

Aug. 29, 1950

A. G. BODINE

2,520,120

ENGINE FUEL SYSTEM

Filed Oct. 12, 1946

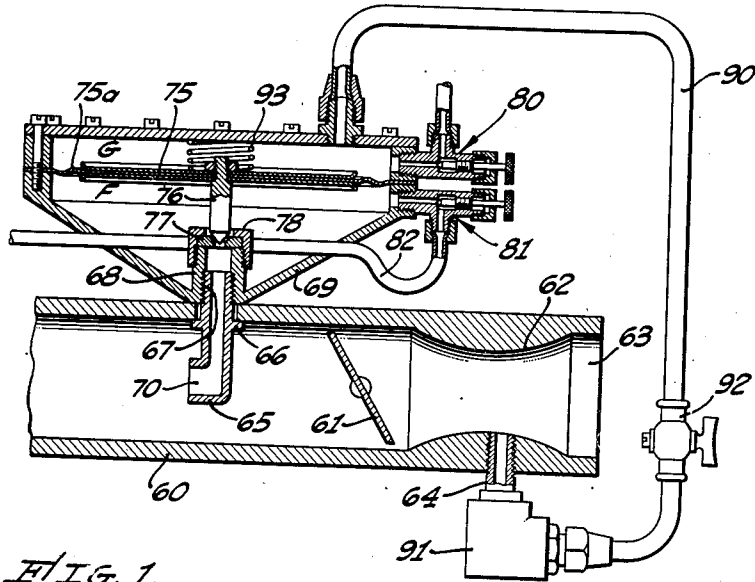


FIG. 1.

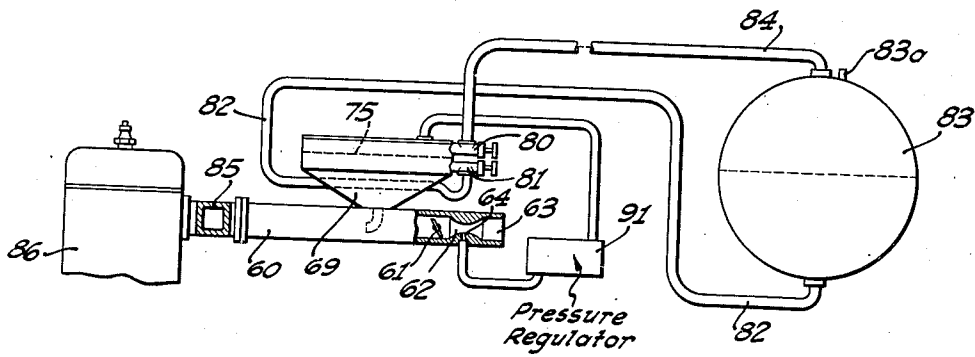


FIG. 2.

ALBERT G. BODINE, JR.

Inventor

34 Ernest Hilley

Attorney

UNITED STATES PATENT OFFICE

2,520,120

ENGINE FUEL SYSTEM

Albert G. Bodine, Van Nuys, Calif.

Application October 12, 1946, Serial No. 702,982

7 Claims. (Cl. 261-9)

1

This invention relates generally to engine fuel systems and more particularly to an extremely simple flow control device for controlling the proportionality between fuel and air for internal combustion engines. The invention includes a carburetor of the type employing venturi control of a flow regulator valve.

This application is a continuation-in-part of my copending parent application Ser. No. 299,830, filed October 17, 1939, now Patent No. 2,409,611, October 22, 1946, and entitled Fuel for Internal Combustion Engines and Method and Apparatus for Using Same. Discussion and claims herein are directed to an especially simple form of my broad invention disclosed in said parent application which I have found by test to be applicable to a large number of engines.

Many carburetion proposals have been offered by other inventors wherein the air-flow-responsive proportional pressure differential created by an air-venturi is used to operate, in pressure differential relationship, a pressure controlled fuel metering valve. These attempts have been extremely ambitious, attempting to accomplish a multitude of advantages. The net result of these prior efforts, however, has been a few successful carburetors of great complication suitable for specialized aircraft but unsuitable from the standpoint of first cost and maintenance difficulties for automotive and other general use.

