United States Patent

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Continuation of application Ser. No. 720,924, Apr. 12, 1968, now abandoned.

[54] **FUEL INJECTION SYSTEM**
4 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **123/33 E,** 123/139 AW, 123/140 MC
[51] **Int. Cl.** **F02m 67/00**

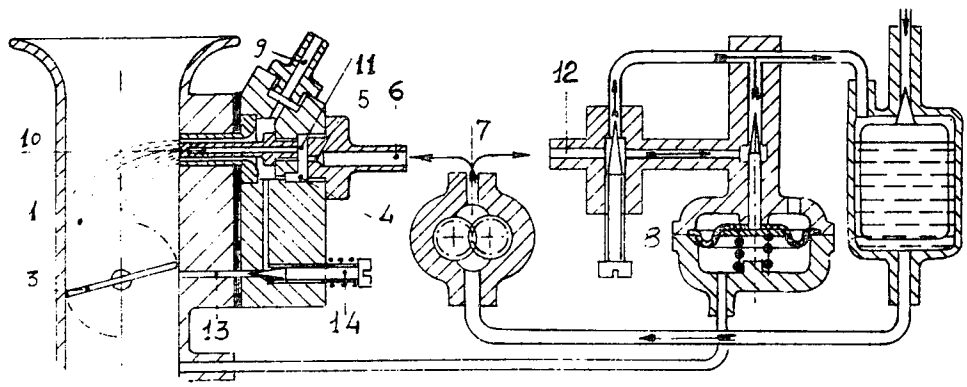
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ABSTRACT: A fuel injection system for internal combustion engines including an injector having a fuel reservoir connected to the intake opening of at least one cylinder and to a fuel pump for supplying fuel to the reservoir. The reservoir collects fuel therein and a second pump or the exhaust gases from the cylinder with which the injector is associated intermittently forces the collected fuel into the cylinder during the intake cycle of the cylinder.

