

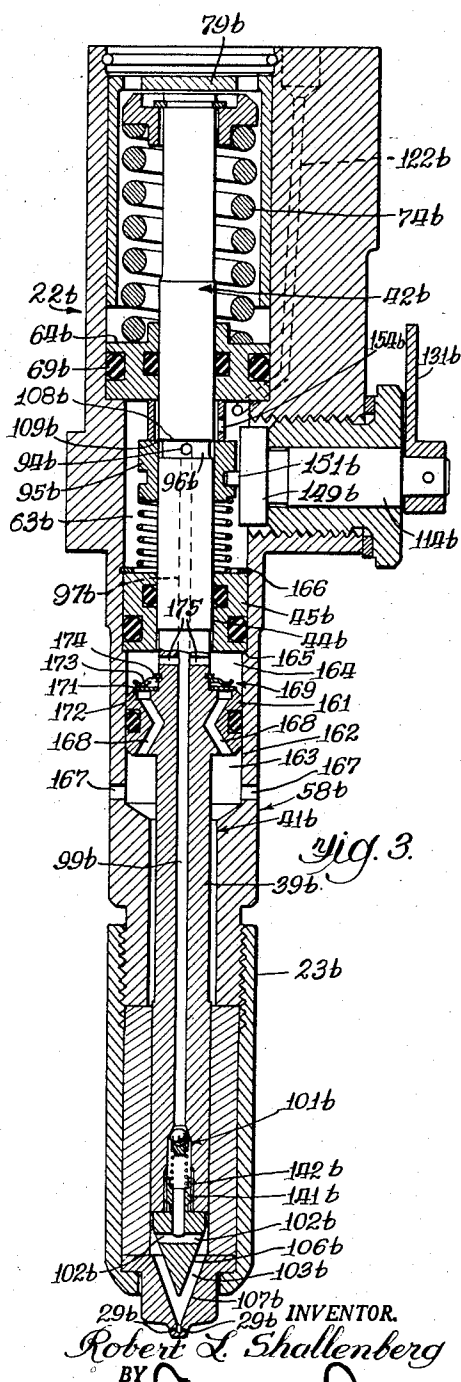
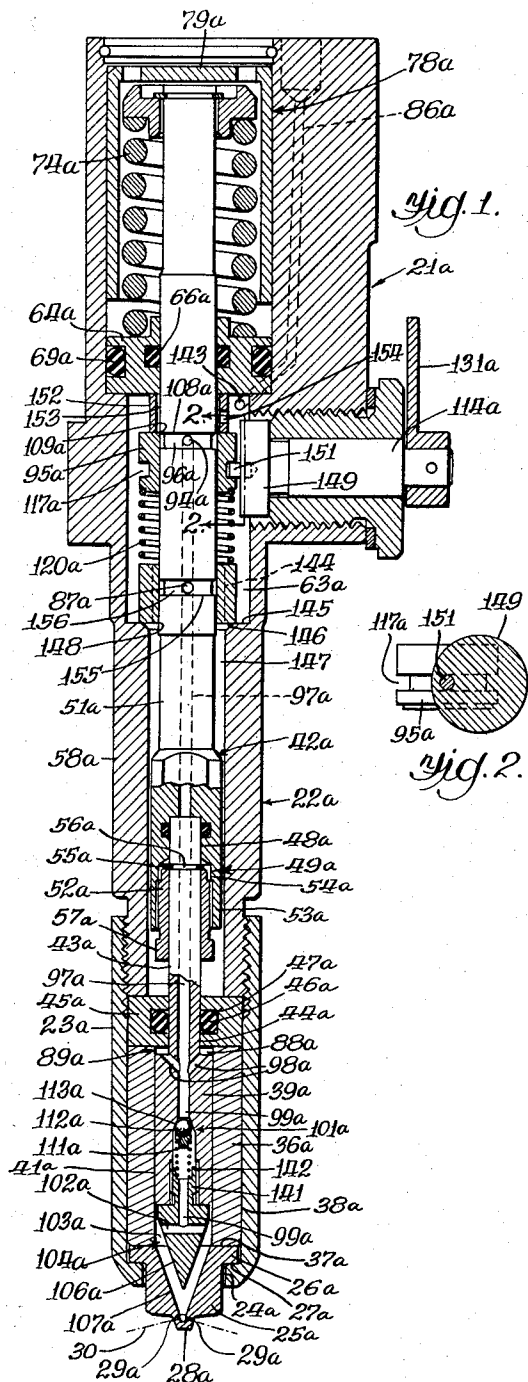
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FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

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## FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

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Original application July 3, 1953, Serial No. 365,901, now Patent No. 2,792,259, dated May 14, 1957. Divided and this application February 21, 1957, Serial No. 641,697

3 Claims. (Cl. 299—107.2)

This invention concerns liquid fuel injection nozzles for internal combustion engines and more particularly relates to such a nozzle incorporated into a unitary structure with a fuel metering pump therefor.

