

Jan. 31, 1961

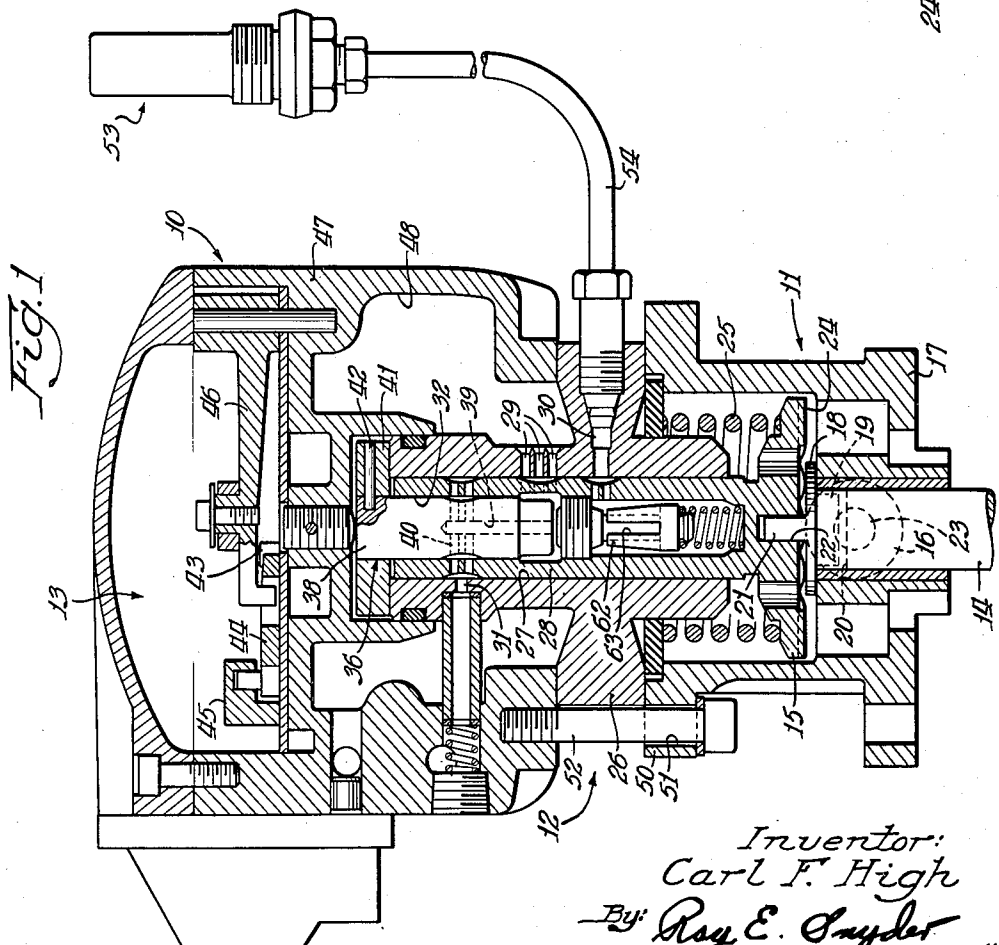
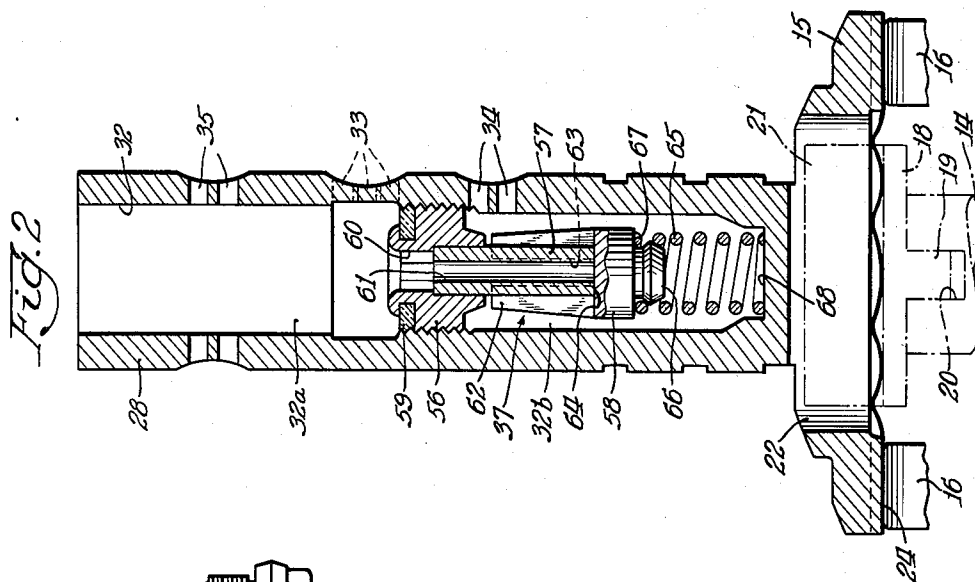
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2,969,784

