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(54) Title: HIGH PRESSURE FUEL PUMPS

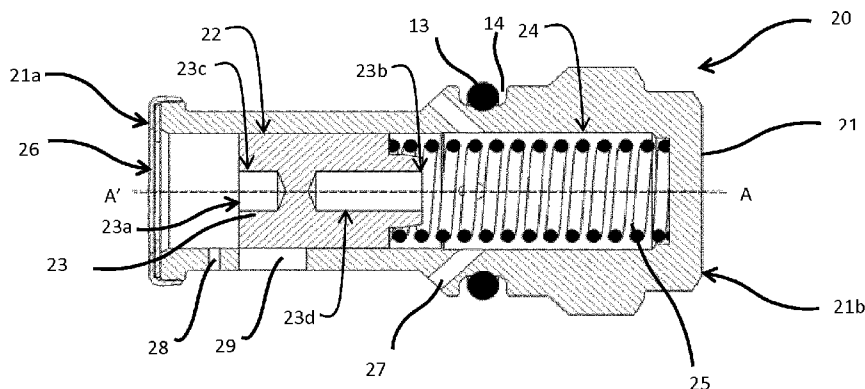


FIGURE 5

(57) Abstract: A high pressure fuel pump (10) comprising a pressure regulator (20, 30, 40) communicable with a cambox (11). The pressure regulator (20, 30, 40) comprises a housing (21, 31, 41) with a plunger chamber (22, 32, 42) at an open end (21a, 31a, 41a) with a plunger (23, 33, 43) and a spring chamber (24, 34, 44) at a second end (21b, 31b, 41b) with a spring (25, 35, 45). The plunger (23, 33, 43) is biased by the spring (25, 35, 45) towards an inlet (26, 36, 46) at the open end (21a, 31a, 41a). The housing (21, 31, 41) comprises a damping orifice (27, 37, 47) linking the spring chamber (24, 34, 44) with a return fuel line (12), and a standard orifice (28, 38, 48) and at least one high flow orifice (29, 39, 49) linking the plunger chamber (22, 32, 42) with the return fuel line (12).

HIGH PRESSURE FUEL PUMPS

BACKGROUND

Technical Field

The present invention relates generally to the field of high pressure fuel pumps. More particularly, but not exclusively, the present invention concerns a pressure regulator arrangement for a high pressure fuel pump.

Description of the Related Art

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.

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.

As shown in Figures 1A and 1B, 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 either a calibrated orifice 8 as shown in Figure 1A, or a low pressure regulator 9 as shown in Figure 1B typically arranged in a wall of the cambox 3.

A calibrated orifice 8 allows flow of the fuel from the cambox 3 back to a fuel tank (not shown) under all pressure conditions as it is continuously open. The disadvantage of the calibrated orifice 8 is that under low pressure cambox conditions, the calibrated orifice 8 allows pressure to be lowered further still. This is particularly problematic in a cold start operation, where high pressure is required in the cambox 3.

As shown in Figure 1B, a typical low pressure regulator 9 also allows flow of the fuel from the cambox 3 back to a fuel tank (not shown). A typical low pressure regulator 9 is shown in Figure 1C 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. The disadvantage of such known low pressure regulators 9 is that, despite allowing variable flow rates back to the fuel tank, the fuel return flow rates can be massively increased in high pressure scenarios, which is not always helpful, e.g. once again in a cold start operation, where high pressure is required in the cambox 3.

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

Therefore, it is now desired to provide an improved pressure limiting arrangement or pressure regulator that is capable of optimising the flow rate of fuel back to the tank depending on the running condition of the pump. In particular, it is desired to provide a pressure limiting arrangement or pressure regulator capable of switching between a standard orifice flow and a (generally higher) variable flow.

SUMMARY OF THE INVENTION

In a first aspect of the present invention there is provided a high pressure fuel pump comprising a pressure regulator communicable with a cambox, the pressure regulator comprising a housing with a plunger chamber at an open end with a plunger located therein, a spring chamber at a second 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 damping orifice linking the spring chamber with a return fuel line, and at least one standard orifice linking the plunger chamber with the return fuel line, characterised in that the housing further comprises at least one high flow orifice linking the plunger chamber with the return fuel line.

By 'standard orifice' what is meant is an orifice allowing a first predetermined (normal) level of outlet flow.

By 'high flow orifice' what is meant is either a single orifice, or a plurality of orifices working together, to create a second predetermined (greater) level of outlet flow in combination with the standard orifice.

With this arrangement, the pressure regulator is able to switch between three different modes depending upon the pressure in the cambox and experienced by the plunger: (1) very low flow where the plunger is operable to close both the standard and the high flow orifices; (2) standard flow where the plunger is operable to open only the standard flow orifice; and (3) high flow where the plunger is operable to open both the standard and high flow orifices. Therefore, where pressure in the cambox 11 is low and yet a high pressure is required for a cold start scenario, the plunger is immovable and so mode (1) is affected. In contrast, where pressure in the cambox 11 is very high, the plunger is movable to effect mode (3). Between modes (1) and (3), in normal operating conditions with normal pressure in the cambox 11, the plunger may be movable to effect mode (2).

Preferably, the high flow orifice comprises a single orifice. The single orifice may be larger in diameter/ width than the standard orifice. Preferably, the single orifice is adapted to be closed, open or partially open. Most preferably, the high flow orifice comprises a slot of approximately 0.5 mm diameter.

Alternatively, the high flow orifice may comprise a series of orifices. Each of the high flow orifices may be smaller, larger or the same size as the standard orifice. The series of the high flow orifices may be arranged so that the plunger can operate to open none, all, or some of the orifices.

The high flow orifice(s) may comprise one or more slots of substantially cuboidal cross-section. Alternatively, the high flow orifice(s) may comprise a bore of substantially cylindrical cross-section.

Preferably, the high flow orifice(s) comprise a total diameter/ width of approximately between 0.5 mm and approximately 2.0 mm diameter/ width.

5 Preferably, the high flow orifice is disposed inwardly of the standard orifice. By 'inwardly of the standard orifice', what is meant is on the opposite side of the standard orifice to the inlet.

