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FLUID AMPLIFIER ARRANGEMENT AND FUEL SYSTEM INCORPORATING SAME

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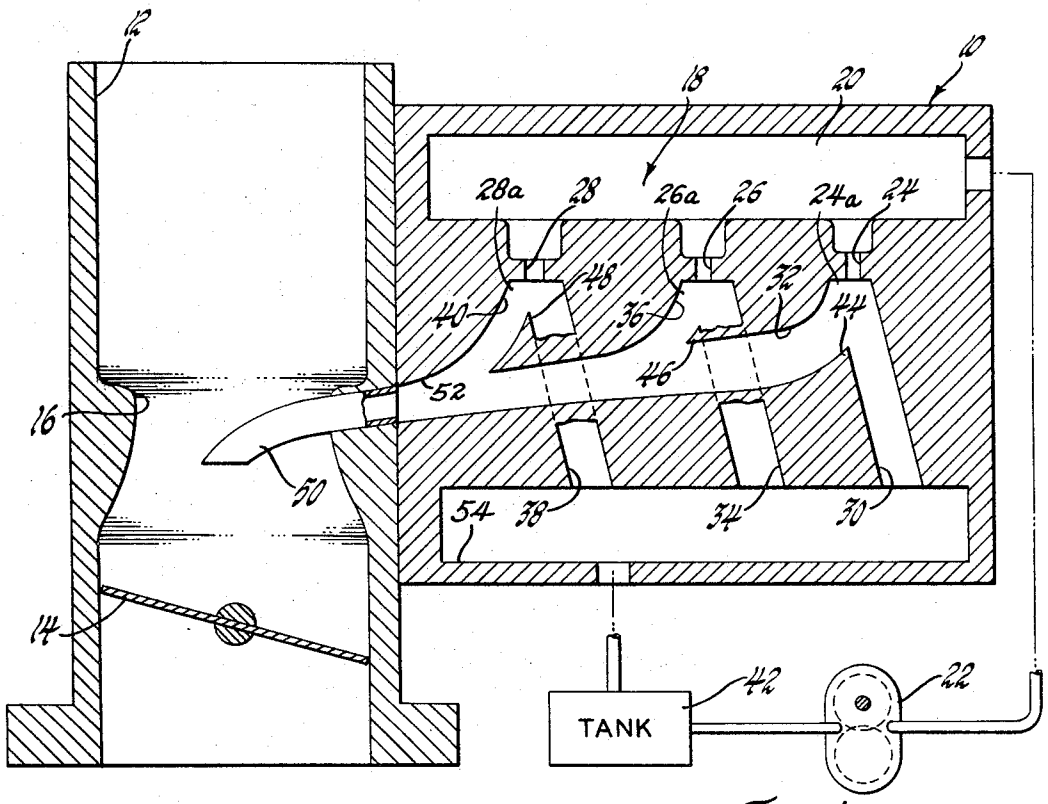


Fig. 1

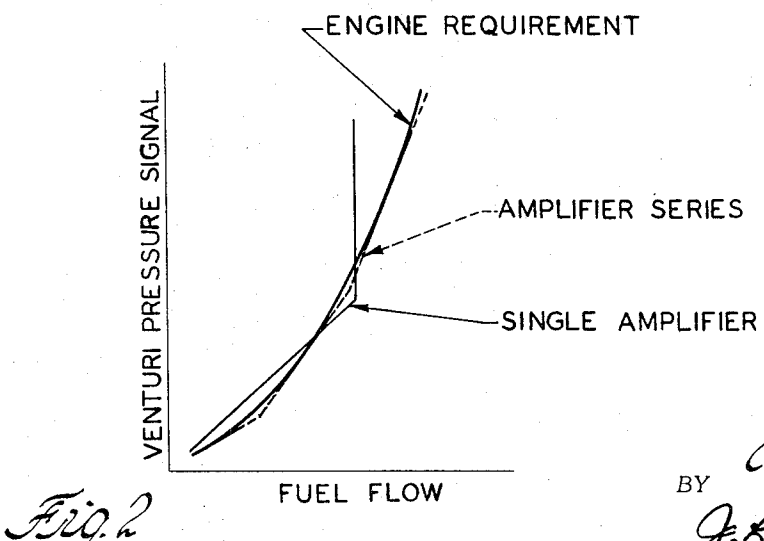


Fig. 2

INVENTOR.