FUEL INJECTION MECHANISM

Filed March 13, 1958

4 Sheets-Sheet 1



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Jan. 31, 1961

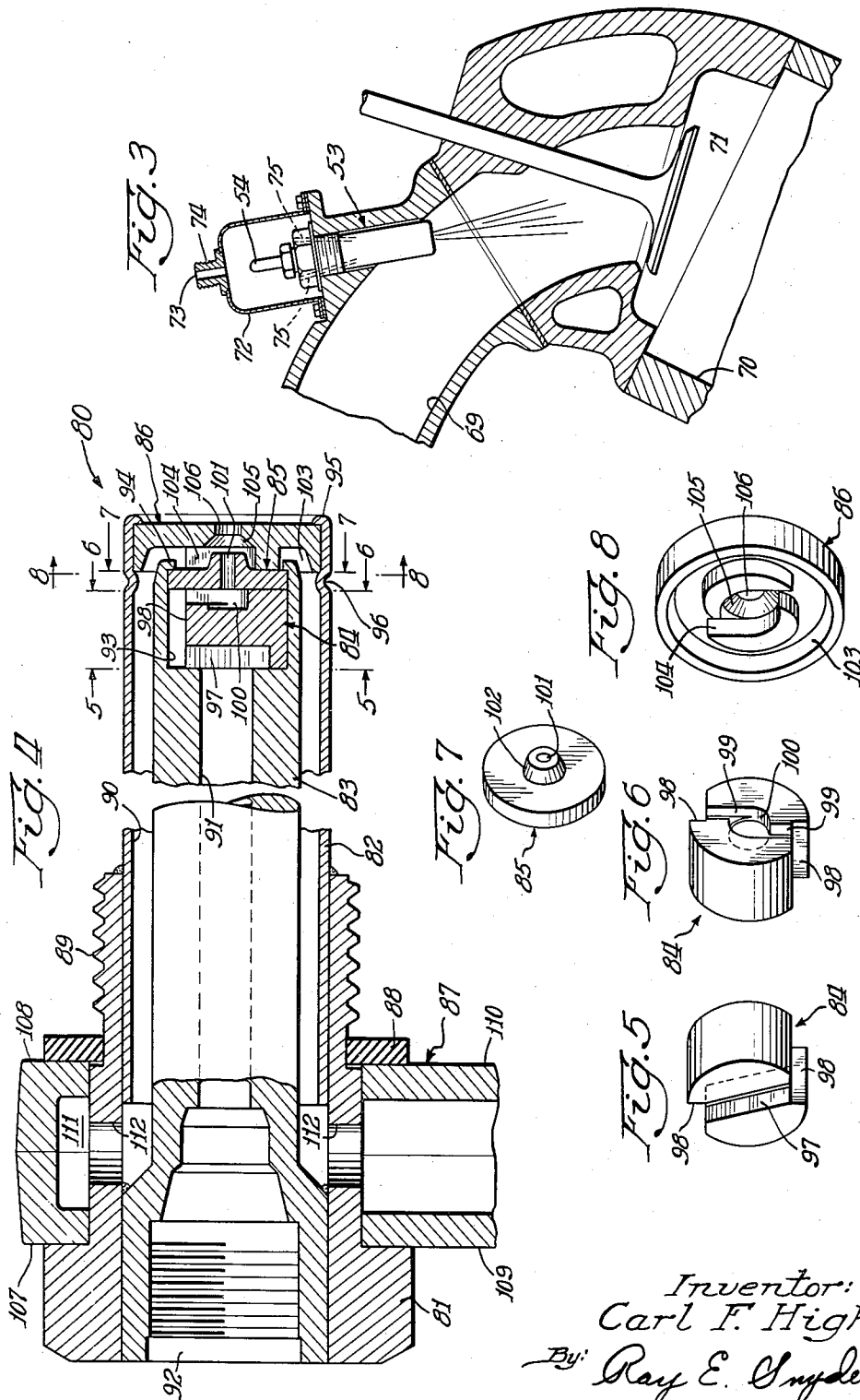
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FUEL INJECTION MECHANISM

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4 Sheets-Sheet 2



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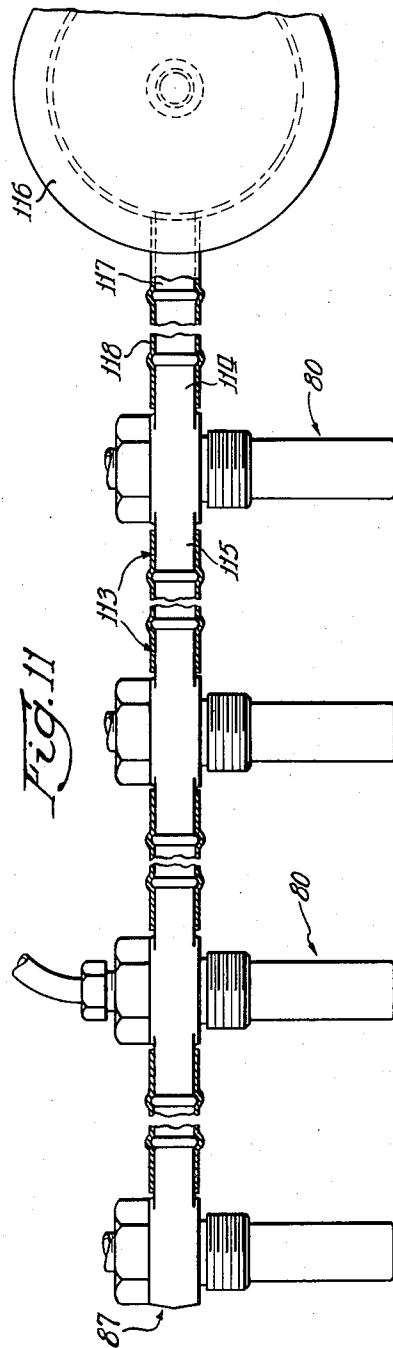
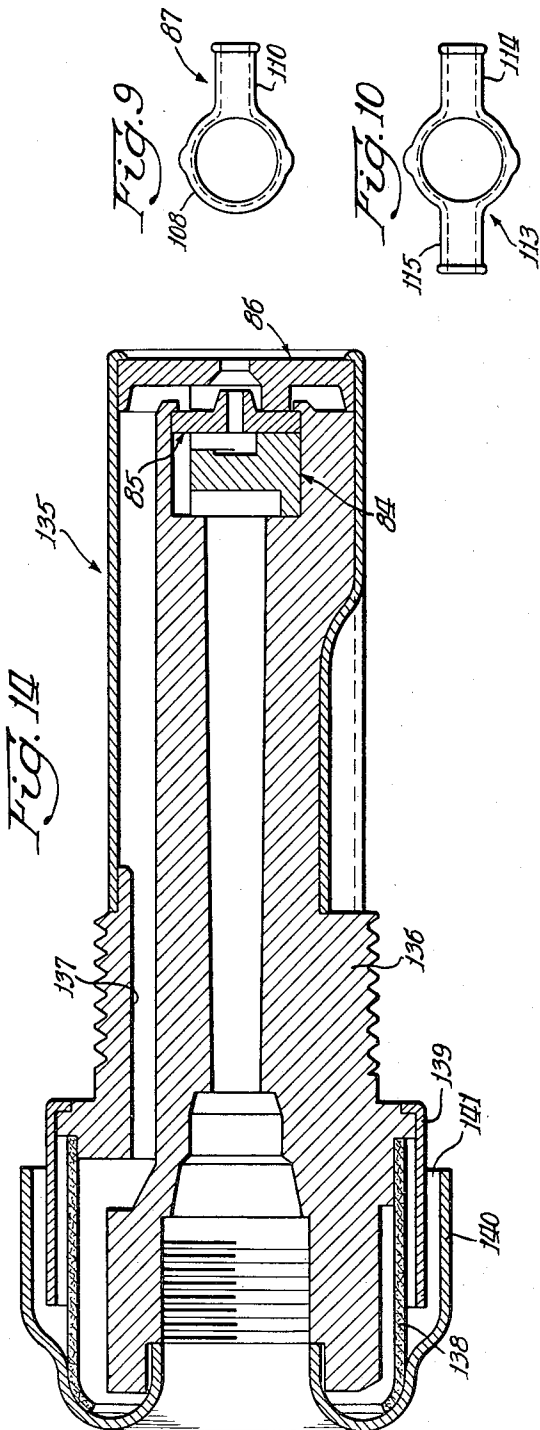
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FUEL INJECTION MECHANISM

