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ABSTRACT

ORIGINAL

OVERFLOW VALVE AND LOW PRESSURE FUEL PUMP COMPRISING THE SAME

The present invention relates to an overflow valve and a lower pressure pump comprising the same. An overflow valve of prior art is disadvantageous in that it cannot be opened quickly and avoid fuel leakage at the same time. The overflow valve in the invention comprises: a valve body, a valve element, an elastic element comprising first and second elastic parts in series, wherein the first elastic part is received in the first cavity part with a first pre-compressed amount; a partition portion arranged between the first and second elastic parts; and a blocking portion provided on an inner wall of the valve body and adapted to be abutted against by the partition portion, wherein the second elastic part is restrained in the second cavity part with a second pre-compressed amount, and the second elastic part is subjected to a pre-compressed force higher than that of the first elastic part. The technical effect of the invention lies in that the overflow valve can be opened quickly when the fuel pressure reaches a predetermined value while avoiding the fuel leakage.

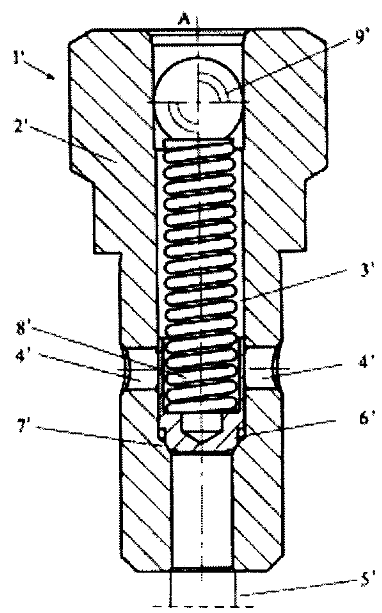

Figure 1

I/We claim:

1. An overflow valve comprising:

a valve body defining a valve seat, a cavity and an outlet channel in communication with the cavity, wherein the cavity defines first and second cavity parts in an axial direction of the valve body, and an end of the second cavity part distal from the first cavity part is sealed;

a valve element arranged in the valve body in such a manner that the valve element is slidable relative to the valve seat in the axial direction;

an elastic element comprising first and second elastic parts in series, wherein the first elastic part is received in the first cavity part with a first pre-compressed amount and pushes the valve element towards the valve seat;

a partition portion arranged between the first and second elastic parts; and

a blocking portion provided on an inner wall of the valve body and adapted to be abutted against by the partition portion, wherein the second elastic part is restrained in the second cavity part with a second pre-compressed amount, and the second elastic part is subjected to a pre-compressed force higher than that of the first elastic part, so that the first elastic part can apply a force to the valve element independently of the second elastic part when the valve element receives a fluid pressure which is lower than the pre-compressed force of the second elastic part.

2. The overflow valve according to claim 1, wherein the first elastic part has a spring stiffness higher than that of the second elastic part.

3. The overflow valve according to claim 1 or 2, wherein the elastic element comprises a dual spring, the first and second elastic parts constituting first and second spring parts of the dual spring respectively.

4. The overflow valve according to claim 1 or 2, wherein the elastic element comprises a single spring, the first and second elastic parts constituting two segments of the single spring, between which the partition portion is provided.

5. The overflow valve according to claim 4, wherein the single spring comprises a conical spring.

6. The overflow valve according to any one of claims 1 to 5, wherein the partition portion comprises a plate like member, which has an outer diameter

smaller than an inner diameter of the cavity and larger than an outer diameter of the first elastic part.

7. The overflow valve according to any one of claims 1 to 5, wherein the partition portion comprises a ring like member, which has an outer diameter smaller than the inner diameter of the cavity and larger than the outer diameter of the first elastic part.

8. The overflow valve according to any one of claims 1 to 7, wherein the blocking portion comprises an annular rib extending radially inwardly from the valve body, the annular rib having an inner diameter smaller than the outer diameter of the partition portion and larger than the outer diameter of first elastic part, so that the second elastic part can be restrained in the second cavity part with the second pre-compressed amount when the partition portion is abutted against by the blocking portion.

9. The overflow valve according to any one of claims 1 to 7, wherein the blocking portion comprises a plurality of projections distributed uniformly or non-uniformly on the inner wall of the valve body, an inner diameter delimited by the plurality of projections being smaller than the outer diameter of the partition portion and larger than the outer diameter of the first elastic part, so that the second elastic part can be restrained in the second cavity part with the second pre-compressed amount when the plurality of projections are abutted against by the partition portion.

