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Rhodes et al.

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[54] **METHOD AND APPARATUS FOR VARYING FUEL FLOW TO COMPENSATE FOR CHANGES IN BAROMETRIC PRESSURE AND ALTITUDE**

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[52] **U.S. Cl.** .... **261/39 A**; 261/52; 261/121 B; 261/DIG. 56

[51] **Int. Cl.** **F02m 7/24**

[58] **Field of Search** .... 261/39 A, 39 D, 121 B, 261/69 A, 52, DIG. 56

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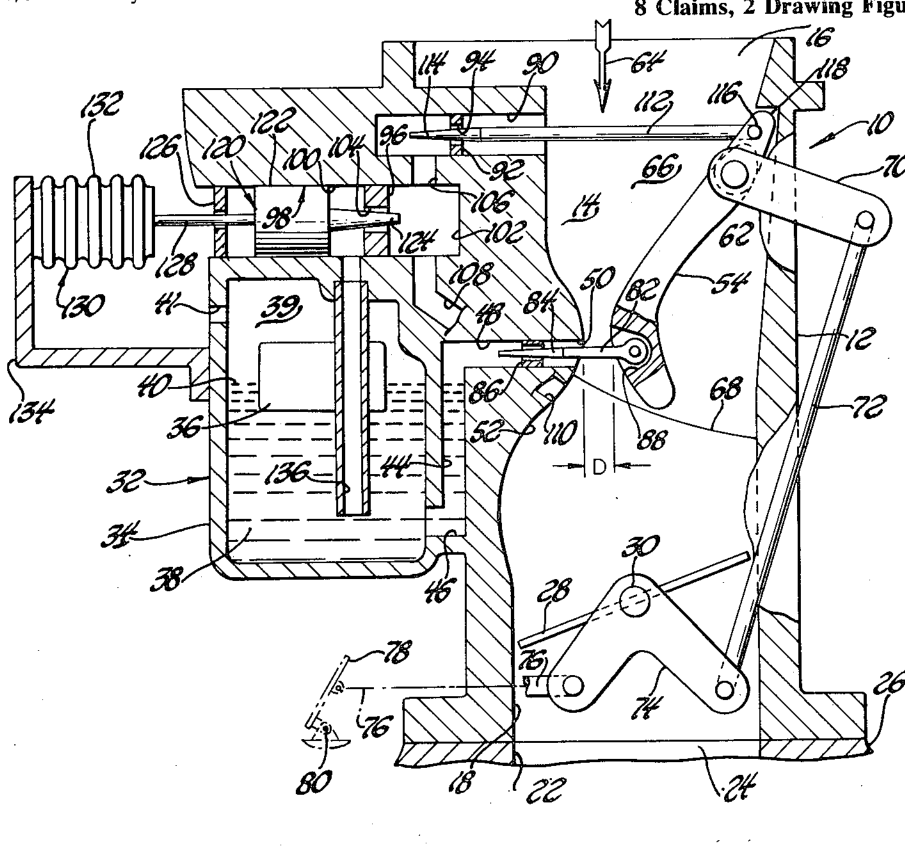
Primary Examiner—Tim R. Miles

[57] **ABSTRACT**

In a carburetor having an induction passage, a variable venturi in the induction passage, a fuel bowl and means for metering fuel flow from the fuel bowl to the induction passage, for example, the method of compensating for changes in barometric pressure due to either atmospheric or altitude changes is disclosed as providing an auxiliary passage including variable restriction means therein communicating between the fuel within the fuel bowl and the induction passage, applying venturi generated vacuum to the auxiliary passage in order to thereby cause flow of fuel therethrough, varying the value of the venturi generated vacuum generally in response to the volume rate of air flow through the variable venturi, and varying the effective flow area of the variable restriction means generally in accordance with barometric pressure.

