June 27, 1944. J. F. HOFFER 2,352,322

PRESSURE REDUCTION CHECK VALVE

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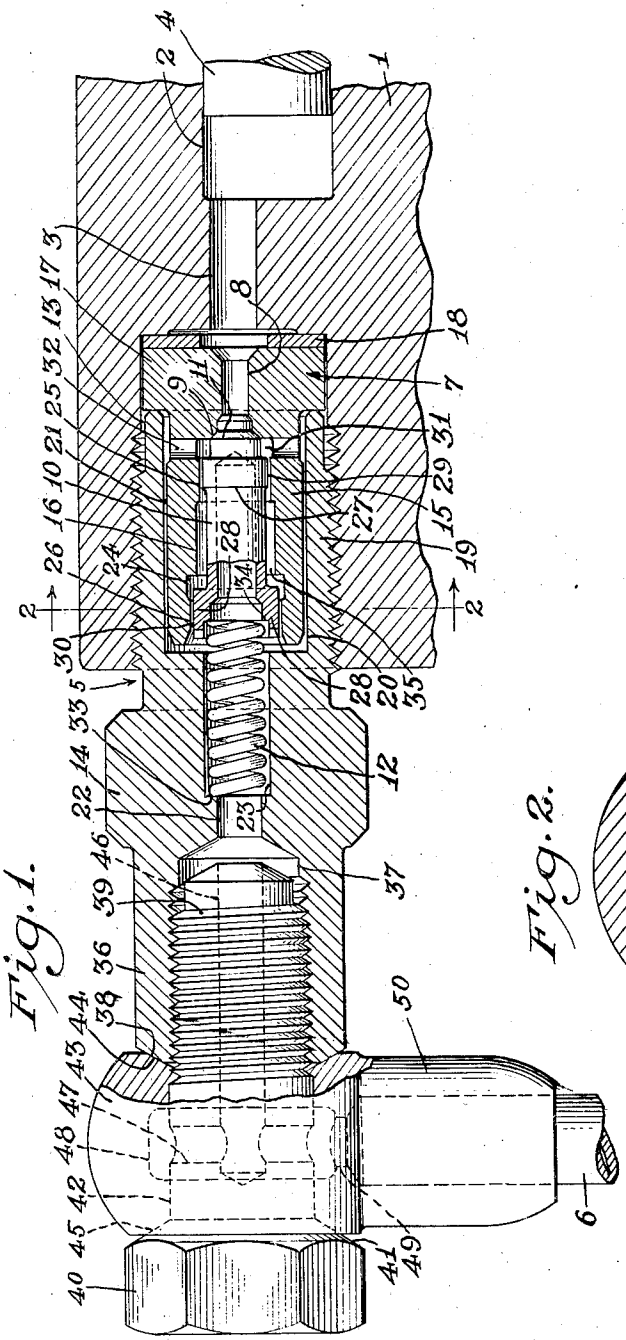


Fig. 1.

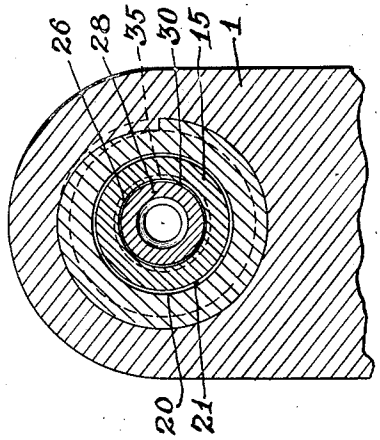


Fig. 2.

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PRESSURE REDUCTION CHECK VALVE

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10 Claims. (Cl. 251—146)

The present invention relates to a novel pressure reduction check valve adapted for use with jerk-type fuel injection pumps.