This application is a division of my co-pending application Serial No. 365,901, filed July 3, 1953, now Patent No. 2,792,259.

A principal object of this invention is the provision of a fuel metering and injection nozzle unit of simplified structure utilizing an arrangement wherein the fuel is metered at low pressure prior to being subjected to the relatively high injection pressure. Metering therefore can be accomplished during a longer time interval which is conducive to accuracy. This low pressure metering system also prolongs the useful service period of the unit since no metering surfaces of concentrated area are subjected to the erosion of rapidly flowing fuel under extremely high pressure.

A further object is the provision of an improved fuel metering and injection nozzle unit wherein the fuel pressure during metering is independent of the injection pressure, wherefore the injection pressure can be made as high as desired.

Another object is the provision of a fuel metering and injection nozzle unit settable to adapt low pressure flow of fuel therethrough to scavenge air from the fuel receiving passages and cavities thereof and thus efficiently prime the system for immediate starting of the engine with initial cranking.

The above and other desirable objects inherent in and encompassed by the invention are elucidated in the ensuing specification, the appended claims and the appended drawings, wherein:

Fig. 1 is a longitudinal sectional view taken through a preferred embodiment of the invention;

Fig. 2 is a fragmentary sectional view taken at the plane indicated at the line 2—2 in Fig. 1 to illustrate details of a control mechanism for a fuel metering element of the unit;

Fig. 3 is a longitudinal sectional view taken similarly to Fig. 1 through a second embodiment of the invention.

### Description of Figs. 1 and 2 embodiment

With continued reference to the drawings and particularly to Figs. 1 and 2, a fuel metering and injection nozzle unit 21a is shown having an elongated fabricated tubular body 22a. An outer shell-like element 23a comprises part of the lower portion of the tubular body 22a. This shell 23a has an opening 24a in its lower end. A nozzle member 25a, inserted through the upper open end of the shell 23 has a flange 26a which abuts against an inner face 27a of the lower end of the shell 23a while the main portion of the nozzle member projects outwardly through the opening 24a. A tip portion 28a of the nozzle element 25a contains a plurality of discharge orifices 29a adapted to spray fuel in the form of atomized jets along respectively associated median lines 30, Fig. 1, into the upper part of a combustion chamber (not shown).

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A cylindrical element 36a of the elongated tubular body 22a has a flat annular lower end 37a which rests in sealed abutting relation upon the upper flat face of the nozzle element flange 26a. This cylindrical element 36a is telescoped downwardly into the inner bore 38a of the shell 23a after insertion of the nozzle element 25a into such shell. The annular lower end face 37a of the cylinder 36a and the face with which it abuts upon the flange 26a are lapped to effect a high degree of smoothness of these surfaces to eliminate leakage of fluid therebetween. A pump plunger or plunger structure 39a is inserted downwardly into a plunger receiving bore 41a formed by the inner periphery of the cylindrical element 36a. A fabricated stem or operating rod 42a for this plunger 39a has a stem portion 43a formed integrally with the plunger and projecting axially upwardly therefrom through a cylindrical bearing 44a of a disk-like element 45a which forms an upper end for the plunger receiving bore 41a. A sealing O-ring 46a disposed within an annular groove 37a of the element 45a is compressed between the side wall of such groove and the outer periphery of the stem 43a to supplement the sealing character of the bearing 44a with the stem. The lower end face of the element 45a and the upper annular end face of the cylindrical element 36a in abutment therewith are also lapped whereby they fit together in essentially perfect conformity to prevent leakage of fluid between these abutting surfaces.

An upper end portion of the stem 43a projects into a small diameter portion 48a of a recess 49a in the lower end of a push rod element 51a of the fabricated stem and operating rod 42a. The rod 51a is connected with the stem 43a by means of an externally threaded sleeve nut 52a turned into an internally threaded portion 53a in a large diameter lower portion 54a of the recess 49a. The upper end of this sleeve nut presses against a small snap ring 55a mounted within an annular groove 56a circumscribing the stem 43a. A lower end portion 57a of the sleeve nut 52a has circumferentially arranged wrench-engaging facets (not shown) facilitating the turning of this nut for firmly advancing it endwise into the threaded recess 49a.