A carburetor having an induction passage with a variable venturi and a fuel bowl has barometrically controlled variable restriction means in combination with passage means communicating between the fuel within the fuel bowl and the induction passage, vacuum generated by the variable venturi is applied to the passage means to cause a pressure differential across the fuel thereby resulting in fuel flow through the passage means, the barometrically controlled variable restriction means is effective to vary the rate of fuel flow therethrough in response to said vacuum, and additional means responsive to the opening and closing movement of said variable venturi is effective to vary the magnitude of said vacuum generated by the variable venturi.

8 Claims, 2 Drawing Figures



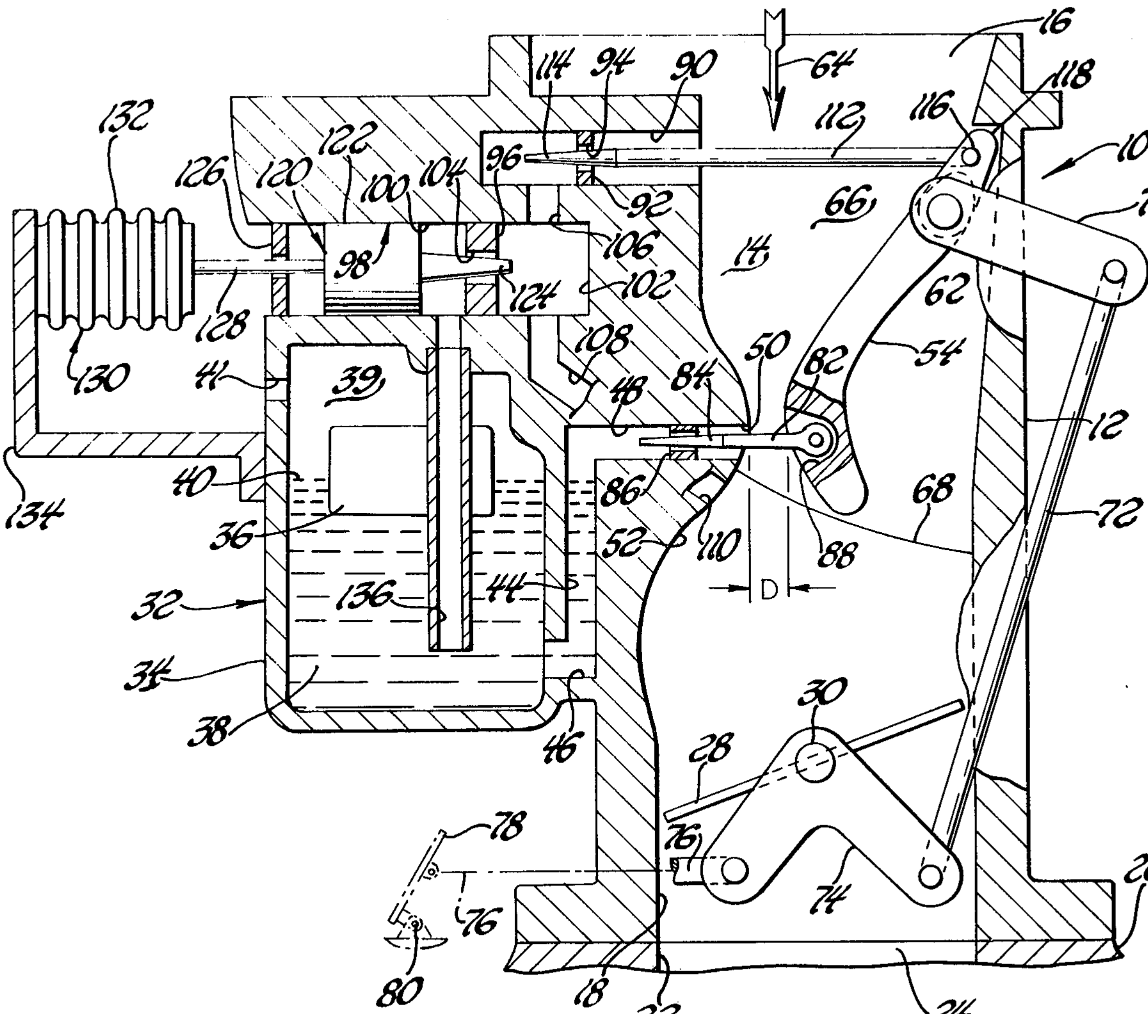

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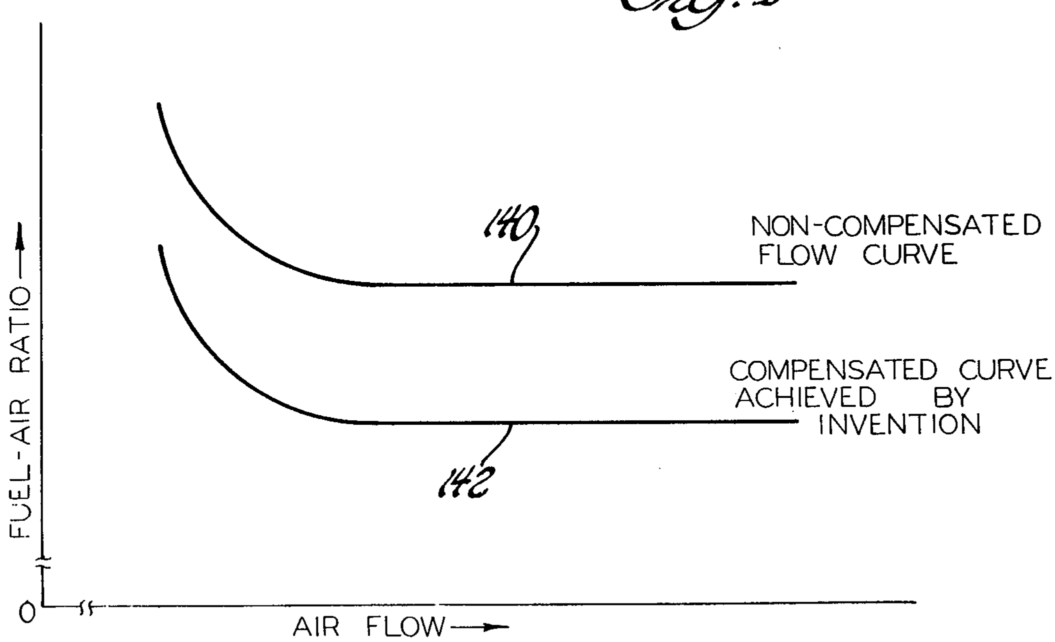
Fig. 1


FUEL-AIR RATIO
140
NON-COMPENSATED FLOW CURVE
COMPENSATED CURVE ACHIEVED BY INVENTION
142
0
AIR FLOW
Fig. 2

METHOD AND APPARATUS FOR VARYING FUEL FLOW TO COMPENSATE FOR CHANGES IN BAROMETRIC PRESSURE AND ALTITUDE

BACKGROUND OF THE INVENTION

It is well known in the art that the rate of fuel flow from a variable venturi carburetor fuel bowl, for any given size of fuel metering restriction employed, is dependent upon the pressure differential existing across the fuel within the bowl as measured, for example, from above the level of the fuel within the bowl to the discharge orifice of the main fuel metering system.

Theoretically, in order to achieve a proper fuel-air mixture discharged by the carburetor, the relationship sought is one where a particular mass of fuel (such as pounds of fuel per hour) is metered as to be mixed with a particular mass of air (also such as pounds of air per hour).

In doing this, carburetors employ either a fixed or variable venturi, or some such functionally equivalent structure, within the induction passage so that as air flows therethrough a reduction in the pressure (often referred to as venturi vacuum) of the air is achieved in the vicinity of the venturi throat. The value of the venturi vacuum is of a variable magnitude generally indicative of the rate of flow of such air through the venturi.

