

Nov. 11, 1969

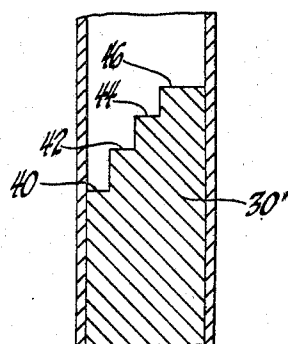
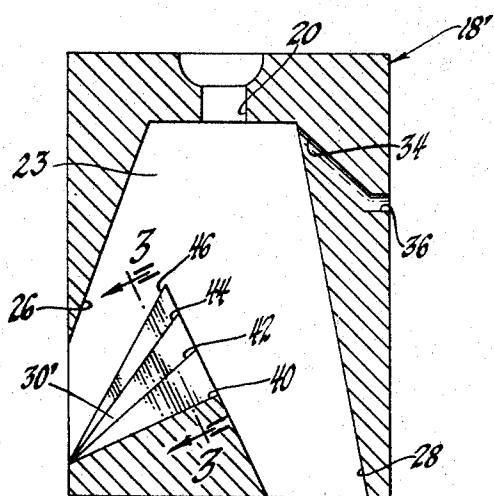
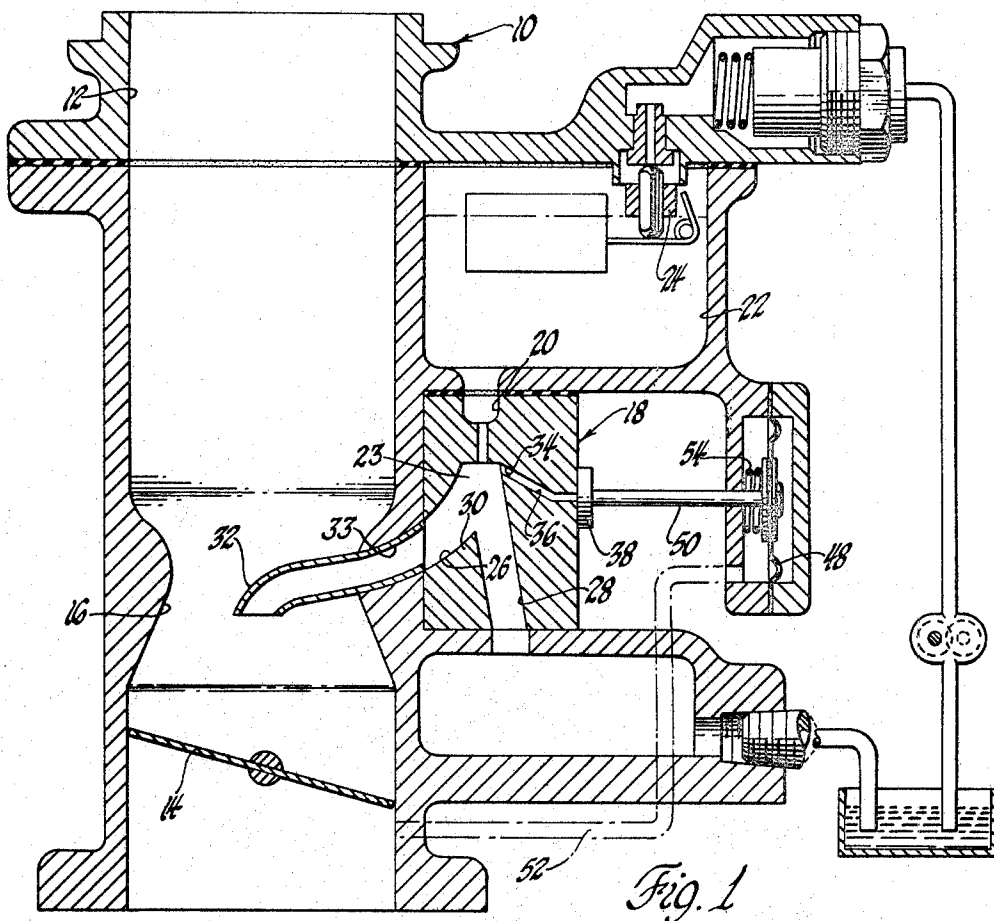
W. L. DRAYER

3,477,699

METERING MEANS

Filed Sept. 16, 1965

2 Sheets-Sheet 1



INVENTOR.