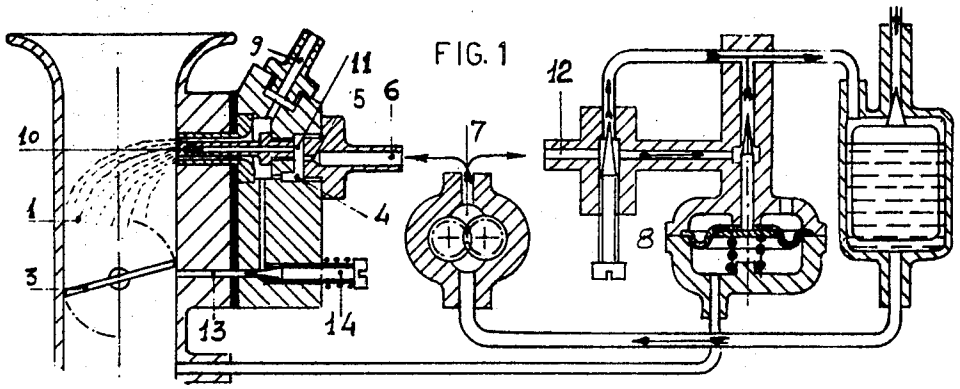


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SHEET 1 OF 2

FIG. 1



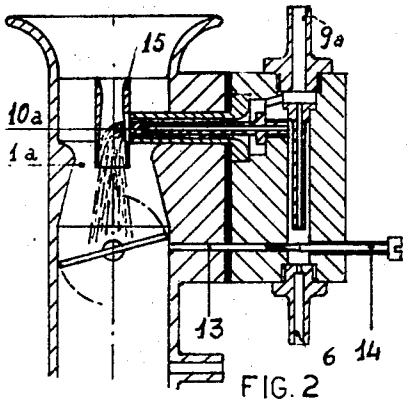


FIG. 2

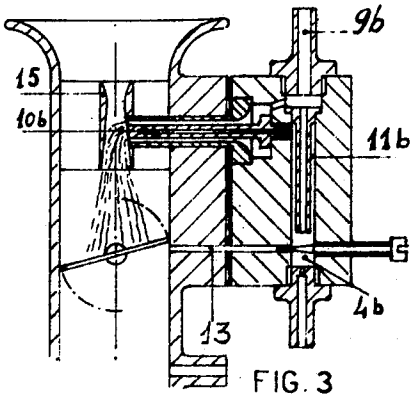


FIG. 3

FIG. 4

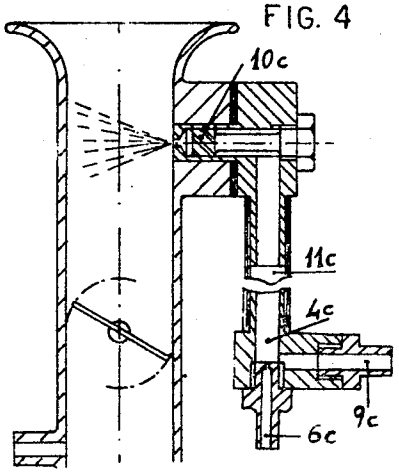
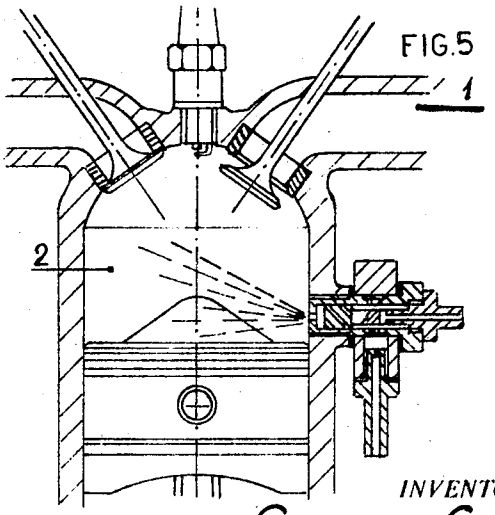


FIG.5



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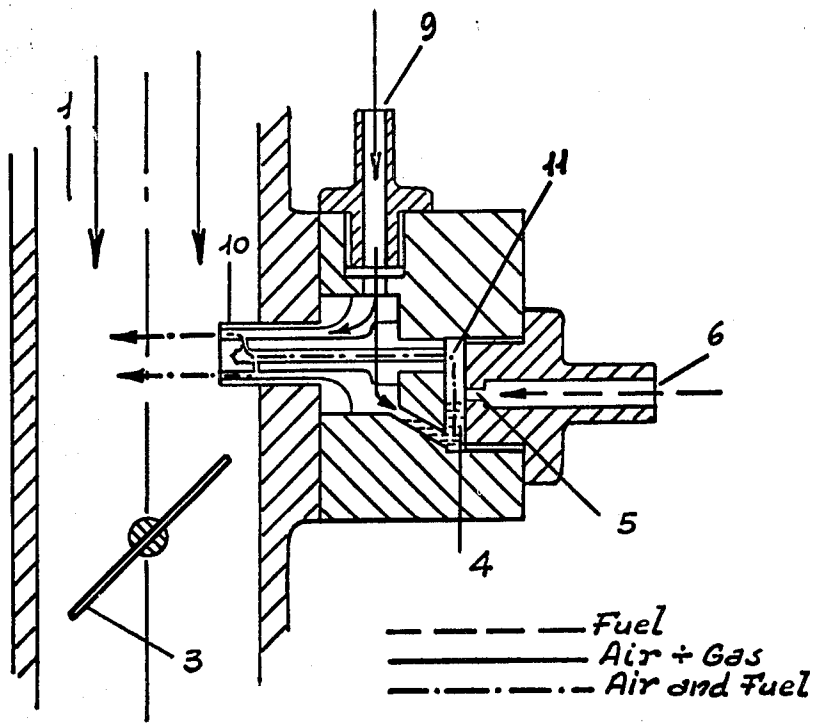


FIG. 6

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FUEL INJECTION SYSTEM

This application is a continuation of my prior application Ser. No. 720,924 filed 4/12/68 for Fuel Injection System and now abandoned.