10. A lower pressure pump assembly, comprising an inlet fuel passage and an overflow valve of any one of the preceding claims 1-9, which is arranged in the inlet fuel passage.

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To,
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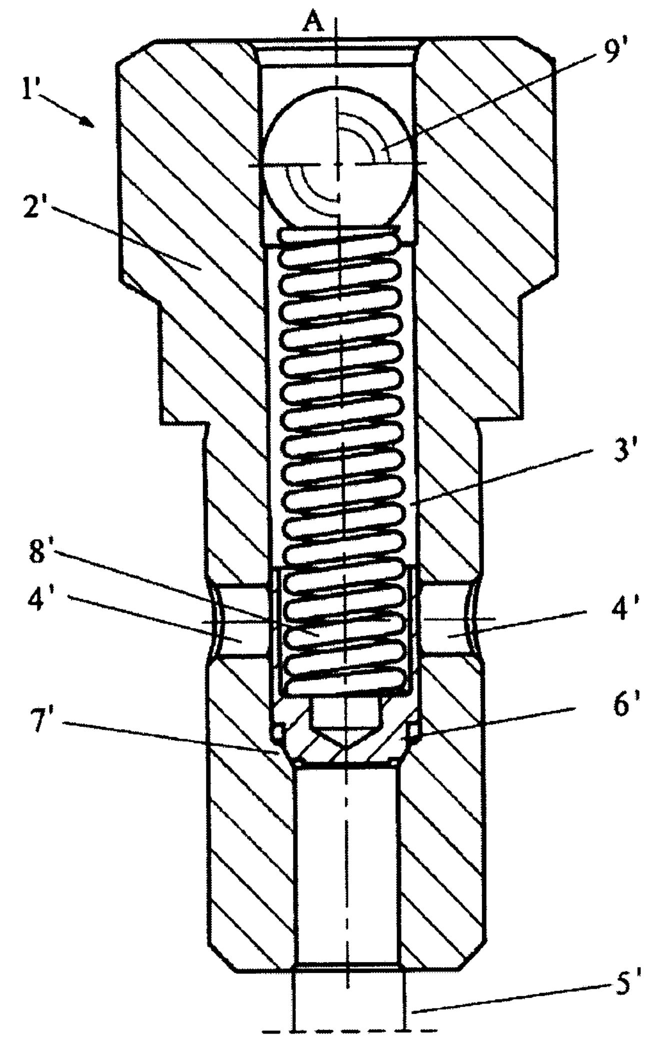

Figure 1

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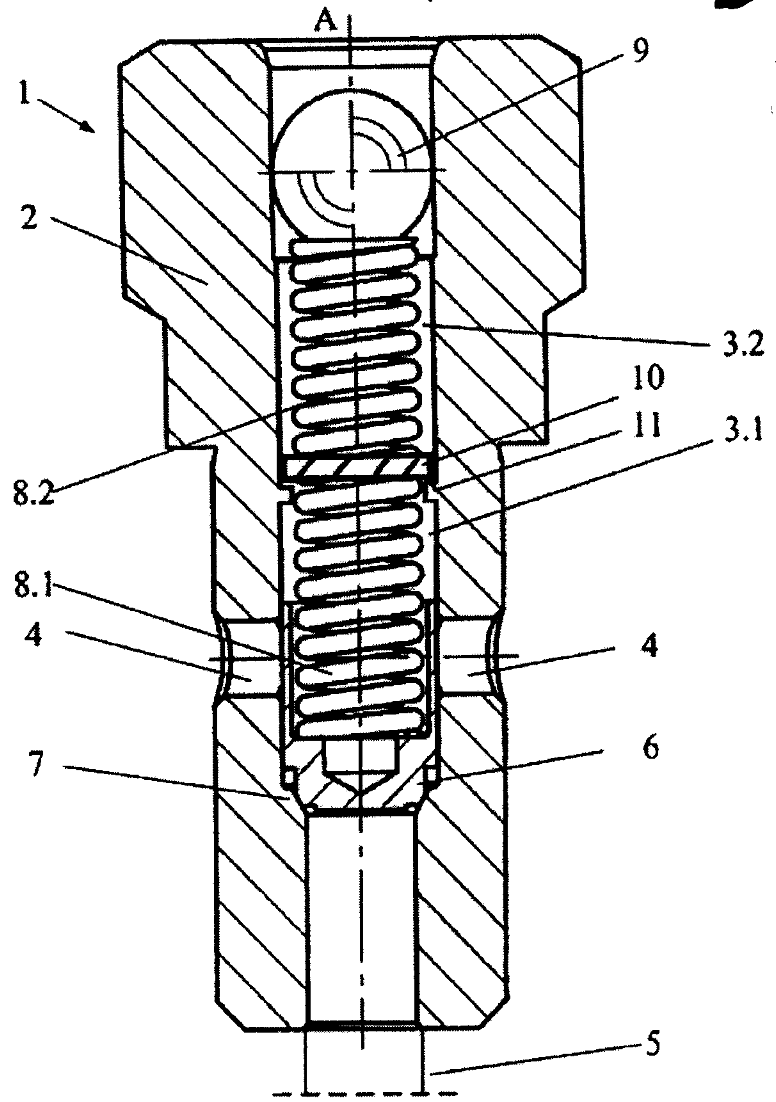

