage 29 proximal to the tapered ledge 29c.

[0050] The spring-actuated piston 46 comprises a wide head portion 46a, a shaft 46b and a neck 46c. The wide head portion 46a gradually tapers into the narrow neck 46c before widening slightly to form the shaft 46b. The wide head 46a is shallower and narrower than the first wide portion 29a of the valve passage 29. The shaft 46b comprises a clearance fit with the narrow portion 29b of the valve passage 29. However, the neck 46c is significantly narrower than the narrow portion 29b of the valve passage 29.

[0051] The wide head portion 46a of the spring-actuated piston 46 and the tapered ledge 29c of the valve passage 29 define an annular flow pathway/ no flow pathway therebetween (the restriction point) depending on the position of the spring-actuated piston 46. By changing the position of the spring-actuated piston 46 relative to the tapered ledge 29c, the annular flow pathway can be negated, restricted (or enlarged) to remove, reduce (or increase), respectively, the rate of flow of fluid through the valve passage 29.

[0052] In the first (closed) position (as shown in Figure 4), the spring-actuated piston 46 is pushed backwards from the spring chamber 24 and the wide head 46a is seated against the ledge 29c, negating the annular flow pathway so that no fluid can by-pass the spring-actuated piston 46 to reach the bore 41. Therefore, the variable damping orifice 40 is considered to be closed.

[0053] In the second (open) position, the spring-actuated piston 46 is pushed forwards towards the spring chamber 24, with the wide head 46a at a maximum distance from the ledge 29c, to provide a wide annular flow pathway therebetween. Likewise, the neck 46c provides an optimal annular space therearound to provide fluid access to the bore 41. Accordingly, in the second position, a maximum flow of fluid can by-pass the spring-actuated piston 46 and the ledge 29a to reach the bore 41. The only restricting factor to the rate of flow is the size of the bore 41, which is larger than that of the standard orifice 27. Therefore, the variable damping orifice 40 is considered to be open.

[0054] Between the first and second positions, the wide head 46a may be at any other distance from the ledge 29c, providing a narrower annular flow pathway and a restricted flow of fluid to the bore 41. Due to the tapering of the ledge 29c and the head 46a, the flow may be graded depending upon the position of the head 46a in the wide portion 29a. This in turn is controlled by the spring 47 and the solenoid mechanism 48. Again, the neck 46c provides an optimal annular space therearound to provide fluid access to the bore 41. Therefore, the variable damping orifice 40 is considered to be partially open.

[0055] The solenoid mechanism 48 is digitally controlled (digitally-controlled valve assembly 45) and is therefore, configured to operate the spring-actuated piston 46 in a number of configurations. Therefore, in both embodiments, the digitally-controlled valve assembly 45 may be configured to operate a mapped open-loop damping system, in which the piston 46 of the variable damping orifice 40 is open to a predetermined amount to allow a required amount of fluid flow therethrough in response to a specific operating condition, e.g. temperature. In contrast, the digitally-controlled valve assembly 45 may be configured to operate a pressure feedback closed-loop damping system, in which the piston 46 of the variable damping orifice 40 is opened or closed depending upon the pressure differentials in the spring chamber 24 versus the plunger chamber 22.

Claims

1. A high pressure diesel fuel pump (10) comprising a pressure limiting assembly (20, 30) communicable with a cambox (11), the pressure limiting assembly (20, 30) comprising a housing (21) with a plunger chamber (22, 32) at an open end (21a) with a plunger (23) located therein, a spring chamber (24, 34) at a second (opposite) end (21b) with a spring (25) disposed therein, the plunger (23) being arranged for axially reciprocating movement along a plunger axis (A-A') and being biased, by the spring (25) towards an inlet (26) at the open end (21a), the housing (21) comprising at least one standard damping orifice (27,

37) linking the spring chamber (24, 34) with a return fuel line (12), and an outlet (28) linking the plunger chamber (22, 32) with the return fuel line (12), **characterised in that** the housing (21) further comprises at least one variable damping orifice (40, 50) linking the spring chamber (24, 34) with the return fuel line (12), and wherein the variable damping orifice (40, 50) comprises a bore (41) of between approximately 0.8 mm and approximately 1.5 mm diameter, a valve passage (29) linking the bore (41) to the spring chamber (24, 34) and a digitally controlled valve assembly (45), the valve assembly (45) comprising a spring-actuated piston (46) being moveably mounted within the valve passage (29) and controlled by a spring (47) mounted therebehind.