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4 Sheets-Sheet 3



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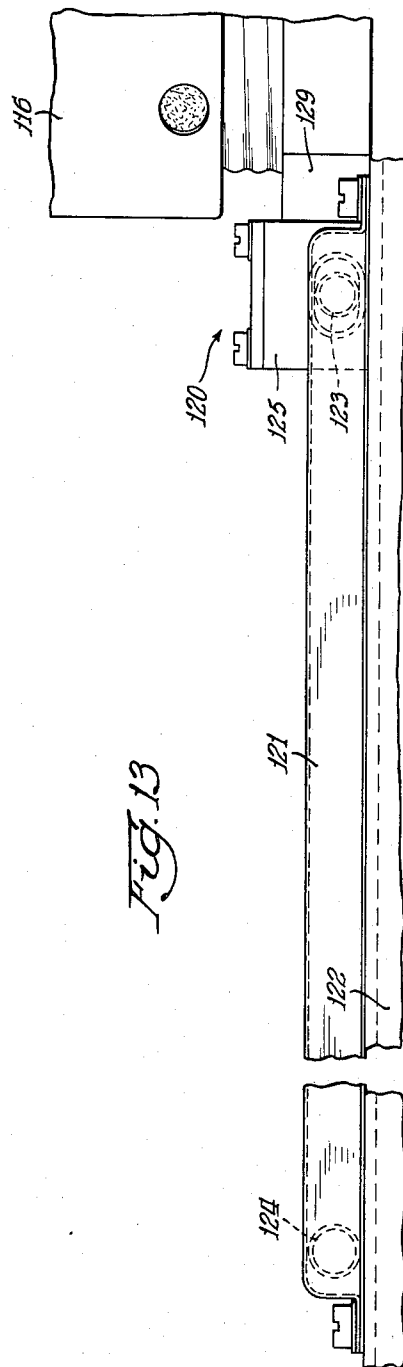
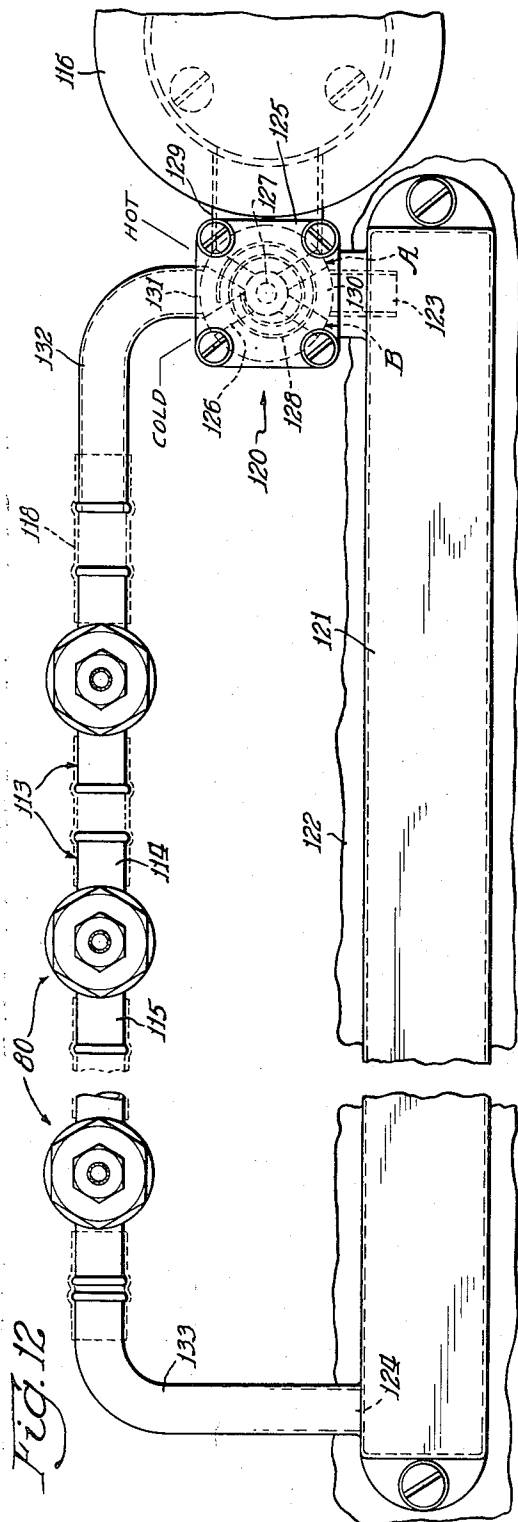
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FUEL INJECTION MECHANISM

Filed March 13, 1958

4 Sheets-Sheet 4



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2,969,784

FUEL INJECTION MECHANISM

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4 Claims. (Cl. 123—139)

This invention relates to fuel injection system particularly for supplying fuel to an internal combustion engine of an automotive vehicle.