William L. Drayer

BY

J. L. Carpenter
ATTORNEY

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2 Sheets-Sheet 2

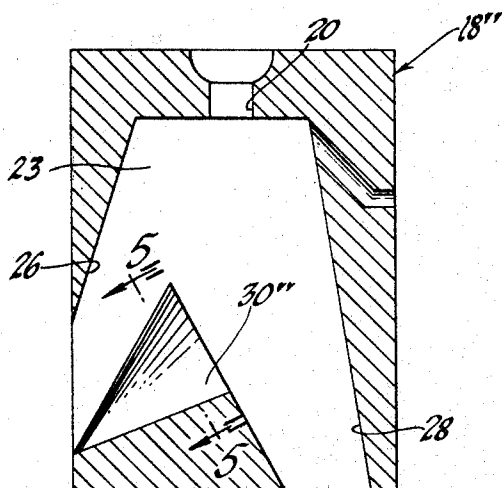


Fig. 4

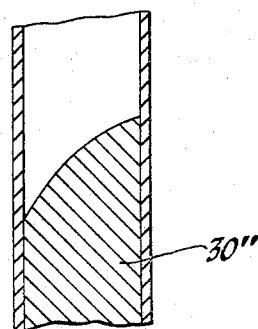


Fig. 5

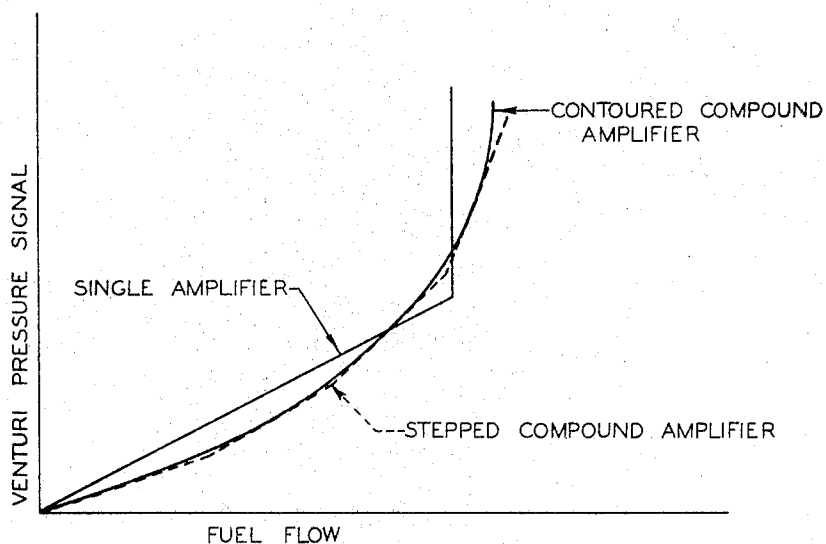


Fig. 6

INVENTOR.
William L. Drayer
BY
J. L. Carpenter
ATTORNEY

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3,477,699

METERING MEANS

William L. Drayer, Warren, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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12 Claims

ABSTRACT OF THE DISCLOSURE

In a carburetor having a throttle for controlling air flow and a venturi for creating an air flow responsive pressure signal, fuel is delivered through a proportional fluid amplifier to a nozzle discharging into the venturi. Fuel is metered by the amplifier in accordance with the venturi pressure signal, transmitted to the amplifier interaction region through one outlet of the amplifier, and in accordance with an opposed atmospheric pressure signal, transmitted past a valve responsive to manifold vacuum. The splitter of the amplifier is contoured to provide a non-linear metering characteristic.

This invention relates to metering means and is particularly directed to fluid amplifiers and 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 such 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 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 compound fluid amplifier which has a non-linear response to a control signal. The

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amplifier provided by this invention permits the gain to be closely controlled over a wide range of operating conditions.

This invention further provides a fuel system including a compound fluid amplifier which closely tailors the rate of fuel delivery for the wide range of engine air-flow rates.

In addition, this invention provides means to enrich the mixture supplied by a fluid amplifier arrangement in an internal combustion engine fuel system.

This invention also provides a fluid amplifier in which a control signal is transmitted to the interaction region through an outlet of the amplifier rather than through a separate control port.