However, the flow of air through such venturi does not necessarily indicate that the mass rate of flow of such air is constant even though the venturi vacuum generated thereby should remain constant. That is, the generated venturi vacuum is produced in response to the volume rate of air flow and not the mass rate of air flow. Consequently, as either barometric pressure changes due to atmospheric conditions or ambient pressures change due to changes in altitude, the volume rate of air flow may in fact remain constant but such a volume rate of air flow will represent differing values of mass rate of air flow as between two different atmospheric pressures. For example, while driving through the mountains a volume rate of flow of air developing the same venturi vacuum as previously experienced at, for example, sea level, will actually represent a lesser mass rate of flow of air because of the decrease in density of the air in such higher altitudes. However, since the rate of metered fuel flow is primarily dependent on the vacuum generated at the venturi (and consequent pressure differential across the fuel in the fuel bowl) substantially the same rate of fuel flow is metered to the less dense air of the higher altitude as was metered to the more dense air of the lower altitude.

Obviously, at times the above results in a somewhat over-rich (in terms of fuel) fuel-air mixture delivered to the engine, which, in turn, to that degree increases engine exhaust emissions.

The above problems have been known in the prior art and heretofore attempts have been made to compensate fuel metering requirements in respect to changes in barometric pressure or altitude. Such prior art attempts have taken the form of, for example, bellows employed for varying the effective area of the main metering system. The determination of such effective area was accomplished as by a variably positioned metering rod cooperating with a fixed orifice. However, such arrangements have not been accepted for various reasons among which are the difficulty of manufacturing the metering rod to the extremely close tolerances required, the accurate and positive location of the metering rod with respect to the surface defining the cooperating fixed orifice and maintaining such relationship during movement of the metering rod, the rather limited travel of the metering rod in which the entire spectrum of compensation must be achieved, and the propensity for such systems to become impaired by virtue of particles of dirt especially when the effective area of the metering orifice is reduced.

Accordingly, the invention as herein disclosed and claimed is primarily directed to the solution of the above as well as other attendant problems.

SUMMARY OF THE INVENTION

According to the invention, a method of providing compensating or auxiliary fuel to an internal combustion engine from a carburetor having a body, induction passage means formed through said body for communicating with said engine, variable venturi means situated within said induction passage means, fuel reservoir means for containing fuel, fuel delivery means including fuel metering means communicating between the interior of said fuel reservoir means and said induction passage means, said fuel metering means being effective to meter the rate of fuel flow from said fuel reservoir means through said fuel delivery means and into said induction passage means in accordance with the volume rate of air flow through said variable venturi means, and auxiliary conduit means communicating between said fuel within said fuel reservoir means and said induction passage means for supplying auxiliary fuel flow to said induction passage means generally in accordance with sensed ambient pressure, comprises the steps of creating a sub-atmospheric pressure within said auxiliary conduit means of a magnitude reflective of volume rate of air flow through said variable venturi means, and variably restricting the effective flow area of said auxiliary conduit means generally in accordance with said ambient pressure as to more nearly close-off said effective flow area as said ambient pressure decreases.

While the invention is shown as embodied in a variable venturi carburetor, the invention or certain features thereof may be equally applicable to other carburetor types, such as certain air valve type carburetors.

Apparatus for carrying out the above inventive method may be described as a carburetor for an internal combustion engine, comprising a carburetor body, induction passage means formed through said body for communication with said engine, variable venturi means situated in said induction passage means effective for defining a variably openable venturi throat, a fuel reservoir, ambient pressure controlled variable restriction means in combination with auxiliary passage means communicating between the fuel within said fuel reservoir and said induction passage means, said auxiliary passage means communicating with a source of vacuum generated by the flow of air through said variably openable venturi throat as to thereby cause a pressure differential across said fuel resulting in the flow of auxiliary fuel through said auxiliary passage means, said ambient pressure controlled variable restriction means being effective to vary the rate of flow of said auxiliary fuel through said auxiliary passage means in response to the magnitude of said vacuum, and additional means responsive to the opening and closing movement of said variably openable venturi throat for varying the effective magnitude of said vacuum communicated to said auxiliary passage means.