Figure 2

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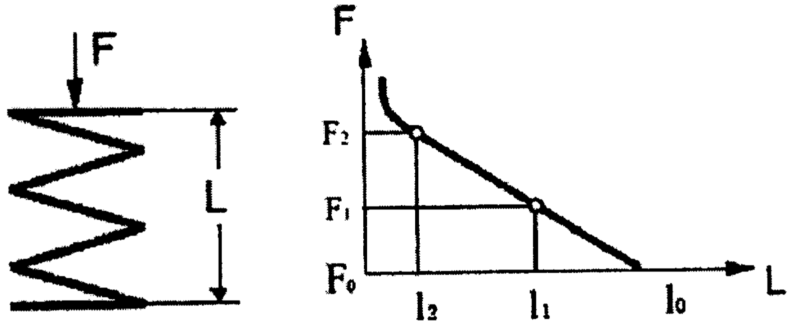

Figure 3

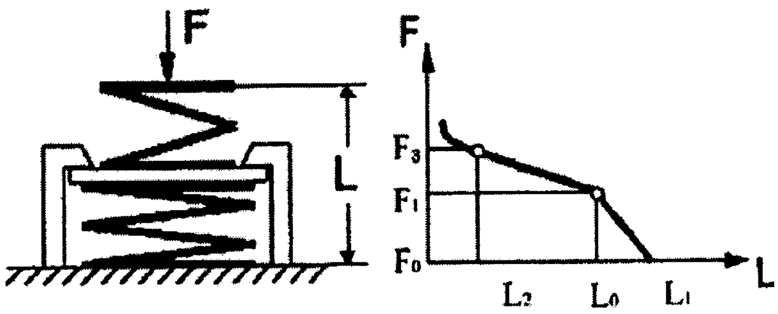

Figure 4

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Technical Field

The present invention relates to an overflow valve and, in particular, to an overflow valve for a low pressure fuel pump used in an internal combustion engine and a low pressure fuel pump comprising the overflow valve.

Background Art

An internal combustion engine generally comprises a low pressure fuel pump, a high pressure fuel pump, a manifold, a low pressure line connecting the low pressure fuel pump to the high fuel pump, and a high pressure line connecting the high pressure fuel pump to the manifold.

The low pressure fuel pump generally comprises an overflow valve which allows redundantly supplied fuel to return to a fuel tank. The overflow valve is used to prevent high pressure from damaging the low pressure fuel pump and the low pressure line.

The overflow valve used for the above-mentioned purposes generally comprises: a valve body defining a valve seat, a cylindrical cavity extending in an axial direction of the valve body and an outlet channel in communication with the cavity, the cavity connecting with an inlet fuel passage, the outlet channel connecting with an outlet fuel passage, and an end of the valve body which is in the axial direction being sealed by a sealing portion; a valve element arranged in the cavity in such a manner that the valve element is slidable relative to the valve body in the axial direction, the valve element being capable of being abutted against by the valve seat to keep the outlet channel from communicating with the cavity; and a single linear spring received in a compressible manner in a volume-variable chamber, wherein the volume-variable chamber is defined by a part of the cavity which is between the valve element and the sealing portion. During operation, in case that the fuel pressure in the inlet fuel passage is too high, the fuel flowing to the cavity connecting with the inlet fuel passage will push the valve element to move upon overcoming a pre-compressed force of the compressed linear spring. The valve element is pushed to move until it does not keep the cavity from communicating with the outlet channel. In this way, the redundant fuel may be conveyed from the inlet fuel passage to the outlet channel and hence to the outlet fuel passage, such that the fuel pressure in the low pressure fuel pump and the inlet fuel passage is decreased.

