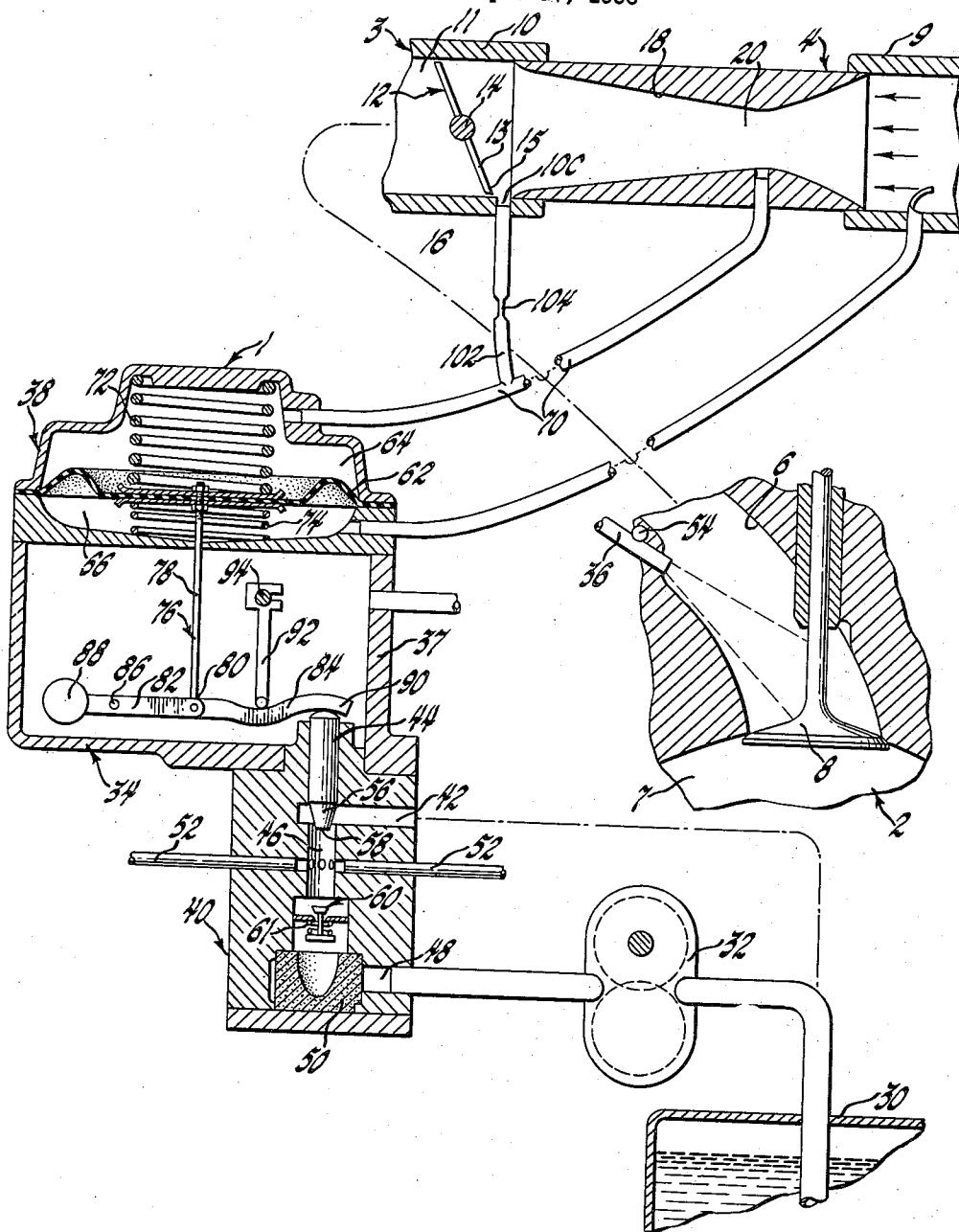


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FUEL INDUCTION SYSTEM

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## FUEL INDUCTION SYSTEM

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The present invention relates to fuel injection systems for internal combustion engines and more particularly to means for insuring the desired air-fuel ratio particularly during a transition while increasing the load above idle.