2. The pump according to claim 1, **characterised in that** the variable damping orifice (40, 50) comprises a valve assembly (45, 55) adapted to control rate of damping flow through the valve passage (29) via a restriction means located within the valve passage (29) to provide a restriction point within the valve passage (29).

3. The pump according to claim 2, **characterised in that** the valve assembly (45, 55) and the valve passage (29) comprise cooperating parts of said restriction means.

4. The pump according to claim 3, **characterised in that** the valve assembly (45, 55) comprises a digitally-actuated solenoid valve.

5. The pump according to any one of claims 2 to 4, **characterised in that** the restriction means comprises a spring-actuated piston (46) moveably mounted within the valve passage (29) and a piston seat (29c) forming part of the valve passage (29).

6. The pump according to claim 5, **characterised in that** the restriction means are configured to provide at least a first closed configuration and a second open configuration for the spring-actuated piston (46).

7. The pump according to any one of claims 3 to 6, **characterised in that** the valve passage (29) comprises a wide portion (29a) disposed at the opening to the spring chamber (24, 34) and a narrow portion (29b) extending to the second (opposite) end (21b) of the housing (21) with the piston seat (29c) therebetween.

8. The pump according to claim 7, **characterised in that** the bore (41) of the variable damping orifice (40, 50) joins the narrow portion (29b) of the valve passage (29) proximal to the piston seat (29c).

9. The pump according to claim 8, **characterised in that** the spring-actuated piston (46) comprises a head (46a) shallower and narrower than the wide portion (29a) of the valve passage (29), a shaft (46b) comprising a clearance fit with the narrow portion (29b) of the valve passage (29), and a narrow neck (46c) significantly narrower than the narrow portion (29b) of the valve passage (29) therebetween.

10. The pump according to any one of claims 6 to 9, **characterised in that** in the first closed configuration the spring-actuated piston (46) is pushed backwards from the spring chamber (24, 34) and the head (46a) is seated against the piston seat (29c) thereby closing the valve passage (29) and the variable damping orifice (40, 50).

11. The pump according to any one of claims 6 to 10, **characterised in that** in the second open configuration the spring-actuated piston (46) is pushed forwards towards the spring chamber (24, 34), with the head (46a) at a maximum distance from the piston seat (29c) thereby fully opening the valve passage (29) and the variable damping orifice (40, 50).

12. The pump according to any one of claims 6 to 11, **characterised in that** the valve passage (29) and the spring-actuated piston (46) comprise intermediate configurations in which the spring-actuated piston (46) is disposed between the first configuration and the second configuration, thereby partially opening the valve passage (29) and the variable damping orifice (40, 50).

13. The pump according to any one of claims 6 to 12, **characterised in that** the configuration of the valve assembly (45, 55) is mapped to the operating temperature and/ or the speed of the high pressure fuel pump (10).

Patentansprüche

1. Hochdruckdieselkraftstoffpumpe (10) mit einer Druckbegrenzungsanordnung (20, 30), die mit einer Nockenbox (11) kommunizierbar ist, wobei die Druckbegrenzungsanordnung (20, 30) ein Gehäuse (21) aufweist mit einer Kolbenkammer (22, 32) an einem offenen Ende (21a) mit einem darin befindlichen Kolben (23), einer Federkammer (24, 34) an einem zweiten (gegenüberliegenden) Ende (21b) mit einer darin befindlichen Feder (25), wobei der Kolben (23) angeordnet ist für eine axiale Hin- und Herbewegung entlang einer Kolbenachse (A-A') und durch die Feder (25) in Richtung eines Einlasses (26) an dem offenen Ende (21a) vorgespannt ist, wobei das Gehäuse (21) zumindest eine Standarddämpfungsöffnung (27, 37) aufweist, die die Federkam-