It is well known in fuel injection systems to employ nozzles having a movable valve or pintle within each of the nozzles. Such nozzles suffer from several operational deficiencies, many of which are inherent in the valves themselves. In particular, some of the deficiencies that have been encountered in using such nozzles are as follows:

(a) The nozzle valves are sensitive to careless machining, to heat treat distortion, to ill fit, and to poor adjustment, all of which may cause the valve to stick or to leak;

(b) Nozzles with movable valves are sensitive to particles of dirt, metal chips, gum, or other foreign matter which may enter the fuel line and cause the valve to stick open or to leak;

(c) Side thrust on the valve head due to a slightly larger area of head being exposed to the hydraulic pressure of small fuel discharges, as at engine idling, causes the valve head to creep sideways as well as outwards up the slope of the valve seat so as to uncover a crescent-shaped opening at one side of the valve head and valve seat and thereby cause leakage;

(d) Side thrust on the valve head due to an infinitesimally larger area on one side of the valve head being exposed to hydraulic pressure during fuel discharge, produces uneven wear of valve head and valve seat so as to cause leakage and uneven discharge of fuel. This wear is especially pronounced when the angle of the valve head is small and is aggravated by prolonged use;

(e) A poppet valve at engine idling conditions tends to remain seated until hydraulic pressure is built up in the fuel supply line, then the valve pops open so as to release an excessive amount of fuel, a condition commonly called double stroking or multiple stroking;

(f) Valves are subject to resonant conditions that may be set up in the fuel supply line which can produce erratic delivery of fuel through the valves;

(g) The valve seats tend to pound out of shape through prolonged use which produces leakage and erratic fuel delivery;

(h) The pintle or stem of the valve head or the valve retainer occasionally break and the freed portion is swallowed by the engine cylinder and the broken parts and/or the resultant excessive fuel release may cause damage to the engine;

(i) The rubbing action of metal upon metal tends to produce galling or chaffing through continued use so that the valve may stick in an open position and cause leakage or the valve may freeze in a closed position if the engine is out of service for a prolonged period of time; and

(j) Poppet valves tend to freeze or stick in their seats when first installed or after the engine has been temporarily out of service. Furthermore, when the engine is started for the first time, or is started after a pro-

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longed period of non-use, the fuel lines and nozzles are filled with air. This air in the fuel line is compressible, and when the valves tend to stick, fuel under pressure supplied from the injection pump merely compresses the air in the fuel line and returns this fuel at the next delivery stroke rather than forces the valve open, making the starting of the engine difficult.

In addition to operational troubles enumerated above, the initial cost of well-constructed and matched nozzles having movable valves is quite substantial and is considered excessive for automotive engine applications.

Wherefore, it is an object of the present invention to provide an improved fuel injection system which supplies charges of fuel in timed relationship to the various cylinders of an internal combustion engine, in combination with improved air-sealed nozzles.

It is an additional object to provide a fuel injection pump having a rotating and reciprocating plunger and a retracting delivery valve disposed within said plunger, in combination with a plurality of air-sealed nozzles for supplying fuel to the individual cylinders of an internal combustion engine.

It is an additional object to provide an improved fuel injection system comprising a pump having a rotating and reciprocating plunger disposed therein, fuel metering means incorporated in said pump, a retracting delivery valve disposed within said plunger, a plurality of air sealed nozzles, and fuel delivery means incorporated in said pump for distributing metered charges of fuel to each of said nozzles in timed relationship for thereby supplying the combustion requirements of an internal combustion engine.

It is still another object to provide an improved fuel injection nozzle of the air-sealed type incorporating a fuel whirlpool chamber adjacent to a fuel delivery orifice and an air whirlpool chamber adjacent to said fuel delivery orifice, said air chamber being effective to seal said fuel orifice from engine manifold vacuum.

The invention consists of the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will appear from the following description of a preferred form of the invention, illustrated with reference to the accompanying drawings, wherein:

Fig. 1 is a longitudinal sectional view of an improved fuel injection pump having a hollow plunger disposed therein;

Fig. 2 is an enlarged sectional view of the plunger of Fig. 1 showing a retracting delivery valve disposed within the plunger;

Fig. 3 is a fragmentary sectional view of a fuel injection nozzle disposed in the air intake manifold of an internal combustion engine;

Fig. 4 is an enlarged longitudinal sectional view of an improved air-sealed nozzle utilized in the present invention;

Figs. 5, 6, 7, and 8 are perspective views of some elements making up the nozzle of Fig. 4;

Figs. 9 and 10 are longitudinal views of connectors utilized for supplying air to nozzles of the type illustrated in Fig. 4;

Fig. 11 is a view showing a plurality of nozzles and an air supply system utilizing the connectors of Figs. 9 and 10;

Figs. 12 and 13 show two views of a modified air supply system for a plurality of nozzles, including an air temperature control; and

Fig. 14 is a longitudinal sectional view of a modified construction of the nozzle of Fig. 4.

Like characters of reference designate like parts in the several views.

Referring now to Fig. 1, there is illustrated an im-

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proved fuel injection pump 10 comprising a drive section 11, a pumping section 12, and a control section 13.

The drive section 11 in general comprises a drive shaft 14, a rotatable cam 15 having a driving connection with the drive shaft 14, and a plurality of rollers 16 which serve as cam followers, all contained within a casing 17. The drive shaft 14 is preferably driven by a cam shaft of an internal combustion engine (not shown) and is journaled through the casing 17. A driving connection between the drive shaft 14 and the cam 15 is provided by means of a coupling member 18. The coupling member 18 is formed with a tang 19 which fits in a slot 20 formed in the drive shaft 14, and also is formed with a tang 21 which fits in a slot 22 formed in the cam 15.

The rollers 16 are mounted on shafts 23 and are in contact with a cam surface 24 of the cam 15. The shafts 23 are mounted in the casing 17 at right angles to the axis of rotation of the drive shaft 14. A spring 25 is disposed within the casing 17 under constant compression and acts against the cam 15 forcing the cam surface 24 into contact with the rollers 16.