In the first embodiment of the invention, the fuel transfer passage 99a is formed within the pump plunger 39a as distinguished from within the cylindrical element 36a. This fuel transfer passage 99a is an axially extension of a bore 97a which constitutes a combined fuel inlet and spill passage means within the fabricated stem and operating rod structure 42a. The conical lower end portion 106a of the plunger 39a is formed separately from the main part of such plunger and has a stem portion 141 screwed into a threaded recess 142 in the lower end of the plunger. A portion of the transfer passage 99a is formed within the conical lower end portion of the plunger where such passage communicates with the fuel delivery chamber 103a through ports 102a. A check valve 101a within the transfer passage 99a comprises a ball 112a urged against a seat 113a therefor by a spring 111a of sufficient strength to require fluid pressure of approximately 100 lbs. per square inch in the upper part of the transfer passage to unseat the ball.

Liquid fuel is forced into the unit under a relatively low constant pressure, 25 lbs. per square inch, for example, through a fuel inlet channel means 86a which communicates with a combined fuel inlet and spill cavity 63a through a port 143. A short cylindrical fuel blocking element 144 of hexagonal or other suitable exterior faceted formation rests upon a shoulder 145 in the tubular body part 58a and because of the faceted outer periphery of this element 144 communication providing spaces 146 are formed between the lower end of this

element and the shoulder 145 enabling fuel to flow downwardly through these spaces from the cavity 63a into a space 147 below a fuel blocking control edge 148 of the element 144.

The axial position of the fuel metering element 95a is determined by a control rockshaft 114a having a manual or governor actuated arm 131a constrained for rocking with its outer end. The inner end of the shaft 114a has a circular head 149 having an operating pin 151 mounted therein eccentrically with respect to the axis of the shaft 114a. This pin projects into a circumferential groove 117a of the metering element 95a and is thus effective for raising or lowering said element 95a when the rockshaft 114a is rocked. A spring 120a reacts downwardly on the blocking element 144 and upwardly on the metering element 95a. A spacer sleeve 152 surrounding the valve stem and operating rod structure 42a is mounted upon the lower end of the annular sealing element 64a and thus establishes an upper limit for the movement of the fuel metering element 95a. O-rings 66a and 69a are associated with the sealing element 64a. An annular clearance space 153 is provided between the spacer sleeve 152 and the valve stem and operating rod structure 42a and this clearance space communicates with the spill cavity 63a through any desired number of openings 154 in the spacer element.

#### *Operation of the Figs. 1 and 2 embodiment*

The plunger stem and operating rod structure 42a of this first embodiment is operated alternately in opposite endwise directions by a rocker arm (not shown) pressable downwardly on the crown 79a of a spring cap 78a and by the spring 74a. It will be assumed that the plunger stem and operating rod 42a is being advanced downwardly under the force of rocker arm pressure applied to the upper end wall or crown 79a of the spring cup 78a. During this rapid downward movement of the stem and rod structure 42a the pump plunger 39a is forced downwardly to expel air-entrained liquid fuel from the fuel delivery chamber 103a outwardly through the fuel discharge orifices 29a in the nozzle tip 28a. While the conical lower end 106a of the plunger is upon or adjacent to the conical lower periphery 107a of the fuel delivery chamber, the lower edge 155 of a fuel inlet groove or annulus 156 circumscribing the plunger stem and operating rod 42a will be disposed slightly below the lower control edge 148 of the fuel blocking element 144 wherewith fuel under a constant low pressure within the space 147 is forced into the annulus 156 and through the fuel inlet port 87a into the combined fuel inlet and spill passage in 97a. At this time the fuel spill groove or annulus 96a will be masked by the fuel metering element 95a wherefore the fuel entering the passage 97a through the inlet annulus 156 and port 87a can flow only downwardly through such passage 97a and through the laterals 93a thereof into the expanded chamber 88a of the metering pump 89a.

