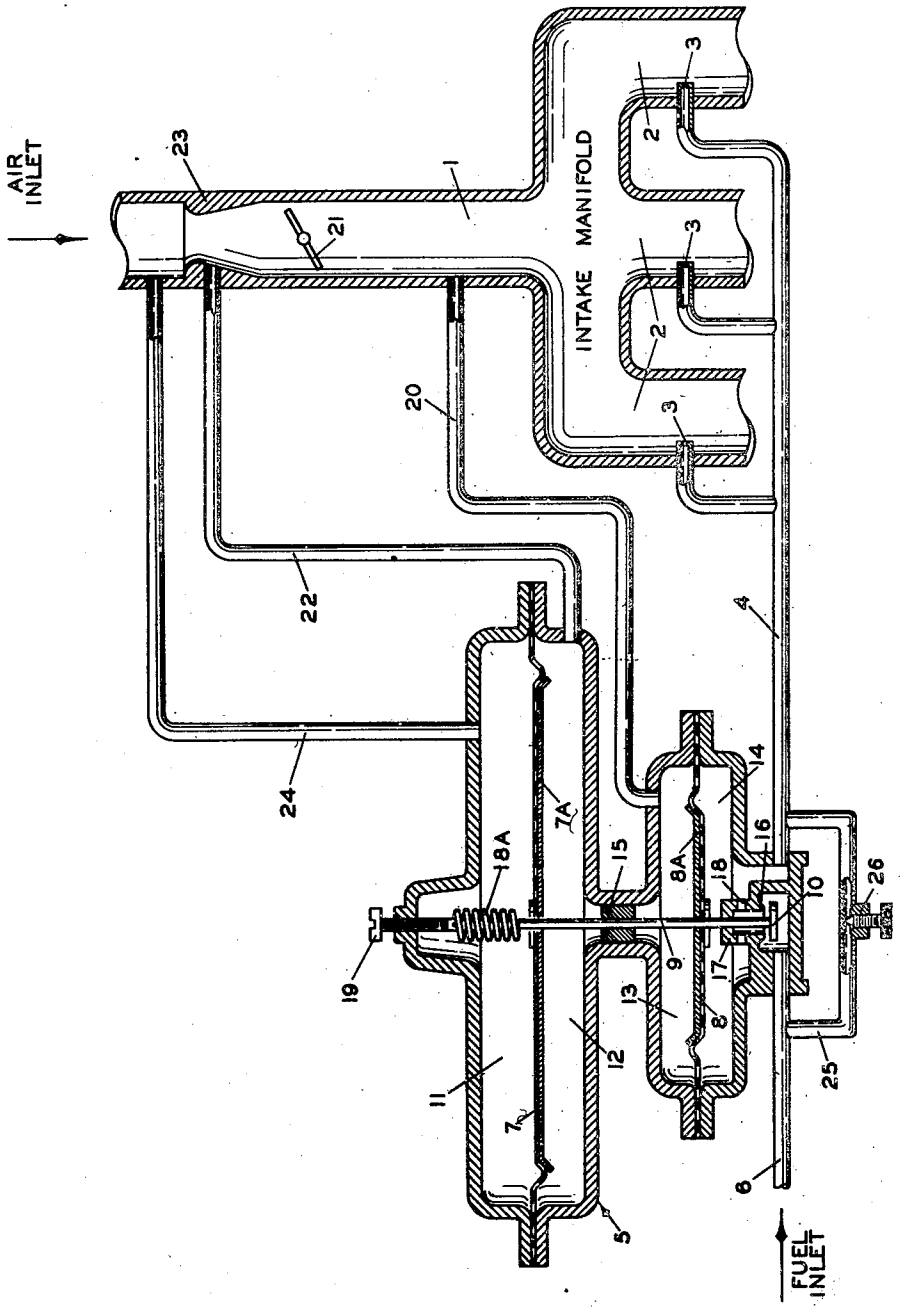
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MANIFOLD INJECTION CARBURETOR

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MANIFOLD INJECTION CARBURETOR

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1 Claim. (Cl. 261—69)

My invention relates to a method of fuel injection in internal combustion engines, and to apparatus for accomplishing the same.

In the development of the internal combustion engine to its present highly refined state, it has long been recognized that many advantages could be realized by injecting the fuel directly to the intake valve ports, or into the separate branches of the manifold system adjacent to the cylinders of the engine. The foremost advantage to be realized by individual injection is in the matter of a uniform distribution of the fuel charge among the various cylinders. This I accomplish without resort to positive displacement piston-type injectors which are common to past devices. The use of cam-operated injector pumps in previous devices has required a modification of the structure of the engine proper, whereas my device may be applied to the manifold of any standard gas engine. My device has a further advantage over conventional charge-forming devices in that the Venturi tube and the main throttle valve are the only major parts which need be attached directly to the engine manifold. All the fuel control elements may be placed at a reasonably remote point by suitable extension of the tubing connections leading to the engine manifold. Thus, all the adjustable moving parts, except the throttle itself, may be placed wherever they will be most accessible for adjustment or repair.

