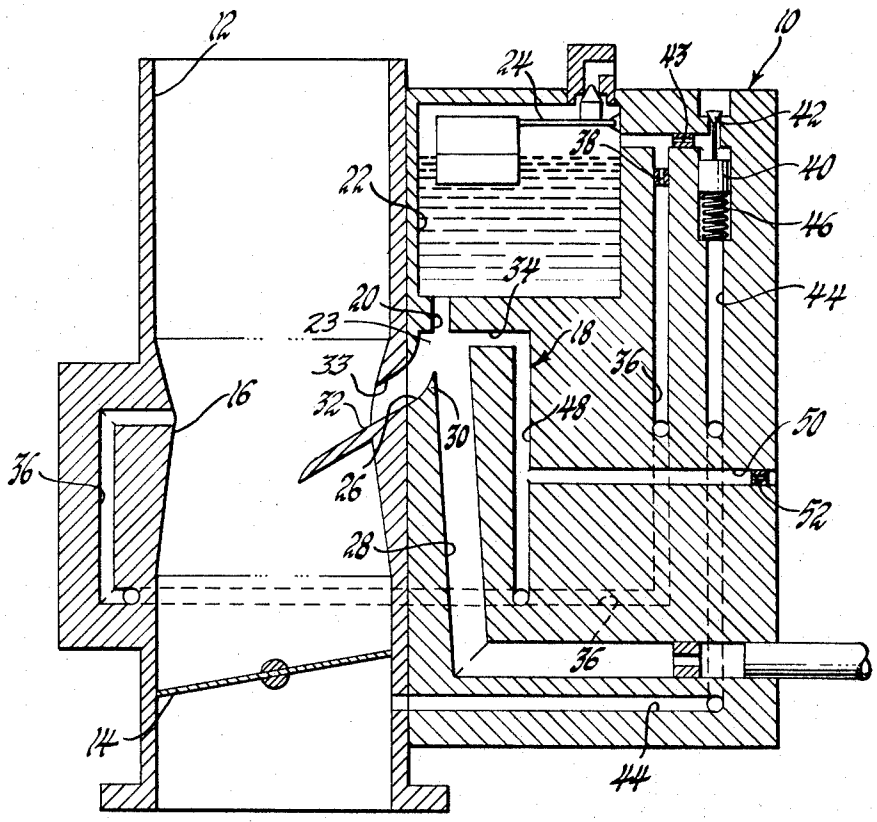
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FUEL SYSTEM

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FUEL SYSTEM

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This invention relates to fuel systems and is particularly directed to fuel systems utilizing fluid amplifier technology.

Because spark ignition internal cumbustion engines are quite sensitive to the proportions of the air-fuel mixture in the combustion chamber, innumerable systems have been developed in attempts to supply the engine with an air-fuel mixture proper for the various operating conditions. The systems in common use, however, include a venturi located in the air inlet to create a pressure signal which varies with the rate of air flow to the engine; this pressure signal determines the rate at which fuel is delivered to the engine.

Unfortunately however, the venturi signal does not vary linearly with air flow. When utilizing a large venturi to avoid restricting air flow at high air flow rates, the venturi signal is weak at low air flow rates. This weak signal would result in insufficient fuel delivery to the engine. On the other hand, a small venturi which would provide an adequate fuel metering signal at low air flow rates would also restrict air flow at high air flow rates. For these reasons, a compromise is generally adopted in which a separate idle system provides fuel at the lowest air flow rates, a large venturi and one or two small boost venturi provide a fuel metering signal over the part throttle and wide-open throttle operating ranges, and off-idle discharge ports smooth the transition from the idle system to the venturi metering system as the throttle opens.

Fuel systems have recently been developed which utilize fluid amplifiers to amplify the venturi pressure signal and deliver fuel to the engine at a rate determined by the amplified signal. Such an arrangement makes a complex system unnecessary.

As more extensively discussed in recent literature, Control Engineering of January 1963, for example, a fluid amplifier uses a relatively weak control signal to deflect a fluid jet. Because relatively large deflections in the jet are obtained with weak control signals, a more sensitive control function is obtained by utilizing the deflection of the jet rather than by directly utilizing the control signal.

This invention, directed to such a fluid amplifier controlled fuel system, provides means to vary the rate of flow through the amplifier in response to engine operating conditions. Thus, this invention causes the mixture to be enriched whenever acceleration or maximum power are required of the engine.