The invention provides a system of carburetion according to the injection method, characterized in that the fuel is made to flow under pressure into a collecting cup with a delivery rate so regulated that during the time interval comprised between the end of an intake phase and the beginning of the next intake phase of the cylinder, into said collecting cup the right quantity of fuel is collected which must be supplied in the said cylinder in the intake phase of said next cycle; during this latter phase, therefore, the quantity of fuel, which has been previously collected into said collecting cup, must be only transferred from said collecting cup into the intake pipe or directly into the cylinder, said transfer being carried out by means of the pneumatic action of a strong jet of gas, operating in combination with means adapted to cause the fuel to be atomized.

According to the present invention means are provided adapted to keep constant the proportion of fuel to air in the mixture in varied running conditions of the engine and/or in varied positions of the means controlling the intaken carburetion air. Said means enable to vary the delivery rate of the fuel which is supplied in the collecting cup in response to any variation of the engine speed or to the variation of the density of the air in the intake pipe of the cylinder on the downstream side of the valve controlling the delivery rate of the carburetion air.

Therefore, said means allow to vary the fuel quantity supplied in the cylinder so as to afford a constant ratio of the fuel-air mixture in every running contingency.

The invention further provides a carburetor for embodying said system; some modifications or variant of the invention are also provided in order to allow the carburetor to be used for particular purposes.

The carburetor according to the present invention may be used for the feeding of internal combustion engines of a conventional type, where it substitutes the carburetors of known types, only very simple mechanical modifications being required.

As already said, the transfer of the fuel from the collecting cup into the cylinder of the engine is obtained by means of a gas jet, which may be, for instance, air supplied by a pump operating under the control of a valve and of a distributor or the like, enabling the air jet to reach the injector, which is a part of the carburetor, with a predetermined advance with respect to beginning of the intake phase of the engine; said jet may be also constituted of a part of the exhaust gas of the engine, the necessary quantity of which being drawn off from the discharge pipe of the cylinder to be fed by means of a small branched pipe; according to such a solution a sufficient advance will be thus automatically obtained; in the cases, wherein several cylinders are provided, the required delivery rate of the exhaust gas is drawn off from that of the cylinders of the engine, in which the exhaust phase substantially coincides with the suction phase of the cylinder to be fed.

According to a further variant, the fuel may be sucked from the collecting cup by means of the same carburetion air, which in this case in caused to pass through a Venturi tube, according to a solution which is similar to that which is applied in the conventional carburetors, with the difference that in the carburetor according to the present invention the fuel to be taken away from the cup has been previously gauged.

as known, the principal defects in types of carburetors commonly in use at the present time, the fuel of which is drawn in by means of a subatmospheric pressure which is effected in the intake pipe in correspondence with the throat, which is a part of the intake pipe, are principally the nonconstancy of the mixture ratio in different conditions of use, which has, as a result, a high fuel consumption and a low efficiency of the engine on account of the fact that the ratio of the fuel-air mixture varies as a consequence of the variations of the running conditions. These defects may be better seen in carburetors

for the high speed engines, more particularly as used for racing cars.

Well known are moreover the defects which appear when injection devices having intermittent jet are used, defects which are the result of the pulsations caused by the very high frequency of the breaks in the fuel stream. Said defects become still more detrimental on account of resonance phenomena in the high-speed engines.

In the injection carburetors of known type, where injectors are used providing for a continuous jet of fuel, the vibrations due to the intermittence of the fuel stream of the preceding system are avoided, but there is the inconvenient that during the closing phase of the cylinder intake valve, the persistence of flow causes fuel storage in the intake manifold, the said storage of fuel being the principal cause of high consumption of fuel and other secondary defects.