My invention has for its main object the accomplishment of direct fuel injection to the various manifold branches of a gas engine by means directly controlled by the engine air intake.

It is a further object to attain the above function with the minimum of parts and at the least expense of manufacture.

Another object is to provide the inherent advantages of direct manifold injection in an embodiment which can be applied to standard engines without modification of the latter.

An important object is to permit installation of the fuel control device at an accessible location, whereas other devices must practically always be mounted directly on the manifold intake riser, regardless of the convenience or inconvenience of such a location.

It is also an important object to permit use of a wide range fuels by simple adaptations of the fuel line pressure and manifold jet size to accommodate them.

The inherent advantages of positive pressure fuel injection to an engine manifold are per se well known, and a complete recitation of them here would be superfluous.

In the drawing, the numeral 1 denotes the intake manifold riser of an internal combustion engine in which the branches 2 are provided for distribution of air and fuel to the various cylinders of the engine in the customary manner. In my device, however, the fuel is introduced by means of individual nozzles 3, located in each of the aforementioned branches, the nozzles receiving their fuel through branches emanating from a common fuel line 4.

The flow of fuel in the line 4 is controlled by the fuel governor indicated generally by the numeral 5, fuel being conducted to the latter, under pressure, through the inlet line 6 from the supply source (not shown).

The fuel governor has the upper and lower diaphragms 7 and 8, respectively, which are mounted on a common stem 9, and attached to the latter part is a valve disc 10 which is thus responsive to the motion of the two diaphragms. By virtue of the two diaphragms, the upper portion of the fuel governor is divided into two chambers 11 and 12; the lower portion is likewise divided into two chambers 13 and 14. A bushing 15 is pressed into the structure so as to separate the chamber 12 from chamber 13, and is provided with an opening to receive the stem 9. This opening is reamed to a close fit with the stem, the clearance being such that the stem is free to move and is well guided, but at the same time provides a substantial restriction to air flow so that chambers 12 and 13 are in effect sealed off from each other. A flexible diaphragm connected to the neck portion and the stem 9 may be substituted for the bushing 15.

In the bottom of the governor is provided a nozzle 16 for the valve disc 10, which together form a throttling valve controlling the fuel flow. The upper end of the nozzle channel is restricted so as to form a guide 17 for the valve stem 9. This guide serves only to center the disc 10 coaxially with respect to the nozzle 16, and has no pressure-sealing function as in the case of the upper guide 15. One or more openings 18 are provided to communicate between the bore of the nozzle 16 and the chamber 14. A coil spring 18A is attached to the upper end of the stem 9. In the form of my device herein illustrated, I prefer to use a tension spring here, in which case the disc 10 would be urged toward the nozzle 16 and the main fuel valve would thus be held closed when the engine is not running. A screw 19 is provided for adjustment of the tension spring. Obviously the degree of tension or compression on spring 18A will de-

pend on the particular installation and relative size of the diaphragms 7 and 8.

A pressure conduit 20 communicates from the chamber 13 to a point below the main throttle 21 in the manifold riser. A second pressure conduit 22 communicates between chamber 12 and a restricted venturi section 23 in the manifold riser. A third pressure conduit 24 connects the chamber 11 to the riser 1 at a point on the air inlet side of the venturi. An idle fuel line 25 by-passes the main governor valve, and is fitted with an adjustable needle valve 26

In operation, liquid hydrocarbon fuel (preferably) is supplied under pressure through the line 6, the pressure being provided by an engine-driven fuel pump, or other means, not shown. Assuming the throttle 21 to be substantially closed and the engine running at idling speed, a high degree of suction will exist in line 20, and the pressure in lines 22 and 24 will be substantially atmospheric. As a result, the dominant force on the governor mechanism will be the upward-acting force on the lower diaphragm 8 due to the suction in line 20 and chamber 13. Hence the valve 10 will be closed tightly, and fuel will enter the engine manifold only by virtue of the by-pass line 25. The needle valve 26 is adjusted to pass the required fuel for good engine idling.

Upon opening of the throttle, the pressure in line 20 and chamber 13 will rise. At the same time, the flow of air will be accelerated through the venturi 23, and a suction will be induced in line 22 leading to chamber 12. A downward force will hence be generated on the large diaphragm 7. This downward force, due to proper proportioning of sizes of the diaphragms, will be great enough to overcome the now diminished upward force on diaphragm 8, resulting in opening of valve 10 and an additional flow of fuel under pressure of the fuel pump will occur through the line 4 and the nozzles 3. As valve 10 opens, the pressure in chamber 14 increases to a point sufficient to balance the force system, and the valve will come to a position determined by the new equilibrium so established. The proper air fuel ratio at this running condition can easily be obtained by proper sizing of the jets 3, and a fine adjustment is also provided by the spring 18A and the screw 19. Having once established the proper relationship of diaphragm, main fuel valve and nozzle sizes, and having made the proper final adjustment of the spring, the maintenance of any desired constant air-fuel ratio is automatic.