This type of overflow valves is disadvantageous as below. The fuel flowing to the cavity will overcome the pre-compressed force of the spring and push the valve element to move when the fuel pressure in the inlet fuel passage is increased to exceed a predetermined value. In case that a spring having a higher stiffness is chosen, however, a force required to push the valve element to move in a continuous way is increased quickly due to the higher stiffness of the spring, such that a longer period of time is needed to open the valve element completely, which will adversely affect the work efficiency of the overflow valve. In contrast, in case that a spring having a lower stiffness is chosen, it is possible that a great amount of the fuel expected to supply to the engine returns to the fuel tank through the overflow valve, causing leakage and insufficient supply of fuel and hence adversely affecting the normal operation of the internal combustion engine.

Summary of the Invention

The technical problem to be solved by the present invention is to provide an overflow valve which overcomes the above disadvantages. In particular, the invention provides an overflow valve having an elastic element. The overflow valve is capable of being opened quickly when fuel pressure reaches a predetermined value, so as to allow redundant fuel to return to a fuel tank, and preventing the fuel from leaking through the overflow valve undesirably. In addition, the invention is to solve the problem by further providing a low pressure fuel pump comprising such an overflow valve.

For this end, the present invention provides the overflow valve comprising: a valve body defining a valve seat, a cavity and an outlet channel in communication with the cavity, wherein the cavity defines first and second cavity parts in an axial direction of the valve body, and an end of the second cavity part distal from the first cavity part is sealed; a valve element arranged in the valve body in such a manner that the valve element is slidable relative to the valve seat in the axial direction; an elastic element comprising first and second elastic parts in series, wherein the first elastic part is received in the first cavity part with a first pre-compressed amount and pushes the valve element towards the valve seat; a partition portion arranged between the first and second elastic parts; and a blocking portion.

The blocking portion is provided on an inner wall of the valve body and adapted to be abutted against by the partition portion. On one hand, the second elastic part is restrained in the second cavity part with a second pre-compressed amount, and the second elastic part is subjected to a pre-compressed force higher than that of the first elastic part, so that the first elastic part can apply a force to the valve element independently of the second elastic part when the valve element receives a fluid pressure which is lower than the pre-compressed force of the second elastic part. On the other hand, the first elastic part can be coupled in series with the second elastic part to apply a force to the valve element when the valve element receives a fluid pressure which is higher than the pre-compressed force of the second elastic part.

Preferably, the first elastic part has a spring stiffness higher than that of the second elastic part. The first elastic part can apply a force to the valve element independently of the second elastic part when the valve element receives a fluid pressure which is lower than the pre-compressed force of the second elastic part. This type of overflow valves can achieve a better fuel leakage prevention effect due to the higher stiffness of the first elastic part.

Preferably, the elastic element comprises a dual spring, the first and second elastic parts constituting first and second spring parts of the dual spring respectively.

Alternatively, the elastic element comprises a single spring, the first and second elastic parts constituting two segments of the single spring, between which the partition portion is provided.

Preferably, the single spring comprises a conical spring. For example, the conical spring has an end with a larger outer diameter abutted against by the valve element. For example, the partition portion has an outer diameter smaller than an inner diameter of the cavity and larger than the maximal outer diameter of the conical spring. For example, the blocking portion has an inner diameter smaller than the outer diameter of the partition portion and larger than the maximal outer diameter of the conical spring.

Preferably, the partition portion comprises a plate like member, which has an outer diameter smaller than the inner diameter of the cavity and larger than an outer diameter of the first elastic part. For example, the first and second elastic parts are attached to opposite sides of the plate like member respectively. Alternatively, the partition portion comprises a ring like member, which has an outer diameter smaller than the inner diameter of the cavity and larger than the outer diameter of the first elastic part.

