United States Patent

Tateishi

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[54] **FUEL INJECTION PUMP CONSTRUCTION**

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[52] **U.S. Cl.** **417/296,** 417/458, 417/501

[51] **Int. Cl.** **F04b 49/00,** F04b 21/02

[58] **Field of Search**.....417/293, 296, 456, 458, 501, 417/569, 571; 123/139 PP

[56] **References Cited**

UNITED STATES PATENTS

2,918,048	12/1959	Aldinger et al.	417/296
2,953,992	9/1960	Bartholomaus et al.	417/501
2,888,876	6/1959	Nichols	417/458
2,922,581	1/1960	Gardy	417/569
1,974,851	9/1934	Hurst	417/296
2,612,841	10/1952	Lasley	123/139 OP
3,195,465	7/1965	Hug	417/296

FOREIGN PATENTS OR APPLICATIONS

860,316	9/1940	France	417/569

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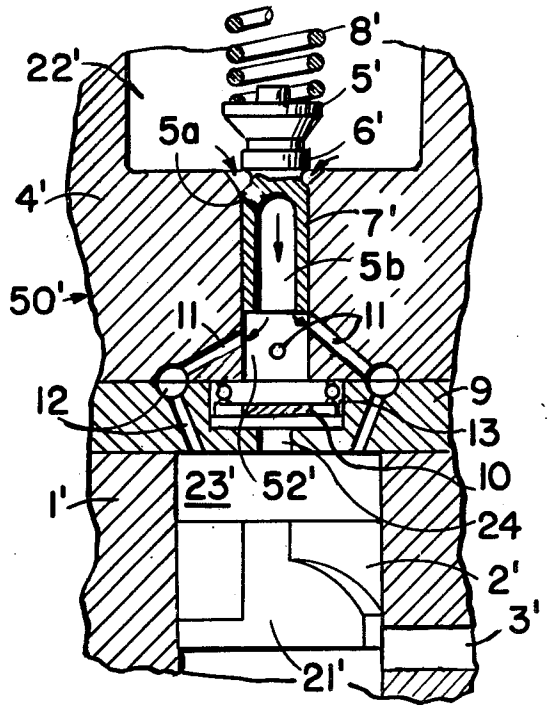
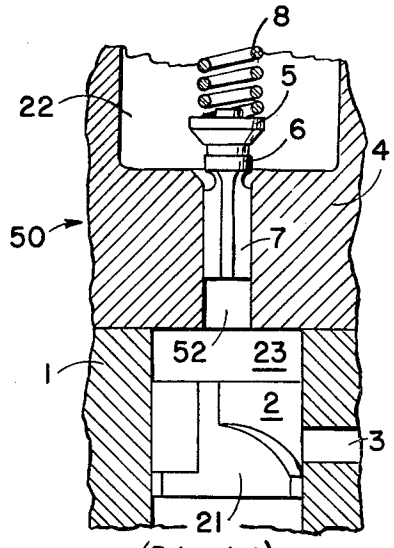
[57] **ABSTRACT**

A fuel injection pump includes a fuel pump plunger which is movable to direct the fuel under pressure through a passage which is regulated by a delivery valve. The delivery valve includes a collar portion which, upon the return movement of the delivery valve, causes a sucking back or unloading action on the fuel in a direction toward the pump plunger chamber. The invention provides means for varying the fuel flow area in the return direction of movement of the delivery valve in accordance with the lift of the delivery valve during its operative opening movement. In one arrangement the delivery valve is constructed to close one or more escape ports during its downward return movement for slowing the return flow of the fuel to the plunger chamber and in another embodiment the delivery valve includes an end portion which provides a variable throttling action on a port communicating with the delivery valve passage and the pump plunger chamber.