In fuel injection systems embodying jerk-type pumps, the pump is connected through an outlet check valve to a supply tube leading to the injection nozzle. In certain check valves heretofore employed, the valve member is arranged to displace a fixed volume of fuel toward the nozzle before fully opening the flow passage between the pump and the supply tube. On closing, the valve member displaces the same volume of fluid in the reverse direction toward the pump. The purpose of this fluid displacement toward the pump is to reduce the pressure in the supply tube and the nozzle passages so as to effect rapid closing of the nozzle at the end of each normal injection period, and to prevent after-injection and nozzle leakage during the comparatively long intervals between the normal injection periods. Such retracting type check valve, however, has the disadvantage that it tends to result in partial cavitation of the injection system at the outlet side of the valve.

One of the objects of the present invention is to provide a new and improved check valve of the pressure reduction type rather than of the retraction type, whereby to obtain all of the advantages while avoiding the disadvantages of the latter type.

A further object is to provide a novel check valve which is operable to reduce the residual pressure as desired in the injection or supply tube without resulting in cavitation under any condition of operation.

Another object is to provide a novel pressure reduction check valve of the foregoing character which is simple and inexpensive in construction, and which is efficient and reliable in operation.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawing, Figure 1 is an enlarged fragmentary axial sectional view of a check valve embodying the features of my invention.

Fig. 2 is a fragmentary transverse sectional view taken along line 2—2 of Fig. 1.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawing and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring more particularly to the drawing, the check valve is adapted for use with a jerk-type fuel pump in a fuel injection system. The pump per se forms no part of the present invention and, hence, is not disclosed in detail. It is sufficient to say that the pump comprises a body 1 having a cylinder 2 with a fuel discharge passage 3. A piston 4 is reciprocable in the cylinder 2, and is operable on each working stroke to displace a charge of fuel under pressure to the passage 3.

The check valve, which is indicated generally at 5, is suitably mounted on the pump body 1 to connect the pump discharge passage 3 with a supply tube 6 leading to an injection nozzle (not shown). In its preferred form, the check valve 5 comprises a stationary valve body 7 having a valve passage 8 formed in its outer end with an annular valve seat 9, and a reciprocable plunger 10 having a valve member 11 on its inner end adapted for engagement with the seat. A coiled compression spring 12 tends to hold the valve member 11 against the seat 9 with a predetermined pressure. The different elements of the valve 5 are confined in assembled relation, and the valve body 7 is secured within a bore 13 in the pump body 1 by means of a suitable retainer 14.

The valve body 7 consists of a sleeve or housing 15 having an axial bore 16, and formed on its inner end with an enlarged circular head 17 seated against a gasket 18 in the inner end of the bore 13. The valve passage 8 opens from the bore 16 coaxially through the head 17 for communication with the pump discharge passage 3. To secure the valve body 7 tightly in position, a clamp sleeve 19 on one end of the retainer 14 is threaded into the outer end of the bore 13 and into end engagement with the head 17.

The clamp sleeve 19 has a large axial bore 20 which loosely receives the sleeve 15 of the valve body 7 and coacts therewith to define an intermediate annular flow passage 21. The inner end of the bore 20 opens axially to a bore or passage 22 formed with a counterbore 23 constituting the fuel outlet from the valve 5.

The valve bore 16 within the sleeve 15 is formed in the outer end with a relatively large counterbore 24. Accurately machined pilot guides 25 and 26 of slightly reduced diameters are formed respectively adjacent the inner end of the bore 16 and in the outer end of the counterbore 24.

The valve plunger 10 extends reciprocably in the bore 16, and is provided adjacent the inner end with a relatively small piston 27 disposed within the guide 25, and at its outer end with a relatively large piston 28 disposed within the guide 26. Predetermined peripheral clearances 29 and 30, selected to give the desired operating characteristics, are provided between the pistons 27 and 28 and their respective guides 25 and 26. The valve member 11 is smaller in diameter than the inner end of the bore 16 to provide an annular passage 31 open to the valve seat 9. This passage 31 opens through radial ports 32 in the sleeve 15 to the flow passage 21. It will be seen that when the valve member 11 is lifted from the seat 9, fuel will flow from the pump cylinder 2 through the discharge passage 3, the seat 9, the passage 31, the ports 32, and the passage 21 to the outer end of the bore 20, and then through the counterbore 23 and bore 22 to the conduit 6.