It must be admitted that, in specialized cases, there is certain advantage in having a carburetor and fuel system, such as the multiple diaphragm types proposed elsewhere, insensitive to the pressure at which fuel is delivered to the metering system and insensitive to the orientation of the carburetor, such as for aerobatics. However, by choosing one form of my fuel system intended for engines that have a regulated pressure fuel source, and that stay right side up, it is possible to make available to the public for the first time a very simple and conservative Venturi-type carburetor having the one major advantage that permits introduction of the fuel stream (after metering) to the air stream at one or more of a number of desirable locations, not necessarily at the venturi, and with any desired application of heating or pumping before said introduction.

An object of my invention is to provide a carburetor in which it is possible to apply heat and/or pressure to the fuel, after the flow rate is metered, before introduction to the air stream. Very good atomization and mixing can thus be accomplished without necessitating heating the entire manifold and air stream, causing consequent loss in volu-

2

metric efficiency of the engine and reduced anti-knock value of the fuel-air mixture.

Another object of my invention is to provide a simple fuel system permitting fuel introduction, after metering, to any desired number of locations in a multi-cylinder engine manifold having less than the corresponding number of air introduction openings.

The invention will be fully understood from the following detailed description of a present illustrative embodiment thereof, reference for this purpose being had to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a fuel-air metering mechanism in accordance with the invention; and

Figure 2 shows the engine fuel system with a fuel chamber ahead of the metering unit.

In the drawings, numeral 50 designates an induction pipe adapted to supply the fuel-air charge to the intake manifold of an engine, this induction pipe 50 being provided with a butterfly valve 51, a restriction, preferably a venturi 52 for creating a pressure differential proportional to air flow, and an air inlet 53 (suitably the open end of pipe 50). The venturi is supplied with a lateral tap or jet 54. An opening is provided in the induction pipe 50 downstream from the butterfly valve, in which opening is snugly fitted a tubular fuel delivery member or conduit 55 adapted at 70 to discharge within pipe 50. This tubular member is provided with a shoulder 66 which abuts against the interior wall of the pipe 50. The member 55 continues exteriorly of the pipe 50 with a threaded portion 67 which is screwed into a re-entrant tubular member 68 integral with a shell or casing 69 for certain presently described carburetor or fuel metering elements. The tubular member 55 is so arranged and dimensioned that it is adapted to receive the fuel discharged from the carburetor and transmit it to the combustion air stream.

The interior of the shell or casing 69 is divided into two compartments F and G by a movable differential pressure responsive element, here in the form of a diaphragm 75 having a compliance at 75a and whose rim portion is clamped and sealed to the casing 69 as indicated. The two sides of this diaphragm provide opposed pressure application areas to which differential pressures are applied as will presently appear.

Securely fixed to and movable with the central portion of the diaphragm 75 is a metering valve member 76 whose conical lower end portion cooperates with a valve seat 77 to form a discharge

valve. The valve seat 77 is securely mounted on the upper end portion of the re-entrant tubular member 68 by means of a threaded collar 78.

Air may, in some cases, be supplied to compartment G through an adjustable needle valve 80 primarily to prevent accumulation of atmospheric vapor condensation; the provision of such an air vent is sometimes necessary when passage 90 is not used to conduct a flow of fuel. A fluid fuel stream is supplied to compartment F through an adjustable needle valve 81 providing a metering orifice. If desired, the fuel stream supplied the adjustable needle valve 81 through the fuel supply conduit or tubing 82 may first be passed in heat exchange relationship with the liquid or metal situated near the discharge valve as has been indicated in the drawings.