4 Claims, 6 Drawing Figures





(Prior Art)

FIG. 1

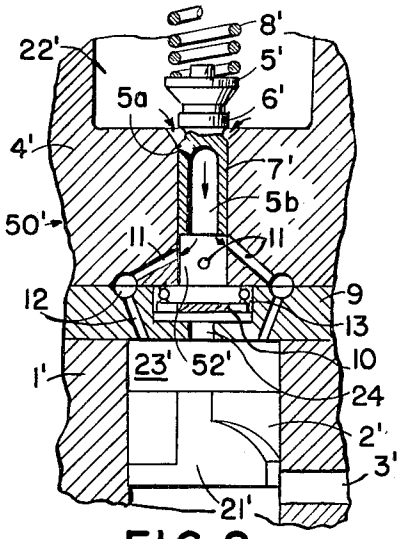


FIG. 2

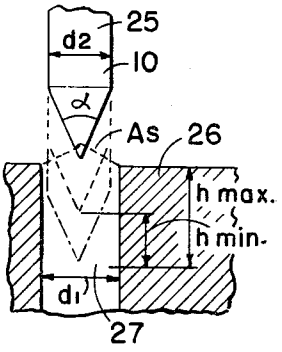


FIG. 4

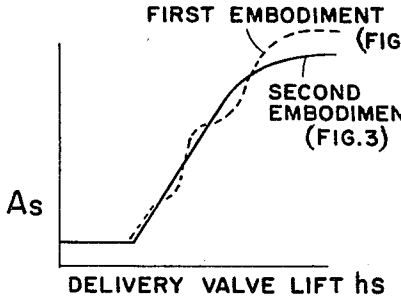


FIG. 5

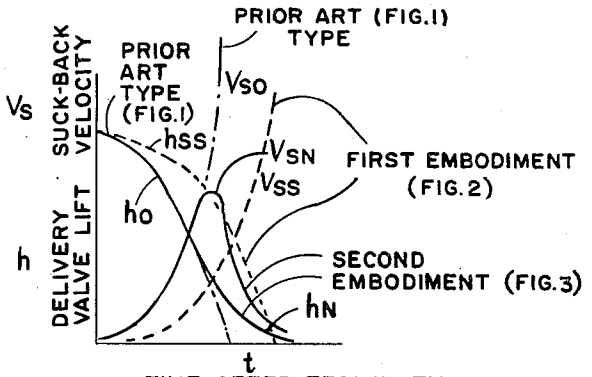
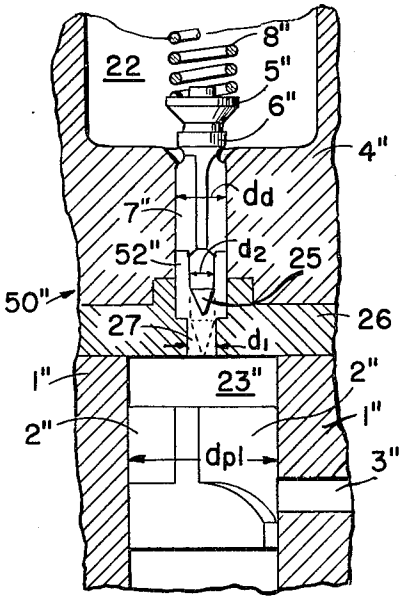


FIG. 6

FIG. 3



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FUEL INJECTION PUMP CONSTRUCTION

SUMMARY OF THE INVENTION

This invention relates in general to the construction of fuel injection pumps and in particular, to a new and useful arrangement of fuel injection pump wherein the pump is discharged through a delivery passage which is controlled by a delivery valve and which includes means for regulating the backward movement of the delivery valve, after delivery of the fuel, in accordance with the amount of movement of the valve in the pumping stroke.

The present invention is particularly concerned with the prevention of the generation of a secondary injection in a fuel injection system during the operation of a fuel injection pump. With the prior art construction, the delivery valves which are opened against spring pressure during the pumping stroke of the plunger move in a return direction through a delivery valve passage and tend to cause a sucking back of the fuel through this passage. A collar formation (or piston) on the valve causes the pressure in the delivery valve chamber to reduce positively so that when the pressure wave which is returned from the nozzle or fuel injection valve side of the fuel injection system is reflected back at the pumping chamber it is propagated to the nozzle or the fuel injection valve side with a reduced pressure. A disadvantage of the constructions of such pump is that:

1. The suck-back (or unloading) fuel velocity cannot be controlled freely and it has a tendency of being slow initially and fast finally.
2. The suck-back period cannot be controlled and generally it is a short period.
3. Although the secondary injection has been prevented to a certain extent the secondary injection is still generated in the case of a high velocity high pressure injection.
4. If the amount of fuel to be sucked back is increased, the suck-back velocity becomes too high and thus a vacuum (or void) is produced in the injection system which results in an uneven injection.