In the operation of an internal combustion engine of the spark ignited type certain advantages can be derived from injecting the fuel directly into the charge in the induction passages immediately anterior to the combustion chambers. One means of accomplishing this is to provide a metering system which is responsive to a signal indicative of the amount of air flow into the engine. For example, an increase in the strength of the signal will produce an increase in the fuel flow. More particularly, the induction system may include a venturi with a restricted throat and the fuel system may include a diaphragm responsive to the vacuum in the venturi throat and effective to actuate a fuel metering valve. Although this is effective to produce a substantially constant air-fuel ratio, in the idle and off idle range, the air flow is very small and the strength of the signal developed in the venturi is extremely weak. Consequently, during the transition period where the air flow is increased from idle to the slightly large amount required in off idle, the inertia and friction in the metering mechanism becomes very critical and may tend to interfere with the responsiveness of the metering mechanism and result in a lean charge at the very time when a rich charge is desired.

It is now proposed to provide a fuel injection system having metering means therein for providing a charge having the desired proportions even during the transition period from one small air flow to another small air flow. More particularly, this is to be accomplished by providing an enrichment port in the surface of the induction passage immediately adjacent to the periphery of the throttle valve when it is in the off idle position. This port will be effective to sense a pressure signal during the off idle range and to reinforce the strength of the primary signal from the venturi. The duration of the enrichment is controlled by the size and position of the port while the magnitude of the enrichment signal is separately controlled by means of a calibrated restriction in the enrichment line.

In the one sheet of drawings:

The figure is a diagrammatic representation of a fuel injection system embodying the present invention.

Referring to the drawing in more detail the present invention may be employed in a fuel system 1 for a so-called spark ignited internal combustion engine 2. An induction system 3 is provided for the engine 2 and includes an air intake 4 and a plurality of induction passages 6 that communicate with the combustion chambers 7 for supplying air thereto. The timing of air flow into the cylinders is controlled by the opening and closing of the intake valves 8.

The intake 4 to the induction system 3 includes an outer end 9 that may have an air cleaner and/or silencer assembly attached thereto. The opposite end of the intake 4 includes a throttle body 10 that has

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a passage 11 extending therethrough. A manually controlled throttle valve 12 is disposed in the passage 11 for controlling the volume of the flow through the passage 11 and into the engine 2. The throttle valve 12 may be of the conventional butterfly type wherein a plate 13 is mounted on a shaft 14 so that the periphery 15 thereof will engage the surface 16 of the passage 11 when it is closed. A venturi 18 or similar metering restriction may be disposed anterior to the throttle valve 12 and have a throat 20 for developing a vacuum signal indicative of the amount of the flow therethrough.

In order to form the combustible charge for the cylinders, the fuel system 1 includes a fuel storage tank 30, fuel pumping means 32 for circulating the fuel through the system 1, a metering mechanism 34 for maintaining the fuel flow in the desired proportions to the air flow, and a plurality of nozzles 36 located in the induction passages 6 adjacent the intake valves 8 for discharging the atomized fuel directly into the air as it flows into the cylinders. The pump means 32 may be of any desired design and, in fact, if desired, may include a transfer or supply pump located adjacent the storage tank and an injection pump. These pumps do not have to be calibrated so as to deliver some predetermined quantities of fuel, i.e., meter the fuel. However, they preferably deliver a surplus of fuel at a pressure in excess of that required to operate the system 1.