Preferably, the high flow orifice is adjacent the standard orifice. Preferably, the high flow orifice is disposed approximately between 2 mm and approximately 4 mm away from the standard orifice.

10

Preferably, the pressure regulator comprises a continuous fluid pathway between the cambox and the spring chamber. Preferably, the continuous fluid pathway comprises a pathway through the plunger. Alternatively, the continuous fluid pathway comprises a further pathway through a wall of the housing into the spring chamber. Preferably, the pathway comprises a
15 bore or an orifice of approximately between 0.3 mm and approximately 0.4 mm diameter/ width.

Preferably, the spring is configured to provide a force of approximately between 1 N/ mm and approximately 4 N/mm.

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Preferably, the high pressure fuel pump is a diesel pump.

In a second aspect of the present invention there is provided a pressure regulator for a high pressure fuel pump comprising a housing with a plunger chamber at an open end with a
25 plunger located therein, a spring chamber at a second 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 damping orifice linking the spring chamber with a return fuel line, and at least one standard orifice linking the plunger chamber with the return fuel line, characterised in that the housing
30 further comprises at least one high flow orifice linking the plunger chamber with the return fuel line.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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 calibrated orifice; fuel injector;

Figure 1B is a schematic view of a PRIOR ART high pressure fuel pump with a low pressure regulator;

10 Figure 1C is a schematic cross-sectional side view of a PRIOR ART low pressure regulator according to Figure 1B;

Figure 2 is a schematic cross-sectional side view of a pressure regulator for a high pressure fuel pump according to a **first** embodiment of the invention in a first (closed) position;

15 Figure 3 is a schematic cross-sectional side view of the pressure regulator of Figure 2 in a second (standard orifice cracking point) position;

Figure 4 is a schematic cross-sectional side view of the pressure regulator of Figure 2 in a third (standard orifice open) position;

Figure 5 is a schematic cross-sectional side view of the pressure regulator of Figure 2 in a fourth (standard orifice open and high flow orifice cracking point) position;

20 Figure 6 is a schematic cross-sectional side view of the pressure regulator of Figure 2 in a fifth (standard orifice open and high flow orifice open) position;

Figure 7 is a schematic view of the high pressure fuel pump of Figure 2 showing the fuel flow pathways;

25 Figure 8 is a schematic cross-sectional side view of a pressure regulator for a high pressure fuel pump according to a **second** embodiment of the invention in a first (closed) position;

Figure 9 is a schematic view of the high pressure fuel pump of Figure 8 showing the fuel flow pathways;

Figure 10 is a schematic cross-sectional side view of a pressure regulator for a high pressure fuel pump according to a **third** embodiment of the invention in a first (closed) position; and

- 5 Figure 11 is a schematic view of the high pressure fuel pump of Figure 10 showing the fuel flow pathways.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

As shown in the Figures, the invention comprises a high pressure fuel pump 10 comprising a pressure regulator 20, 30, 40 communicable with a cambox 11, the pressure regulator 20, 30, 40 comprising a housing 21, 31, 41 with a plunger chamber 22 at an open end 21a, 31a, 41a with a plunger 23, 33, 43 located therein, a spring chamber 24, 34, 44 at a second end 21b, 31b, 41b with a spring 25, 35, 45 disposed therein, the plunger 23, 33, 43 being arranged for axially reciprocating movement along a plunger axis A-A' and being biased, by the spring 25, 35, 45, towards an inlet 26, 36, 46 at the open end 21a, 31a, 41a, the housing 21, 31, 41 comprising at least one damping orifice 27, 37, 47 linking the spring chamber 24, 34, 44 with a return fuel line 12, and at least one standard orifice 28, 38, 48 linking the plunger chamber 22, 32, 42 with the return fuel line 12, characterised in that the housing further comprises at least one high flow orifice 29, 39, 49 linking the plunger chamber 22, 32, 42 with the return fuel line 12.

20

The housing 21, 31, 41 of the pressure regulator 20, 30, 40 is substantially cylindrical in shape and 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 regulator 20, 30, 40 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 (not shown), and to a return fuel line 12 via a fluid outlet port (not shown). The housing 21, 31, 41 is retained in the bore via an o-ring seal 13 located in a peripheral annular groove 14 in an exterior thereof. The groove 14 and the o-ring 13 are disposed approximately half way down the spring chamber 24, 34, 44.

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As can be seen more clearly in Figures 2 to 6, 8 and 10, the plunger chamber 22, 32, 42 and the spring chamber 24, 34, 44 are substantially cylindrical in shape, of similar or identical diameter and arranged end-to-end with one another within the housing 21, 31, 41.

5 The plunger 23, 33, 43 comprises a body shaped for a clearance fit with the plunger chamber 22, 32, 42. Accordingly, the plunger 23, 33, 43 comprises a substantially cylindrical body to fit within a substantially cylindrical plunger chamber 22, 32, 42. The plunger 23, 33, 43 comprises a substantially flat driven end 23a, 33a, 43a adapted to sit flush within the open end 21a, 31a, 41a and a seating end 23b, 33b, 43b with a raised central portion adapted to
10 seat the spring 25, 35, 45. The plunger 23, 33, 43 comprises two axial bores 23c/ 23d, 33c/ 33d, 43c/ 43d, which approach one another from the open end 21a, 31a, 41a and the seating end 23b, 33b, 43b respectively.

The spring 25, 35, 45 is fixedly attached to the second end 21b, 31b, 41b of the housing 21,
15 31, 41 at one end (fixed end), and seated over the raised central portion of the seating end 23b, 33b, 43b of the plunger 23, 33, 43 at an opposite end (seated end).

The at least one damping orifice 27, 37, 47 comprises a bore through the housing to open into the spring chamber 24, 34, 44. The damping orifice(s) 27, 37, 47 exit the housing on the
20 plunger-side of the o-ring seal 13 and is adapted to connect with the return fuel line 12.

