

Oct. 1, 1940.

E. SCHIMANEK

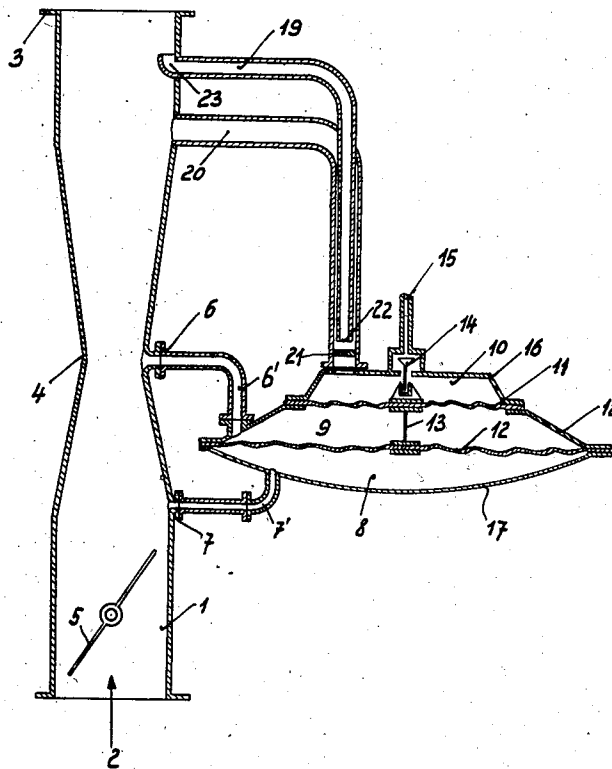
2,216,422

CHARGE FORMER

Filed June 18, 1937

3 Sheets-Sheet 1

Fig. 1



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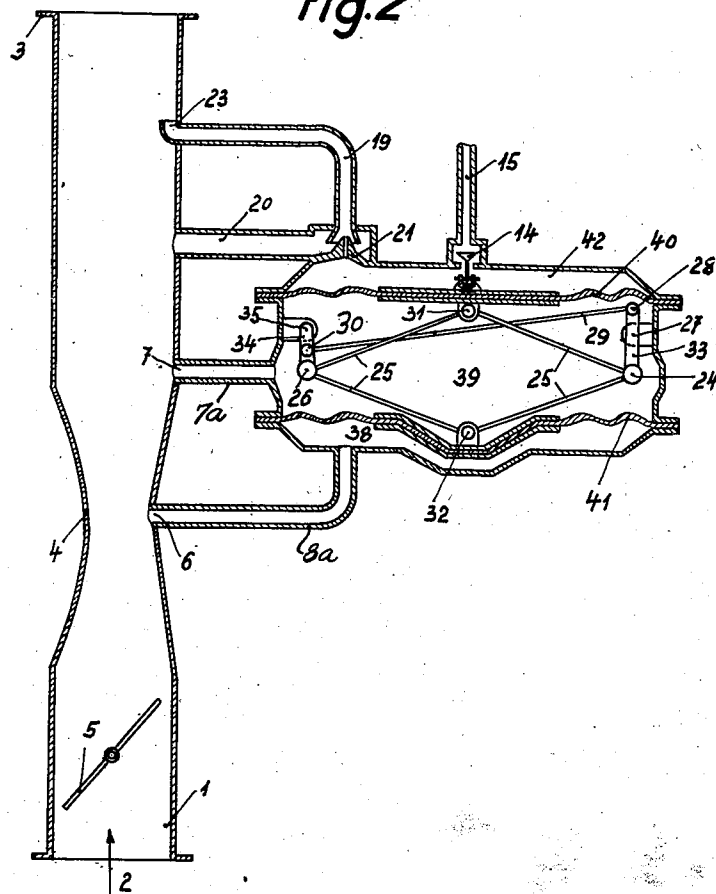
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Fig. 2