mer (24, 34) mit einer Rücklaufkraftstoffleitung (12) verbindet, und einen Auslass (28), der die Kolbenkammer (22, 32) mit der Rücklaufkraftstoffleitung (12) verbindet, **dadurch gekennzeichnet, dass** das Gehäuse (21) weiter zumindest eine variable Dämpfungsöffnung (40, 50) aufweist, die die Federkammer (24, 34) mit der Rücklaufkraftstoffleitung (12) verbindet, und wobei die variable Dämpfungsöffnung (40, 50) eine Bohrung (41) mit einem Durchmesser zwischen ungefähr 0,8 mm und ungefähr 1,5 mm, einen Ventildurchlass (29), der die Bohrung (41) mit der Federkammer (24, 34) verbindet, und eine digital gesteuerte Ventilanordnung (45) aufweist, wobei die Ventilanordnung (45) einen federbetätigten Kolben (46) aufweist, der bewegbar in dem Ventildurchlass (29) angebracht ist und durch eine dahinter angebrachte Feder (47) gesteuert wird.

2. Die Pumpe gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die variable Dämpfungsöffnung (40, 50) eine Ventilanordnung (45, 55) aufweist, die ausgebildet ist zum Steuern einer Rate eines Dämpfungsflusses durch den Ventildurchlass (29) über Restriktionsmittel, die sich in dem Ventildurchlass (29) befinden, um einen Restriktionspunkt in dem Ventildurchlass (29) vorzusehen.

3. Die Pumpe gemäß Anspruch 2, **dadurch gekennzeichnet, dass** die Ventilanordnung (45, 55) und der Ventildurchlass (29) zusammenwirkende Teile der Restriktionsmittel aufweisen.

4. Die Pumpe gemäß Anspruch 3, **dadurch gekennzeichnet, dass** die Ventilanordnung (45, 55) ein digital betätigtes Magnetventil aufweist.

5. Die Pumpe gemäß einem der Ansprüche 2 bis 4, **dadurch gekennzeichnet, dass** das Restriktionsmittel einen federbetätigten Kolben (46) aufweist, der bewegbar in dem Ventildurchlass (29) angebracht ist, und einen Kolbensitz (29c), der einen Teil des Ventildurchlasses (29) bildet.

6. Die Pumpe gemäß Anspruch 5, **dadurch gekennzeichnet, dass** die Restriktionsmittel konfiguriert sind zum Vorsehen zumindest einer ersten geschlossenen Konfiguration und einer zweiten offenen Konfiguration für den federbetätigten Kolben (46).

7. Die Pumpe gemäß einem der Ansprüche 3 bis 6, **dadurch gekennzeichnet, dass** der Ventildurchlass (29) einen breiten Teil (29a) aufweist, der an der Öffnung zu der Federkammer (24, 34) angeordnet ist, und einen schmalen Teil (29b), der sich zu dem zweiten (gegenüberliegenden) Ende (21b) des Gehäuses (21) erstreckt, mit dem Kolbensitz (29c) dazwischen.

8. Die Pumpe gemäß Anspruch 7, **dadurch gekennzeichnet, dass** die Bohrung (41) der variablen Dämpfungsöffnung (40, 50) in den schmalen Teil (29b) des Ventildurchlasses (29) proximal zu dem Kolbensitz (29c) eintritt.

9. Die Pumpe gemäß Anspruch 8, **dadurch gekennzeichnet, dass** der federbetätigte Kolben (46) einen Kopf (46a), der flacher und schmaler als der breite Teil (29a) des Ventildurchlasses (29) ist, einen Schaft (46b), der eine Spielpassung mit dem schmalen Teil (29b) des Ventildurchlasses (29) aufweist, und einen schmalen Hals (46c) dazwischen aufweist, der wesentlich schmaler ist als der schmale Teil (29b) des Ventildurchlasses (29).