The metering mechanism 34 includes a housing 37 having a diaphragm chamber 38 in the top thereof and a fuel distributor and regulator portion 40 in the bottom thereof. The fuel distributor and regulator portion 40 includes an outlet 42 with a flow control valve 44 therein, a distributing chamber 46 and an inlet 48 which may be connected to the pump means 32. It has been found desirable to provide a strainer or filter element 50 in this inlet 48 for removing any impurities that might otherwise impair the operation of the system 1. The inlet 48 includes a chamber connected to the bottom of the vertical distributing chamber 46 so that the fuel from the inlet 48 will flow vertically upwardly through the distributing chamber 46. A plurality of identical injector lines 52 may radiate outwardly from the chamber with the outer ends thereof including nozzles 36 located in the induction passages 6 and aimed to direct streams of fuel toward the intake valves 8. In order to obtain uniform distribution of the fuel to all of the cylinders, it is desirable for the hydraulic resistances of the nozzles 36 to be considerably larger than that of the injector lines 52 and thereby be the primary factor controlling the quantity of fuel flow. Thus any minor irregularities in the injector lines 52 will have little or no effect on the metering and distribution of fuel to the cylinders. Each of these nozzles 36 preferably includes a small or restricted orifice which is continuously open for discharging the fuel into an envelope of air at substantially atmospheric pressure. This orifice is aimed to direct a stream of fuel into the induction system toward the intake valve. The resistance of the small orifices will represent a metering resistance that will create a pressure differential indicative of the amount of metered fuel flow.

The outlet or fuel control valve 44 may be disposed in the top of the distribution chamber 46 for regulating the amount of spill fuel by-passed from the distributing chamber 46 and returned to the fuel storage tank 30. Accordingly, it will be seen that the position of the control valve 44 will regulate or meter the amount of fuel flow to the cylinders. In the present instance this valve is a piston slidably disposed in a vertical bore with an end 56 reciprocating in the outlet opening 42 so that axial movement will vary the effective area thereof. The lower end

of the piston has some predetermined area that will be exposed to the pressure of the fuel in the distributing chamber 46. This will result in an upwardly directed force on the piston tending to lift it out of the outlet 42. It should be noted that the resistances of all the injector lines 52 and nozzles 36 are the equivalent of a single orifice. Thus the pressure of the fuel in the distributing chamber 46 will be indicative of the quantity of fuel flowing to the cylinders and the vertical force on the piston will be indicative of the quantity of the metered fuel flowing to the cylinders. It has been found desirable to provide a one-way check valve 60 in the inlet end of the distributing chamber that will prevent any backing up of the vapors. In the present instance this is a poppet valve biased closed by a spring 61. Although an excess spring tension is not desirable the spring 61 should maintain sufficient pressure in the upstream portion of the system 1 to reduce the formation of any vapors.

The diaphragm chamber 38 includes a flexible diaphragm 62 that extends horizontally thereacross so as to divide the chamber into an upper compartment 64 and a lower compartment 66. The upper compartment 64 is preferably connected directly to the throat 20 of the venturi 18 by a nonrestricted tube 70 while the lower compartment 66 is preferably vented to atmosphere or to the intake 4 immediately anterior to the venturi 18. It may thus be seen that as the air flows through the venturi 18 and a vacuum develops in the throat 20, the diaphragm 62 will have a force thereon indicative of the quantity of air flowing through the venturi 18 and into the cylinders. It has been found desirable to maintain the volume of the diaphragm chamber as small as possible so that the air therein can be rapidly evacuated so as to be able to rapidly follow the changes in the throat vacuum.

The diaphragm 62 may be connected to the control valve by a linkage 76 that will transfer the force on the diaphragm to the piston. A pair of springs 72 and 74 may be provided, if desired, to bias the diaphragm toward some predetermined position. Although the linkage 76 may be of any suitable form, in the present instance it includes a vertical pin 78 connected to the joint 80 between a counterweight lever 82 and a control lever 84. The counterweight lever 82 may pivot about a fixed point 86 and have a weight 88 on the end thereof that will tend to balance the weight of the various portions of the linkage system 76. The outer end 90 of the control lever 84 bears on the upper end of the plunger 44 while the center thereof pivots about the lower end of an adjustable ratio arm 92. Thus it will be seen that the difference in air pressure on the diaphragm 62 will produce a downward force on the piston that will bias it against the fuel pressure in the distributing chamber 46.