The system of injection carburetion, which is the object of the present invention, provides the following advantages:

1. A very good distribution of the fuel in the air mass drawn in by the engine, as a consequence of the atomization of the fuel carried out in advance by means of a gas jet, more particularly air.
2. The stream of fuel in the pipe feeding the gauged jet is always constant so that no pulsations are caused in the fuel intake pipe, which are generated by fluid hammerings; said pulsations, as a result of resonance phenomena, can increase in their intensity so as to endanger the constancy of the quantity of fuel drawn in in the operative intake phase, as, on the contrary, happens, when injectors having an intermittent fuel flow, provided with means which open and shut suddenly the outlet aperture for the fuel are used, especially for the high-speed engines.

According to the system which is the object of the invention no pulsation is then caused in the fuel supply pipe, since the means used to transfer intermittently the fuel from the collecting cup into the intake pipe or into the cylinder during the suction phase is a gas, that is-to-say, a means in which hammerings are negligible.

3. Absence of pumping devices having reciprocating movements and operating in the fuel circuit; said devices, more particularly in the high-speed engines provided with injectors intermittently feeding the fuel, must have, as well known, very rapid reciprocating movements.

Some embodiments of means for carrying out the invention will be now described by way of example and without limitation of the invention, reference being made to the accompanying drawing, in which:

FIG. 1 is the diagrammatic view showing an injection carburetor according to a first embodiment in which the injection takes place in the air intake pipe, as well as the control devices associated therewith.

FIGS. 2 to 6 show the longitudinal sectional views of further embodiments of the carburetor, in said FIGS. the network for supplying the fuel and the gas, as well as the respective control devices, are omitted.

Referring to the embodiment of FIG. 1, at 1 is marked the intake pipe, through which the air is drawn in and sent in the cylinder of the engine, which is not shown in FIGS. 1 to 4; in the said intake pipe 1 the injector supplies the atomized fuel. A throttle valve 3 or any other suitable device is placed in the intake pipe 1.

At 4 is indicated the collecting cup of the fuel, which is situated at a certain distance from the intake pipe 1 or from the cylinder 2 of the engine, in the case wherein provision is made that the fuel is directly supplied in the cylinder, as, for instance, has been provided in the variant shown in FIG. 5. In the said cup or trap 4 is collected the fuel issuing from the gauged outlet aperture or nozzle 5 of a pipe 6 which is connected with pumping devices 7 designed to maintain the fuel under pressure and associated with known means generally marked 8 adapted to control the delivery rate of the fuel stream so as to vary it in response of the variation of the engine speed and of the variation of the density of the air drawn in by the cylinder 2.

At 9 is marked the pipe supplying a gas stream under pressure; said gas may be the air supplied by an independent source or a part of the exhaust gas supplied by a pipe branched off from the exhaust conduit of the cylinder.

In the first case, the pipe 9 is directly connected with a pump (not shown in the drawing) which operates under the control of means which cause the air jet to be delivered with the predetermined advance with respect to the beginning of the intake phase of the engine. As, on the contrary, exhaust gas of the engine is used, such means become unnecessary. In the fact the exhaust phase of an engine takes place immediately before the suction phase and according to the diagram amplitude said phase is partially superposed on this latter. Therefore, an injection which is obtained by the use of the exhaust gas will take place automatically with the suitable advance with respect to the suction phase. Furthermore the hot exhaust gas promotes the vaporization of the fuel.

The gas jet issuing from the pipes 9 carries away all the fuel collected into the cup 4 in consequence of the pressure of the gas acting against the fuel collected into said cup 4, as well as on account of the suction each generated near the outlet orifice of the atomizing device 10 which is of a conventional type, the inlet orifice of this latter being put in communication with the cup 4 through the pipe 11 so that the atomized fuel mixed with the gas is discharged n the pipe 1 on the upstream side of the throttle valve 3.