10. Die Pumpe gemäß einem der Ansprüche 6 bis 9, **dadurch gekennzeichnet, dass** in der ersten geschlossenen Konfiguration der federbetätigte Kolben (46) von der Federkammer (24, 34) nach hinten gedrückt wird und der Kopf (46a) an den Kolbensitz (29c) gesetzt wird, wodurch der Ventildurchlass (29) und die variable Dämpfungsöffnung (40, 50) geschlossen werden.

11. Die Pumpe gemäß einem der Ansprüche 6 bis 10, **dadurch gekennzeichnet, dass** in der zweiten offenen Konfiguration der federbetätigte Kolben (46) nach vorne in Richtung der Federkammer (24, 34) gedrückt wird, wobei sich der Kopf (46a) in einem maximalen Abstand von dem Kolbensitz (29c) befindet, wodurch der Ventildurchlass (29) und die variable Dämpfungsöffnung (40, 50) vollständig geöffnet werden.

12. Die Pumpe gemäß einem der Ansprüche 6 bis 11, **dadurch gekennzeichnet, dass** der Ventildurchlass (29) und der federbetätigte Kolben (46) Zwischenkonfigurationen aufweisen, bei denen der federbetätigte Kolben (46) zwischen der ersten Konfiguration und der zweiten Konfiguration angeordnet ist, wodurch der Ventildurchlass (29) und die variable Dämpfungsöffnung (40, 50) teilweise geöffnet werden.

13. Die Pumpe gemäß einem der Ansprüche 6 bis 12, **dadurch gekennzeichnet, dass** die Konfiguration der Ventilanordnung (45, 55) an die Betriebstemperatur und / oder die Geschwindigkeit der Hochdruckkraftstoffpumpe (10) angepasst ist.

Revendications

1. Pompe à haute pression pour carburant diesel (10) comprenant un assemblage de limitation de pression (20, 30) susceptible d'être mis en communication avec une boîte à came (11), l'assemblage de

limitation de pression (20, 30) comprenant un boîtier (21) avec une chambre à piston (22, 32) à une extrémité ouverte (21a) avec un piston (23) situé à l'intérieur, une chambre à ressort (24, 34) à une seconde extrémité (opposée) (21b) avec un ressort (25) disposé à l'intérieur, le piston (23) étant agencé pour un mouvement axial en va-et-vient le long d'un axe de piston (A-A') et étant sollicité par le ressort (25) en direction d'une entrée (26) à l'extrémité ouverte (21a), le boîtier (21) comprenant au moins un orifice d'amortissement standard (27, 37) qui relie la chambre à ressort (24, 34) avec une ligne de retour de carburant (12), et une sortie (28) qui relie la chambre à piston (22, 32) avec la ligne de retour de carburant (12), **caractérisée en ce que** le boîtier (21) comprend en outre au moins un orifice d'amortissement variable (40, 50) qui relie la chambre à ressort (24, 34) avec la ligne de retour de carburant (12), et dans laquelle l'orifice d'amortissement variable (40, 50) comprend un perçage (41) d'un diamètre entre approximativement 0,8 mm et approximativement 1,5 mm, un passage de valve (29) reliant le perçage (41) à la chambre à ressort (24, 34), et un assemblage formant valve à commande numérique (45), l'assemblage formant valve (45) comprenant un piston (46) actionné par ressort, qui est monté de façon déplaçable à l'intérieur du passage de valve (29) et qui est commandé par un ressort (47) monté derrière celui-ci.

2. Pompe selon la revendication 1, **caractérisée en ce que** l'orifice d'amortissement variable (40, 50) comprend un assemblage formant valve (45, 55) adapté pour commander le débit d'écoulement d'amortissement à travers le passage de valve (29) via un moyen de restriction situé à l'intérieur du passage de valve (29) pour constituer un point de restriction à l'intérieur du passage de valve (29).