On the ensuing upward retractive stroke of the plunger, initial contraction of the pumping chamber 88a causes a back surge of fluid upwardly through the passage 97a and outwardly through the inlet annulus 156 until the lower edge 155 of this annulus moves upwardly into registry with the lower annular control edge 148 of the fuel blocking element 144. When such registration occurs both the annuluses 156 and 96a will be masked respectively by the elements 144 and 95a so that continued retractive movement of the plunger develops sufficient pressure, approximately 100 lbs. per square inch, within the fuel transfer passage 99a for opening the check valve 101a and forcing fluid through the ports 102a into the fuel delivery chamber 103a. The pumping rate of the fuel metering pump 89a is exceeded by that of the fuel injection pump 104a so that air or hot gas from an associated engine combustion chamber (not

shown) passes through the fuel discharge orifices 29a into the chamber 103a for heating and mixing with the fuel being transferred into this chamber. The transfer of fuel from chamber 88a into chamber 103a continues until the upper metering edge 108a of the spill groove 96a commences to rise above the metering edge 109a of the fuel metering element 95a. When this occurs a wide opening is suddenly formed between the edges 108a and 109a of a considerable curvilinear extent to allow rapid escape of fuel from the metering pump 89a upwardly through the passage 97a, port 94a, groove 96a and ports 154 into the clearance space 153 and outwardly through the openings 154 into the spill cavity 63a. Immediately upon movement of the spill edge 108a above the fuel metering edge 109a the low pressure release thus afforded for fuel pumped by the metering pump 89a will diminish the pressure in the upper part of the fuel transfer passage 99a to result in instantaneous closing of the check valve 101a and termination of the metering period when no more fuel will be delivered into the delivery chamber 103a. Had the metering element 95a been in a lower position the spill edge 108a would have passed registration with the metering edge 109a earlier to correspondingly shorten the effective metering stroke and cause a correspondingly smaller quantity of fuel to be metered and transferred into the delivery chamber 103a. This completes the operating cycle as the plunger reaches its upward stroke limit preparatory to being again forced downwardly for ejecting air mixed fuel from the delivery chamber 103a through the fuel discharge orifices 29a.

The fact that this species of the invention provides no coolant cavity in the lower end of the structure, together with the fact that the fuel transfer passage 99a is placed within the plunger instead of within the wall of the tubular casing body 22a makes it possible for the outside diameter of the cylindrical element 36a to be small. As a consequence the shell or casing element 23a has a small outside diameter, thus resulting in an extremely slender unit requiring a relatively small amount of space for the mounting thereof in the head of an engine combustion chamber.

#### *Description of the Fig. 3 embodiment*

This second embodiment of the invention has numerous elements corresponding to respective elements in the first embodiment and to expedite this disclosure these corresponding elements in the second embodiment will be designated by the same respective reference numerals with the suffix "b" substituted for the suffix "a" in the drawing without necessarily repeating them in this description.

In this second embodiment an upper end portion 161 of the plunger 39b is of relatively larger diameter and serves to divide a larger diameter portion 162 of the plunger receiving bore 41b into a lower primary pumping chamber 163 and an upper secondary pumping chamber 164. A bearing element 45b forming the upper end wall for the chamber 164 contains a plunger stem receiving bearing 44b in which a portion of a power drivable pump operating member in the form of a plunger operating stem 42b projecting upwardly from the plunger 39b is in sliding sealing relation. An internal shoulder 165 of the tubular body 22b cooperates with a snap ring 166 in maintaining the bearing element 45b fixed axially of said body.

Fuel inlet ports 167 communicate inwardly through the body with the primary pumping chamber 163. These inlet ports 167 may be connected with a fuel supply through a conventional annular coupling fitting girdling the tubular casing part 58b and having an annular delivery duct registering communicatively with such inlet ports. Communication from the pumping chamber 163 to the secondary pumping chamber 164 is had through fuel conducting passages 168 and past a check valve 169

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comprising an annular wafer element 171 liftable from an upper end face 172 of the valve plunger enlargement 161 against the force of an annular spring element 173 which reacts upwardly against a snap ring 174 mounted on the plunger operating stem 42b.