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3 Sheets-Sheet 3

Fig. 4

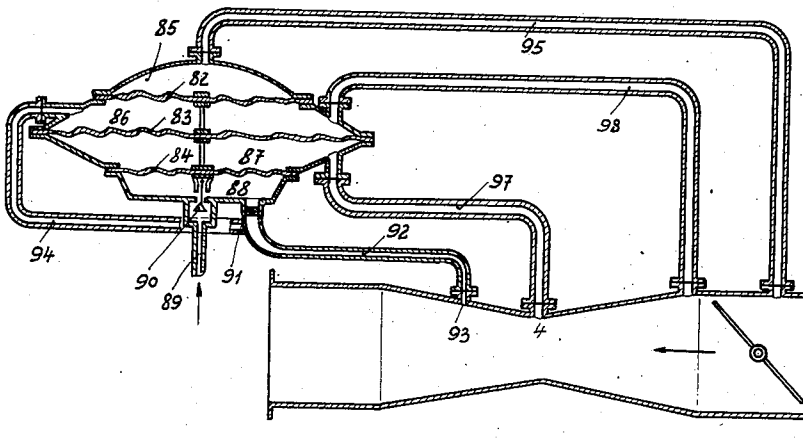
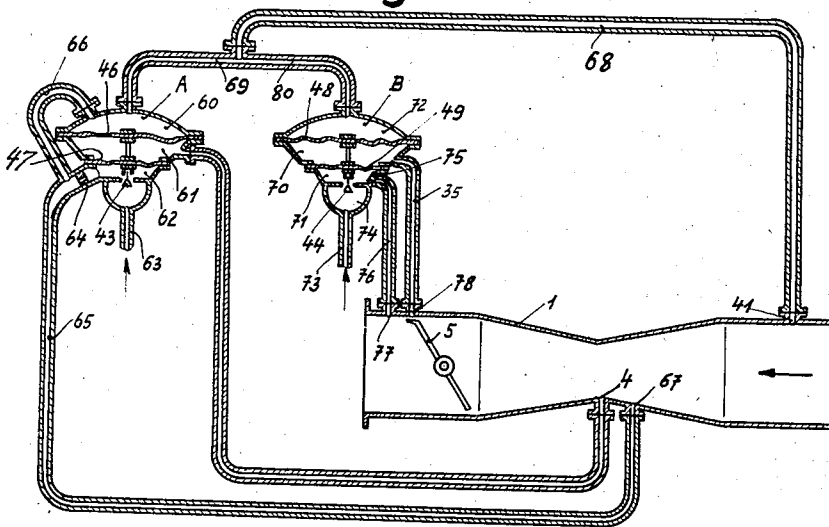


Fig. 3



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UNITED STATES PATENT OFFICE

2,216,422

CHARGE FORMER

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Application June 18, 1937, Serial No. 149,037
In Austria June 25, 1936

2 Claims. (Cl. 261-69)

This invention relates to internal combustion engines working with a mixture of fuel and air, wherein the fuel is injected under pressure into the current of air flowing to the engine cylinder, and wherein the carburettor is replaced by a fuel injection device.

The known methods of injecting fuel into the suction air have the disadvantage that the quantities of fuel injected are not adapted to the various operative conditions. It is found by experience that the compositions of the mixture in the case of mixture motors (explosion motors), in which the carburettor is replaced by an injection device is very variable, so that the composition of the mixture, when correctly adjusted for a certain load and speed of revolution, undergoes at other loads and other speeds such an alteration that the power output of the engine diminishes, whereas the fuel consumption is increased. It even happens in certain circumstances that at the altered load the mixture is no longer explosive. These disadvantages particularly apply in the case of those engines which work with air of very variable specific gravity, for instance aircraft engines. At a height of about 6000 metres aircraft engines work with air of half the specific gravity of the air in the neighbourhood of the earth's surface. It is, in these engines that the need arises for replacing the carburettor, in which the fuel is sucked in by an artificially increased vacuum in the induction pipe, by devices injecting into the suction air, that is to say, devices delivering at a raised pressure. Not only in aircraft engines without compressors but also in aircraft engines with compressors the replacing of the carburettor by a device which injects the fuel into the induction pipe or into the air path leading to the engine cylinder under a raised pressure presents substantial advantages, including prevention of the formation of snow and ice on the throttle valve.

This invention relates to means for regulating the delivery of fuel under a raised pressure into the path of the air to the cylinder of a mixture engine, and the invention consists in the feature that between the device that delivers the fuel under pressure and the path of the air to the engine (induction pipe of the engine, injection nozzle or the like) one or more pressure regulators are interposed, which vary the injection pressure and therefore the quantity of fuel injected, according to the weight of the air that is being dealt with at any particular time.