The valve closing spring 12 seats at one end against a shoulder 33 at the end of the counterbore 23, and at the other end against a shoulder 34 in the piston 28. It will be evident that the valve plunger 10 is of the differential type with the piston 28 defining a relatively large pressure area, and the piston 27 defining a relatively small pressure area. The intermediate portion of the bore 16 between the collars 27 and 28 constitutes a dashpot chamber 35 having inlet and egress orifices defined by the selected clearances 29 and 30.

To provide suitable means for connecting the passage 22 with the pressure tube 6, the retainer 14 is formed with a sleeve 36 having an internally threaded bore 37 open to the passage 22 and a beveled or conical outer end face 38. A bolt 39 is threaded into the bore 37, and has a head 40 with a conical face 41 in opposed relation to the face 38. The bolt 39 extends through a bore 42 in a coupling member 43 adapted to be clamped between the sleeve 36 and the head 40. Opposite ends of the bore 42 are formed with conical faces 44 and 45 complemental to and adapted for fluid-tight engagement respectively with the faces 38 and 41 when the bolt 39 is tightened.

The bolt 39 is formed with an axial bore 46 open at the inner end to the passage 22, and opening at the other end through radial ports 47 to the bore 42. An annular groove 48 in the bore 42 is connected through a port 49 to the interior of a tubular projection 50 on the coupling member 43 in which the pressure tube 6 is tightly secured.

In operation, the spring 12 normally seats the valve 5 with a force determining the desired valve opening pressure. When this pressure is attained during the working stroke of the pump piston 4, the valve 5 will open, and fuel will be supplied at a high injection pressure to the nozzle. In the return stroke of the piston 4, the pressure will drop to terminate the injection period. To dissipate or reduce the stored pressure energy in the injection line at the end of each injection period, the closing of the valve 5 is retarded so as to permit the return flow or escape of a small volume of fuel past the valve seat 9 into the pump cylinder 2 before the valve is fully closed. This is accomplished by a dashpot action. During outward movement of the valve plunger 10, the dashpot chamber 35 is filled with fuel entering through the clearances 29 and 30. During closing movement, the spring 12 acts on the plunger 10 to maintain the fuel in the chamber 35 under considerable pressure, and the magnitude of this pressure is determined by the ratio of the differential areas of the collars 27 and 28. Consequently, the valve 5 will close at a rate determined by the escape of fuel from the chamber 35 through the clearances or orifices 29 and 30.

The valve 5 lends itself, through selective dimensioning, to control of the closing period in accordance with the operating characteristics desired. The pressure of injection, and hence the stored pressure energy in the system at the end of injection will increase upon an increase in the rate or quantity of injection due to the compressibility of the fuel. Usually, the valve closing period is determined to relieve the maximum stored pressure energy that is attained over the operating range.

By selective proportioning of the maximum valve lift, the spring rate, the valve seat diameter, and the restrictive flow area of the orifices 29 and 30, the degree of valve lift can be caused to vary with the rate and quantity of injection from minimum to maximum, so as to vary correspondingly the duration of the valve closing period.

Ordinarily, the pressure in the dashpot chamber 35 is induced only by the action of the spring 12. However, the force tending to close the valve can be increased by restricting the flow area of the passage 21 so as to cause a pressure drop therethrough. In this event, the flow area of the orifice 29 preferably is held to a minimum, while that of the orifice 30 is suitably increased. During the valve closing movement, the pressure acting on the area of the collar 28 will then be higher than the opposing pressure acting on the area of the collar 27, thus increasing the pressure in the dashpot chamber 35. As a result, the residual pressure in the line is caused to vary directly in accordance with the rate and quantity of injection.