Various general and specific objects and advantages of the invention will become apparent when reference is made to the following detailed written description considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein for purposes of clarity certain details and elements may be omitted:

FIG. 1 illustrates, in cross-section, a variable venturi carburetor constructed in accordance with the teachings of the invention; and

FIG. 2 is a graph illustrating characteristic fuel flow curves of prior art structures and of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in greater detail to the drawings, FIG. 1 illustrates a carburetor assembly **10** having a body or housing means **12** with an induction passage **14** formed therethrough with such induction passage **14** having an inlet end **16** and an outlet or discharge end **18** leading to an inlet **22** of the interior **24** of an intake manifold **26** of an associated internal combustion engine. A variably positionable throttle valve **28**, mounted as for rotation on a throttle shaft **30**, is situated within the induction passage and effective for controlling the flow of a motive or combustible mixture from said induction passage **14** into the intake passage **24** of engine manifold **26**. Generally, such combustible mixture will, of course, be comprised of atmospheric air admitted into inlet end **16** and fuel supplied to the induction passage **14** from an associated fuel reservoir or fuel bowl assembly **32**.

The fuel bowl assembly **32** is illustrated as comprising a suitable bowl or housing structure **34** which may contain a float member **36** controlling an associated fuel inlet needle valve assembly (not shown but well known in the art) so as to maintain the level of the fuel **38** within the bowl **34** at a preselected level as at **40**. The interior **39** of the fuel bowl may be vented to the atmosphere as by vent means **41**.

The related fuel metering means is shown as comprising a fuel well or conduit **44** with the lower end thereof being in communication with the fuel **38** as at **46**. Conduit **44** leads to a fuel discharge conduit or nozzle-like portion **48** which communicates with the induction passage **14** as at an outlet or discharge orifice **50**. Preferably, the discharge orifice **50** is located as to be just below or downstream of the throat of a variable venturi arrangement as by having such opening formed in the fixed wall or fixed half **52** of the variable venturi.

As illustrated, the variable venturi may be comprised of a variably positionable venturi plate **54** which may be fixedly secured to a rotatable shaft **62** journalled in the housing means **12**. The venturi arrangement may be such as to define a generally rectangular opening at the throat of the variable venturi when viewed, for example, in the direction of arrow **64**. In fact, opposite walls, one of which is shown at **66**, may define flat planar surfaces permitting the variable or movable venturi plate **54** to be closely received therebetween for swingable motion about the centerline of rod or shaft **62**. Such flat planar surfaces would terminate as at a boundary line **68** from which the continuing portion of the induction passage means **14** downstream thereof would transitionally change configuration until it became circular to accommodate the throttle valve **28**.

A lever **70** is fixedly secured at one end to shaft **62**, for rotation therewith, and has its swingable arm portion connected as to a linkage rod **72** leading to a throttle valve actuating lever **74** fixedly secured to throttle shaft **30**. Throttle actuating lever **74** is, in turn, connected as by linkage means **76** leading to a vehicle operator foot-controlled throttle pedal **78** which may be mounted for pivotal rotation as at a pivot **80**. As throttle pedal **78** is rotated clockwise about pivot **80**, throttle valve **28** is moved counter-clockwise in the opening direction about the centerline of shaft **30**.

Generally, as throttle valve **28** is moved in the opening direction, movable venturi plate **54** is rotated counter-clockwise about the axis of shaft **62** thereby increasing the opening of the throat of the variable venturi as depicted by the dimension, D. As venturi plate **54** thusly moves toward and away from the opposite venturi section, a metering rod or valve **82**, having a metering surface **84**, is correspondingly moved toward and away from a cooperating metering orifice as provided by the restriction depicted at **86**. Generally, as rod **82**, which may be suitably pivotally connected to the venturi plate **54** as within a recess **88**, moves toward restriction **86**, the coaction of metering surface **84** and orifice member **86** results in a reduced effective flow area thereby correspondingly reducing the rate of flow of fuel supplied through conduits **44** and **48** and into induction passage **14**.

FIG. 1 also illustrates, as being formed within housing means **12**, a passage or conduit **90** having a member **92** situated therein and defining an orifice **94**. A member **96**, situated within a chamber **98**, divides the chamber **98** generally into portions or conduit sections **100** and **102** with communication therebetween being established through an orifice **104** formed in member **96**. A first interconnecting conduit or passage means **106** serves to complete communication between conduit **90** and conduit portion **102**. A discharge or delivery conduit **108** has one end in communication with conduit section **102** and its other end terminating in a discharge orifice **110** opening into the induction passage **14**, preferably, at a point downstream of the throat of the variable venturi. Although discharge orifices **50** and **110** are illustrated as being at different elevational levels, it should be apparent that such may in fact be at identical levels.