The invention is diagrammatically illustrated

by way of example in the accompanying drawings, in which

Figure 1 shows an example in which the supply of fuel is regulated by means of a difference of pressure occurring in the air path to the engine, this pressure difference acting upon the differential diaphragms;

Figure 2 shows an example in which surfaces of the same area are presented to the pressures obtained from different points on the air path, and

Figures 3 and 4 show examples in which a plurality of pressures in the induction pipe serve for the regulating.

In the constructional example illustrated in Figure 1 the suction pipe 1 of the engine, into which the air flows in the direction of the arrow 2, is constricted at 4, and then widens out again so that the connection 3 to the engine is of the full cross-sectional area of the induction pipe. Owing to the constriction in the cross-sectional area of the pipe a difference of pressures of the flowing air available for regulating purposes is obtained on the principle of the Venturi tube, the pressures utilized for regulating being preferably obtained at 6, the narrowest point, and at a point of maximum cross section, as at 7, these two points furnishing the maximum difference of pressure. Owing to the throttling, which may however be obtained in some other way, if preferred, for instance by means of a throttle disc or the like, a difference of pressure in the flowing air is produced, which varies with the weight of air flowing through. The device is preferably such that the cross-sectional area of the tube at the widest part is greater than the opening or diameter of the suction pipe.

In the suction pipe 1 is provided a throttle valve 5 regulating the power output of the engine, either before or after the Venturi tube or the connections 7 and 6 of the regulating appliance.

The pressure difference occurring in the induction pipe is utilized by two diaphragms of different sizes, namely a small diaphragm 11 and a large diaphragm 12, which are united by a connecting piece 13 to form a differential diaphragm for the purpose of regulating the supply of fuel. These diaphragms are so arranged in a casing that by fixed walls 16, 18 and 17 and the diaphragms 11 and 12 three closed chambers 8, 9 and 10 are formed. To the chamber 9 is transmitted, by a tube 6', the pressure prevailing in the suction pipe at the connection point 6, while in the chamber 8 the pressure transmitted

by a tube 7' from the connection point 7 prevails. To the chamber 10 fuel under pressure flows through a pipe 15 and a valve 14, which is controlled by the differential diaphragm and regulates the fuel injection pressure in the chamber 10.

The pressure under which the fuel is supplied through the pipe 15 to the regulating member, for instance by a fuel pump or the like, must be higher than the maximum injection pressure required, which prevails in the chamber 10. The pump delivery pressure is preferably kept constant by regulating it to any convenient height, by means for example of an over-flow valve with adjustable loading.

In the regulating device the pressure prevailing in the chamber 9, the smaller of the two pressures employed for regulating, namely the one obtained at the point 6 of greater air speed, acts upon the adjacent surfaces of the larger and smaller diaphragms, while the greater pressure, prevailing in the chamber 8, only acts upon the larger diaphragm. There is therefore exerted, by the pressures prevailing in the chambers 8 and 9, upon the differential diaphragm, an upward force which counterbalances the fuel injection pressure prevailing in the chamber 10. Owing to the differential action of the diaphragms of different sizes, the result is here obtained that the fuel pressure adjusted in the chamber 10 is greater than the greater of the two pressures employed for regulating, namely, the pressure prevailing in the chamber 8; this pressure prevailing in the chamber 8 may however be atmospheric pressure.

In order to make the fuel pressure act upon the diaphragm 11 independently as far as possible of the position of the regulating means, which is particularly important in the case of aircraft engines, which must be capable of working even in an inverted position, the chamber 10 is kept so low, or the distance of the nozzle 21 from the diaphragm 11 is kept so small, that the weight of the column of fuel loading the diaphragm 11 may be neglected in practice.

Under the pressure prevailing in the chamber 10, fuel is forced out of the nozzle 21, through the pipe 19, to the place 23 in the induction pipe 1, the introduction of the fuel into the air path being effected at any convenient point, before or after the throttle valve, or, in the case of compressor engines, before or after the compressor.

In the example illustrated in Figure 1, the fuel forced through the nozzle, mixed with a certain quantity of air, flows as froth or preparatory mixture into the suction pipe. The air necessary for the formation of froth is obtained from the suction pipe and led by a tube 20 to the mixing point 22, where the air is mixed with the fuel forced out of the fuel nozzle 21, and the preliminary mixture, or foam, flows to the suction pipe through the tube 19. In this case the tube 20 is connected to the suction pipe at a point at which a pressure prevails which is equal to one of the two pressures employed for regulating.