It is required that the intake air at 63 and fuel to valve 81 be delivered at substantially the same pressure or at least in some definite pressure relationship. The fuel is preferably a liquid, and can be either a high or a low vapor pressure liquid fuel. In some instances, the valve 80 may be closed entirely, as will later appear. The fuel chamber is indicated by the numeral 83, the lower end thereof being connected to the needle valve 81 by the tube 82 whereby the valve 81 may be supplied with the liquid fuel from said chamber. The upper end of the chamber 83 may be connected to valve 80 by tubing 84, and, as shown, the top of chamber 83 will be vented to atmosphere as by means of vents 83a, or atmospheric venting can be accomplished by breaking tube 84, as shown. If a high vapor pressure fuel is to be utilized, the unbroken tubing 84 is useful as it prevents loss of fuel vapors. However, this provision is not essential, since even with high vapor pressure fuels, the line 84 can be broken, or valve 80 closed or omitted, without substantial penalty. In either event, air entering valve 80, if open, will then be only air, and further, fuel line 82 will be at substantially atmospheric pressure. It will be evident that the system in this form (with or without the line 84 broken), or with the valve 80 closed or omitted, is suitable when low vapor pressure fuel, such as will not give off a substantial gaseous fraction, is to be utilized. In Figure 2 the induction pipe 60 is shown as connected to a manifold 85 feeding the cylinders of an internal combustion engine 86.

Differences in source pressure may also be taken care of by appropriate adjustment of the valve 81 provided that under conditions of no fuel flow the discharge valve 76 will remain stable in closed position. It is frequently desirable to add a slight closing bias to the discharge valve as by means of a spring 93 adapted to exert a slight closing force on the diaphragm 75.

Air introduced through the needle valve 80 into compartment G is introduced into the induction pipe 60 at venturi 62 through the tap 64 which may act as a jet restriction. The air in compartment G is in communication with tap 64 by means of interconnecting tubing 90. A pressure regulator 91 and cut-off valve 92 have been shown in fluid line 90, in accordance with the disclosure in my original Patent No. 2,409,611, but for present purposes, where the fluid introduced to the system through needle valve 80 is only air, at atmospheric pressure, or the needle valve 80 is closed (or omitted), these members may be dispensed with if desired.

If it is assumed that the air into 63 and fuel into 81 are at the same pressure, which pressure will be hereinafter referred to as storage pressure

(being in the present case substantially atmospheric), then the pressure in compartment G will drop below storage pressure by an amount dependent upon the suction developed in line 90 by the action of venturi 62.

The valve 81 is constantly open an adjusted amount. However, in the absence of any substantial flow of fuel through the valve 81 and into compartment F, due to the closing of valve 76, 77, the pressure in compartment F would be substantially storage pressure. Under these conditions the pressure unbalance across the diaphragm 75 caused by pressure drop in G from air flow through 62 would cause the discharge nozzle to open, thus permitting flow of fuel through compartment F and into the induction pipe 60 via member 65. This flow of fuel results in a pressure drop across the needle valve 81 which reduces the pressure in compartment F so that the diaphragm 75 will eventually come to rest at an equilibrium setting of the discharge valve so that the pressure drops become equalized. The rate of flow of fuel is thus proportional to the pressure decrease in chamber G and both are effectively controlled by the rate of air travel through the venturi so that the desired relationship between total air induction and total fuel induction is thus had.

Valve 80 may be closed down to any desired degree, or even closed entirely. In this closed example, the air in pipe 90 becomes simply a displaceable pressure transmitting body still maintaining a proportionality between venturi air flow pressure and pressure in G, which proportionality is in this instance an exact equality. The net result in all cases of my invention is maintenance of the metering pressure in F proportional to the air-metering head produced by the venturi, and in the special case here given this proportionality becomes an equality as just mentioned. When valve 80 is closed the standard pressure regulator 91 automatically opens full wide in conventional manner, therefore becoming not harmful but unnecessary and easily substituted by a simple continuation of pipe 90. It is also obvious that tap 64 is the source of air for tubing 90 and compartment G when valve 80 is closed. Thus the source of air in pipe 90 is air at atmospheric pressure taken in at 63. Increasing the air flow through venturi 62 will cause extraction of air from G and back into the air stream at tap 64, as described above, giving consequent pressure drop in G, and therefore movement of diaphragm 75 to increase the flow of air through valve 76, 77. When valve 80 is closed the pressure decrease is the full suction created by the venturi, thus giving the simplest example of related function between pressure in G and venturi air flow.