Preferably, the blocking portion comprises an annular rib extending radially inwardly from the valve body, the annular rib having an inner diameter smaller than the outer diameter of the partition portion and larger than the outer diameter of first elastic part, so that the second elastic part may be restrained in the second cavity part with the second pre-compressed amount when the partition portion is abutted against by the blocking portion.

Alternatively, the blocking portion comprises a plurality of projections distributed uniformly or non-uniformly on the inner wall of the valve body, an inner diameter delimited by the plurality of projections being smaller than the outer diameter of the partition portion and larger than the outer diameter of the first elastic part, so that the second elastic part can be restrained in the second cavity part with the second pre-compressed amount when the plurality of projections are abutted against by the partition portion.

According to the present invention, when the valve element receives a force higher than the pre-compressed force of the second elastic part, the first and second elastic parts will be coupled in series to apply a force to the valve element, and during this period of time the first elastic part may be moved to the second cavity part in the axial direction.

Preferably, the present invention further provides a low pressure fuel pump comprising an inlet fuel passage and an overflow valve having the above-mentioned features arranged in the inlet fuel passage.

The technical effect of the invention lies in that the overflow valve provided here can avoid leakage, and can be opened quickly when the fuel pressure reaches the predetermined value.

<u>Brief Description of the Drawings</u>

The invention will be further understood by reading the following detailed description with reference to the drawings in which:

Figure 1 shows a sectional view of an overflow valve of prior art for a low pressure fuel pump;

Figure 2 shows a sectional view of an overflow valve according to an embodiment of the invention;

Figure 3 shows a schematic view and a diagram illustrating a relationship between fuel pressure and a working length of a linear spring;

Figure 4 shows a schematic view and a diagram illustrating a relationship between the fuel pressure and a working length of an elastic element according to an embodiment of the invention.

In different figures, similar reference numbers represent corresponding components, and repeated descriptions about these components are omitted.

<u>Detailed Description of Preferred Embodiments</u>

Figure 1 shows a sectional view of an overflow valve 1' of prior art for a low pressure fuel pump. The overflow valve 1' comprises a valve body 2' extending substantially in an axial direction A and defining a valve seat 7', a cavity 3' and an outlet channel 4' in communication with the cavity 3'. The cavity 3' connects with an inlet fuel passage 5' directly. The cavity 3' extends in the axial direction A, while the outlet channel 4' is substantially perpendicular with the axial direction A and in communication with the cavity 3'.

The overflow valve 1' further comprises: a valve element 6' arranged in the cavity 3' in such a manner that the valve element 6' is slidable relative to the valve body 2' in the axial direction A, the valve element 6' being capable of being abutted against by the valve seat 7' so as to keep the cavity 3' from communicating with the outlet channel 4'; a spring 8' received in the cavity as a single linear spring with a certain pre-compressed amount and hence with a certain pre-compressed force; and a sealing portion 9' defining a volume-variable chamber in the cavity 3' with the valve element 6'. The spring 8' may be moved in the cavity as fuel pushes the valve element 6' to move.

In particular, the sealing portion 9' is driven to the cavity 3' in an interference fit manner and defines a stop for the linear spring 8'. Preferably, the sealing portion 9' is a sphere positioned in the cavity 3' distal from the valve element 6' during assembly.

Figure 2 shows an overflow valve 1 according to an embodiment of the present invention. The overflow valve 1 of this embodiment is different from the overflow valve 1' of prior art in that the cavity 3 of the overflow valve 1 comprises first and second cavity parts 3.1, 3.2 in communication with each other, and the overflow valve 1 is provided with an elastic element 8 comprising first and second elastic parts 8.1, 8.2 in series, wherein the first elastic part 8.1 is restrained in the first cavity part 3.1 with a first pre-compressed amount so as to be abutted against by the valve element 6, and the second elastic part 8.2 is restrained in the second cavity part 3.2 with a second pre-compressed amount, and wherein the first elastic part 8.1 is subjected to a pre-compressed force higher than that of the second elastic part 8.2.

The overflow valve 1 further comprises a partition portion 10 formed or assembled between the first and second elastic parts 8.1, 8.2 for connecting with both of them. The partition portion 10 has an outer diameter smaller than an inner diameter of the cavity 3 and larger than an outer diameter of the first elastic part 8.1.

In a preferred embodiment, the partition portion 10 may be a plate like member to opposite sides of which the first and second elastic parts 8.1, 8.2 are attached respectively. In another preferred embodiment, the partition portion l0 may be a ring like member formed or assembled between the first and second elastic parts 8.1, 8.2.