A metering rod or valving member **112**, having a contoured metering surface **114** cooperating with orifice **94**, is shown as being pivotally connected, as at **116**, to an arm **118** which is operatively fixedly secured to venturi plate **54** so as to rotate therewith about the centerline of shaft **62**. As venturi plate **43** is moved as to increase the throat dimension, D, rod **112** is moved to the left causing the effective flow area, defined between metering surface **114** and orifice **94**, to decrease.

A second valving member **120**, having a body **122** slidably received within chamber **98**, has a contoured metering surface **124** which, as shown, is adapted to coact with orifice **104** to define an effective flow area therebetween. Chamber **98** may be closed as by a wall member **126** which permits the slideable passage therethrough of an extension portion **128** of valve member **120**. Altitude or barometric pressure responsive means, such as an evacuated bellows means **130** having body means **132** resiliently urged toward a direction of elongation, is suitably secured as through the stem or linkage **128** to valving means **120**. The other end of body **132** may be suitably secured as to a support **134**. Generally, as altitude increases and therefore the value of atmospheric pressure decreases, bellows **130** will move valve means **120** toward the right causing valving portion **124** to more nearly close the effective flow area through orifice **104** and thereby increasingly restrict the communication from passage means **102** to passage or chamber means **100** which, in turn, communicates with the fuel **38** via conduit means **136** extending into the fuel **38**.

OPERATION OF THE INVENTION

Generally, as has already been indicated, as throttle valve **28** is increasingly opened in order to provide a greater volume rate of flow of fuel-air mixture to the engine intake **24**, variable venturi throat, D, is increasingly opened to provide a greater flow area for the air passing through the induction passage. Venturi vacuum, generated by the velocity rate of air flowing through the venturi throat, is employed in creating a metering depression or pressure differential across the fuel **38** and orifice **50** thereby causing fuel flow the main or primary fuel delivery system comprised of conduit means **44, 48** and effective orifice or flow area of orifice member **86** as determined by the contoured metering surface **84** of metering rod **82.** The main fuel delivery system will function to provide a particular fuel flow curve which may be determined by, for example, plotting the value of the fuel-air ratio (with both fuel and air being measured in pounds) against the corresponding mass rate of air flow (measured in terms of pounds per hour). The main fuel delivery system is capable of maintaining any such selected performance curves.

However, as previously indicated, such selected values of fuel-air ratios become effected by barometric pressure changes. That is, the metering or venturi vacuum is generated as a function of the velocity rate of air flow through the venturi throat, but the fuel-air ratios selected are based on the mass rate of flow of fuel compared to the mass rate of flow of air. This, of course, means that the air flowing through the venturi throat is assumed to be of substantially constant density. Such prior art assumptions have been found to be grossly in error.

That is, for purposes of illustration, let it be assumed that a vehicle equipped with a carburetor, according to the prior art, which supplied fuel to precisely meet the required fuel-air ratio at sea-level, is now placed at an altitude of 4,000 feet above sea-level. The accompanying reduction in barometric pressure would cause a decrease in the density of the atmospheric air at that elevated level; however, the carburetor would not be aware of the change in density of the air because the carburetor venturi is sensitive only to the velocity rate of flow of air. Therefore, for the same metering depression (caused by the flow of less dense air) the same amount of fuel would be supplied to be mixed with such less dense air. Obviously, this would result in an overabundance of fuel raising the fuel-air ratio (in terms of richness of fuel) and increasing exhaust emissions while decreasing engine efficiency. A characteristic or typical fuel flow curve of such a prior art carburetor is generally illustrated as at **140** of FIG. **2.**

In order to overcome such deficiencies of the prior art the invention provides what may be referred to as a second compensating fuel delivery system, generally parallel to the primary or main fuel delivery system, comprised of conduit means **108, 102, 106, 90, 104,** 100 and **136.** Such a compensating fuel delivery system is adapted to provide for a metered fuel flow, discharged as at a nozzle or discharge orifice **110,** which is controlled so that the quantity of fuel supplied thereby when added to the fuel supplied by the main fuel supply system will result in a fuel flow required to produce the desired fuel-air ratio (based on pounds of fuel and pounds of air) regardless of variations in air density caused by variations in ambient atmospheric pressures.