The quantity of air passing the throttle plate for any given degree of opening is dependent upon the pressure differential across the throttle. Upon analysis of the above-described mode of operation of the fuel governor, it is obvious that the main fuel flow is also in proportion to the same differential (i. e. the difference in pressures in lines 20 and 22), and hence the air-fuel ratio is maintained at a substantially constant value so far as the main fuel is concerned.

It is realized that the by-pass line 25 is not directly governed by the air differential, and may under certain conditions introduce a slight departure from constancy in the overall air-fuel ratio. If the discharge pressure from the fuel pump increases uniformly throughout the speed range of the engine, however, even the by-passed idling fuel will not disturb the overall air-fuel ratio, since the air flow through the manifold and the fuel flow through the line 25 will both be in proportion to engine speed. Moreover, the by-pass line 25 could be eliminated by providing an adjustable stop on the main fuel valve stem, so that it could always be maintained sufficiently open to pass the required fuel for idling.

By proper design of the spring 18A, any desired air-fuel ratio characteristic can be developed. For example, if a particular orifice chosen for the fuel jet 3 had the characteristic of varying as to coefficient of flow discharge (as most orifices actually do), then the air-fuel ratio would be influenced accordingly at various engine speeds. By selecting a spring of proper rate, this deviation from a constant mixture ratio could be modified to suit the requirement at hand. In many cases, a variation of mixture ratio is desired at different speeds.

Other possible modifications in the matter of fuel governing are obviously afforded by my device. The rate of response to varying pressure conditions can be regulated by providing needle valves or other restrictions in the lines 20 and 22. Moreover, the pressure differential between these two lines could be adjusted by connecting the lines together at some point between the manifold riser and the governor and installing an adjustable restriction in the connecting line. Further, the distribution of fuel to the various cylinders can be compensated to suit the manifold flow characteristics by calibrating the fuel jets and thus obtaining perfect distribution of the total fuel charge among the various cylinders. Pressure drop in the fuel line leading to the various jets could be compensated in the same manner.

The line 24 is provided simply to insure that the top of the diaphragm 7 will always be subjected to the inlet air pressure, and thus the effect of air cleaner resistance or other disturbing influences will be nullified. This line is desirable but not necessary to the operation of my invention.

It is to be understood that I do not limit my device to any particular fuel. High or low vapor pressure liquid fuels, or high pressure vapor-form fuels could be accommodated by proper proportioning of the fuel pressure, the diaphragms sizes, and the fuel valve and jet sizes. In the case of low pressure liquid fuels, a fuel pump would serve to provide the injection pressure. In the case of high vapor pressure liquid or vapor fuels, a pressure reducing regulator could be made to serve in place of the fuel pump. The only requirement vital to operation of the system is that the fuel be supplied to the control valve at a pressure high enough to afford control by throttling the fuel pressure through the valve, and that the residual pressure after throttling will be high enough to afford positive injection into the manifold.

There are of course certain additional requisites of a practical nature. For example, if liquid fuels are used, vapor lock must be prevented by maintaining the pressure on the fuel at a relatively high level, depending upon the composition of the particular fuel. Conversely, in using a vapor phase fuel, care must be taken to avoid condensation of the vapor due to using fuel pressures in excess of the dew point pressure at the lowest temperature to be encountered.

These are factors which can be controlled or allowed for in selecting the fuel pressure, in the placing of the fuel lines with respect to sources of heat, etc. The refinements necessary to pro-

vide satisfactory operation will vary, therefore, in accordance with the fuel selected and the selection of the fuel and the refined form of my device are matters simply of engineering and mechanics.

I recognize that my device is most easily adaptable to ordinary gasoline fed to the system by means of an engine-driven fuel pump, but this is only a preferred adaptation, and other fuels are usable in view of the discussion set forth above.

I claim:

In a fuel system for an engine having an intake manifold, a source of fuel under pressure, a fuel supply pipe connecting said source with the intake manifold and including at least one metering orifice opening into the manifold, an air inlet communicating with the intake manifold having a venturi and throttle therein downstream of said venturi, the improvement comprising a fuel control device including a valve in said supply pipe controlling the flow of fuel to the intake manifold, said valve having a stem connected to a lower diaphragm and an upper diaphragm, a first and a second housing, the upper diaphragm dividing the first housing into two chambers and the lower diaphragm dividing the second housing into two chambers, said housings being separated from each other, resilient means in the upper chamber of the first housing urging the valve closed, a pipe connecting the lower chamber of the first housing with the venturi section and being at the same pressure as the venturi section, a pipe connecting the upper chamber of the first housing with the air inlet pipe upstream of the venturi section, the diaphragm of the first housing being responsive to suction induced by increased air flow through the venturi section which results in a higher pressure in the upper chamber of the first housing than in the lower chamber of the first housing to open the valve against the force of the resilient means, a pipe connecting the upper chamber of the second housing with the air inlet downstream of the throttle and said chamber being under suction upon decreased air flow through the venturi by closing of the throttle valve, the lower chamber of the second housing communicating with the fuel supply pipe when said valve is open, said resilient means closing said valve under the unstable conditions existing when the throttle is in idling position, and a fuel idling connection around said valve to by-pass fuel from said source to said orifice when said valve is closed.

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