The metering remains unchanged by any variations in the pressure in the induction piping into which the fuel is discharged. This point is particularly important since it permits the injection of the fuel into the manifold at a point downstream from the butterfly valve. The pressure at this point downstream is variable but is usually substantially less than atmospheric. This relatively low pressure or partial vacuum at the point of fuel discharge is of great value in improving the rapid vaporization and dispersion of the fuel throughout the air. The tendency toward icing is also thereby decreased since partial vacuum effects corresponding reduction in the vapor pressure of the water normally associated with the air and also because the point of injection which is permissively downstream from

5

the butterfly valve can be located closer to the engine where the manifold walls are warmer.

This carburetor is adapted to meter the fuel in the liquid phase and under the pressure necessary to insure the maintenance of the fuel in the liquid phase. Furthermore, no metering pumps are necessary to thus meter the liquid, the metering being performed solely in response to the venturi pressure. This carburetor may be aptly described as a Venturi-controlled, injector type carburetor.

Another important feature is that the effective metering is done by the discharge valve and at the point of discharge so that the metered liquid may be immediately completely free to escape into the induction pipe. This is of particular advantage in using high vapor pressure fuels where the attempt to first meter a given quantity of the liquid and subsequently to discharge it through a pressure reduction valve may give rise to very uneven discharge from such a pressure reduction valve due to partial vaporization and/or changes in pressure and temperature between the metering device and the final discharge valve.

The tubular member 65 may be extended as a long duct in heat exchange relationship with the air moving through the pipe 60 so that the vaporization of the fuel in the duct cools the air indirectly. The vaporized fuel may then be injected directly into the combustion cylinders beyond the intake manifold suitably by means of an injecting or distributing system, so that some further increase in volumetric efficiency may be obtained.

I prefer to use a portion of the latent heat of vaporization to cool the fuel charge in the carburetor and to prevent the premature gasification of any portion of the fuel such as might tend to rise from the flow of engine heat into the carburetor shell or from pressure reductions incident to the transfer of the fuel from the storage tank to the carburetor and the passage of the fuel through the pilot orifice. This is preferably accomplished by the use of a re-entrant discharge duct such as the tubular member 68. The refrigeration at and immediately below the discharge valve thus becomes available for cooling the contents of the carburetor. This refrigeration may also be very advantageously used to pre-cool the feed to the carburetor, as is indicated by the tubular means 82. If such pre-cooling of the feed and/or refrigeration of the carburetor is not employed, it will usually be found necessary to employ a pump in the fuel transfer lines to build up the pressure to a value sufficient to prevent premature vaporization.

Many other advantages of my method of carburetion over the conventional carburetion will be apparent to one skilled in the art. The severity of backfire is lessened in my device since I inject the main portion of the fuel downstream from the venturi and butterfly whereby the total volume of inflammable material can be made materially less than in the conventional practice of introducing all of the fuel at the venturi and/or upstream from the butterfly valve.