Generally, the rate of metered compensating fuel will be controlled and determined by the action of valving means comprised of apertures **104** and **94** respectively co-acting with metering surfaces **124** and **114.**

For example, let it be assumed that the engine is running and that the various related elements are held in the positions shown in order to maintain the effective bleed area between orifice **94** and metering surface **114** constant. If it is further assumed that the engine is operating at, for example, sea level then bellows **130** will be a maximum contracted condition causing valving member **120** to move to the left to some corresponding position as against wall member **126.** Consequently, because of the movement of metering surface **124** to the left, the effective flow area through orifice **104** is at a maximum.

The air flowing through the venturi throat at this time is providing a metering or venturi vacuum for causing fuel to be metered and discharged from orifice **50**; additionally, the same air-flow-generated venturi vacuum is applied to the parallel compensating fuel system via port **110** and conduit means **108.** Such reduced pressure or venturi vacuum is further communicated to passage means **102,** through orifice means **104,** chamber portion **100** and conduit **136** to the fuel contained therein. However, it should be made clear that the full magnitude of the venturi vacuum is not applied to the fuel within the conduit **136** because of passages **106** and **90** communicating between a source of ambient atmospheric pressure and passage or conduit means **102.** Such communication with the ambient permits a degree of atmospheric pressure to be bled into passage means **102** with the degree of such bleed being determined by the effective flow area through orifice **94.**

In any event, the modified venturi vacuum applied to the fuel within conduit means **136,** causes compensating fuel to flow upwardly through conduit **136,** chamber portion **100,** orifice **104,** passage means **102,** conduit means **108** and out of orifice or port **110** into the induction passage **14.** The rate of flow of such additional fuel will depend on the pressure differential created across the fuel within conduit **136** by the modified venturi vacuum as well as the effective flow area through orifice **104.** Consequently, it should be apparent that as ambient pressure decreases bellows **130** will correspondingly lengthen and valve means **120** will be correspondingly moved to the right resulting in metering surface **124** further restricting the effective flow area through orifice means **104.** In turn, of course, since one of the variables in determining the rate of flow of fuel through the auxiliary or compensating fuel delivery system is the effective area of orifice means

104, a reduction in the rate of flow of compensating or auxiliary fuel is experienced.

Further, regardless of whether the carburetor is operating at sea level or at some elevated altitude when the throttle valve 28 is moved in an opening direction venturi plate 54 is also moved in an opening direction thereby simultaneously increasing the effective flow area through restriction 86 of the main metering system, thereby increasing the rate of metered fuel-flow therethrough, and decreasing the effective flow are a through orifice means 94.

The reduction of the effective flow area through orifice means 94 causes a reduction in the degree of atmospheric bleed therethrough so as to result in a greater percentage of the then generated venturi vacuum to be applied to the compensating or auxiliary fuel system. This, of course, assures the availability of a sufficient rate of flow of auxiliary fuel to maintain the desired fuel-air ratio.

Accordingly, it can be seen that regardless of the fact that the invention may be operating at a substantially elevated altitude and regardless of the ambient atmospheric pressure, the carburetor of the invention will continue to provide a fuel flow curve of specified fuel-air ratios, as generally depicted at 142 of FIG. 2, and not the overly fuel-rich fuel-air ratios of the prior art as depicted at 140 of FIG. 2.

Further, if the contributions of the air bleed means and the pressured responsive means are considered in their broad aspects, it can be seen that the pressure responsive valving means 120 is effective for determining a family of compensating fuel flow curves (independent of the fuel flow curves developed by the main fuel supply system) while the air bleed means 94, 114, responsive generally to air flow demands of the engine, is effective for determining or altering the shape of such family of compensating or auxiliary fuel flow curves.