The apparatus according to Figure 1 operates in the following manner: When the motor is at rest the same pressure prevails in all three of the chambers 8, 9 and 10. Consequently the valve 14 remains closed, and the admission of fuel to the chamber 10 is shut off. This closure may also be assisted by a weak spring closing the valve 14.

When the engine is rotated a difference of pressure arises between the connecting points 7 and 6. The pressure at the point 6 is less than

that at the point 7. The differential diaphragm is thus deformed in an upward direction, and the valve 14 is opened.

Through the open valve fuel flows into the chamber 10 until the pressure in this chamber has attained a certain magnitude; that is, the pressure with which the fuel is forced through the nozzle 21. When this pressure is reached, it remains unaltered so long as the engine is working with the same weight of air, for if the pressure in the chamber 10 increases, the valve 14 closes; or if the pressure decreases the valve 14 opens. The fuel is therefore forced through the nozzle 21 by a raised pressure, and passes thence, either unmixed or mixed with air to form a froth, into the suction pipe.

To a larger or smaller weight of air dealt with in the engine there corresponds a greater or smaller difference of pressure in the path of the air to the engine, and therefore a greater or smaller difference of pressure in the chambers 8 and 9. The fuel pressure in the chamber 10 is thereby regulated to a higher or lower value, the quantity of fuel expelled through the nozzle 21 being increased, in dependence upon the fuel pressure, to correspond to the greater weight of air, or diminished to correspond to the smaller weight of air.

The arrangement according to the invention is such that for one cylinder, or in place of one carburettor, either one or more such regulating appliances are provided, the fuel being supplied to the regulating appliances by a single fuel pump or to each regulating appliance by a separate pump. Thus for example in multi-carburettor engines, one carburettor in each instance may be replaced by a regulating appliance according to the invention.

In the embodiment illustrated in Figure 2, the suction tube 1 of the engine, into which air flows in the direction of the arrow 2, is constricted at 4 and then widens out again so that the full cross-sectional area is restored at the point 3, to which the engine is connected. The pressure difference, which effects the regulation, in the air flowing through the suction pipe, is also obtained or increased artificially here by constricting the cross section of the pipe in the manner of a Venturi tube, the pressures employed for regulating preferably being taken from the narrowest point at 6 and from a point of maximum cross section such as 7, that is to say, at points between which the difference of pressure is greatest. It is preferable that the cross-sectional area of the tube at the widest point should be greater than the cross-sectional area of the suction pipe. Owing to the throttling, which may alternatively be obtained in some other way, for instance by means of a throttle disc or the like, a difference of pressure is therefore produced in the flowing air, which varies with the weight of air moving through the pipe 1.

A throttle valve 5 regulating the power output of the engine is provided in the suction pipe 1, either before the Venturi tube 4 and the connections 7 and 6 of the regulating means, or after the said Venturi tube and connections.

The pressure difference arising in the induction pipe is here utilized for regulating the supply of fuel by means of two diaphragms 40 and 41. These two diaphragms are arranged in a casing, which is divided by the diaphragms into three parts 38, 39 and 42. To the chamber 42 the fuel pipe is connected by way of the valve 14, through which the fuel delivered by the fuel pump enters

the chamber 42. The chambers 38 and 39 are subject to the pressures obtained from the suction pipe at two different positions, namely the outer chamber 38 through the medium of the pipe 8a to the smaller of the two pressures, and the chamber 39 between the two diaphragms through the medium of the pipe 7a to the greater of the two pressures, so that the fuel pressure in the chamber 42 is determined by the gaseous pressures prevailing in the chambers 38 and 39.

The two diaphragms are connected with one another by a sort of toggle mechanism, consisting of rods 25, which are attached to the diaphragms by pivotal joints 31 and 32 and are pivotally connected with one another on guiding levers 33 and 34 at 24 and 26, so as to form a jointed quadrilateral, two corners of which are attached to the diaphragms and the other two corners to the guiding levers. The guiding levers are rotatable about pivotal points 27 and 35, and effect the guidance of the pivotal points 24 and 26 in a direction normal to the direction of movement of the pivotal points 32 or of the diaphragms 40 and 41. For the purpose of balancing the weight the guiding levers 33 and 34 may be connected with one another by a rod 29, which is connected to the guiding levers 33 and 34 at the points 28 and 30 respectively.