The standard orifice 28, 38, 48 comprises a narrow radial bore extending between the plunger chamber 22, 32, 42 and an exterior of the housing 21, 31, 41 for connection with the return fuel line 12. The standard orifice 28, 38, 48 is disposed proximal to the open end 21a, 31a, 41a of the housing 21, 31, 41. in the present embodiment, the standard orifice 28, 38, 48
25 is located approximately 2 mm to approximately 4 mm from the open end 21a, 31a, 41a. It is to be appreciated that this distance is dependent upon the pressure at which the plunger 23, 33, 43 is intended to open the standard orifice 28, 38, 48. The standard orifice 28, 38, 48 is approximately 0.6 mm to approximately 1.0 mm in diameter. Again, it is to be appreciated
30 that the diameter of the standard orifice 28, 38, 48 depends upon the cooling requirements of the pump 10.

The high flow orifice 29, 39, 49 comprises a wider radial bore extending between the plunger chamber 22, 32, 42 and an exterior of the housing 21, 31, 41 for connection with the return fuel line 12. The high flow orifice 29, 39, 49 is disposed proximal to the standard orifice 28, 38, 48. The high flow orifice 29, 39, 49 is located approximately 2 mm to approximately 4 mm from the standard orifice 28, 38, 48, although it is to be appreciated that this distance is dependent upon the pressure at which the plunger 23, 33, 43 is intended to open the high flow orifice 29, 39, 49. The high flow orifice 29, 39, 49 is approximately 0.5 mm up to approximately 2.0 mm in width/ diameter.

10 In each of the embodiments shown, the high flow orifice 29, 39, 49 comprises a single wide bore. However, it is to be appreciated that the high flow orifice 29, 39, 49 may comprise a series of discrete bores, or a slots that are adapted to either work together to achieve a maximum outward flow, or in smaller groupings to achieve varying degrees of outward flow.

15 In each embodiment, the spring 25, 35, 45 is configured with the desired compression force to achieve a particular rate of exceeding fuel return flow depending upon the pressure level in the cambox 11. Accordingly, the spring may be configured in the range of approximately 1 N/mm to approximately 4 N/mm.

20 A first embodiment of the invention as described above is shown in Figures 2 to 7.

In a second embodiment, as shown in Figures 8 and 9, the plunger 33 comprises two axial bores 33c, 33d as before, which approach one another from either end thereof. However, linking the two bores 33c, 33d is a narrow bore 33e. This bore 33e creates a fluid pathway between the open end 31a and the spring chamber 34 and the damping orifice(s) 37 at all times, regardless of the position of the plunger 33. The diameter of the bore 33e is approximately 0.3 mm to approximately 0.4 mm in diameter, which limits the fluid flow through the plunger 31, although the axial bores 33c, 33d may be larger.

30 In a third embodiment, as shown in Figures 10 and 11, the housing comprises an additional inlet fuel feed that by-passes the plunger 43, in the form of an inlet bore 50 through the housing 41 to open into the spring chamber 44. Fluid flow is diverted from the cambox 11 through this permanently open inlet bore 50 into the spring chamber 45 and out through the

damping orifice 47 and to the return fuel line 12. The diameter of the inlet bore 50 is approximately 0.3 mm to approximately 0.4 mm in diameter, which limits the fluid flow into the spring chamber 44. This operates in a similar way to the bore 33e through the plunger 31 of the second embodiment.

5

In use, in both the second and third embodiments, a permanent low rate of fluid flow is facilitated back to the return fuel line via the plunger pathway via bores 33c, 33d, 33e in the second embodiment and via the additional inlet 50 in the third embodiment. Both of these flow pathways are calibrated to provide only a very low continuous rate of flow to the fuel return line in order that cold start situations are not compromised.

10

In all three embodiments, described above, the pressure regulator 20, 30, 40 is adapted to open when the pressure in the cambox 11 exceeds a predetermined pressure level, in order to discharge exceeding fuel towards a return fuel line 12, typically leading back to the fuel tank.

15

In very high pressure situations in the cambox 11 as shown in Figure 5 and 6, the high pressure is felt on the driven end 23a, 33a, 43a of the plunger 23, 33, 43, which is pushed back to open both the standard orifice 28, 38, 48 and the high flow orifice 29, 39, 49. Exceeding fuel can flow in through the inlet 21a, 31a, 41a into the plunger chamber 22, 32, 42 and out through both the standard orifice 28, 38, 48 and the high flow orifice 29, 39, 49, thereby dramatically increasing the flow of exceeding fuel back to the return fuel line 12. As demonstrated by the difference between Figures 5 and 6, the high flow orifice 29, 39, 49 may be opened to cracking point (Figure 5), or partially (Figure 6), or fully (not shown) to provide a variable flow of exceeding fuel, in direct response to the high pressure felt.

20

25

In contrast, a low pressure situation in the cambox 11, as shown in Figures 2, 8 and 10 may provide too little pressure on the driven end 23a, 33a, 43a of the plunger 23, 33, 43 to push it back/ far enough to reach the standard orifice 28, 38, 48. Accordingly, the standard orifice 28, 38, 48 remains closed, thereby significantly restricting flow of exceeding fuel back to the return fuel line 12.

30

A normal pressure situation in the cambox 11, as shown in Figures 3 and 4, may push the driven end 23a, 33a, 43a of the plunger 23, 33, 43 back far enough to open just the standard orifice 28, 38, 48. Exceeding fuel can flow in through the inlet 21a, 31a, 41a into the plunger chamber 22, 32, 42 and out through both the standard orifice 28, 38, 48 thereby causing a normal measured amount of flow back through the return fuel line 12. As demonstrated by the difference between Figures 3 and 4, the standard orifice 28, 38, 48 may be opened to cracking point (Figure 3), or partially (Figure 4), or fully (not shown) to provide a slight variable flow of exceeding fuel, in direct response to the high pressure felt.

- 10 The arrangements therefore, allow maintenance of the pressure in the cambox 11 at a predetermined level.

Although the above embodiments are shown and have been described in relation to a fuel combustion engine, it is to be appreciated that the invention may be applied to other fuel consuming devices.