Craig Marks

BY

J. K. Carpenter

ATTORNEY

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FLUID AMPLIFIER ARRANGEMENT AND FUEL SYSTEM INCORPORATING SAME

Craig Marks, Grosse Pointe Woods, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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This invention relates to fluid amplifiers and to fuel systems utilizing fluid amplifier technology.

Because spark ignition internal combustion 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 very 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 idle 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 the path of a fluid stream. Because relatively large deflections in the fluid path are obtained with weak control signals, a more sensitive control function is obtained by measuring the deflection of the path rather than by directly measuring the control signal. However, when an amplifier has a linear response to a control signal, a fuel system relying on a single amplifier for fuel metering may not supply the most desirable air-fuel mixture throughout the entire range of engine operating conditions.

This invention provides a fuel system including a fluid amplifier arrangement which closely tailors the rate of fuel delivery for the wide range of engine air flow rates. The fuel system includes a plurality of amplifiers which are sequentially actuated, each in a predetermined range of air flow rates, so that the pressure signal is sufficiently amplified to deliver fuel at a rate which closely approximates that required by the engine.

The details as well as other objects and advantages of this invention are disclosed in the following description and in the drawing in which:

FIGURE 1 illustrates a fuel system carburetor embodying this invention; and

FIGURE 2 graphically illustrates the fuel metering characteristics of this invention.

Referring to FIGURE 1, 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 arrangement, indicated generally by **18**, has a common inlet **20** connected to a fuel pump **22**. In the amplifier arrangement **18**, a series of amplifiers, three being illustrated, each has an inlet **24**, **26**, and **28** opening into an interaction region **24***a*, **26***a*, **28***a* and a pair of outlets **30–32**, **34–36**, and **38–40** opening therefrom. Fuel is drawn from a tank **42** by pump **22**, passes through the common inlet **20**, and is issued from the individual inlets **24**, **26**, **28** in streams each having a predetermined path within an interaction region **24***a*, **26***a*, **28***a* and a predetermined energy state. The fuel streams are discharged from the interaction regions through outlets **30** through **40**. With the amplifier arrangement so far described, the proportion of fuel discharged from outlets **32**, **36**, **40** is determined by the location of the splitters **44**, **46**, **48**.

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 **50**, a passage **52**, and the outlets **32**, **36**, **40** to the individual amplifiers. This pressure signal has an energy state much lower than that of the fuel streams issued from ports **24**, **26**, **28**, but deflects fuel stream to change the proportion of fuel discharged through outlets **32**, **36**, **40**.

Amplifiers which operate as described are known as "proportional" amplifiers since the proportion of the fluid discharged through the outlets **32**, **36**, **40** varies with the pressure drop in the venturi **16**.

As is well-known, the venturi pressure signal varies as the square of the rate of air flow through the inlet **12**. Because the engine requires fuel flow more directly proportional to air flow, it is desirable to have the venturi pressure signal also vary as the square of the rate of fuel flow. It will be appreciated that, as illustrated by the single amplifier curve of FIGURE 2, a single amplifier controlled by the venturi signal can only roughly approximate such a fuel delivery requirement.

Therefore, this invention provides an amplifier arrangement **18** in which the splitters **44**, **46**, **48** of the various individual amplifiers are arranged so that splitter **44** initially divides fuel flow from inlet **24** between outlets **30** and **32** while splitters **46** and **48** direct the entire fuel flow from inlets **26** and **28** to outlets **34** and **38** and then to a sump **54** which drains back to tank **42** The arrangement is such that when substantially the entire fuel flow from inlet **24** is discharged through outlet **32**, the pressure in outlet **36** is sufficient to cause splitter **46** to divide the fuel flow from inlet **26** between outlets **34** and **36**, and similarly, when substantially the entire fuel flow from inlets **24** and **26** is directed through outlets **32** and **36**, the pressure in outlet **40** is sufficient to cause splitter **48** to divide the fuel flow from inlet **28** between outlets **38** and **40**.