*Operation of the Fig. 3 embodiment  
of the invention*

It will be assumed that fuel under a modest constant pressure is being maintained in the pumping chamber via the fuel inlet ports 167, and that a rocker arm (not shown) is being operated for forcing plunger-operating stem 42b and the plunger 39b sharply downwardly for ejecting fuel from the fuel delivery chamber 103b outwardly through the orifices 29b. During this descent of the plunger 39b the secondary pumping chamber 164 will be expanding to create a low pressure condition therein less than the pressure in the primary chamber 163 wherefore this pressure differential across the plunger end and portion 161 will cause opening of the check valve 169 and the conduction of fuel from chamber 163 through the passages 168 into the secondary pumping chamber. Therefore, when the conical lower end 106b of the plunger arrives in seating relation with the conical lower end face 107b of the fuel delivery chamber 103b, secondary pumping chamber 164 will contain a charge of liquid fuel. During the ensuing upward retractive stroke of the plunger 39b under the force of the spring 74b fuel within the chamber 164 will be discharged inwardly through stem ports 175 and downwardly through the fuel transfer passage 99b past the check valve 101b and outwardly through the ports 102b into the fuel delivery chamber 103b. During this initial upward movement of the plunger 39b, the fuel discharged from the pumping chamber 164 inwardly through the ports 175 cannot flow upwardly through the spill passage 97b because the spill annulus 96b associated with the spill port 94b is masked by the sleeve-like metering element 95b. The metering period terminates with the arrival of the upper spill edge 108b of the annulus 96b in registry with the upper or metering edge 109b of the metering sleeve 95b. Further upward movement of the plunger to carry the edge 108b above the metering edge 109b enables the fuel to spill from the annulus 96b, thereby reducing the pressure in the fuel transfer passage 99b and permitting the check valve 101b to close. Thereupon no further fuel is transferred into the fuel delivery chamber 103b. Earlier termination of the fuel metering period to cause a smaller quantity of fuel to be metered and transferred into the fuel delivery chamber 103b is accomplished by lowering the metering element 95b whereby the spill edge 108b arrives in registry with the metering edge 109b after a shorter portion of the upward movement of the plunger. Fuel spilled from the spill annulus 96b enters the spill cavity 63b from which it is conducted through a drain passage 122b back to the inlet side of a supply pump (not shown) for maintaining the constant fuel pressure through the inlet ports 167 in the primary pumping chamber 163.

The metered fuel transferred through the passage 99b into the fuel delivery chamber 103b is injected through orifices 29b during the next ensuing downward advancement of the pump plunger.

The lower portion of this unit constituting the second embodiment of this invention, that is, that portion of the unit including shell 23b and the parts embraced thereby are constructed very similarly to the parts embraced by the shell 23a of the first embodiment so that this second embodiment of the invention is also relatively slender for occupying a small space within the head of an engine cylinder. This species of the invention has the advantage over the first embodiment that the plunger 39b and the operating stem 42b therefor are formed integrally, thus

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dispensing with the necessity of a joint structure such as that utilizing the coupling nut 52a of the first embodiment.

Having thus described these two embodiments of the invention with the view of fully, clearly and concisely illustrating the same, I claim:

1. In a combined fuel metering and injection nozzle unit, a body containing a bore with fuel pumping and delivery chambers spaced apart axially therein, a plunger-stem-receiving bearing of less diameter than the portion of said bore having the pumping chamber and extending axially of the bore from such chamber, fuel discharge orifice means communicating outwardly from the fuel delivery chamber, a plunger axially reciprocal in said bore and constituting a partition separating said chambers from one another, a plunger-operating stem of less diameter than the plunger and projecting axially therefrom through the pumping chamber and through said bearing with which such stem is in sliding sealing relation, a fuel inlet channel extending axially in said stem into communication with the pumping chamber, a fuel transfer passage extending axially in the plunger and having ports respectively communicating with said chambers, said plunger being axially retractable into the pumping chamber to displace a metered quantity of fuel therefrom through the transfer passage into the delivery chamber attendant to expanding the delivery chamber to accommodate reception thereby of the metered and transferred fuel, valve means in the transfer passage and preventing reverse flow of the transferred fuel therethrough, and the plunger being axially advanceable into the delivery chamber to eject the metered and transferred fuel therefrom through the discharge orifice means.

2. In a combined fuel metering and injection nozzle unit, a body containing a bore with fuel pumping and delivery chambers spaced apart axially therein, a plunger-stem-receiving bearing of less diameter than the portion of said bore having the pumping chamber and extending axially of the bore from such chamber, fuel discharge orifice means communicating outwardly from the fuel delivery chamber, a plunger axially reciprocal in said bore and constituting a partition separating said chambers from one another, a plunger-operating stem of less diameter than the plunger and projecting axially therefrom through the pumping chamber and through said bearing with which such a stem is in sliding sealing relation, said stem being endwise movable to alternately effect endwise advancement of the plunger into the delivery chamber and retraction thereof into the pumping chamber, a fuel transfer passage extending axially in the plunger communicatively between the chambers, a check valve in said passage to accommodate flow of fuel therein only from the pumping chamber to the delivery chamber, a fuel spill port communicating outwardly through a side portion of the stem beyond the opposite end of said bearing with reference to the plunger, a fuel inlet port also in a side portion of the stem beyond said opposite end of said bearing, fuel inlet and spill passage means extending communicatively from said ports axially through the stem into communication with the pumping chamber, a metering element in masking relation with the spill port and having a metering edge past which the stem moves the spill port during retractive movement of the plunger and stem, a fuel blocking element in masking relation with the fuel inlet port and having a control edge past which the stem moves the inlet port during advancement of the plunger into the delivery chamber to admit fuel through said inlet port and passage means into the pumping chamber, the inlet port being moved retractively past the control edge into masked relation with the blocking element during retraction of the stem and plunger whereupon said blocking and metering elements maintain the inlet and spill ports concurrently masked during continuation of such retraction for a fuel pumping period terminated by eventual movement of the spill port into registry with the metering edge, the re-