The pumping section 12 in general comprises a block 26 having a longitudinally extending central bore 27 formed therein and a hollow plunger 28 rotatably and reciprocally disposed within the bore 27. The plunger 28 is formed integrally with the cam 15 of the drive section 11.

The block 26 is formed with a plurality of fuel inlet ports 29, a plurality of fuel delivery ports 30 axially displaced from the fuel inlet ports 29, and a fuel spill port 31. The plunger 28 is formed with a central longitudinal bore 32, a plurality of fuel inlet ports 33 adapted to be aligned with the ports 29, a fuel delivery port 34 adapted to be aligned with the ports 30, and fuel metering ports 35 adapted to be aligned with the spill port 31.

A fuel metering valve 36 and a retracting delivery valve 37 are disposed within the central bore 32 of the plunger 28. The valve 36 comprises a rotatable core 38 having a longitudinally extending central passage 39 and radially extending passages 40 formed therein. The central passage 39 is in communication with the radially extending passages 40 and with the interior of the central bore 32, and the radially extending passages 40 are adapted to be aligned with the fuel metering ports 35. An annular cap 41 is attached to the core 38 by means of a pin 42, and a longitudinally extending control pin 43 is mounted in the cap 41 in a position axially displaced from the axis of rotation of the core 38 for rotating the core 38 within the bore 32.

The control section 13 of the pump 10 may be similar to that illustrated in my Patent No. 2,849,998, and in general comprises a cam 44 in contact with the control pin 43, and levers 45 and 46 for moving the cam 44. The levers 45 and 46 are adapted to be moved under the influence of suitable control elements such as vacuum motors for moving the cam 44 and the control pin 43 and thereby vary the output of the pump 10 in accordance with the fuel demand of the internal combustion engine. The control section 13 and a portion of the pumping section 12 is enclosed within a casing 47. The casing 47 also forms the exterior of an annular fuel supply chamber 48 for the pumping section 12.

The casing 17 is formed with a flange 50 having a plurality of elongated holes 51 bored therethrough, and the casing 17 is attached to the casing 47 by means of a plurality of bolts 52 which extend through the elongated holes 51. A portion of the pump block 26 is sandwiched between the flange 50 and the casing 47, and the elongated holes 51 allow a slight rotation of the casing 17 with respect to the pumping section 12 so that the compression stroke of the plunger 28 can be timed in unison with the delivery of fuel through a port 30. Each of the fuel delivery ports 30 in the pump block 26 is connected to a fuel injection nozzle 53 through a fuel supply line or conduit 54.

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Referring now to Fig. 2, there is illustrated an enlarged longitudinal sectional view of the plunger 28 showing the retracting delivery valve 37 disposed within the central bore 32. The retracting delivery valve 37 in general comprises a plug 56 threaded within the bore 32, a longitudinally extending hollow sleeve 57 pressed within the plug 56, and a valve 58 seated on an end of the sleeve 57. The plug 56 divides the bore 32 into two chambers 32a and 32b. A nylon washer 59 is crimped on one end of the plug 56 and serves as both a lock and as a seal for the plug 56. The plug 56 is formed with an axial central opening 60 which communicates with a hollow central opening 61 of the sleeve 57.

The valve 58 is formed with a plurality of fingers 62 which extend longitudinally over the exterior of the sleeve 57. The fingers 62 are separated by longitudinally extending slots 63. The valve 58 is maintained seated against an end or seat 64 of the sleeve 57 by means of a spring 65. The spring 65 encircles a cap 66 formed on the valve 58 and is disposed under constant compression between a shoulder 67 of the valve 58 and a bottom surface 68 of the central bore 32.

Referring now to Fig. 3, there is illustrated a nozzle 53 mounted in an air intake manifold 69 of an internal combustion engine. A portion of the cylinder bore 70 is shown and an intake valve 71 is mounted in a position above the cylinder bore 70.

The nozzle 53, shown in Figs. 1 and 3, is of the air-sealed type which will be described in more detail hereinafter. The nozzle 53 discharges fuel in the form of a fine spray into the intake manifold 69 of the internal combustion engine whenever fuel under pressure is supplied from the pump 10.

In operation, the pump 10 functions to supply metered fuel in timed relationship to the various nozzles 63 and cylinders 70 of the internal combustion engine as will now be described.

The drive shaft 14 drives the cam 15 and the plunger 28 so that during the fuel intake stroke, or downstroke of the plunger 28, the fuel inlet ports 33 become aligned with the inlet ports 29 and fuel is drawn from the supply cavity 48 into the chamber 32a. As the drive shaft 14 rotates the plunger 28, communication is cut off from the inlet ports 29 and the fuel within the chamber 32a is caused to be compressed by the plunger 28. The ports 35 become aligned with the radial ports 40 of the metering valve 36 and with the fuel spill port 31. A portion of the fuel within the chamber 32a is allowed to pass through the axial passage 39 and the radial ports 40 through the ports 35 and the spill port 31. The quantity of fuel spilled depends on the relative opening of the ports 40 with respect to the ports 35. As the plunger 28 rotates still further, communication is cut off from the spill port 31 and the fuel within the chamber 32a is further compressed. A portion of the fuel within the cavity 32a then is forced through the central opening 60 and through the central passage 61 of the sleeve 57, and forces the valve 58 off of the seat 64. This fuel passes into the cavity 32b, and as the fuel delivery ports 34 become aligned with a delivery port 30, the fuel is discharged through a fuel line 54 and through a nozzle 53 into the air intake manifold 69. The fuel discharged from the nozzle 53 is timed with the opening of the valve 71 so that a fuel-air mixture passes into the cylinder 70. As the plunger 28 rotates still further, communication is cut off from the fuel delivery port 30 and the plunger 28 again commences its downstroke or fuel intake stroke.

The retracting delivery valve 37 disposed within the plunger 28 serves a dual purpose in the present invention. Firstly, the valve 37 functions to seal the nozzles 53 from the fuel compressed within the chamber 32a until a portion of this fuel has been metered through the spill port 31. Secondly, the valve 37 functions to

reduce the output per stroke of the plunger 28 with increasing engine speed as will now be described.