Although a few preferred embodiments have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

CLAIMS

1. A high pressure fuel pump (10) comprising a pressure regulator (20, 30, 40) communicable with a cambox (11), the pressure regulator (20, 30, 40) comprising a housing (21, 31, 41) with a plunger chamber (22, 32, 42) at an open end (21a, 31a, 41a) with a plunger (23, 33, 43) located therein, a spring chamber (24, 34, 44) at a second end (21b, 31b, 41b) with a spring (25, 35, 45) disposed therein, the plunger (23, 33, 43) being arranged for axially reciprocating movement along a plunger axis (A-A') and being biased by the spring (25, 35, 45) towards an inlet (26, 36, 46) at the open end (21a, 31a, 41a), the housing (21, 31, 41) comprising at least one damping orifice (27, 37, 47) linking the spring chamber (24, 34, 44) with a return fuel line (12), and at least one standard orifice (28, 38, 48) linking the plunger chamber (22, 32, 42) with the return fuel line (12), characterised in that the housing (21, 31, 41) further comprises at least one high flow orifice (29, 39, 49) linking the plunger chamber (22, 32, 42) with the return fuel line (12), wherein the high flow orifice (29, 39, 49) comprises a slot of approximately 0.5 mm width.

2. The high pressure fuel pump (10) according to claim 1, wherein the high flow orifice (29, 39, 49) comprises a single orifice.

3. The high pressure fuel pump (10) according to claim 2, wherein the single orifice is adapted to be closed, open or partially open.

4. The high pressure fuel pump (10) according to claim 1, wherein the high flow orifice (29, 39, 49) comprises a series of orifices.

5. The high pressure fuel pump (10) according to any one of claims 1 to 4, wherein the high flow orifice(s) (29, 39, 49) comprise a total diameter/ width of approximately between 0.5 mm and approximately 2.0 mm diameter/ width.

6. The high pressure fuel pump (10) according to any one of claims 1 to 5, wherein the high flow orifice (29, 39, 49) is disposed inwardly of the standard orifice (28, 38, 48).

7. The high pressure fuel pump (10) according to any one of claims 1 to 6, wherein the high flow orifice (29, 39, 49) is disposed approximately between 2 mm and approximately 4 mm away from the standard orifice (28, 38, 48).

5 8. The high pressure fuel pump (10) according to any one of claims 1 to 7, wherein the pressure regulator (20, 30, 40) comprises a continuous fluid pathway between the cambox (11) and the spring chamber (24, 34, 44).

9. The high pressure fuel pump (10) according to claim 8, wherein the continuous fluid
10 pathway comprises a bore (23e, 33e, 43e) through the plunger (23, 33, 43).

10. The high pressure fuel pump (10) according to claim 8, wherein the continuous fluid pathway comprises an orifice (50) through a wall of the housing (21, 31, 41) into the spring chamber (24, 34, 44).

15

11. The high pressure fuel pump (10) according to any one of claims 9 or 10, wherein the bore (23e, 33e, 43e) or orifice (50) is between approximately 0.3 mm and approximately 0.4 mm diameter/ width.

20 12. The high pressure fuel pump (10) according to any one of claims 1 to 11, wherein the spring (25, 35, 45) is configured to provide a force of approximately between 1 N/mm and approximately 4 N/mm.

13. The high pressure fuel pump (10) according to any one of claims 1 to 12, wherein the
25 high pressure fuel pump (10) is a diesel pump (10).

14. A pressure regulator (20, 30, 40) for a high pressure fuel pump (10) comprising a housing (21, 31, 41) with a plunger chamber (22, 32, 42) at an open end (21a, 31a, 41a) with a plunger (23, 33, 43) located therein, a spring chamber (24, 34, 44) at a second end (21b, 31b,
30 41b) with a spring (25, 35, 45) disposed therein, the plunger (23, 33, 43) being arranged for axially reciprocating movement along a plunger axis (A-A') and being biased by the spring (25, 35, 45) towards an inlet (26, 36, 46) at the open end (21a, 31a, 41a), the housing (21, 31, 41) comprising at least one damping orifice (27, 37, 47) linking the spring chamber (24, 34, 44)

with a return fuel line (12), and at least one standard orifice (28, 38, 48) linking the plunger chamber (22, 32, 42) with the return fuel line (12), characterised in that the housing (21, 31, 41) further comprises at least one high flow orifice (29, 39, 49) linking the plunger chamber (22, 32, 42) with the return fuel line (12).

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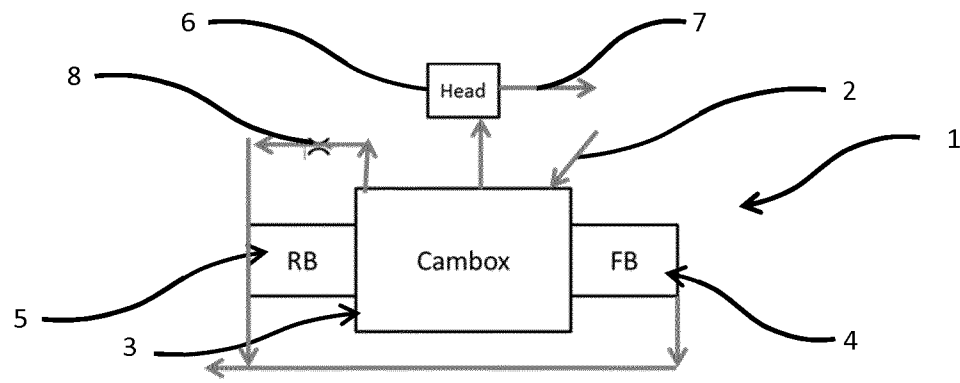