In accordance with the present invention, there is provided a fuel injection pump which does not have the disadvantages of the prior art and which includes a delivery valve which moves backwardly during a return stroke and which is constructed and arranged in such a manner that the flow area of the fuel moving ahead of it on the return movement may be varied in accordance with the amount of lift of the valve during the fuel delivery portion of the stroke. The construction includes means for providing an escape path between the delivery valve chamber and the plunger chamber. In one embodiment this comprises an arrangement of the valve to close one or more escape ports for the fuel which lead to the plunger chamber from the delivery chamber. The member of ports closed and their rate of closing will depend upon the amount of lift of the valve during its upward fuel delivery movement. In another embodiment the valve is provided with means for varying the flow area between the delivery valve passage and the plunger chamber during its return movement and independence upon the amount of upward lift movement. By controlling the cross sectional area of the escape passages from the delivery valve chamber to the plunger chamber in accordance with the amount of lift of the delivery valve the invention ensures that there will be no secondary injections and there will be no passing of gas in a combustion chamber into the fuel injection system through the fuel valve and this results in a remarkable advantage in the use of the device for diesel, gasoline and piston engines.

Accordingly, it is an object of the invention to provide an improved fuel injection pump which includes a delivery valve arranged in a delivery valve passage between the pump plunger chamber and the fuel delivery line and with means associated with the valve for regulating the back flow area from the delivery valve chamber to the pump plunger chamber in accordance with the amount of lift of the valve.

A further object of the invention is to provide a fuel injection device which includes a delivery valve passage extending from a plunger passage chamber and which includes a delivery valve member therein having a collar formation (or piston) at its delivery end and which includes a body movable in the delivery valve chamber in an opening direction against biasing means such as a spring and in a closing direction to successively close one or more escape ports for the fuel which provide a connection for by-passing the fuel backwardly into the plunger chamber.

A further object of the invention is to provide a fuel injection device which includes a delivery valve having an end portion which engages with a constricted passage portion of the delivery valve passage during the return movement of the valve for regulating the flow from the passage to the plunger chamber of the injection device in accordance with the amount of lift of the valve.

A further object of the invention is to provide a fuel injection pump which is simple in design, rugged in construction, and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a partial sectional view of a portion of a fuel injection pump constructed in accordance with the prior art;

FIG. **2** is a view similar to FIG. **1** but of a construction of a first embodiment of the present invention;

FIG. **3** is a view similar to FIG. **2** of another embodiment of the invention; and

FIG. **4** is an enlarged view of a portion of the apparatus indicated in FIG. **3**;

FIG. **5** is a diagram showing the relation between the cross sectional area of the escape ports and the delivery valve lift; and

FIG. **6** is a diagram showing the relationship of the suck-back (or unloading) velocity and the delivery valve lift in respect to time after the termination of pump delivery.

PRIOR ART

Referring to FIG. 1 of the drawings, a fuel injection pump generally designated **50** of the construction of the prior art includes a plunger barrel **1** defining a plunger chamber **23** in which is movable a plunger barrel or pump plunger **2**. An oil feed and exhaust conduit **3** is defined in the barrel **1** and communicates during the operation of the plunger through a plunger notch portion **21** with the chamber **23**.

The plunger chamber **23** communicates with a delivery chamber **52** formed in a guide member **4** over the plunger barrel **1**. A delivery valve **5** is movable within the passage **52** and it is biased by a spring **8** in a closing direction toward the plunger chamber **23**. A delivery chamber **22** is in communication with the delivery passage **52** during the upward movement of the plunger **2** and the delivery valve **5**. The delivery valve **5** includes a collar portion **6** adjacent its delivery end and a guide rod portion **7** which rides in the passage **52**.