Under the pressure prevailing in the chamber 42 the fuel is forced out of the nozzle 21, through the pipe 19, and into the induction pipe 1 at 23, in which case, in the constructional example illustrated in the drawings, the fuel passes into the pipe 19 already mixed with air supplied by the pipe 20.

If two diaphragms of equal size are employed there acts upon the lower diaphragm 41 from above the greater pressure p_1 , and from below, the smaller pressure p_2 , thus producing a downward force equal to the pressure difference p_1 minus p_2 . This force is converted, by the mechanism formed by the four rods 25, into an upwardly directed force, and thus transmitted to the upper diaphragm 40, upon which there acts, in addition to this force, the pressure differences in the chambers 39 and 42, amounting to p_3 minus p_1 . In a state of equilibrium, the pressure difference p_3 minus p_1 must counterbalance the force p_1 minus p_2 .

If the two diaphragms are made equal in size, and the greater pressure p_1 prevails in the chamber 39 and the smaller pressure p_2 in the chamber 38, the fuel pressure p_3 in the chamber 42 will be equal to p_1 plus p_1 minus p_2 . The same effect is therefore obtained as if a differential diaphragm were employed, of which one surface is twice as great as the other, and the pressure p_1 acts on the external surface of the larger diaphragm, whereas the force p_2 acts between the two diaphragms.

In the embodiment illustrated in Figure 3, besides a pressure regulator A, hereinafter referred to as the main pressure regulator, which is similar to that of Figure 1, a second pressure regulator B is provided, which serves for idle running. The main pressure regulator A includes two diaphragms or the like 46 and 47, which are connected with one another and which control the fuel valve 43. The fuel regulator is divided by the diaphragms 46 and 47 into three chambers 60, 61 and 62. The fuel flows to the pressure regulator through a tube 63 and passes into the chamber 62, from which, after being mixed with air, if desired, supplied by a tube 66 connected to the chamber 60, it passes through a

main nozzle 64 and a tube 65 and is supplied to the suction tube 1, which it enters at the point 67. The chamber 61 is subject to the pressure that prevails in the suction tube at the narrowest point 4. The chamber 60, however, is subject to the pressure supplied through tubes 68 and 69, which are connected to the suction pipe at a position of full width.

The second pressure regulator B is similarly equipped with two diaphragms 48 and 49, which are connected with one another and control the fuel valve 44. These diaphragms divide this pressure regulator into three chambers 70, 71 and 72. The fuel here passes through a tube 73 into a chamber 74 and from there, controlled by the fuel valve 44, into the chamber 71, from which it is delivered by way of a nozzle 75, and a tube 76 into the suction pipe 1, which it enters at the point 77.

In order to utilize as great a pressure difference as possible for regulating the pressure the arrangement is such that the chamber 70 of the pressure regulator is subject to a partial vacuum obtained at the margin of the throttle valve 5, by means of a pipe 35 which is connected at the point 78 in the suction pipe, where the throttle valve, in its closed position, establishes a rather marked vacuum, and the chamber 72 is connected by the tube 68 and a branch pipe 80 with as wide a part as possible of the suction pipe. The tube 76 leading the fuel into the suction pipe opens into the suction pipe at a point beyond the position where the throttle valve 5 is arranged therein.

These two pressure regulators operate in the following manner: The fuel is delivered jointly by the two pressure regulators A and B. At relatively large loads, at which the throttle valve 5 is open, the fuel supply is effected for the most part by the main pressure regulator A, through the nozzle 64. At relatively low loads, and when there is no load on the engine, the quantity of fuel flowing in through this nozzle is small, owing to the small difference of pressure which occasions the fuel pressure in the fuel pressure regulator, and the main quantity of the fuel required passes into the suction pipe through the nozzle 75, and is regulated by the second pressure regulator B. It is of course also possible to employ more pressure regulators, which deliver the fuel into the suction pipe in dependence upon two other suitably selected pressures each.