FIGURE 1A
PRIOR ART

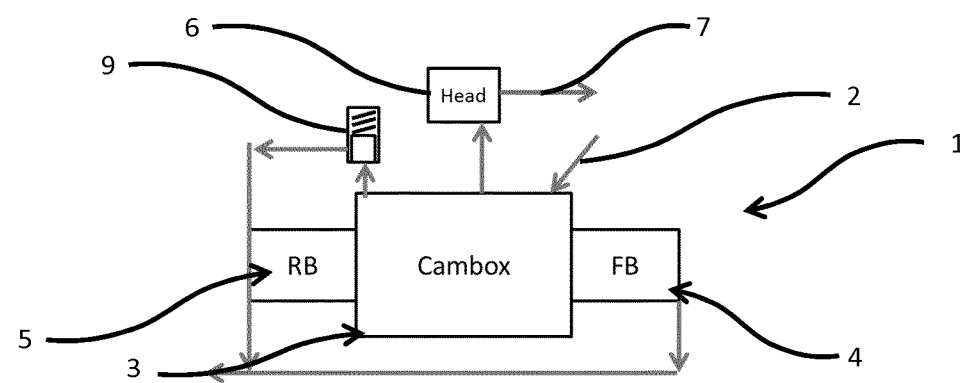


FIGURE 1B
PRIOR ART

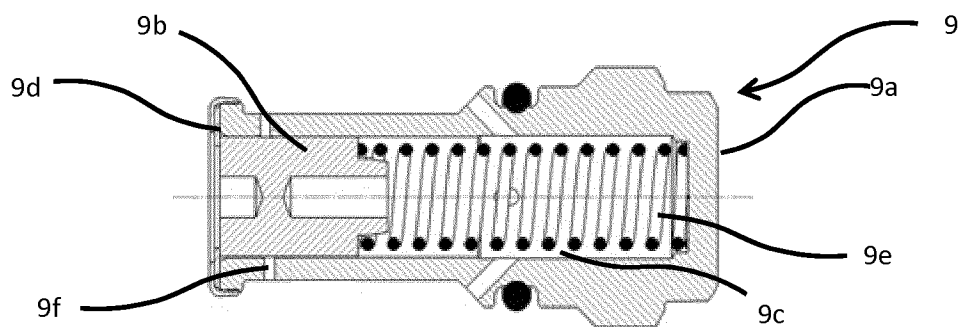


FIGURE 1C
PRIOR ART

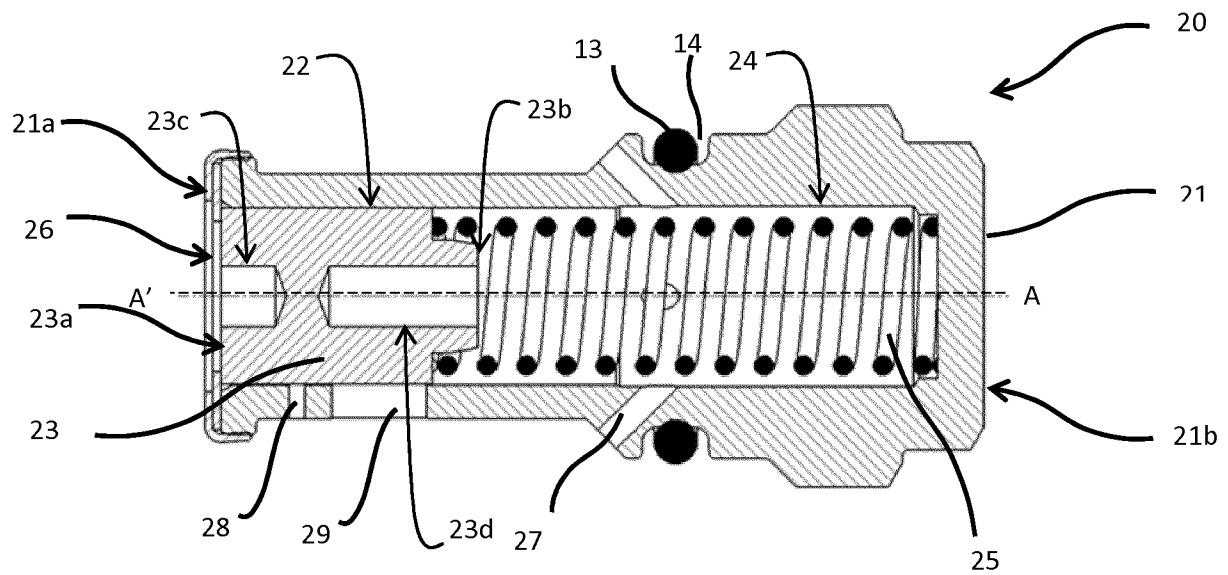