3. Pompe selon la revendication 2, **caractérisée en ce que** l'assemblage formant valve (45, 55) et le passage de valve (29) comprennent des parties coopérantes dudit moyen de restriction.

4. Pompe selon la revendication 3, **caractérisée en ce que** l'assemblage formant valve (45, 55) comprend une valve solénoïde à commande numérique.

5. Pompe selon l'une quelconque des revendications 2 à 4, **caractérisée en ce que** le moyen de restriction comprend un piston actionné par ressort (46) monté de façon déplaçable à l'intérieur du passage de valve (29) et un siège de piston (29c) qui fait partie du passage de valve (29).

6. Pompe selon la revendication 5, **caractérisée en ce que** le moyen de restriction est configuré pour assurer au moins une première configuration fermée et une seconde configuration ouverte pour le piston actionné par ressort (46).

7. Pompe selon l'une quelconque des revendications 3 à 6, **caractérisée en ce que** le passage de valve (29) comprend une portion large (29a) disposée au niveau de l'ouverture vers la chambre à ressort (24, 34) et une portion étroite (29b) s'étendant vers la seconde extrémité (opposée) (21b) du boîtier (21) avec le siège de piston (29c) entre elles.

8. Pompe selon la revendication 7, **caractérisée en ce que** le perçage (41) de l'orifice d'amortissement variable (40, 50) rejoint la portion étroite (29b) du passage de valve (29) à proximité du siège de piston (29b).

9. Pompe selon la revendication 8, **caractérisée en ce que** le piston actionné par ressort (46) comprend une tête (46a) moins profonde et plus étroite que la portion large (29a) du passage de valve (29), une tige (46b) présentant un assemblage avec jeu avec la portion étroite (29b) du passage de valve (29), et un collet étroit (46c) significativement plus étroit que la portion étroite (29b) du passage de valve (29) entre elles.

10. Pompe selon l'une quelconque des revendications 6 à 9, **caractérisée en ce que** dans la première configuration fermée le piston actionné par ressort (46) est poussé vers l'arrière depuis la chambre à ressort (24, 34) et la tête (46a) est en assise contre le siège de piston (29c) en fermant ainsi le passage de valve (29) et l'orifice d'amortissement variable (40, 50).

11. Pompe selon l'une quelconque des revendications 6 à 10, **caractérisée en ce que** dans la seconde configuration ouverte le piston actionné par ressort (46) est poussé vers l'avant en direction de la chambre à ressort (24, 34), et la tête (46a) est à une distance maximum depuis le siège de piston (29c), en ouvrant ainsi totalement le passage de valve (29) et l'orifice d'amortissement variable (40, 50).

12. Pompe selon l'une quelconque des revendications 6 à 11, **caractérisée en ce que** le passage de valve (29) et le piston actionné par ressort (46) comportent des configurations intermédiaires dans lesquelles le piston actionné par ressort (46) est disposé entre la première configuration et la seconde configuration, en ouvrant ainsi partiellement le passage de valve (29) et l'orifice d'amortissement variable (40, 50).

13. Pompe selon l'une quelconque des revendications 6 à 12, **caractérisée en ce que** la configuration de l'assemblage formant valve (45, 55) est associée à la température de fonctionnement et/ou à la vitesse de la pompe à haute pression pour carburant (10).