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

FIGURE 1 illustrates a fuel system carburetor embodying this invention;

FIGURE 2 is an enlarged view of a laminated compound amplifier;

FIGURE 3 is a sectional view along line 3—3 of FIGURE 2 illustrating the contour of the fluid amplifier splitter;

FIGURE 4 is an enlarged view of a contoured compound amplifier;

FIGURE 5 is a sectional view along line 5—5 of FIGURE 4 illustrating the contour of the fluid amplifier splitter; and

FIGURE 6 graphically illustrates the 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, indicated generally at 18, has an inlet 20 opening from a carburetor fuel bowl 22 into an interaction region 23. Fuel is maintained at a substantially constant level in bowl 22 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 air inlet 12 and venturi 16, a pressure drop is produced to create a signal which is transferred through the fuel inlet nozzle 32, a passage 33, and the outlet 26 to the amplifier 18. This pressure signal has an energy state much lower than that of the fuel stream issued from inlet 20 but deflects the fuel stream to change the proportion of fuel discharged through outlet 26.

A regulating or bias port 34 in amplifier 18 is connected with atmosphere by a passage 36. Passage 36 is controlled by a valve 38, the function of which will be described below in greater detail.

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

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 6, a single amplifier controlled by the venturi signal can only roughly approximate such a fuel delivery requirement.

Therefore, this invention provides the compound amplifiers 18' and 18'' illustrated in FIGURES 2 and 4. In these compound amplifiers the splitters 30' and 30'' are constructed so that only a portion of the fuel flow from inlet 20 is divided between outlets 26 and 28 while the remainder is directed through outlet 28. As air flow to the carburetor inlet 12 increases, the venturi signal sensed in outlet 26 increases to cause splitters 30' and 30'' to divide a greater portion of the fuel flow from inlet 20 between outlets 26 and 28.

Referring more particularly to the laminated compound amplifier 18' illustrated in FIGURES 2 and 3, the splitter 30' comprises a series of stepped portions 40, 42, 44, 46. Fuel flow will be initially divided by the splitter portion 40 and, as the pressure signal sensed in outlet 26 increases, subsequently by splitter portions 40 and 42; 40, 42 and 44; or 40, 42, 44 and 46 in accordance with the value of the pressure signal.

Referring more particularly to the contoured compound amplifier 18'' illustrated in FIGURES 4 and 5, the splitter 30'' is countoured to provide a continuous increase in the rate of fuel discharged through outlet 26 as the pressure signal sensed through outlet 26 increases.

The metering characteristics of this invention are graphically illustrated in FIGURE 6 where it will be noted that the fuel delivery of the compound amplifiers very closely approximates the requirements of the engine.

Referring again to FIGURE 1, a pressure responsive diaphragm 48 is secured through a plunger 50 to valve 38. Manifold vacuum, existing in inlet 12 below the throttle 14, is directed through a conduit 52 against diaphragm 48 in opposition to the bias exerted by a spring 54. Under normal operating conditions, manifold vacuum is sufficient to cause diaphragm 48 to close valve 38 across passage 36. The pressure at bias port 34 will then be at a slightly subatmospheric value determined by the flow conditions within the amplifier 18. When the manifold vacuum reaches a predetermined value indicative of the engine's requirement for an enriched mixture, spring 54 opens valve 38 so that the pressure at bias port 34 becomes atmospheric. The pressure provides a signal having an energy state much lower than that of the fuel stream but which deflects the fuel toward outlet 26 to direct additional fuel through the inlet nozzle 32. An enriched mixture is thereby provided for the engine.

This invention, in providing a fuel system having a compound amplifier to meter and deliver fuel throughout the various ranges of engine operating conditions, therefore allows close tailoring of the fuel delivery to the requirements of the engine. 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

- a single interaction region,
- an inlet port opening into said interaction region,
- a source of fluid connected to said inlet port for issuing a fluid stream along a predetermined path within said interaction region,
- control means connected to said interaction region for supplying a control signal variations of which cause the path of the fluid stream to vary in a certain plane within said interaction region in proportion to the control signal variations,
- a pair of outlets opening from said interaction region for receiving the fluid stream,
- and a single splitter for dividing the fluid stream between said outlets 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 having lateral portion means converging to line intersection means, said line intersection means forming that portion of said lateral portion means most closely adjacent said inlet port and defining splitter apex means, said splitter apex means being disposed relative to said certain plane for non-linearly changing the division of the fluid stream between said outlets upon a predetermined change in the path of the fluid stream to establish a fluid condition in one of said outlets which varies in predetermined accordance with variations in the control signal.