It is evident, that this carburetor may be also used to supply the mixture to a combination of more than one cylinder. In this case the gas jet will effect the injection with the predetermined advance with respect of the suction phase of each cylinder.

Several injector sets could be also provided each associated with a single intake pipe ending into a collector connected to several cylinders, said injectors being so regulated to become in turn operative, as the suction phase takes place in the cylinder associated with the respective injector

It is to point out that the cross section of the inlet orifice of the fuel which opens into the cup is constant. As the period during which the mixture is supplied in the intake pipe 1 is directly proportional to the opening period of the intake valve so as to have a constant ratio of the fuel-air mixture on the power curve (a more or less braked engine with a constant maximum opening of the throttle valve), it is necessary that the fuel flows from the nozzle 5 with a directly proportional speed with regard to the engine revolutions.

When, on the contrary, the engine operates with a partially opened throttle valve (utilization curve) so as to maintain the ratio of the fuel-air constant, it is necessary that the discharge speed of the fuel stream flowing out from the gauged nozzle 5 decreases according to the decreasing of the density of the air drawn in by the cylinder 2; in the fact said density becomes more and more low, as the free area of the passage controlled by the throttle valve 3 decreases from the maximum value to the minimum.

Therefore, the delivery of the fuel stream which flows out from the gauged orifice or orifices 5 of the pipe or pipes 6 must be constantly controlled. This is achieved by modifying the fuel pressure by suitable means which are responsive to the speed variations of the engine and to the variations of the air density in the intake pipe on the downstream side of the throttle valve 3 so as to maintain constant the ratio of the fuel-air mixture in every running conditions.

In the shown embodiment provision is made that the fuel is fed by means of a volumetric pump 7 (with paddles or gears) driven by the same engine and, therefore, operating according to the same Law of speed variation; said pump 7 has one or many outlet orifices 12 placed in parallel with the feeding pipe 6 of the gauged orifice or nozzle, the sections of said outlet orifice or orifices being caused to vary by means of a suitable control device 8 which works accordingly to any variation of the density of the air intaken by the cylinders (for instance, a manometric cap or bellows control device); it could also operate indirectly according to the position of the throttle valve axis (by means of a cone-shaped needle having predetermined cross sections, operated by means of the same control device of the throttle valve and which has been not shown in the drawing).

If a constant pressure pump is used, instead of a volumetric pump, the pressure must be controlled not only by the densymetric control device, but also as a function of the engine revolutions, and this by means of the insertion of a centrifugal governor, for instance. These modifications are not shown in the drawing, being well known solutions.

it is evident, that in particular circumstances an automatic control may be also provided, when it is necessary to take into account also the pressure variations due to the ambient conditions or to the season or temperature conditions, said automatic device including means which are responsive to the said variations, and actuating the device controlling the delivery of the fuel.

According to an already well known solution, a pipe is further provided for directly supplying the fuel in the pipe 1 required for the slow running, said pipe 13 being branched off from the cup 4 and may be controlled by a conical-gauging screw 14.

The carburetor of the present invention operates as follows: If, for instance, reference is made to the embodiment of FIG. 1, the fuel is made to flow with a delivery rate which is automatically caused to vary by the device 8 in response of the variations of the speed of the engine and of the variations of the density of the air in the intake pipe 1; said fuel flows into the cup 4 with a constant delivery rate according to the predetermined speed of the engine, said delivery rate being so regulated that during the time interval comprised between the end of a suction phase and the beginning of the next suction phase, as much fuel is collected into said cup as much must be sent in the cylinder 2 in the said next suction phase. As the injection must take place, a gas jet comes out of the pipe 9, said gas jet forcing the fuel to pass from the cup 4 through the pipe 11 in the atomized 10 and then from the outlet orifice of this latter the fuel in atomized condition enters the intake pipe 1.

It is to point out that in the different variants (which will be hereinafter described) the parts which have the same functions are marked with the same references, while the similar parts are marked with the same references but with the addition of a letter.