It can be appreciated that by rotating the ratio arm 92 about the shaft 94, the mechanical advantage of the linkage 76 can be varied so that the amount of the force transferred from the diaphragm 62 to the plunger 44 can be readily adjusted.

As previously stated the position of the plunger 44 in the outlet 42 regulates the volume of by-passed fuel and thereby controls or meters the amount of fuel distributed to the various cylinders and also the fuel pressure inside of the distributing chamber 46 will exert an upward force on the bottom of the plunger 44 which will tend to raise the plunger 44 and increase the amount of fuel by-passed. This will, in turn, decrease the amount of fuel flowing to the cylinders. However, the force produced by the air flow will tend to force the plunger 44 downwardly into the outlet 42 and increase the supply of fuel to the cylinders. Thus it may be seen that the air flow and fuel flow will produce forces opposing each other and cause movement of the plunger 44 until the two forces are balanced. When these two forces are balanced the air and fuel will be flowing in some predetermined ratio. The proportions of this ratio will be determined by the area of the diaphragm 62, the area of the plunger 44 exposed

to the fuel pressure, and the mechanical advantage of the linkage 76. It should be noted that this ratio can readily be adjusted by varying the position of the ratio arm 92.

It has been found that when the engine is idling the throttle valve 12 is in the substantially fully closed position and the amount of air flow through the venturi 18 is very small. As a result under such circumstances the signal developed in the throat 20 will be correspondingly weak and the force on the diaphragm 62 is very small. In fact the signal may not have adequate strength to insure a precise positioning of the metering mechanism due to the friction therein. Moreover when the throttle valve 12 moves from the closed or idle position through the slightly open or off idle position, the increase in the air flow and the venturi throat vacuum will be very small. As a result the friction and inertia of linkage 76, etc. in the metering mechanism will become of major importance and these factors tend to cause the resultant charge to become sufficiently lean to cause misfiring, etc. of the engine. Accordingly, an off idle enrichment device may be provided which includes a port 100 in the surface 16 of the passage 11. This port 100 is positioned immediately adjacent the throttle plate 13 and slightly anterior thereto. The port 100 is interconnected with the control signal line 70 by an enrichment line 102 having a calibrated restriction 104 therein. When the throttle valve 12 passes through the off idle range the air will flow around the edge 15 of the throttle plate 13 and across the port 100. Thus the port 100 will be subjected to a vacuum which is a combination of the induction vacuum and the localized venturi effect produced by the air flow through this restricted space. As a consequence this port 100 will sense a vacuum higher than the venturi throat vacuum. A portion of this increased vacuum signal will be transmitted through the enrichment line 102 to the control line 70 so as to reinforce the venturi throat vacuum and produce a slightly greater force on the diaphragm 62. The amount of this increased force will be controlled by the resistance of the restriction 104 and will be effective to compensate for the inertia and friction in the metering mechanism so as to insure the charge maintaining at least some predetermined minimum air-fuel ratio. The timing and duration of the enrichment may be regulated by the position and shape of the enrichment port 100.

I claim:

1. Charge forming means for an internal combustion engine comprising an induction system and a fuel system, said induction system having a throttle valve for controlling the amount of the charge for said engine and a venturi for creating a vacuum signal indicative of the amount of said charge, said fuel means being adapted to inject metered quantities of fuel into said charge and including metering means responsive to said vacuum signal from said venturi, said metering means being interconnected with said induction system at a plurality of points anteriorly of said throttle valve one of said metering means points of connection being adjacent said throttle valve and adapted to cooperate with the latter to provide a metering signal under low air flow conditions.

2. Charge forming means for an internal combustion engine comprising an induction system having a throttle valve for controlling the amount of the charge for said engine and a venturi for creating a signal indicative of said amount of said charge, fuel means adapted to inject metered quantities of fuel into said charge and including metering means responsive to the signal from said venturi, said metering means being interconnected with said induction system by a conduit forming a first port immediately upstream of said throttle valve and positioned to register with the periphery of said throttle valve when in the off idle position, said conduit including a calibrated restriction, and a second port communicating with said induction system anteriorly of said first port.