With a pump of a type of the prior art as indicated in FIG. **1**, when the notched portion **21** of the plunger **2** aligns with the oil exhaust port **3** and the port is thus opened, regardless of the rising motion of the plunger **2** the delivery by the fuel pump is terminated and the fuel oil flows backwardly from the delivery valve chamber **22** into the passage **52** and into the plunger chamber **23**. At this time the suck-back collar (or unloading piston) portion **6** of the delivery valve **5** is engaged with the guide member **7** then the pumping effect of the collar causes the pressure in the delivery valve chamber **22** to reduce positively so that when the pressure wave returned from the nozzle side is reflected at the pump it is propogated to the nozzle side with a reduced pressure. Therefore, the pump operates in a manner preventing the injection caused by the reflected wave after termination of the pump delivery (the secondary injection). But a pump of this type has the disadvantages which have already been mentioned herein.

GENERAL DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, in particular, the invention embodied therein in FIG. **2**, comprises a first embodiment of fuel pump generally designated **50'** which includes a plunger barrel **1'** defining a plunger chamber **23'** in which a plunger **2'** is movable. A delivery valve **5'** is biased by a spring **8'** in a direction toward the chamber **23'** and it is movable in a delivery passage or chamber **52'**.

In accordance with the invention, means are associated with the delivery valve **5'** for regulating the return flow of the fuel from the delivery passage **52'** to the plunger chamber **23'**. In the embodiment of FIG. **2**, this comprises a check valve seat member **9** which is interposed between the guide member **4'** and the plunger barrel **1'**. A check valve member **10** is arranged to close a passage **24** from the delivery chamber **52'** to the pump chamber **23'**. A spring **13** is arranged to bias the valve member **10** into a closing position. A plurality of escape ports **11** are defined along the chamber **52'** and these communicate with annular passages **12** which form a by-pass for the fuel from the chamber **52'** back to the pump chamber **23'**. The escape ports **11** are advantageously bored in multiple stages and they have different diameters and they are arranged at vertically spaced locations along the height of the delivery chamber **52'**.

The operation of the pump indicated in FIG. **2** is as follows:

When the plunger **2'** terminates the delivery of the fuel, such as when the notched portion **21'** communicates with the exhaust port **3'**, the delivery valve **5'** moves backwardly so that the collar **6'** produces a suction effect on the fuel in the delivery chamber **22'** to cause it to flow in the direction of the arrows through one or more ports **5a** into the center **5b** of the delivery valve rod portion or stem **7'** and into the chamber **52'** ahead of the valve **5'**. The passage **24** is closed by the check valve **10** during this reversal movement of the delivery valve **5'** therefore the oil passage through the escape (or by-pass) ports **11** and the annular passages **12** into the plunger chamber **23** simultaneously with the counterflow of the fuel the delivery valve **5'** is lowered and when the collar portion **6'** is engaged with the guide portion or delivery chamber **52'** the flow of the oil from the delivery valve chamber **22** to the plunger chamber **23** stops. This results in an expansion of the oil in the delivery valve chamber corresponding to the amount of descent of the delivery valve **5'**. Because of the arrangement of the escape ports **11**, however, so that they become successively closed during the downward movement of the delivery valve **5'** the flow of the fuel ahead of the delivery valve **5'** through the by-pass passages **12** become gradually lessened until only the lower most port **11** is still open. This means that the flow area for the fuel varies in accordance with the amount of lift of the delivery valve **5'** to uncover a corresponding number of escape ports **11**. The cross sectional area of the escape ports varies in a vertical direction, for example, the largest areas are uppermost so that they are cut off first during the descending movement of the valve **5'**. This means that the descending velocity of the delivery valve **5** may be controlled in accordance with the variation of the cross sectional area of the escape portion **11** in a manner shown graphically in FIG. **5**. Thus, according to the invention, when the delivery valve is moved upwardly during the discharge of the fuel by the plunger **1'** through the passage **52'** the number of ports **11** which are opened depends on the amount of upward movement of the valve **5'** the greatest number of ports **11** are open and in a lower position, the least number of ports or no ports are opened. This reducing of the number of escape ports enhances the choke effect on the movement of the valve and thereby the descending velocity of the delivery valve is limited.