In the variant shown in FIG. 2, provision is made that the fuel is intaken by the air stream passing through a center nozzle 15, into which opens the outlet orifice of the atomizer 10*a* said nozzle 15 being positioned in the throat 1*a* of the Venturi tube arranged in the intake pipe 1.

In this case, the carburetion system is the same as applied in the conventional suction-type carburetors, but it differs from this latter in the fact that the quantity of the issuing fuel has been previously gauged and controlled. According to such a modified embodiment the gas jet supplied through the pipe 9*a* has not been put under pressure, but said gas jet becomes operative owing to the suction effect generated by the air, as it passes through the constricted section of the Venturi tube 1*a*.

FIG. 3 shows a lightly modified embodiment of the injector shown in FIG. 1. This injector differs from the preceding one only in the fact that the atomized fuel comes out in the inside of the center nozzle 15 which is concentric with the intake pipe 1. In he variant shown in FIG. 4 it is provided that the collecting cup 4*c* is located at a greater distance from the atomizer 10*c* so that the connecting pipe 11*c* must be accordingly longer. This disposition allows the groups to be better centralized, each group comprising a collecting cup 4*c*, a pipe 6 supplying the fuel, a pipe 9*c* feeding the gas and a pipe 11*c* conveying the partially atomized fuel to the atomizer 10*c*.

In this case, especially, when the pipe 11*c* has a remarkable length, it is advisable that heating means be associated with said pipe 11*c*, designed to prevent depositions of atomized fuel on the walls, since in this case said fuel could be again transformed into liquid state (said heating means not being shown in FIG. 4).

According o the variant of FIG. 5 a direct injection of the mixture in the cylinder 2 is provided. In this case the outlet orifice of the injector opens directly in the cylinder 2, but it must so positioned as to be covered by the piston body during the explosion phase in order to prevent that the injector may be subjected to the heat and to the sudden change of pressure which are the result of the explosion process. According to this embodiment only air is drawn in from the intake pipe 1 by the cylinder 2, while said air will be then mixed with the atomized fuel in the inside of said cylinder 2.

I claim:

1. A fuel injection system for an internal combustion engine having at least one cylinder with an intake opening and an exhaust opening and an exhaust opening comprising:

a. a fuel injector comprising a closed reservoir of a size at least as great as the volume of the maximum amount of fuel to be injected into the cylinder in any intake phase, said reservoir being in communication with the inside of the cylinder through a duct terminating in an atomizer;

b. a fuel source;

c. pumping means including automatic control means in communication with said reservoir and said fuel source and adapted to supply fuel continuously from said source to said reservoir at a selectively variable rate responsive to engine speed and to the pressure in said intake opening, said pumping means delivering fuel at such a rate that there will be collected in the reservoir substantially between one intake phase and the next one only the quantity of fuel necessary to provide a predetermined air/fuel ratio when combined with each air charge supplied to the cylinder during the intake phase;

d. a source of gas under pressure in communication with said reservoir for intermittently supplying a gas flow into said reservoir; and

e. means for controlling the supply of such gas so that it will be fed in phase with the opening of the engine intake valve and at a pressure adapted to force and atomize the metered quantity of fuel which has been collected in the reservoir during the interval between one intake phase and the next one into the air charge being supplied to such cylinder.

2. A fuel injection system according to claim 1, in which the source of gas under pressure comprises a pump means and a distributor adapted to supply the gas flow only substantially during the intake phase.

3. A fuel injection system as in claim 1, wherein the source of gas under pressure is the exhaust opening of said cylinder at a point downstream from the exhaust valve and wherein a duct is provided for conveying a part of the exhaust gas to said reservoir.

4. A fuel injection system as in claim 1, wherein the engine includes a plurality of cylinders and the source of gas under pressure is the exhaust opening of the particular cylinder whose exhaust takes place at substantially the same time as the intake phase of the cylinder to which fuel is to be supplied.