In addition, this invention provides means for controlling the gain of a fluid amplifier so that the desired amplification of a control signal such as venturi pressure may be achieved.

The details as well as other objects and advantages of this invention are disclosed in the following description and in the accompanying drawing which illustrates a fuel system carburetor embodying this invention.

Referring to the drawing, a carburetor **10** has an air inlet **12** controlled by a throttle **14** in the customary manner. A venturi **16** provides a restriction within air inlet **12** which reduces the pressure of the air flow therethrough to create a control signal related to the rate of air flow.

A fluid amplifier, indicated generally at **18**, has an inlet **20** opening from the carburetor fuel bowl **22** into an interaction region **23**. The fuel level within bowl **22** is maintained at a substantially constant level by a conventional float and inlet valve mechanism **24**. Fuel flow from bowl **22** provides a stream of fuel through amplifier **18** which is issued along a predetermined path within interaction region **23** and which has a predetermined energy state. The fuel stream is discharged from interaction region **23** through outlets **26** and **28**. With the amplifier construction so far described, the proportion of fuel discharged from outlet **26** is determined by the location of the splitter **30**.

As air flows through the carburetor inlet **12** and the venturi **16**, a pressure drop is produced to create a signal which is transferred through a fuel inlet nozzle **32**, a passage **33**, and amplifier outlet **26** to amplifier **18**. This pressure signal has an energy state much lower than that of the air stream issued from inlet **20** but deflects the fuel stream to change the proportion of fuel discharged through outlet **26**. As air flow through the carburetor inlet **12** increases, the pressure in venturi **16** drops further; this reduced pressure sensed through amplifier outlet **26** deflects more of the fuel flow through amplifier **18** to outlet **26**.

In addition to the control by venturi pressure, the pressure at a bias port **34** provides a low energy signal which affects fuel flow through amplifier **18**. As the pressure at bias port **34** increases, more of the fuel flow from inlet **20** will be deflected to outlet **26**. The pressure at bias port **34** is controlled by means to be described below.

An amplifier which operates as described is known as a "proportional" amplifier since the proportion of fuel discharged through outlet **26** varies with the pressure differential across the fuel stream, i.e., with the pressure differential between bias port **34** and venturi **16**.

The rate of fuel flow through inlet **20** is determined by the difference in the pressure on the free surface of the fuel and the pressure in amplifier inlet **20**. As described above the pressure in venturi **16** is sensed within amplifier **18** adjacent inlet **20**, thereby causing the pressure in inlet **20** to vary with the venturi signal. A passage **36** connects the bowl chamber **22** above the fuel level with venturi **16** to vary the pressure above the fuel level with the venturi signal. Thus, the difference in the pressure on the free surface of the fuel and the pressure in amplifier inlet **20** is held substantially constant so that fuel flows through amplifier **18** at a predetermined rate. Amplifier **18** is constructed so that the fuel flow from inlet **20** is divided and a portion directed through fuel inlet **32** to form an air-fuel mixture suitable for economy operation of the engine.

A restriction **38** in passage **36** prevents a sudden change in the rate of air flow through carburetor air inlet **12** and the concomitant pressure change in venturi **16** from suddenly changing the pressure above the fuel in bowl **22**. Therefore, upon a sudden throttle opening and the sudden increase in the air flow rate, the pressure above the fuel will be slowly reduced until it is balanced with venturi pressure. During this period of gradual fuel bowl pressure reduction, the fuel flow through amplifier inlet **20** and thus the fuel flow discharged through amplifier outlet **26** and fuel inlet **32** will temporarily be greater than that which would provide an economy air-fuel mixture. This increased fuel flow provides an enriched mixture to accelerate the engine.

A pressure responsive piston **40** controls a valve **42** to admit air through a restriction **43** to the fuel bowl chamber **22** above the fuel level. Intake manifold vacuum which exists in carburetor inlet **12** below throttle **14** is applied through a passage **44** against piston **40** in opposition to the bias of a spring **46**. During normal engine operation, the manifold vacuum will be sufficient to cause piston **40** to close valve **42**. When manifold vacuum reaches a value indicative of the engine's requirement for

an enriched mixture for maximum power operation, spring 46 overcomes the vacuum to raise the piston 40 and open valve 42. The air admitted to fuel bowl chamber 22 increases the pressure above the fuel level and causes an increased rate of fuel flow through amplifier inlet 20. As discussed above, this increased rate of fuel flow causes fuel to be delivered through fuel inlet 32 at a rate greater than that which would form an economy air-fuel mixture. The increased fuel flow thus provides an enriched mixture for power operation of the engine.