As the fuel is compressed within the chamber 32a, the portion flowing through the central passage 61 forces the valve 58 off the seat 64, and the fuel flows through the longitudinal slots 63 into the chamber 32b. The valve 58 raises off the seat 64 by a very small amount, e.g., approximately .018 inch, for allowing the passage of the maximum quantity of fuel into the cavity 32b. The distance that the valve 58 is raised off of the seat 64 depends upon the speed at which the pump 10 is driven and consequently on the quantity of fuel being delivered into the cavity 32b. Therefore, during each compression stroke, the valve 58 is going to be displaced downward, as shown in Fig. 2, and occupy a portion of the space within the chamber 32b. There is a substantial reduction of pressure following the end of the fuel delivery stroke and the spring 65 acting on the valve 58 forces the valve 58 back toward the valve seat 64. The fuel trapped between the valve 58 and the valve seat 64 is returned to the chamber 32a through the central passage 61. As the valve 58 reseats against the seat 64, it will, in effect, leave a void within the cavity 32b of an amount equal the product of the unbalanced cross sectional area of the sleeve 57 times the displacement of the valve 58. This void must be filled during the next delivery stroke of the plunger 28 before any fuel can be supplied through the fuel lines 54 to the nozzles 53.

It is well known that the fuel requirement per stroke of the engine decreases with increasing engine speed. This phenomenon is due to the fact that, at high speed, the air intake valves 71 are open for an insufficient length of time to allow the same quantity of air to flow into the cylinders 70 as enters at lower engine speeds. Therefore, in order to keep the fuel-to-air ratio essentially constant, it is desirable to reduce the output per stroke of the pump 10 in accordance with increasing engine speed.

The valve 58 can be designed originally so as to give a predetermined fuel delivery output per stroke of the plunger 28. The amount of retraction of fuel produced by the valve 58 can be predetermined by the width of slots 63. For example, for narrow slots 63, the valve 58 must raise farther off of the seat 64 to allow the passage of the same amount of fuel in a unit of time into the cavity 32b through the fingers 62 as for wide slots 63. Therefore, the amount of fuel retracted per stroke of the plunger 28 will be increased when the slots 63 are narrow. Correspondingly, for wider slots 63, the amount of fuel retracted per stroke of the plunger 28 will be decreased.

Referring again to Fig. 3, there is illustrated one method for supplying filtered air and fuel to the nozzles 53 of the fuel injection system. As stated above, each of the nozzles 53 is disposed in the air intake manifold 69 adjacent to an intake valve 71 for each of the cylinders 70. The fluid supply conduits 54 and the fluid input ends of the nozzles 53 are contained within a sheet metal cover 72 which is bolted on to the intake manifold 69.

Filtered air is supplied to the interior of the cover 72 through a port 73. The port 73 is formed in a plug 74 fixedly mounted on the cover 72 and is connected to a suitable air filter (not shown). The filtered air supplied to the interior of the cover 72 enters each of the nozzles 53 through access ports 75 formed in the nozzles 53 adjacent to the fuel input end thereof. The air supplied through the ports 75 functions to seal the tips of the nozzles 53 from manifold vacuum as will be described hereinafter.

Referring now to Fig. 4, there is illustrated an improved fuel injection nozzle, designated generally by the numeral 80. The nozzle 80 has filtered air supplied to it through an air supply system that is different from that previously described for the nozzle 53. The nozzle 80, otherwise, is intended to be substantially identical to the nozzle 53.

The nozzle 80 in general comprises a nozzle body 81, a sheet metal sleeve 82, a longitudinally extending central tube 83, a fuel-duct plate 84, a fuel orifice disc 85, an air orifice plate 86, an air supply connector 87, and a sealing washer 88. The nozzle body 81 is generally in the form of a sleeve and is threaded on its exterior at 89 for mounting the nozzle 80 in the air intake manifold 69.

The nozzle tube 83 extends through and is bonded to the interior of the nozzle body 81. The nozzle sleeve 82 also extends through a portion of the nozzle body 81 and is bonded to the interior thereof. The nozzle sleeve 82 surrounds the tube 83 forming a cylinder air passage 90 between the exterior of the tube 83 and the interior of the sleeve 82.

The nozzle tube 83 is formed with an axial longitudinally extending fuel supply passage 91 and a fuel supply port 92 communicating with the passage 91. The nozzle tube 83 is threaded on its interior adjacent to the fuel supply port 92 and is adapted to receive a suitable connecting member for connecting the port 92 to a fuel supply line.

The nozzle tube 83 also is formed with an enlarged cylindrical recess 93 in communication with the fuel discharge end of the passage 91. The fuel duct plate 84 and the fuel orifice disc 85 are retained within the cylindrical recess 93 by means of a crimped end 94 of the tube 83. The air orifice plate 86 is disposed adjacent to the fuel orifice disc 85 and is held in place between a crimped end 95 of the nozzle sleeve 82 and an annular locating groove 96 formed on the sleeve 82.

Referring now to Figs. 5 and 6, the fuel duct plate 84 is seen to be generally cylindrical in shape and is formed with a radially extending groove 97, longitudinally extending external grooves 98 in communication with the groove 97, tangential fuel ducts 99 in communication with the longitudinal grooves 98, and a whirlpool chamber 100. The whirlpool chamber 100 is in communication with a fuel discharge orifice 101 formed in the fuel orifice disc 85.

Referring to Fig. 7, the fuel orifice disc 85 is seen to be formed with an axially extending boss 102 through which the fuel discharge orifice 101 extends.

Referring now to Fig. 8, the air orifice plate 86 is seen to be generally annular in shape and is formed with an annular cavity 103, tangential air supply ducts 104, an air whirlpool chamber 105, and a discharge orifice 106. The annular cavity 103 is in communication with the air supply passage 90, and the tangential air ducts 104 are in communication with the cavity 103 and open tangentially into the whirlpool chamber 105. The air orifice 106 is an outlet for the whirlpool chamber 105 and permits the discharge of fuel from the orifice 101 and air from the ducts 104 into the intake manifold 69.

