

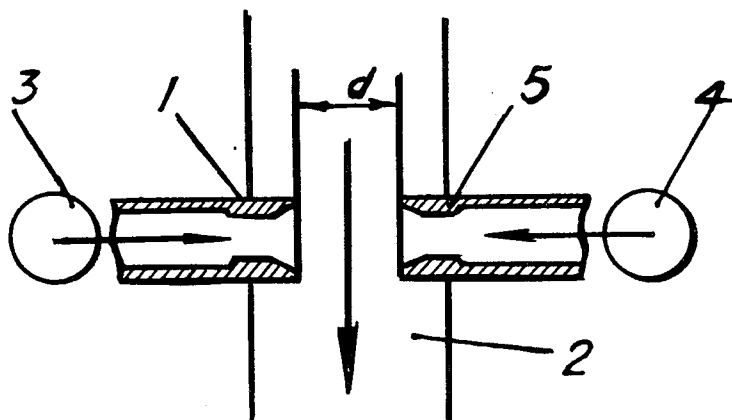
[54] **FUEL INJECTION APPARATUS**
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[58] Field of Search **123/119, 139.17, 139.18, 140.2, 123/140.3**

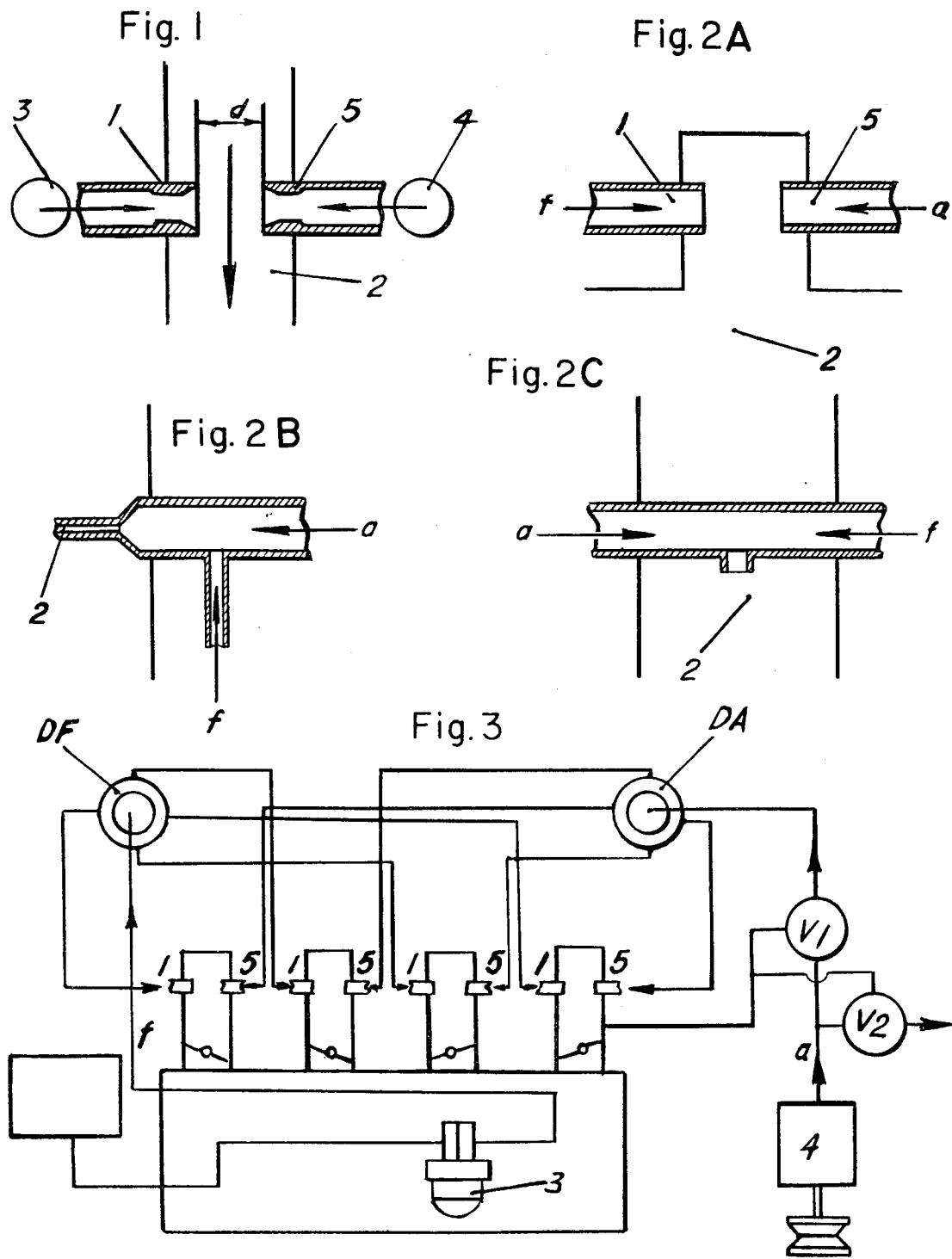
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[57] **ABSTRACT**
A fuel injection apparatus including a fuel pump and an air pump. The outputs of the pumps interact and the output pressure of the air pump is controllable to thereby control the output of the fuel pump. In one embodiment, the air and fuel are injected separately into an intake cylinder of a spark-ignition combustion engine through opposing inlets, the inlets being aligned so that the injected air is directed toward the fuel inlet to control the amount of fuel entering the cylinder. In a second embodiment, the outputs from the pumps connect with a common fluid duct through which the mixed fuel and air are injected into the intake.