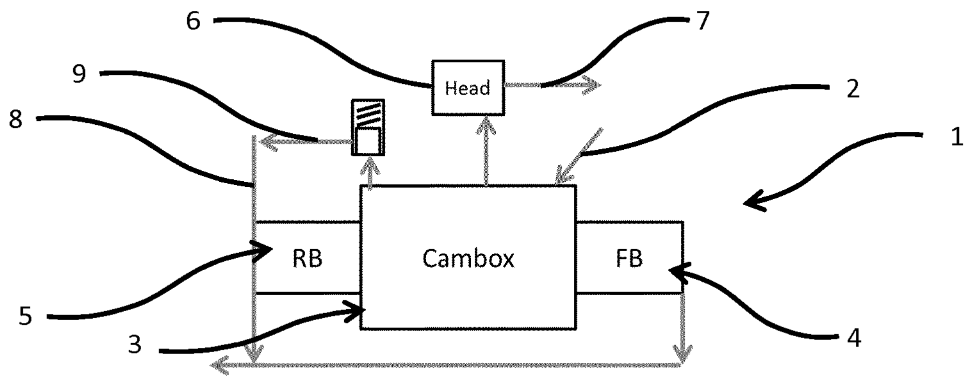

FIGURE 1A
PRIOR ART

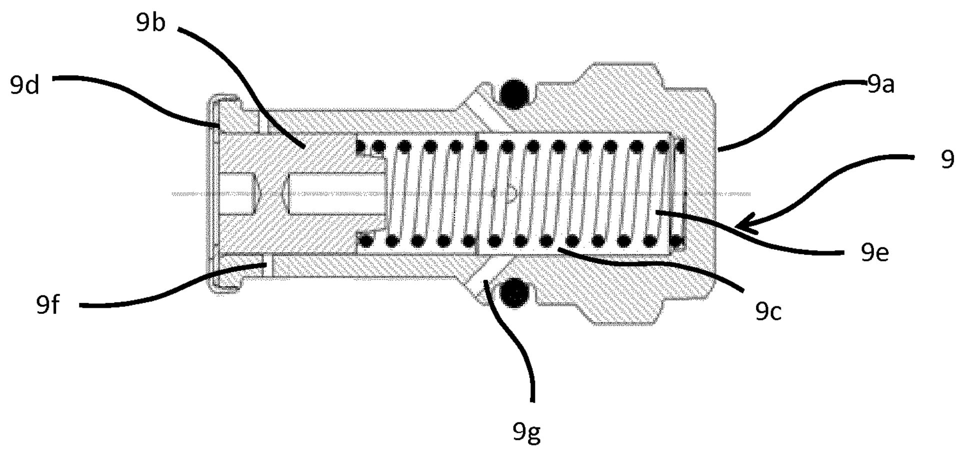

FIGURE 1B
PRIOR ART