I claim:

1. An apparatus for continuously metering fuel and air to an internal combustion engine comprising: an air conduit for a combustion air stream having an air inlet and having an outlet adapted to be connected to said internal combustion engine, a restriction in said air conduit, a movable differential pressure responsive valve

6

actuating means comprising a single wall having only two sides defining two opposed pressure application areas, an air pressure communication between said restriction and one only of said pressure application areas, an open continuous-flow fuel supply conduit in pressure communication with only the other of said pressure application areas, said valve actuating means being subject to air pressure influence solely at said one of said pressure application areas, and being subject to fuel supply pressure influence solely at said other of said pressure application areas and solely from the said open continuous-flow fuel supply conduit, in such manner that decrease in air pressure tends to move said valve actuating means in one direction, and decrease in fuel supply pressure tends to move said valve actuating means in the opposite direction, whereby said means moves under a differential of said pressures, a fuel delivery conduit in communication with said fuel supply conduit and arranged to discharge to said combustion air stream, a metering valve controlling fluid flow through said fuel delivery conduit, said metering valve being operably connected to said differential pressure responsive valve actuating means in such manner that said metering valve tends to open with decrease in pressure communicated from said restriction to said first mentioned pressure application area and tends to close with decrease in continuous flow pressure communicated from said fuel supply conduit to the second mentioned pressure application area.

2. An apparatus for metering fuel and air to an internal combustion engine comprising: an air conduit for a combustion air stream having an air inlet and having an outlet connected to said internal combustion engine, a restriction in said air conduit, a casing, a movable differential pressure responsive diaphragm dividing said casing into two chambers, opposite sides of said diaphragm forming two opposed pressure application areas, a pressure communication between said restriction and one of said chambers, a fuel supply conduit in pressure communication with the other of said chambers, a fuel delivery conduit in communication with said fuel supply conduit and arranged to discharge to the said combustion air stream, a metering valve controlling fluid flow through said fuel delivery conduit, said metering valve being operably connected to said differential pressure responsive diaphragm in such manner that said metering valve tends to open with decrease in pressure communicated from said restriction to the first mentioned chamber and tends to close with the decrease in pressure communicated from said fuel supply conduit to the second mentioned chamber.

3. A combination as defined in claim 2, including means delivering fuel to said fuel supply conduit at a pressure substantially equal to the pressure at the inlet of said air conduit.

4. A combination as defined in claim 2, including a fuel chamber delivering fuel to said fuel supply conduit at a pressure substantially equal to the pressure at the inlet of said air conduit.

5. A combination as defined in claim 2, including an atmosphere vented fuel chamber delivering fuel to said fuel supply conduit at a pressure substantially equal to the pressure at the inlet of said air conduit.

6. An apparatus for metering fuel and air to an internal combustion engine comprising: an air conduit for a combustion air stream having

7

an air inlet and having an outlet connected to said internal combustion engine, a restriction in said air conduit, a movable differential pressure responsive element having two opposed pressure application areas, a pressure communication between said restriction and one of said areas, a fuel supply conduit in pressure communication with the other of said areas, a fuel delivery conduit in communication with said fuel supply conduit and arranged to discharge to said combustion air stream, said fuel supply and fuel delivery conduits being arranged in heat exchange relation with one another, a metering valve controlling fluid flow through said fuel delivery conduit, said metering valve being operably connected to said differential pressure responsive element in such manner that said metering valve tends to open with decrease in pressure communicated from said restriction to said first mentioned pressure application area and tends to close with decrease in pressure communicated from said fuel supply conduit to the second mentioned pressure application area.

7. An apparatus for metering fuel and air to an internal combustion engine comprising: an air conduit for a combustion air stream having an air inlet and having an outlet connected to said internal combustion engine, a restriction in said air conduit, a movable differential pressure

8

responsive element having two opposed pressure application areas, a pressure communication between said restriction and one of said areas, an air vent for said one of said areas, a fuel supply conduit in pressure communication with the other of said areas, a fuel delivery conduit in communication with said fuel supply conduit and arranged to discharge to said combustion air stream, a metering valve controlling fluid flow through said fuel delivery conduit, said metering valve being operably connected to said differential pressure responsive element in such manner that said metering valve tends to open with decrease in pressure communicated from said restriction to said first mentioned pressure application area and tends to close with decrease in pressure communicated from said fuel supply conduit to the second mentioned pressure application area.

ALBERT G. BODINE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,861,352	Miquelon	May 31, 1932
2,409,611	Bodine	Oct. 22, 1946