Referring now to Figs. 4 and 9, the air supply connector 87 in general comprises two adjacent annular shaped members 107 and 108 each having a radially extending portion 109 and 110 which together form a stem to which an air supply tube or hose can be connected. The annular members 107 and 108 define an annular air chamber 111 around the nozzle body 81. The nozzle body 81 is formed with radially extending ports 112 which allow the passage of air from the chamber 111 into the cylindrical air supply passage 90.

Referring now to Fig. 10, there is illustrated a double-end connector 113 which is similar to the single connector end 87 except that it has two radially extending stems 114 and 115.

Referring now to Fig. 11, there is illustrated a system through which filtered air can be supplied to a plurality of nozzles 80. Filtered air is supplied from an air filter 116 through a hollow stem 117. The stem 117 is connected to a stem 114 of double end connector 113 by means of a flexible tube or hose 118. The other stem 115 of the double-end connector 113 is connected to another stem 114 of a connector 113 through a second tube or hose 118, and so on to the last of the nozzles 80 comprising the bank of the fuel injection system. The chain of

nozzles 80 just described terminates at a single-end connector 87.

In operation, the nozzle 80 functions as follows:

Fuel under pressure is supplied in timed relationship from the pump 10 through a conduit 54 to the fuel input port 92 of the nozzle tube 83. This fuel passes through the central passage 91 into the radial groove 97 and through the longitudinal grooves 98 into the tangential fuel ducts 99. The fuel from the ducts 99 enters tangentially at the periphery of the whirlpool chamber 100 at a comparatively high velocity. This fuel is compressed toward the center of the whirlpool chamber 100 and the rotational velocity of the fuel increases as it approaches the center, in a manner similar to the air velocity at the vortex of a cyclone. The compressed fuel is discharged axially through the orifice 101 into the air whirlpool chamber 105.

The fuel leaving the orifice 101 is completely atomized by centrifugal force and forms a cone of minute fuel particles or vapor that passes through the air orifice 106 into the manifold 69. The width of the cone of fuel vapor thus discharged can be predetermined by the size and length of the orifices 101 and 106 and by the normal operating injection pressure of the pump 10.

The air supplied from the air filter 116 to the respective nozzles 80 functions to seal the fuel discharge orifices 101 from the vacuum of the air intake manifold 69 of the engine, as will now be described.

The air passing through the filter 116 and out through the stem 117 is substantially at atmospheric pressure and passes through a tube or hose 118, a stem 114, ports 112, passage 90, annular cavity 103, and tangential ducts 104 into whirlpool chamber 105. The air present within the whirlpool chamber 105 is still substantially at atmospheric pressure and acts as a barrier between the air orifice 106 and the fuel orifice 101 so as to prevent a partial vacuum within the intake manifold 69 from sucking fuel from the fuel orifice 101.

There will be an air flow through the nozzles 80 into the manifold 69 whenever a partial vacuum exists within the manifold 69. It is important that the quantity of air passing through the nozzles 80 not exceed a predetermined percentage of the total idling air requirement of the engine. In particular, this quantity should not exceed fifty to sixty percent of the idling air so that engine idling speed can be controlled by the conventional air throttle valve of the engine.

It has been found desirable that the air flowing through the nozzles 80 amount to approximately fifty percent of the total air requirement of the engine at idling speed. To obtain this approximate percentage, it has been determined in a typical test installation comprising eight nozzles, and augmented by other tests and by calculation, that the air orifices 106 should be approximately .06 inch in diameter.

The air supplied to the whirlpool chamber 105 is admitted through the tangential ducts 104 at the periphery of the chamber 105. The velocity of the air so entering is substantial, and the rotational velocity of this air increases as it moves toward the center of the chamber 105. This whirling mass of air is particularly advantageous during the periods of fuel discharge through the orifice 101. The air entering the whirlpool chamber 105 creates an envelope of whirling air surrounding the cone of fuel spray discharged from the fuel orifice 101 and a portion of this air is mixed with the fuel vapor so as to form a uniform mass of air-fuel mixture which enters the engine cylinder 70. The whirling air within the chamber 105 has the additional advantage of preventing the accumulation of droplets of fuel on the boss 102 so that the fuel actually discharged into the manifold 69 uniformly constitutes a fine cone of vapor or minute fuel particles.

Referring now to Figs. 12 and 13, there is illustrated a modification of the air supply system shown in Fig. 11

which is adapted to automatically supply heated air to a chain of nozzles 80 for particular climatic conditions. It is well known that under certain climatic conditions, as for example, when the outside air temperature is near freezing and the relative humidity is high, icing can develop in the carburetor of an internal combustion engine. This icing is caused by the vaporization of fuel which absorbs heat from the incoming air, lowering the temperature thereof, and freezing the water vapor present in the air. It is possible for this same icing condition to develop at the nozzles of some fuel injection systems.

The air supply system shown in Figs. 12 and 13 is designed to obviate any icing condition that may develop due to the passage of air through the fuel injection nozzles 80. The illustrated system, in general, comprises the air filter 116, a thermostatically controlled valve 120, and a manifold stove 121 mounted on an exhaust manifold 122 of the internal combustion engine. The manifold stove 121 comprises a sheet metal cover attached to the exhaust manifold 122 and is formed with an inlet duct 123 and an outlet port 124. It is contemplated that the air contained within the cover 121 will be heated by conduction from the exhaust manifold 122.

The thermostatically controlled valve 120, in general, comprises a housing 125, a butterfly valve 126 rotatably mounted within the housing 125 on a pin 127, and a spiral bi-metallic element 128. The housing 125 is formed with an air inlet conduit 129 connected to the air filter 116 and air outlet ports 130 and 131. The outlet port 130 is connected through the duct 123 to the manifold stove 121, and the port 131 is connected through a conduit 132 to an and supply hose 118 for the chain of nozzles 80. The air outlet port 124 of the manifold stove 121 is connected through a conduit 133 to an opposite end of the chain of nozzles 80.