The overflow valve 1 further comprises a blocking portion 11 arranged in the first cavity part 3.1 and provided at a partition point between the first and second cavity part 3.1, 3.2 in such a manner that the valve element 6 can be moved in the first cavity part 3.1 until the cavity 3 communicates with the outlet channel 4 completely.

In a preferred embodiment, the blocking portion 11 may be formed integrally with or attached to the valve body 2. In particular, the blocking portion 11 may be formed as an annular rib extending radially inwardly from the valve body 2. The annular rib has an inner diameter smaller than an outer diameter of the partition portion 10 but larger than the outer diameter of the first elastic part. Thus, the second elastic part 8.2 may be restrained in the second cavity part 3.2 with the second pre-compressed amount as the partition portion 10 between the first and second elastic parts 8.1, 8.2 is abutted against by the blocking portion 11 on the valve body 2, wherein the second elastic part 8.2 is subjected to a pre-compressed force higher than that of the first elastic part 8.1. In particular, the blocking portion

11 may be a plurality of projections distributed uniformly or non-uniformly on the periphery of the valve body.

In particular, the blocking portion 11 may have a cross section of rectangle, circular, triangle or any other shape allowing the partition portion 10 to be abutted against, so that the second elastic part 8.2 may be restrained in the second cavity part 3.2 with the second pre-compressed amount, wherein the blocking portion 11 has a minimal inner diameter larger than the outer diameter of the first elastic part.

In a preferred embodiment, in case that the second elastic part 8.2 is subjected to the pre-compressed force higher than that of the first elastic part 8.1, the first and second elastic parts 8.1, 8.2 may be configured to have certain characteristics according to specific applications, for example, the first and second elastic parts 8.1, 8.2 may have same or different stiffnesses and outer diameters, etc. Preferably, to achieve a better fuel leakage prevention effect, the first elastic part 8.1 may have a stiffness larger than that of the second elastic part 8.2. Alternatively, the elastic element 8 is a dual spring, wherein the first and second elastic parts 8.1, 8.2 constitute first and second spring parts of the dual spring responsively. Alternatively, the elastic element 8 is formed of a single spring (for example, a conical spring), wherein the first and second elastic parts 8.1, 8.2 constitute two segments of the single spring, between which the partition portion 10 is formed or assembled.

During operation, when fuel pressure in the inlet fuel passage 5 is insufficient to overcome the pre-compressed force of the first elastic part 8.1, the partition portion 10 between the first and second elastic part 8.1, 8.2 is abutted against by the blocking portion 11 on the valve body 2, so that the second elastic part 8.2 is restrained in the second cavity part 3.2 with the second pre-compressed amount, while the valve element 6 is abutted against by the valve seat 7 under the action of the pre-compressed force of the first elastic part 8.1, which is to keep the outlet channel 4 from communicating with the inlet fuel passage 5. Thus, all the fuel will be supplied to a downstream system through a low pressure line. In this case, the first elastic part 8.1 can apply a force to the valve element 6 independently of the second elastic part 8.2.

When the fuel pressure in the inlet fuel passage 5 overcomes the pre-compressed force of the first elastic part 8.1 but is insufficient to overcome the pre-compressed force of the second elastic part 8.2, the partition portion 10 between the first and second elastic parts 8.1, 8.2 is still abutted against by the blocking portion 11 on the valve body 2, so that the second elastic part 8.2 is restrained in the second cavity part 3.2 with the second pre-compressed amount, while the valve element 6 is pushed into the first cavity part 3.1. During this period of time, the valve element 6 may reciprocate in the space of the first cavity part 3.1. However, communication is not established between the outlet channel 4 and the inlet fuel passage 5 yet, so all the fuel will be supplied to the downstream system through the low pressure line. In this case, the first elastic part 8.1 can still apply a force to the valve element 6 independently of the second elastic part 8.2.