It will be evident that I have provided a valve of the pressure reduction type which serves to prevent the trapping of highly compressed fluid in the injection line simply by delaying slightly the closing of the valve. By relieving the residuual pressure after injection, the nozzle will close quickly, and the after-injection and the nozzle leakage will be avoided. Partial cavitation will also be avoided. Since the line is always filled with fuel, sudden changes in pump delivery will not result in troublesome irregularities in the engine torque curve.

I claim as my invention:

1. A check valve for controlling the supply of liquid fuel from a jerk-type pump into a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a reciprocable valve member normally urged by spring pressure into engagement with said seat and being adapted to lift in response to a predetermined pressure in said inlet passage and to close upon relief of said pressure, a differential dashpot chamber, a differential piston disposed in said chamber and movable with said valve member in response to said spring pressure, opposite ends of said piston having peripheral clearances with said chamber to provide restricted inlet and egress orifices open to said outlet passage, said piston acting to maintain fuel in said chamber under pressure during the closing movement of said valve member.

2. A check valve for controlling the supply of fuel from a jerk-type pump into a fuel injection

line, said valve comprising, in combination, a body, a stationary valve member in said body and having an inlet passage with a valve seat, an axial sleeve on said valve member formed with a differential bore having pilot guides of different diameters at opposite ends, a retainer threaded into said body to confine said valve member in position and having an axial bore loosely encircling said sleeve and communicating with an outlet passage, said sleeve having radial ports opening from the inner end of said first mentioned bore to an annular passage defined between said sleeve and said retainer, a differential plunger reciprocable in said differential bore and having a valve member on one end adapted for engagement with said seat, pistons on opposite ends of said plunger and reciprocable in said pilot guides and defining therewith intermediate clearances constituting restricted inlet and egress orifices, said differential bore intermediate said pistons constituting a dashpot chamber, and spring means acting on the large end of said plunger in a direction to close said valve member against the resistance of the pressure induced in said chamber.

3. A check valve for controlling the supply of fuel from a jerk-type pump into a fuel injection line, said valve comprising, in combination, a body, a stationary valve member in said body and having an inlet passage with a valve seat and formed with a differential bore having pilot guides of different diameters at opposite ends, a housing having an axial bore loosely encircling said stationary valve member and communicating with an outlet passage, said stationary valve member having radial ports opening from the inner end of said first mentioned bore to an annular passage defined between said stationary valve member and said housing, a differential plunger reciprocable in said differential bore and having a valve member on one end adapted for engagement with said seat, pistons on opposite ends of said plunger and reciprocable in said pilot guides and defining therewith intermediate clearances constituting restricted inlet and egress orifices, said differential bore intermediate said pistons constituting a dashpot chamber, and spring means acting on said plunger in a direction to close said valve member against the resistance of the pressure induced in said chamber.

4. A check valve for controlling the supply of liquid fuel from a jerk-type pump through a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a passageway in said member providing communication between said inlet and outlet passages, a dashpot chamber located within said stationary valve member at the outlet side of said valve seat and opening at opposite ends respectively to said passageway, a dashpot piston reciprocable in said chamber, a valve member movable with said piston and adapted for engagement with said valve seat, and spring means normally urging said valve member toward said valve seat, the opposite ends of said piston respectively presenting unequal pressure areas and coacting with the opposite ends of said chamber to define inlet and egress openings.

5. A check valve for controlling the supply of liquid fuel from a jerk-type pump through a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a passageway in said member providing communication between said inlet and outlet passages, a dashpot chamber located within said stationary valve member at the outlet side of said valve seat and opening at opposite ends respectively to said passageway, a dashpot piston reciprocable in said chamber, a valve member movable with said piston and adapted for engagement with said valve seat, and spring means normally urging said valve member toward said valve seat, the opposite ends of said piston respectively presenting unequal pressure areas and coacting with the opposite ends of said chamber to define inlet and egress openings, said passageway having a restricted flow area at a point between said opposite ends of said chamber.