The fuel metering characteristics of this invention are graphically illustrated in FIGURE 2 where it will be noted that the fuel delivery of the amplifier series very closely approximates the requirements of the engine.

This invention, in providing a fuel system having a series of amplifiers to meter and deliver fuel in various ranges of engine operating conditions, therefore allows a close tailoring of the fuel delivery to the requirements of the engine. In addition, enrichment of the air-fuel mixture under particular operating conditions may be easily accomplished by using an amplifier with an increased gain to control fuel delivery in the range of the desired air flow rate. Those skilled in fuel system and fluid amplifier technologies will readily appreciate that this invention may be utilized in many other arrangements to supply fuel to an engine.

I claim:

1. A proportional fluid amplifier arrangement comprising

interaction region means,

inlet port means opening into said interaction region means,

a source of fluid connected to said inlet port means for issuing a fluid stream along a predetermined path within said interaction region,

control means connected to said interaction region means for supplying a control signal variations of which cause the path of the fluid stream to vary within said interaction region in proportion to the control signal variations,

and outlet means opening from said interaction region for receiving the fluid stream, said outlet means having

a pair of outlet port means,

and splitter means for dividing the fluid stream among said outlet port means in accordance with variations in the path of the fluid stream and for continuously varying the division of the fluid stream over the range of variations in the path of the fluid stream, said splitter means having lateral portion means converging to line intersection means, said line intersection means forming that portion of said splitter means most closely adjacent said inlet port means and defining splitter apex means, said splitter apex means being disposed relative to said inlet port means for non-linearly changing the division of the fluid stream among said outlet port means upon a predetermined change in the path of the fluid stream to establish a fluid condition in a portion of said outlet port means which varies in predetermined accordance with variations in the control signal.

2. The fluid amplifier arrangement of claim 1 wherein

said interaction region comprises a number of independent interaction regions,

said inlet port means comprises an inlet port opening into each independent interaction region,

said source of fluid is connected to said inlet ports for issuing a portion of the fluid stream within each independent interaction region,

said pair of outlet port means comprises a pair of outlet ports opening from each independent interaction region,

and said splitter means comprises a separate splitter apex associated with each pair of outlet ports,

and which includes means connected to one outlet port of each pair of outlet ports to form a common outlet passage comprising said portion of said outlet port means,

and wherein the apexes are disposed relative to the inlet ports to sequentially divide the portions of the fluid stream issued within said independent interaction regions.

3. An internal combustion engine fuel system comprising

a nozzle adapted to discharge fuel for mixture with air,

fluid amplifier means including interaction region means, and inlet port means opening into said interaction region means,

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

control means connected to said interaction region means for supplying a control signal indicative of an engine demand for fuel and having an energy state substantially lower than the energy state of the fuel stream and variations of which cause the path of the liquid fuel stream to vary within said interaction region in proportion to the control 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 plurality of outlet port means, and splitter means for dividing the liquid fuel stream among said outlet port means in accordance with variations in the path of the fuel stream and for continuously varying the division of the fluid stream over the range of variations in the path of the fluid stream, said splitter means being disposed relative to said inlet port means to non-linearly change the division of the fuel stream among said outlet port means upon a predetermined change in the path of the fuel stream to establish a rate of liquid fuel flow through a portion of said outlet port means which varies in accordance with variations in the control signal,

and passage means connecting said portion of said outlet means to said nozzle for directing liquid fuel flow from said portion to said nozzle.

4. The fuel system of claim 3 wherein

said interaction region comprises a number of independent interaction regions,

said inlet port means comprises an inlet port opening into each independent interaction region,

said source of liquid fuel is connected to said inlet ports for issuing a portion of the fuel stream within each independent interaction region,

said plurality of outlet port means comprises a pair of outlet ports opening from each independent interaction region,

said splitter means comprises a splitter associated with each pair of outlet ports,

and said passage means connects one outlet port of each pair of outlet ports to said nozzle.

5. The fuel system of claim 3 wherein said control means comprises an air inlet for air flow to the engine and a venturi in said air inlet connected to said interaction region means, the rate of air flow through said venturi providing an air flow pressure signal which forms the control signal indicative of an engine demand for fuel.

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HARRY B. THORNTON, *Primary Examiner.*

T. R. MILES, *Assistant Examiner.*