2. The fluid amplifier arrangement of claim 1 wherein said splitter apex means extends transversely of said certain plane and is inclined to the general direction of flow of the fluid stream.

3. The fluid amplifier arrangement of claim 1 wherein said splitter apex means extends transversely of said certain plane and is inclined to the general direction of variations in the path of the fluid stream.

4. The fluid amplifier arrangement of claim 1 wherein said splitter apex means extends transversely of said certain plane and is inclined both to the general direction of flow of the fluid stream and to the general direction of variations in the path of the fluid stream.

5. The fluid amplifier arrangement of claim 4 wherein said apex means comprises a plurality of stepped apex portions which extend perpendicularly to said certain plane and which are longitudinally spaced in the general direction of flow of the fluid stream and transversely spaced in the general direction of variations in the path of the fluid stream.

6. The fluid amplifier arrangement of claim 1 wherein said splitter apex means has a contour disposed across the path of the fluid stream and incremental portions of which are sequentially effective to divide the fluid stream between said outlets upon incremental variations in the path of the fluid stream.

7. The fluid amplifier arrangement of claim 6 wherein said contour is smooth and is inclined both to the general direction of flow of the fluid stream and to the general direction of variations in the path of the fluid stream.

8. A proportional fluid amplifier arrangement comprising

- an interaction region,
- an inlet port opening into said interaction region,
- a source of regulated fluid connected to said inlet port for issuing a fluid stream along a predetermined path within said interaction region,
- a fluid flow conduit,
- a source of regulating fluid connected to said conduit for causing fluid flow therethrough,
- control means in said conduit for providing a fluid pressure signal indicative of the rate of flow of regulating fluid therethrough,
- a pair of outlets opening from said interaction region, one of said outlets opening into said conduit and connecting said control means with said interaction region whereby said fluid pressure signal is transmitted through said one outlet to cause the path of the fluid stream to vary in proportion to the signal and within said interaction region,
- and a splitter for dividing the fluid stream issued from said inlet port between said outlets 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 and for directing an increased portion of the regulated fluid stream to said one outlet upon a change in the signal indicative of an increased rate of flow of regulating fluid through said conduit whereby regulated fluid is delivered to said conduit at a rate of flow in accordance with the rate of flow of regulating fluid.

9. An internal combustion engine fuel system comprising

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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 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,

a source of air at atmospheric pressure,

a regulating port opening into said interaction region in said certain plane and connecting said source of air to said interaction region, said source of air providing a pressure signal variations of which also cause the path of the fuel stream to vary within said interaction region,

valve means associated with said regulating port for selectively permitting the transmittal of a pressure signal from said source of air to said interaction region,

a throttle in said air inlet for controlling air flow therethrough,

means connected to said valve means and responsive to an increase in the pressure within said air inlet downstream of said throttle above a predetermined level for opening said valve and transmitting a pressure signal from said source of air to said interaction region,

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 portion of the fuel stream to one of said outlets upon a change in the pressure signal indicative of increased air flow through said air inlet to provide a flow of metered liquid fuel through said one outlet,

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

10. 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 fuel stream and variations of which cause the path of the fuel stream to vary in a cer-

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tain 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 single 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 portion of the fuel stream to one of said outlets upon a change in the pressure signal indicative of increased air flow through said air inlet to provide a flow of metered liquid fuel through said one outlet, said splitter being disposed relative to said certain plane for non-linearly varying the division of the fuel stream over the range of variations in the path of the fuel stream whereby the flow of metered fuel through said one outlet may be provided in a desired relation to the flow of air through said air inlet,

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

11. The fuel system of claim 10 wherein said single splitter comprises an apex portion having a smooth contour disposed transversely of said certain plane and inclined both to the general direction of flow of the fuel stream and to the general direction of variations in the path of the fuel stream.

12. An internal combustion engine fuel system comprising

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 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 portion of the fuel stream to one of said outlets upon a change in the pressure signal indicative of increased air flow through said air inlet to provide a flow of metered liquid fuel through said one outlet,

a nozzle adapted to discharge fuel into said venturi for mixture with air

and passage means connecting said one outlet to said nozzle for directing liquid fuel from said one outlet to said nozzle, said venturi being connected to said interaction region by said nozzle and said one outlet whereby said pressure signal is transmitted from said

venturi to said interaction region through said discharge nozzle and said one outlet.

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10 TIM R. MILES, Primary Examiner

U.S. Cl. X.R.

123—119; 137—81.5; 261—69