FIGURE 2

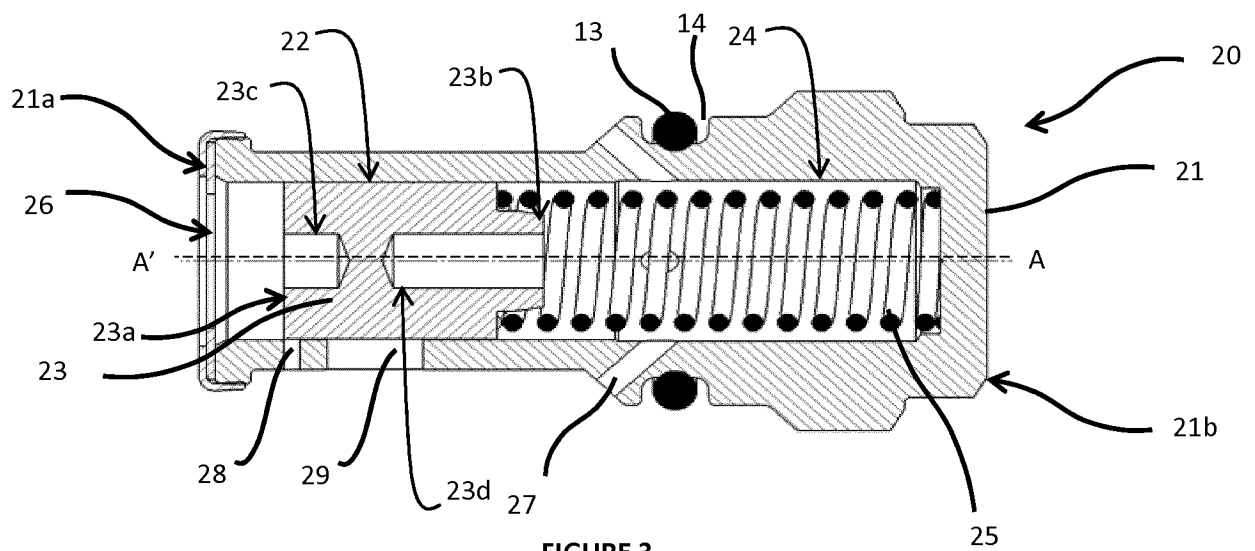


FIGURE 3

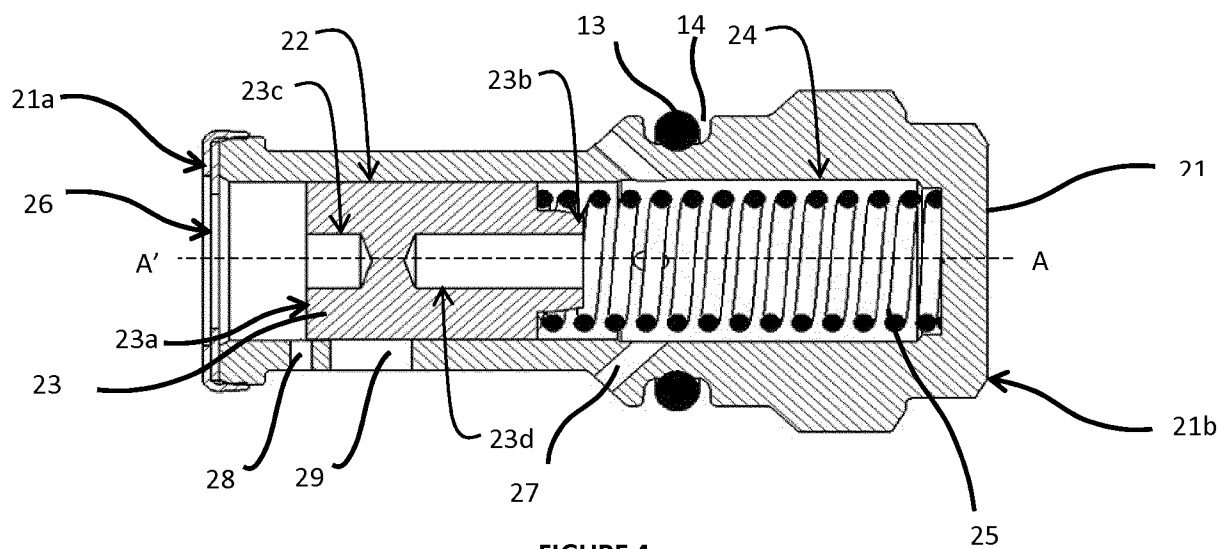


FIGURE 4

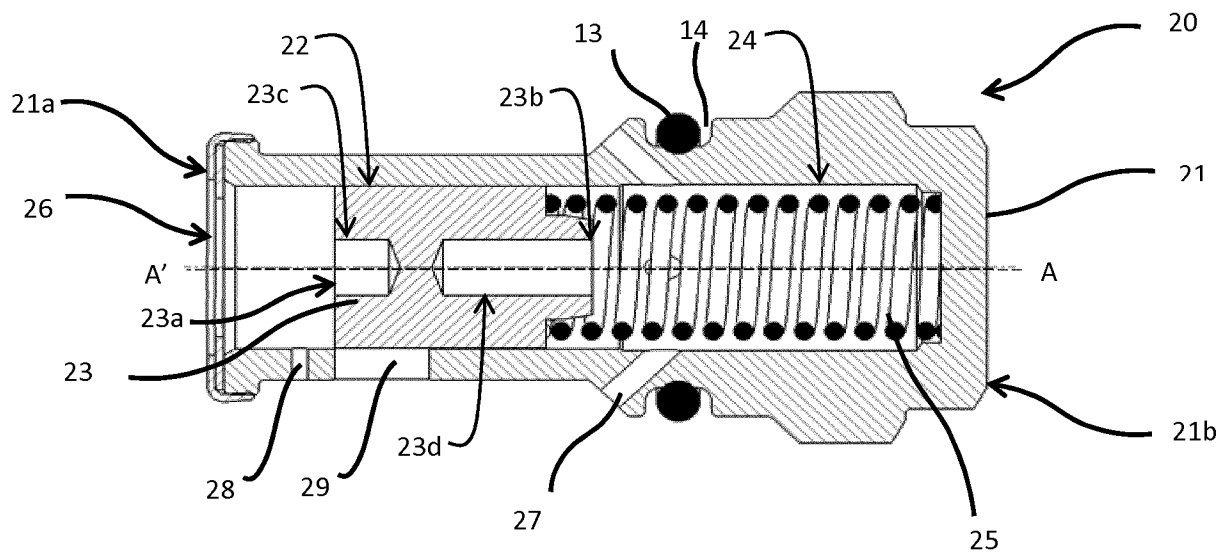


FIGURE 5