When the fuel pressure in the inlet fuel passage 5 is increased to exceed a predetermined value and the pre-compressed force of the second elastic part 8.2, under the action of a force transmitting from the valve element 6 to the first elastic part 8.1, the fuel flowing to the cavity overcomes the pre-compressed force of the second elastic part 8.2 and pushes the partition portion 10 to move. In this case, the valve element 6 is further moved in the first cavity part. Since the partition portion 10 between the first and second elastic parts 8.1, 8.2 is not abutted against by the blocking portion 11 on the valve body 2, the first and second elastic parts 8.1, 8.2 are coupled in series to form a combined spring, the combined spring has a stiffness lower than that of either one of the first and second elastic parts 8.1, 8.2. Therefore, when the fuel pressure is increased to exceed the pre-compressed force of the second elastic part 8.2, a force required to push the valve element 6 to move continuously decreases, so that the valve element will be pushed to move more quickly, to allow the valve element to be opened completely, and hence the inlet fuel passage 5 will communicate with the outlet channel 4 completely through the cavity 3. During this period of time, the redundant fuel can return quickly to a fuel tank through the overflow valve 1.

Figure 3 shows a schematic view and a diagram, illustrating a relationship between fuel pressure and a working length l of a linear spring.

As can be seen from the schematic view of Figure 3, the working length l of the linear spring having a stiffness K_0 varies as the linear spring is subjected to the fuel pressure F.

As can be seen from the diagram of Figure 3, when the fuel pressure F does not exceed the pre-compressed force F_0 of the linear spring, the working length l_0 of the linear spring is maintained with a pre-compressed amount. When the fuel pressure F is increased to exceed the pre-compressed force F_0 of the linear spring, the working length l of the linear spring decreases proportionally in a linear manner. When the working length reaches l_1 due to the increased fuel pressure F_1 the valve element has been pushed to allow the inlet fuel passage to begin to communicate with the outlet channel. When the working length reaches l_2 due to the further increased fuel pressure F_2, the valve element has been pushed to be opened completely. This type of linear springs is disadvantageous. If the linear spring has a higher stiffness, the fuel pressure required to push the valve element to move in a continuous way is increased quickly, such that a longer period of time is needed to open the valve element completely, the pressure relief from the overflow valve is therefore adversely affected. However, if the linear spring has a lower stiffness, the valve element would be vulnerable to leakage.

Figure 4 shows a schematic view and a diagram illustrating a relationship between fuel pressure and a working length L of an elastic element according to an embodiment of the invention.

As can be seen from the schematic view of Figure 4, the elastic element comprises a first elastic part having a stiffness K_1 and a second elastic part having a stiffness K_2, wherein the second elastic part is restrained in a schematic second cavity part with a second pre-compressed amount due to a schematic blocking portion, the first elastic part with a first pre-compressed amount pushes a valve element towards a valve seat, and the second elastic part is subjected to a pre-compressed force higher than that of the first elastic part. Similar to the linear spring shown in Figure 3, the working length L of the elastic element varies as the elastic element is subjected to the fuel pressure F. For comparison purpose, the first elastic part has the stiffness K_1 larger than that of the linear spring, and the second elastic part has the stiffness K_2 equal to that of the linear spring.

As can been seen from the diagram of Figure 4, in case that the elastic element has the first elastic part with the first pre-compressed amount and the second elastic part with the second pre-compressed amount, the working length of the elastic element is L_0 when the fuel pressure F does not exceed the pre-compressed force F_1 of the first elastic part of the elastic element. As the fuel pressure F is increased to exceed the pre-compressed force F_0 of the first elastic part of the elastic element, the length of the first elastic part having the stiffness K_1 varies in a substantially linear manner independently of the second elastic part. Since the first elastic part has the stiffness K_1 larger than that of the linear spring shown in Figure 3, it is more difficult for the fuel to push the valve element to move in a continuous way as compared to that with the linear spring, such that the fuel leakage is avoided. When the fuel pressure F exceeds the pre-compressed force F_1 of the second elastic part of the elastic element, the working length of the spring becomes L_1 due to the increased fuel pressure, in which case the valve element is pushed to allow the inlet fuel passage to begin to communicate with the outlet channel, and the first and second elastic parts are coupled in series to form a combined spring. It is understood that the combined spring has a stiffness of $K'=K_1xK_2/(K_1+K_2)$, which is smaller than the stiffness K_1 of the first elastic part and the stiffness K_2 of the second elastic part, and hence smaller than the stiffness of the linear spring. Therefore, the valve element is pushed quickly by the fuel pressure F_3 smaller than the fuel pressure F_2 shown in Figure 3, until the valve element is opened completely.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. The attached claims and their equivalents are intended to cover all the modifications, substitutions and changes as would fall within the scope and spirit of the invention.