Referring to FIG. **6** of the drawings, the inventive construction is compared with the prior art. In general in the case of the prior art pumps the suck-back velocity is expected to become greater, the greater the time which has elapsed, as shown in the curved Vso. However, according to the present invention it is limited up to a certain suck-back velocity as shown by the curved V_{SN} and also the suck-back period can be prolonged. In the same Figure curves h_{ss} and V_{ss} represent the lift of the delivery valve and the suck back velocity respectively. These curves are applicable in the case where only one escape port is employed where the sucked back period can be prolonged but the

suck-back velocity cannot be controlled with respect to the lift of the delivery valve or the time after termination of the pump delivery.

In the embodiment of the invention indicated in FIG. 3, there is provided a fuel injection pump generally designated **50''** which includes parts which are similarly designated to those of FIGS. **2** but with a double prime. In this second embodiment, the principle of operation is the same as that of the first embodiment shown in FIG. **2**, but the flow area is varied by means of a conical extension **25** formed on the rod portion **7''** of the delivery valve **5''**. For this purpose an intermediate member **26** is provided between the delivery valve member **4''** and the barrel **1''** and this member defines a passageway **27** which defines a variable flow area from the delivery valve chamber **52'** to the plunger chamber or pump chamber **23''**. The pointed valve member **25** is movable with the delivery valve **5''** between the solid line position shown in the drawings to the dotted line position at which the passage **27** is throttled down to its lowest flow area. The movement and operation of the delivery valve **5''** is the same as that of the embodiment of FIG. **2**, and during the return movement the member **25** is moved from the solid line position at which the passage **27** is fully opened to the dotted line position at which it is substantially closed. In FIG. **4**, the various end positions and single intermediate position of the member **25** are indicated with greater detail. The maximum flow area is indicated by A_s and this corresponds to the maximum height *h* max. of the delivery valve **5**. The minimum position of the delivery valve *h* min. may be the intermediate dotted line position indicated if desired or a lower position.

What is claimed is:

1. A fuel injection pump, comprising a body defining a plunger chamber with a discharge end, a valve delivery passage having one end connected into the discharge end of said plunger chamber and having an opposite delivery chamber end, said body defining a delivery chamber connected to said delivery chamber end of said delivery passage, a delivery valve having a stem portion movable in said delivery passage and a valve head portion with an intermediate collar of substantially the same diameter as the diameter of said delivery passage and being movable toward and away from the delivery chamber end of the passage, plunger movable in said plunger chamber to move fluid therein through said valve delivery passage and into said delivery chamber and to move said valve portion away from the delivery chamber end of said passage, said valve head portion and said collar being movable with said stem portion in an opposite return direction toward said plunger chamber, flow control means associated with said delivery valve for controlling the descending velocity of said delivery valve and for varying the flow area from said valve delivery passage to said plunger chamber end ahead of said valve stem portion in the return movement thereof in accordance with the lift of said delivery valve during the operational stroke of said plunger, said flow area being less than the area of said collar, a check flow passage defined between said delivery passage and said plunger chamber, and check valve means associated with said passage for closing said passage against return flow in a direction from said delivery valve passage to said plunger chamber, said means associated with said delivery valve for varying the flow area comprising at least one bypass passage extending from said delivery passage to said plunger chamber and being openable by movement of said delivery valve.

2. A fuel injection pump, according to claim **1**, wherein said means for varying the flow area from said valve delivery passage to said plunger chamber comprises a plurality of separate escape passages extending from said plunger chamber to said delivery passage, each of said escape passages terminating in a separate port in said delivery passage, said ports being spaced vertically along said delivery passage and being coverable by said valve stem portion during its return movement toward said plunger chamber.

3. A fuel injection pump, according to claim **2**, wherein said ports are of different sizes.

4. A fuel injection pump, according to claim **2**, wherein said ports and said passages define different flow areas, said port having the greatest flow area being located uppermost in said valve delivery passage.

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