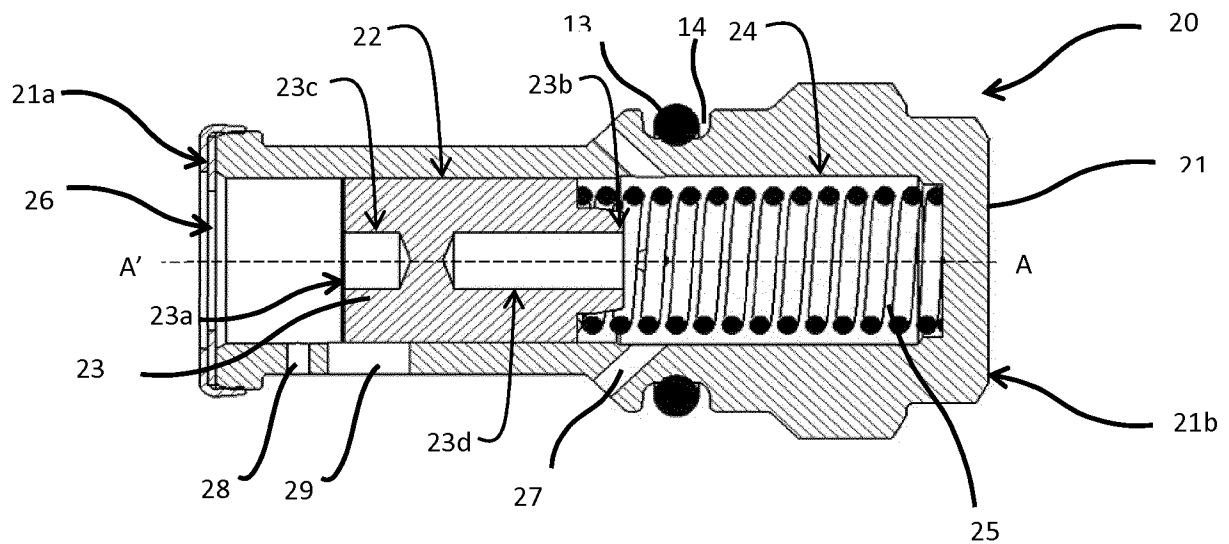


FIGURE 6

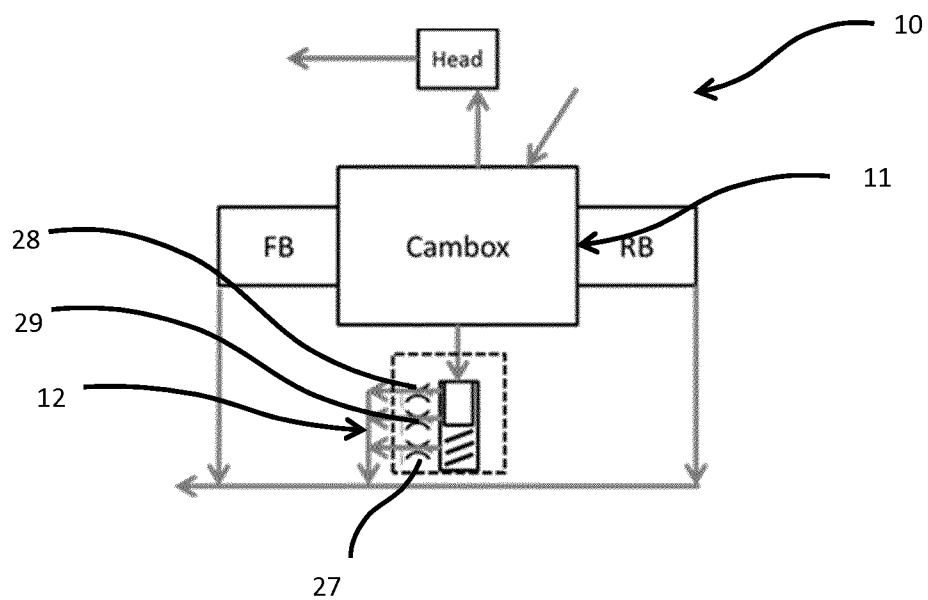
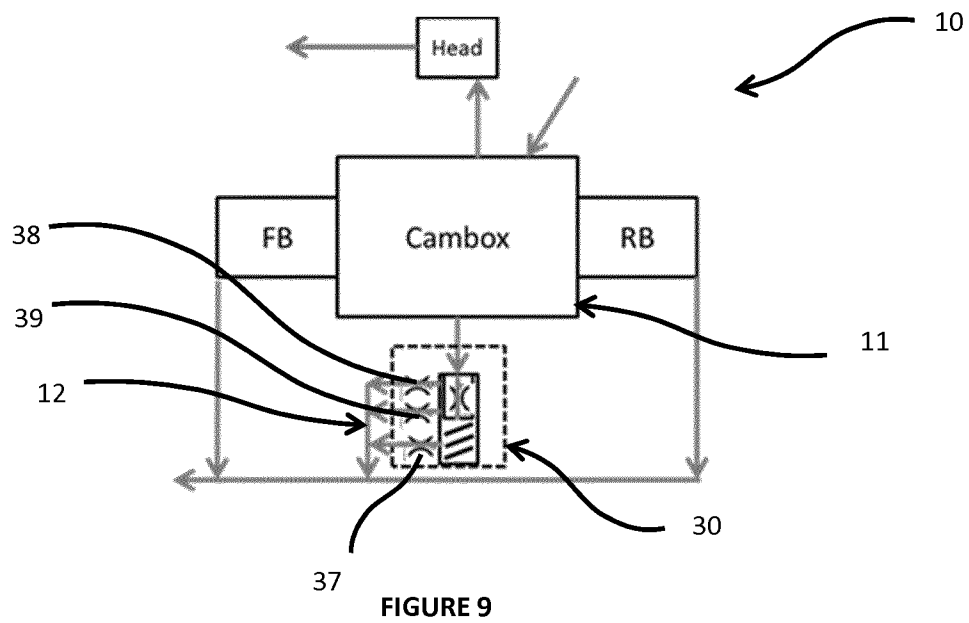
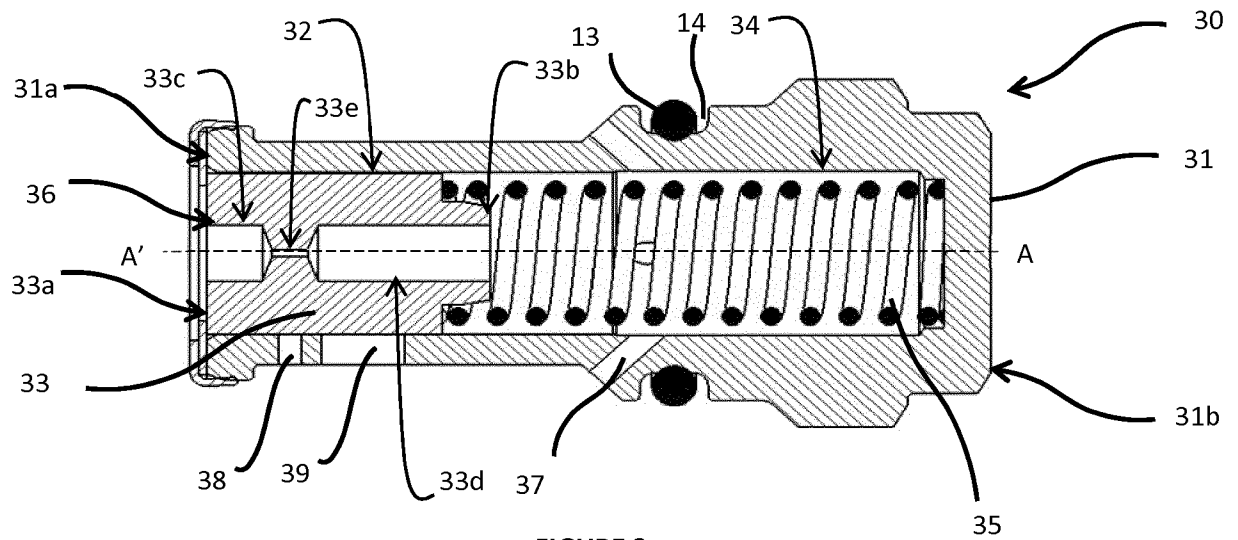