3. Charge forming means for an internal combustion engine comprising an induction system having an inlet

passage with a throttle valve therein for controlling the amount of the charge for said engine and a venturi anterior to said valve for creating a signal indicative of the amount of said charge, fuel means adapted to inject metered quantities of fuel into said charge posterior to said throttle valve and including metering means responsive to the signal from said venturi, a port in the surface of said passage disposed upstream of said throttle valve when in the idle position, said port also being positioned to register with the periphery of said valve when said valve is in the off idle position, said port being interconnected with said metering means by a conduit having a calibrated restriction.

4. Charge forming means for an internal combustion engine comprising an induction system and a fuel system, said induction system having an inlet passage with a throttle valve therein for controlling the amount of the charge for said engine and a venturi anterior thereto for creating a vacuum signal indicative of the amount of said charge, said fuel means being adapted to inject metered quantities of fuel into said charge and including pressure sensitive means responsive to said vacuum signal for metering said fuel in proportion thereto, a port in the surface of said inlet passage disposed adjacent the periphery of said valve when it is in the off idle range, said port being interconnected with said pressure sensitive means by a conduit having a calibrated restriction.

5. Charge forming means for an internal combustion engine comprising an induction system having an inlet passage with a butterfly throttle valve therein for controlling the amount of charge for said engine and a venturi anterior thereto for creating a signal indicative of the amount of said charge, fuel means adapted to inject metered quantities of fuel into said charge and including a pressure sensitive diaphragm responsive to the signal from said venturi for metering the fuel in proportion thereto, a port in the side of said passage disposed anterior to said throttle valve when in the closed position and further positioned to register with the periphery thereof when in the off idle position, said port being interconnected with said diaphragm by a conduit having a calibrated restriction therein.

6. Charge forming means for an internal combustion engine comprising an induction system having an inlet passage with a butterfly throttle valve therein for controlling the amount of charge for said engine and a venturi anterior thereto for creating a signal indicative of the amount of said charge, fuel means adapted to inject metered quantities of fuel into said charge and including a fuel valve and a pressure sensitive diaphragm respon-

sive to said signal and connected to said fuel valve for metering the fuel in proportion thereto, a port in the side of said inlet passage disposed anterior to said throttle valve when in the closed position and positioned to register with the periphery thereof in the off idle position, said port being interconnected with said diaphragm by a conduit having a calibrated restriction therein.

7. Charge forming means for an internal combustion engine comprising an induction system having an inlet passage with a butterfly throttle valve therein for controlling the amount of charge for said engine and a venturi anterior thereto for creating a signal indicative of the amount of said charge, fuel means adapted to inject metered quantities of fuel into said charge and including a fuel by-pass valve and a pressure sensitive diaphragm responsive to said signal from said venturi and connected to said fuel valve for actuating said fuel valve to meter the fuel in proportion to said signal by by-passing the surplus fuel, a port in the side of said inlet passage disposed anterior to said throttle valve when in the closed position and positioned to register with the periphery thereof when in the off idle position, said port being interconnected with said diaphragm by a conduit having a calibrated restriction therein.

8. Charge forming means for an internal combustion engine comprising an induction system having an inlet passage with a butterfly throttle valve therein for controlling the amount of charge for said engine and a venturi anterior thereto for creating a signal indicative of the amount of said charge, fuel means adapted to inject metered quantities of fuel into said charge and including a by-pass fuel valve responsive to a fuel pressure indicative of the flow of metered fuel, a pressure sensitive diaphragm responsive to said signal pressure from said venturi and a linkage interconnecting said valve with said diaphragm to allow said by-pass valve to move until said pressures are balanced, a port in the side of said inlet passage disposed anterior to said throttle valve when in the closed position and positioned to register with the periphery thereof when in the off idle position, said port being interconnected with said diaphragm by a conduit having a calibrated restriction.

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

##### UNITED STATES PATENTS

2,749,898 Isley ----- June 12, 1956

##### FOREIGN PATENTS

246,529 Switzerland ----- Sept. 16, 1947