Even though only one curve 142 has been depicted, merely for purposes of comparative illustration, it should be clear and evident that in actual practice the shape of curve 142 may be of any desired configuration suitable for the particular requirements of any associated engine.

Although only one preferred embodiment of the invention has been disclosed and described, it is apparent that other embodiments and modifications are possible within the scope of the appended claims.

We claim:

1. A method of providing compensating fuel to an internal combustion engine from a carburetor having a body, induction passage means formed through said body for communicating with said engine, variable venturi means situated within said induction passage means, fuel reservoir means for containing fuel, fuel delivery means including fuel metering means communicating between the interior of said fuel reservoir means and said induction passage means, said fuel metering means being effective to meter the rate of fuel flow from said fuel reservoir means through said fuel delivery means and into said induction passage means in accordance with the volume rate of air flow through said variable venturi means, and auxiliary conduit means communicating between said fuel within said fuel reservoir means and said induction passage means for supplying compensating fuel flow to said induction passage means generally in accordance with sensed ambient atmospheric pressure, comprising the steps of creating a sub-atmospheric pressure within said auxiliary conduit means of a magnitude reflective of the volume rate of air flow through said variable venturi means, and variably restricting the effective flow area of said auxiliary conduit means generally in accordance with said atmospheric pressure as to more nearly close-off said effective flow area as said atmospheric pressure decreases, said step of creating a sub-atmospheric pressure within said auxiliary conduit means comprising the steps of communicating substantially venturi vacuum to said auxiliary conduit means and variably venting such communicated vacuum generally in accordance with the degree to which said variable venturi means is moved toward a more nearly closed condition.

2. A carburetor for an internal combustion engine, comprising a carburetor body, induction passage means formed through said body for communication with said engine, variable venturi means situated in said induction passage means effective for defining a variably openable venturi throat, a fuel reservoir, main fuel delivery means including fuel metering means communicating between the interior of said fuel reservoir and said induction passage means, said main fuel metering means being effective to meter the rate of fuel flow from said fuel reservoir through said fuel delivery means and into said induction passage means in accordance with the rate of air flow through said variable venturi means, variable restriction means in combination with auxiliary passage means communicating between the fuel within said fuel reservoir and said induction passage means, said auxiliary passage means communicating with a source of vacuum generated by the flow of air through said variably openable venturi throat as to thereby cause a pressure differential across said fuel resulting in the flow of auxiliary fuel through said auxiliary passage means, first additional pressure responsive means operatively connected to said variable restriction means to make said variable restriction means effective to vary generally in accordance with a parameter of ambient atmospheric pressure the rate of flow of said auxiliary fuel through said auxiliary passage means caused in response to the magnitude of said vacuum, and second additional means responsive to the opening and closing of said variably openable venturi throat for varying the effective magnitude of said vacuum communicated to said auxiliary passage means.

3. A carburetor according to claim 2 wherein said variable restriction means is situated generally in said auxiliary passage means and comprises aperture means of fixed dimensions cooperating with a variably positionable valving member.

4. A carburetor according to claim 3 wherein said aperture means of fixed dimensions is situated generally between said induction passage means and said fuel.

5. A carburetor according to claim 2 wherein said variable restriction means is situated generally in said auxiliary passage means and comprises an aperture of fixed dimensions cooperating with a variably positionable valving member for variably controlling the effective flow area of said aperture, and wherein said first additional pressure responsive means is operatively connected to said valving member.

6. A carburetor according to claim 5 wherein said pressure responsive means comprises bellows means.

7. A carburetor according to claim 2 wherein said second additional means comprises variable venting means operatively communicating between said auxili-

ary passage means and a source of substantially atmospheric pressure.

8. A carburetor according to claim **7** wherein said venting means comprises fixed aperture means cooperating with movable valving means, said movable valving means being effective to vary the effective flow area of said fixed aperture means.

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