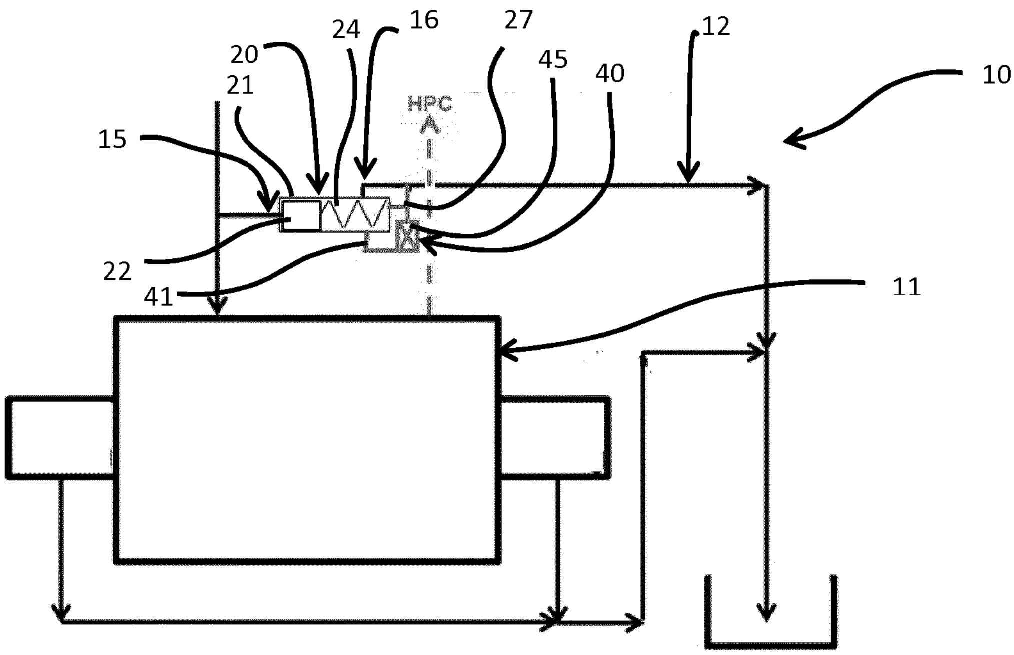

FIGURE 2

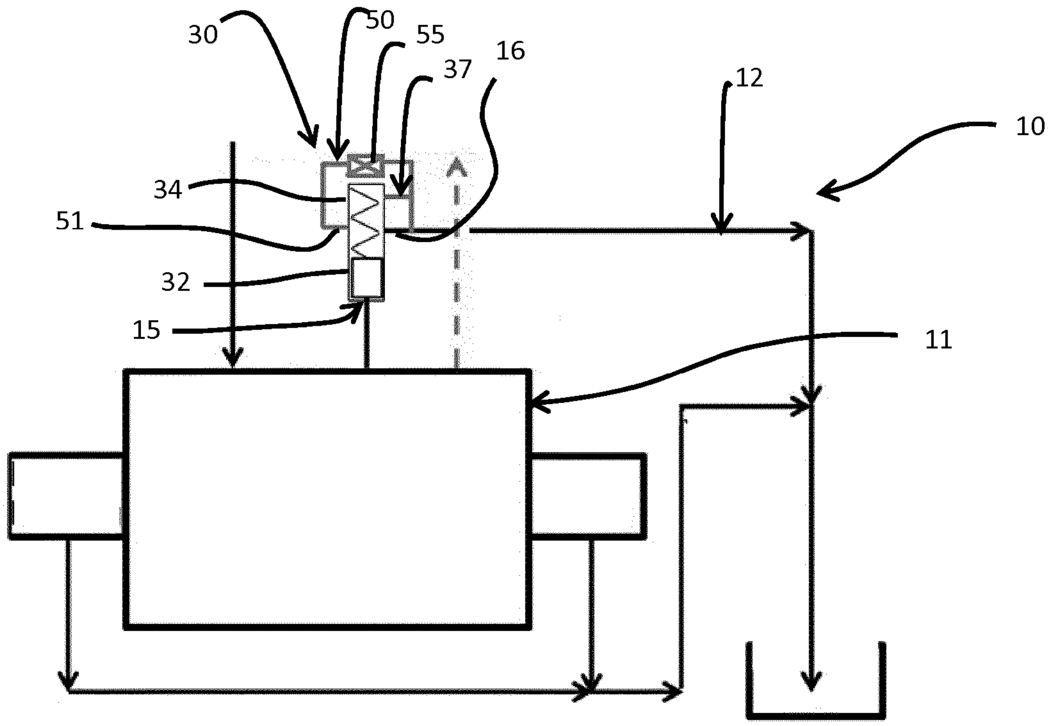

FIGURE 3

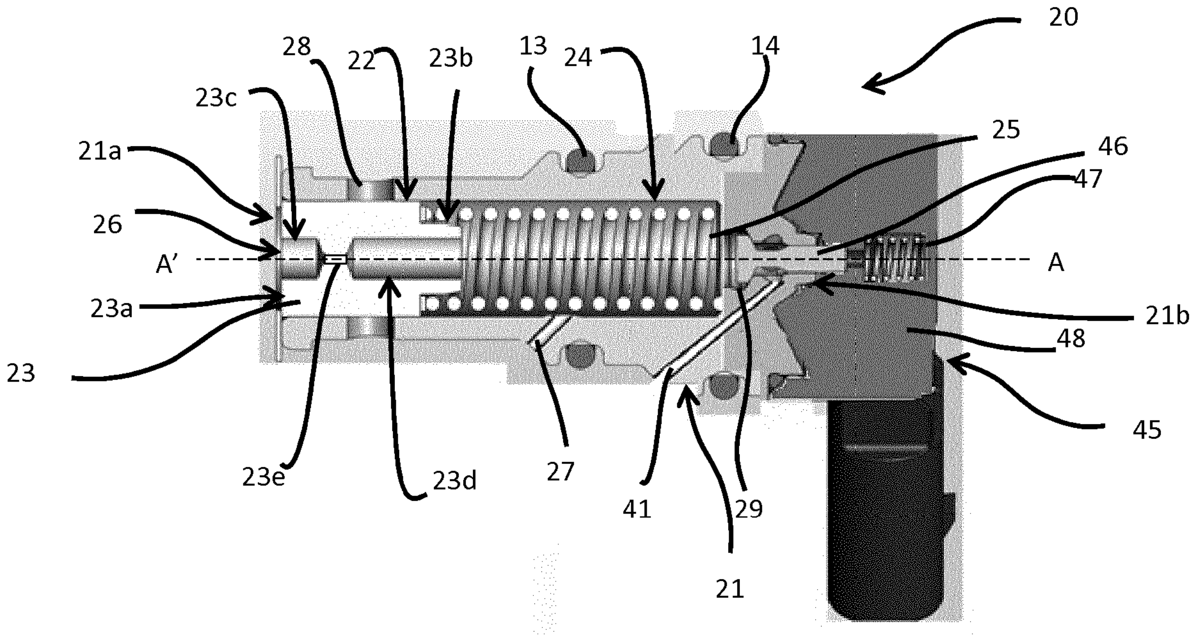

FIGURE 4