In certain cases, in aircraft engines for example, it is not sufficient to make the delivery pressure of the fuel dependent upon only two pressures in the suction pipe. It is necessary to utilize a third pressure as well, which may for instance advantageously be dependent upon the existing pressure of the atmosphere, or may be the pressure of the atmosphere itself, for regulating the supply of fuel. According to a further feature of the invention such a pressure regulator may be constructed in which the fuel pressure is regulated in dependence upon three different pressures. Such an arrangement presents advantages in numerous cases. The utilization of the atmospheric pressure for regulating purposes has a special advantage in aircraft engines for example, since the mixture can be automatically regulated to correspond to the specific gravity of the air in altitude flight.

It is of course also possible to employ for regulating purposes three different pressures in the suction pipe.

Figure 4 illustrates by way of example an em-

bodiment of a regulator which is influenced by three different pressures.

The pressure regulator is divided by three diaphragms or the like, 82, 83, 84, which are connected with one another, into four spaces or chambers 85, 86, 87 and 88.

The chamber 88 is the flow-through chamber for the fuel entering from a tube 89, this fuel flowing, in a quantity regulated by a valve 90, through a jet 91 and a tube 92 to the point 93, where it enters the suction pipe. The fuel may be mixed beyond the jet 91 with air obtained from the chamber 86 of the pressure regulator, through a tube 94.

The chamber 87 is connected with the narrowest part of the suction tube at 4 by a tube 97. The chamber 86 is connected with a wide part of the suction pipe by a tube 98, and the chamber 85 is connected by a tube 95 with a wide part of the suction pipe or with the atmosphere, the connection of one of these two chambers to the suction pipe being established before the throttle valve and the connection of the other beyond the throttle valve.

The action of this device is the same as if there were only two diaphragms. The difference resides merely in the fact that three different pressures influence or control the fuel pressure in the chamber 88. The fact that among these pressures the pressure of the atmosphere has some action is of special consequence in aircraft engines.

The embodiment illustrated in Figure 3 can of course also be so constructed that one of the two pressure regulators is made in accordance with Figure 4.

What I claim is:

1. In charge forming apparatus for internal combustion engines, an air induction pipe having a constricted portion providing a Venturi tube, a throttle valve in said pipe anterior to said Venturi tube, means for supplying fuel under variable pressure to said air induction pipe comprising a sealed casing having fixed end walls, diaphragms of unequal areas constituting yielding walls separating said casing into chambers one constituting a fuel chamber bounded by the smaller diaphragm and one end wall of the casing, a nozzle discharging fuel from said fuel chamber into an unconstricted portion of said

pipe including a calibrated metering restriction, a conduit leading from a source of fuel under substantially constant pressure having a discharge orifice in said fuel chamber, a valve regulating the fuel flow through said orifice, rigid means connecting the central portion of said diaphragms and said valve, fluid pressure transmitting conduits extending between the Venturi tube and a second of said chambers and between the unrestricted pipe and a third of said chambers whereby the larger diaphragm is subjected to a differential pressure varying with the air flow in said pipe while the smaller diaphragm is subjected to the Venturi pressure and the fuel pressure, and movement of the smaller diaphragm against the fuel increasing the valve opening and permitting the production of increased fuel pressure in said fuel chamber.

2. In charge forming device for internal combustion engines, an air induction pipe having a constricted portion providing a Venturi tube, a throttle valve in the pipe beyond the Venturi tube, means for supplying fuel under variable pressure to said air induction pipe including a sealed casing having fixed walls, yieldable diaphragms of unequal areas separating said casing into chambers one of which provides a fuel chamber bounded by the smaller diaphragm and one end wall of the casing, a tube for introducing fuel under pressure into said fuel chamber, means for discharging fuel from said fuel chamber into an unconstricted portion of said pipe including a calibrated metering restriction, a fuel valve regulating the fuel flowing from said tube into said fuel chamber, rigid means connecting the central portion of said diaphragms and said valve, a pipe extending from the constricted portion of the air induction pipe to a second of said chambers, a conduit extending from the unrestricted portion of the air induction pipe to a third of said chambers whereby the larger diaphragm is subjected to a differential pressure varying with the air flowing in said pipe while the smaller diaphragm is subjected to the Venturi pressure and the fuel pressure, and movement of the smaller diaphragm against the fuel increasing the valve opening and permitting the production of increased fuel pressure in said fuel chamber.

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