In operation, the air supply system functions as follows:

For comparatively high temperature conditions, the butterfly valve 126 is in position indicated at A and the air supplied from the air filter 116 passes through the conduit 129, the port 131, and through the conduit 132 to the nozzles 80. The air supply system for high temperature conditions thus functions in a manner identical to that described for the system shown in Fig. 11.

For low temperature conditions, that is, near the freezing point of water or below, the thermostatic element 128 attached to the valve 126 causes the valve 126 to rotate about the pin 127 to a position indicated at B on Fig. 12. When the valve 126 is in this position, air supplied from the filter 116 passes through the conduit 129, the port 130, and duct 123 into the manifold stove 121. The air present within the manifold stove 121 is heated by the exhaust manifold 122 and this heated air passes out through the port 124 and conduit 133 to the nozzles 80. The air inlet port 131 to the conduit 132 is blocked by the valve 126 for this condition. The heated air supplied from the manifold stove 121 to the nozzles 80 is effective to maintain the nozzle tips above the freezing temperature of water and thereby prevent icing conditions at the fuel discharge ends of the nozzles 80.

It is contemplated that as the ambient temperature of the air surrounding the vehicle engine increases, the thermostatic element 128 can rotate the valve 126 back to the position indicated at A and air can be supplied thereafter to the nozzles 80 in the manner previously described.

Referring now to Fig. 14, there is illustrated a modification 135 of the nozzle 80 shown in Fig. 4. The fuel and air discharge portion of the nozzle 135 is substantially identical in construction and operates in a identical manner to that described for the nozzle 80. The nozzle 135 differs in construction from the nozzle 80 in the air supply portion of the nozzle.

The nozzle 135 comprises a nozzle body 136 formed with an air supply passage 137. The air supply passage 137 is enclosed by a cylindrical filter screen 138 mounted

on the nozzle body 136. Two sheet metal cylindrical members 139 and 140 are mounted on the nozzle body 136 and enshroud the filter screen 138. An air supply passage 141 is provided between the cylindrical members 139 and 140 so that air can pass to the filter screen 138 and into the air supply passage 137.

The nozzle 135 functions in a manner identical to that previously described for the nozzle 80; however, it is contemplated that the nozzles 135 having individual filter screens 138 would be substantially cheaper in any given installation than the comparable nozzles 80 together with their associated air supply system.

There has been provided by this invention an improved fuel injection system utilizing a pump having a rotating and reciprocating plunger with a valve disposed therein in combination with a plurality of improved air sealed nozzles. The improved air sealed nozzles obviate many of the operational deficiencies associated with the injection nozzles having movable valves or pintles.

In addition to the improved fuel injection pump and nozzles, there has also been provided by this invention improved air supply systems for supplying filtered air to a plurality of air sealed nozzles.

It is to be understood that my invention is not to be limited to the specific constructions and arrangements shown and described except only insofar as the appended claims may be so limited, as it will be apparent to those skilled in the art that changes may be made without departing from the principles of the invention.

I claim:

1. In a fuel injection system for supplying charges of fuel in timed relationship to a plurality of nozzles, a fuel injector pump comprising a pump body, a rotatable and reciprocative hollow plunger disposed within said pump body, a fuel metering valve disposed on one end of said plunger and having a core extending into a central cavity formed in said plunger, a second valve disposed within the hollow central cavity of said plunger, and fuel supply means for said plunger, said second valve being effective to prevent delivery of fuel from said supply means to said nozzles until the fuel has been metered by said metering valve.

2. In a fuel injection system for supplying fuel in timed relationship to a plurality of fuel injection nozzles, a fuel injector pump comprising a reciprocative plunger and a retracting-delivery valve associated with said plunger, said valve comprising a longitudinally extending stem portion and a valve head formed with a plurality of fingers extending longitudinally over said stem portion and defining slots therebetween, and spring means effective to maintain said valve seated on an end of said sleeve, said valve head and spring means being operable to retract a portion of the fuel delivered to the nozzles.

3. In a fuel injection system for supplying fuel in

timed relationship to a plurality of fuel injection nozzles, a fuel injector pump comprising a reciprocable rotatable hollow plunger, a first valve including a core portion extending longitudinally within said hollow portion of said plunger and operative with said plunger for metering said fuel, and a second retracting-delivery valve also contained within the hollow portion of said plunger, said second valve comprising a longitudinal stem having a fuel passage therethrough, and a valve head formed with a plurality of longitudinal fingers defining slots therebetween and adapted to seat at one end of said stem thereby closing said fuel passage, and biasing means operable to seat said valve head against said stem during at least a portion of the pumping stroke, said valve head being further operable to retract a portion of the fuel delivered to the nozzles.

4. In a fuel injection system for supplying fuel in timed relationship to a plurality of fuel injection nozzles, a fuel injector pump comprising a reciprocable rotatable plunger, said plunger having a longitudinal second bore therethrough, a first valve operatively associated with said plunger and including a core extending into a portion of said bore, a second retracting-delivery valve also contained within said bore of said plunger and effective to divide said plunger into a first chamber and a second chamber, said second valve comprising a longitudinal stem having a passage therethrough for allowing the flow of fluid from said first chamber to said second chamber, said second valve having a valve head operable to seat at one end of said stem in sealing relation and formed with a plurality of fingerlike longitudinal projections defining slots therebetween for allowing the passage of fuel when said valve head is unseated, biasing means operable to hold said valve head in sealing relation during at least a portion of the pumping stroke, fuel inlet means operable to fill said first chamber during a portion of said pumping stroke, means for unseating said valve head in opposition to said biasing means for allowing fluid to enter said second chamber, said valve head being operable to retract a predetermined portion of the fuel delivered to said second chamber, and fuel delivery means leading from said second chamber to said nozzle.

References Cited in the file of this patent

UNITED STATES PATENTS

2,157,034	Tice	May 2, 1939
2,354,403	Reggio	July 25, 1944
2,396,602	Posch	Mar. 12, 1946
2,702,535	Links	Feb. 22, 1955
2,833,260	Dolza et al.	May 6, 1958
2,869,529	Oxenfurt	Jan. 20, 1959

FOREIGN PATENTS

777,536	Great Britain	June 26, 1958
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