tracting plunger being operable during such pumping period to displace fuel through the transfer passage and check valve into the expanding fuel delivery chamber, said metering element being adjustable axially of the stem to vary the time when the spill port retracts into registration with the metering edge to thus selectively vary the length of the pumping period and the amount of fuel transferred into the delivery chamber during plunger retraction, and the plunger being operable during its ensuing advancement to expel the metered and transferred fuel from the delivery chamber through the discharge orifice means.

3. In a fuel metering and injection nozzle unit, an elongated body having a stepped plunger-receiving bore extending lengthwise therein, a relatively large diameter portion of the bore being spaced axially from an end of the body and a smaller diameter portion of the bore being interposed between the large diameter portion and said end of the body, a plunger reciprocal in said bore, said plunger having a smaller diameter portion slidable in the small diameter portion of the bore and cooperable therewith when spaced from said end of the body to form a fuel delivery chamber, the body containing a fuel discharge orifice communicating from said chamber outwardly through said end of the body, the plunger having a large diameter portion reciprocal in the large diameter bore portion and of less axial extent than said large diameter bore portion to divide the same into a primary pumping chamber disposed adjacently to the step of the stepped bore and a secondary pumping chamber adjacently to opposite and large diameter end of said bore, the body having a fuel inlet port communicative with the primary pumping chamber, the body having a plunger-stem-receiving bearing extending axially from the secondary pumping chamber and of less diameter than this secondary chamber, a plunger-operating stem projecting axially from the large diameter plunger portion through and in sliding sealing relation with said bearing, a fuel spill port in a side of said stem on the opposite side of the bearing from the secondary pumping chamber, a spill passage extending axially within said stem communicatively between said port and the secondary chamber, a fuel transfer passage extending axially through the plunger communicatively between the secondary chamber and the fuel delivery chamber, a check valve in the transfer passage facilitating flow of fuel therethrough from the secondary chamber into the delivery chamber but pre-

cluding reverse flow of fuel through the transfer passage, a fuel conducting passage communicating through the large diameter plunger portion between the primary and secondary pumping chambers, a check valve facilitating fuel flow through the conducting passage from the primary chamber to the secondary chamber but precluding reverse flow through such conducting passage, a metering element in masking relation with said spill port and having a metering edge at which the spill port becomes unmasked by the metering element attendant to retractive axial movement of the plunger and stem a distance carrying such port into registry with said metering edge, said stem being endwise movable to alternately effect endwise advancement of the plunger into the delivery chamber and retraction for withdrawing the plunger from the delivery chamber attendant to expanding the same, said plunger being operable during a first retractive phase in an operating cycle thereof to expand the primary pumping chamber attendant to accommodating admittance of fuel thereinto through the fuel inlet port, the plunger being operable during a succeeding advancement phase in its operating cycle to contract the primary pumping chamber incident to forcing the fuel therefrom through the conducting passage and past the check valve associated therewith into the secondary chamber which is being concurrently expanded, the plunger being operable during an ensuing retractive operational phase to pump fuel from the secondary pumping chamber through the transfer passage into the fuel delivery chamber until the retractive movement of the plunger carries the spill port into registry with the metering edge of the metering element, the metering element being adjustable axially of the plunger stem for selectively variably determining when fuel pumped from the secondary chamber can escape through the spill passage as an alternative to being displaced through the transfer passage into the delivery chamber and thereby selectively determine the amount of fuel with which the delivery chamber is charged, and the plunger being operable during the ensuing advancement phase to eject metered fuel charge from the delivery chamber through the discharge orifice.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

|            |             |               |
|------------|-------------|---------------|
| Re. 23,862 | Simon       | Aug. 31, 1954 |
| 2,589,505  | Morris      | Mar. 18, 1952 |
| 2,792,259  | Shallenberg | May 14, 1957  |