6. A check valve for controlling the supply of liquid fuel from a jerk-type pump through a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, means defining a differential dashpot cylinder having a large end and a small end opening into said outlet passage, a differential plunger in said cylinder and having relatively large and small pistons on opposite ends thereof reciprocably disposed respectively in the large and small ends of said cylinder, the space within said cylinder between said pistons defining a dashpot chamber opening to said outlet passage to permit the restricted inlet and egress of fluid, a valve member movable with said piston and adapted for engagement with said valve seat, and spring means acting on said plunger for normally urging said valve member toward and into engagement with said valve seat, said large piston in response to the pressure in said outlet passage tending to move into said cylinder in opposition to the pressure in said outlet passage acting on said small piston in the closing movement of said valve member.

7. A check valve for controlling the supply of liquid fuel from a jerk-type pump into a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a reciprocable valve member in said outlet passage normally urged by spring pressure into engagement with said seat and being adapted to lift in response to a predetermined pressure in said inlet passage and to close upon relief of said pressure, a differential dashpot chamber fixed in said outlet passage and having restricted communication with said outlet passage for the inlet and egress to and from said chamber of fuel respectively in the opening and closing movements of said valve member, and a differential piston disposed for reciprocation in said chamber and movable with said valve member, the opposite ends of said piston presenting external and face areas of unequal size exposed at spaced points to the pressure in said outlet passage, and the large end of said piston being movable into said chamber to expel fluid therefrom during the closing movement of said valve member, whereby to retard said movement.

8. A check valve for controlling the supply of liquid fuel from a jerk-type pump into a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a reciprocable valve member in said outlet passage normally urged by spring pressure into engagement with said seat and being adapted to lift in response to a predetermined pressure in said inlet passage and to close upon relief of said pressure, a differential dashpot chamber fixed in said outlet passage and having restricted communication with said outlet passage for the inlet and egress to and from said chamber of fuel respectively in the opening and closing movements of said valve member, and a differential piston disposed for reciprocation in said chamber and movable with said valve member, the opposite ends of said piston presenting external end face areas of unequal size exposed at spaced points to the pressure in said outlet passage, said outlet passage intermediate said spaced points being restricted to effect a pressure drop upon the flow of fuel therethrough, and the large end of said piston being movable into said chamber to expel fluid therefrom during the closing movement of said valve member, whereby to retard said movement.

9. A check valve for controlling the supply of liquid fuel from a jerk-type pump into a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a reciprocable valve member in said outlet passage normally urged by spring pressure into engagement with said seat and being adapted to lift in response to a predetermined pressure in said inlet passage and to close upon relief of said pressure, a differential dashpot chamber fixed in said outlet passage and having restricted communication with said outlet passage for the inlet and egress to and from said chamber of fuel respectively in the opening and closing movements of said valve member, and a differential piston disposed for reciprocation in said chamber and movable with said valve member, with the small end of said piston located adjacent said valve seat and the large end of said piston located remote from said valve seat, the opposite ends of said piston presenting external end face areas of unequal size exposed at spaced points to the pressure in said outlet passage, and the large end of said piston being movable into said chamber to expel fluid therefrom during the closing movement of said valve member, whereby to retard said movement.

10. A check valve for controlling the supply of liquid fuel from a jerk-type pump into a fuel injection line, said valve comprising, in combination, a stationary valve member having an inlet passage with an annular valve seat adapted for connection to said pump and having an outlet passage adapted for connection to said line, a reciprocable valve member normally urged by spring pressure into engagement with said seat and being adapted to lift in response to a predetermined pressure in said inlet passage and to close upon relief of said pressure, a differential dashpot chamber, a differential piston disposed in said chamber and movable with said valve member in response to said spring pressure with the small end of said piston located adjacent said valve seat and the large end of said piston located remote from said valve seat, opposite ends of said piston having peripheral clearances with said chamber to provide restricted inlet and egress orifices located at spaced points to said outlet passage, the clearance about said small end of said piston being more restricted than the clearance about said large end of said piston, said outlet passage intermediate said spaced points being restricted to effect a pressure drop upon the flow of fuel therethrough, said piston acting to maintain fuel in said chamber under pressure during the closing movement of said valve member.

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