FIGURE 7



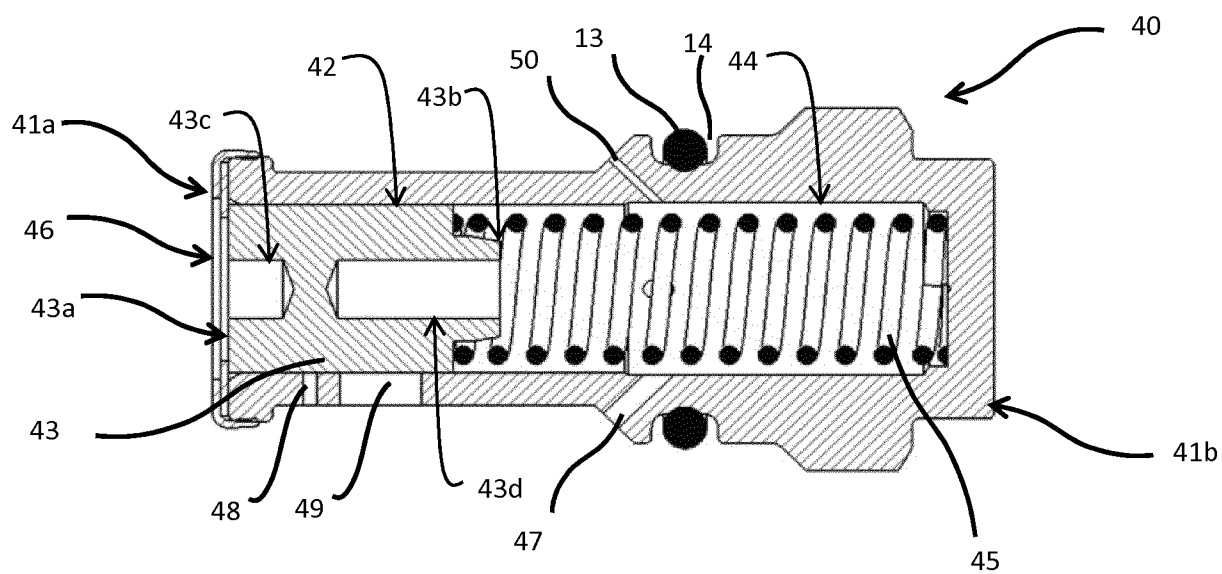


FIGURE 10

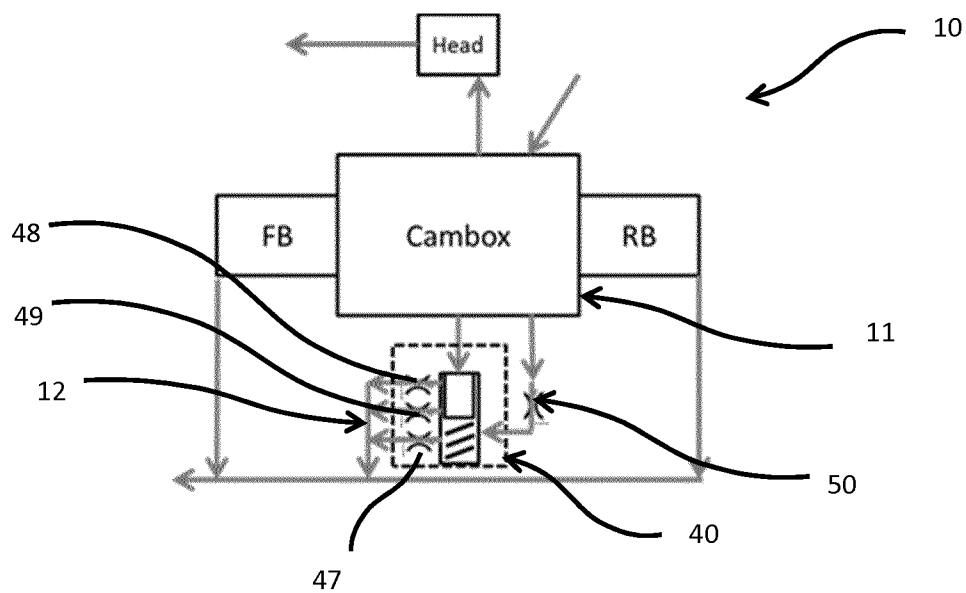


FIGURE 11

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/082273

A. CLASSIFICATION OF SUBJECT MATTER

INV. F02M63/00 F02M69/54 F02M59/42 F02M37/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02M

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/183904 A1 (BOSCH GMBH ROBERT [DE]) 20 November 2014 (2014-11-20)	1-7, 12-14
Y	page 3, line 5 - page 4, line 12; figures 1-3 page 4, lines 26-32 page 6, line 30 - page 7, line 6	8,9,11
X	WO 01/40656 A1 (BOSCH GMBH ROBERT [DE]; MATTHAEIS SISTO LUIGI DE [IT]) 7 June 2001 (2001-06-07) page 6, line 4 - page 10, line 20; claims 1-14; figures 1-3	1-5,8,9, 11-14
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

9 March 2017

Date of mailing of the international search report

17/03/2017

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Boye, Michael

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PCT/EP2016/082273

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	WO 02/40857 A2 (BOSCH GMBH ROBERT [DE]; SCHUELER PETER [DE]) 23 May 2002 (2002-05-23) page 13, line 30 - page 14, line 10; claim 1; figure 4 -----	1-14

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International application No

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