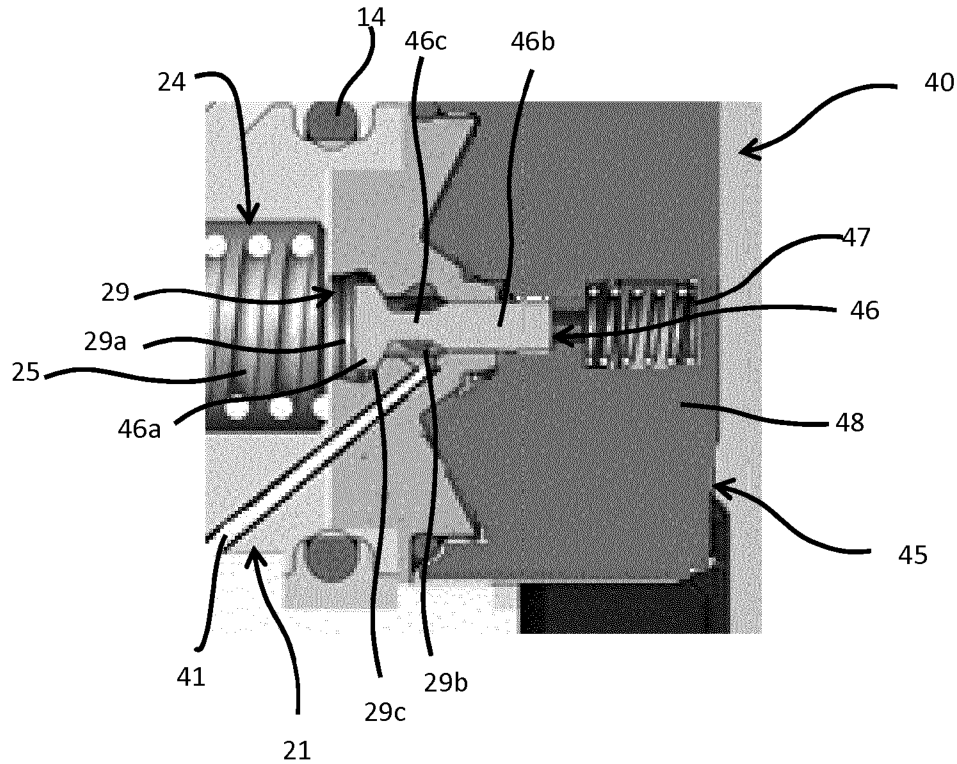

FIGURE 5

REFERENCES CITED IN THE DESCRIPTION

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