In some fluid amplifier constructions, the gain of the control signal causes too great a flow of fuel through the outlet 26. In order to reduce the sensitivity or gain of the fluid amplifier, this invention provides means to vary the pressure at bias port 34 in accordance with the control signal. A passage 48 connects bias port 34 to passage 36 and thus to venturi 16. A passage 50 connects passage 48 to atmosphere through a restriction 52. The pressure at bias port 34 is thus related to the venturi pressure signal but has an actual value intermediate the vacuum signal and the atmospheric pressure. Since the delivery of fuel through outlet 26 is determined by the pressure differential between bias port 34 and venturi 16, a reduction in pressure at bias port 34 reduces fuel delivery through outlet 26 and fuel inlet 32. By properly proportioning the restriction 52 within the atmospheric passage 50, the gain of amplifier 18 may be reduced to deliver fuel at any desired rate.

I claim:

1. An internal combustion engine fuel system comprising

a nozzle adapted to discharge fuel for mixture with air,

fluid amplifier means including

an interaction region

and an inlet port opening into said interaction region,

a source of liquid fuel connected to said inlet port for issuing a liquid fuel stream along a predetermined path within said interaction region, said fuel stream having a certain energy state,

an air inlet for air flow to the engine,

a venturi in said air inlet connected to said interaction region for supplying a pressure signal indicative of the rate of air flow through said air inlet and having an energy state substantially lower than the energy state of the liquid fuel stream and variations of which cause the path of the fuel stream to vary within said interaction region in proportion to the pressure signal variations,

said amplifier means further including outlet means opening from said interaction region for receiving the liquid fuel stream, said outlet means having

a pair of outlets

and a splitter for dividing the liquid fuel stream between said outlets in accordance with variations in the path of the fuel stream and for continuously varying the division of the fuel stream over the range of variations in the path of the fuel stream and for directing an increased flow of fuel to one of said outlets upon a change in the pressure signal indicative of increased air flow through said air inlet,

passage means connecting said nozzle to said one outlet for directing liquid fuel from said one outlet to said nozzle,

and regulating means for controlling the rate of fuel flow through said inlet port to compensate for the variations in pressure within said interaction region caused by the venturi pressure signal.

2. The fuel system of claim 1 wherein said source of fuel comprises a fuel bowl having means for maintaining fuel at a substantially constant level therein and wherein said regulating means comprises a regulating passage extending from said venturi to the top of said fuel bowl whereby the pressure on the free surface of the fuel in said fuel bowl may vary in accordance with the venturi pressure signal.

3. The fuel system of claim 2 wherein said regulating passage includes a restriction for delaying a reduction in the pressure in said fuel bowl to provide an enriched mixture for acceleration.

4. The fuel system of claim 2 which further includes a vent passage opening into the top of said fuel bowl to supply air thereto and vent valve means responsive to an engine demand for an enriched mixture for opening said vent valve means whereby the pressure in said fuel bowl is increased.

5. An internal combustion engine fuel system comprising

a nozzle adapted to discharge fuel for mixture with air,

fluid amplifier means including

an interaction region

and an inlet port opening into said interaction region,

a source of liquid fuel connected to said inlet port for issuing a liquid fuel stream along a predetermined path within said interaction region, said fuel stream having a certain energy state,

an air inlet for air flow to the engine,

a venturi in said air inlet connected to said interaction region for supplying a pressure signal indicative of the rate of air flow through said air inlet and having an energy state substantially lower than the energy state of the liquid fuel stream and variations of which cause the path of the fuel stream to vary in a certain plane within said interaction region in proportion to the pressure signal variations,

said amplifier means further including outlet means opening from said interaction region for receiving the liquid fuel stream, said outlet means having

a pair of outlets

and a splitter for dividing the liquid fuel stream between said outlets in accordance with variations in the path of the fuel stream and for continuously varying the division of the fuel stream over the range of variations in the path of the fuel stream and for directing an increased flow of fuel to one of said outlets upon a change in the pressure signal indicative of increased air flow through said air inlet,

passage means connecting said nozzle to said one outlet for directing liquid fuel from said one outlet to said nozzle,

said amplifier means still further including a regulating port opening into said interaction region in said certain plane,

and passage means connecting said venturi to said regulating port for transmitting another pressure signal to said interaction region in opposition to the first-mentioned pressure signal to reduce the variations in the path of the fuel stream caused by the first-mentioned pressure signal.

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