2 Claims, 5 Drawing Figures





INVENTOR

ATTORNEY

FUEL INJECTION APPARATUS

In a conventional fuel feeding apparatus of a spark-ignition combustion engine with fuel injector, fuel is primarily controlled by the pressure of a fuel pump, and is either injected into cylinders or injected into intake tubes. Therefore, vaporization of the fuel tends to be poor at both low and full load. In another fuel feeding apparatus the areal resistance of an injection valve is controlled by a needle valve or similar device. However, this apparatus has poor reliability and because of structural deficiencies is especially inaccurate. Moreover, all the above-mentioned fuel injection apparatus are more expensive than carburetors and have a narrower range of uses.

An object of the present invention is to provide a fuel injection apparatus comprising a fuel pump, an air pump, means for varying the output pressure of said air pump, and means for conveying the outputs from said pumps to an intake cylinder in a manner that the output of the air pump controls the amount of fuel conveyed to the cylinder. The conveying means may comprise fluid ducts terminating at oppositely directed openings in the intake cylinder. Alternatively, the conveying means may comprise fluid ducts including one duct into which both fuel and air are pumped for mixing and subsequent injection into the cylinder.

In the drawings:

FIG. 1 is a descriptive drawing which explains the fundamental principles of this invention;

FIGS. 2a, 2b and 2c illustrate three examples of an application of this invention; and

FIG. 3 is a line-drawing of an embodiment of the invention as applied to an engine.

Referring now to FIG. 1, one embodiment of the invention comprises a fuel nozzle 1, an intake cylinder 2, a fuel pump 3, a variable air pump 4, and an air nozzle 5. The nozzles 1 and 5 are oppositely directed in the intake cylinder so that air exiting under pressure from nozzle 5 collides with the fuel exiting under pressure from nozzle 1. As illustrated in FIG. 3, the intake cylinder 2 comprises that portion of the air intake conduit to an engine extending upstream of the throttle valve.

The amount of fuel entering the intake cylinder is controlled by varying the pressure at which pump 4 supplies air to the cylinder. When the air pressure is at zero, fuel flow is maximum. As the air pressure is increased the fuel flow decreases until some fixed value of air pressure is reached which completely stops the flow of fuel into the cylinder. As will be evident from FIG. 1, the amount of air necessary to control the fuel flow may be varied by varying the distance d between the nozzles. Furthermore, it is evident that, because of the collision of the air and fuel the system provides a good fuel mixture to the engine. Good vaporization of the fuel is obtained because of the increase of air flow when the fuel flow is small.

FIGS. 2a, 2b, and 2c show alternative ways in which the present invention may be adapted for injecting fuel and air into an intake cylinder of an engine. In each figure a designates air flow and f designates fuel flow. In FIGS. 2b and 2c, the fuel and air are mixed before being injected into the intake cylinder. However, as with the embodiment of FIG. 1, the pressure of the air controls the amount of fuel flowing into the air stream.

FIG. 3 shows a system including an air distributor DA and a fuel distributor DF for distributing fuel and air to the nozzles 1 and 5 of a four cylinder engine. Fuel from a supply source is pumped by the fuel pump 3 through distributor DF to each of the nozzles 1. The air pump 4 is driven from the engine by a V-belt (not shown). Since the amount of air from the air pump varies depending upon the number of revolutions of the en-

gine, a coupling is installed at the air pump side so that the number of revolutions of the pump becomes constant at an arbitrary point where the air pressure is large enough to stop the jet flow of fuel.

The air pressure is controlled by two diaphragm-type pressure control valves V1 and V2. Air pressure from the pump 4 is supplied to both V1 and V2. Both V1 and V2 are operated by the negative pressure upstream of a throttle valve, said pressure being in proportion to the flow of intake air. At slow engine speeds V1 is fully opened and V2 is closed, thus supplying higher air pressure through DA to the air nozzles 5. This reduces the flow of fuel into the intake cylinders.

At moderate speeds V1 is kept open and V2 partially opened with V2 venting to the atmosphere to partially relieve the pressure developed by the pump. At highest speeds, V1 is fully opened and V2 is fully opened, so there is minimum air pressure developed at nozzles 5 and fuel flow into the intake cylinders is at a maximum.

The invention has several advantages. After setting up throttle valves at each cylinder between the nozzles and the intake valve, fuel flow can be controlled with less influence from engine vacuum as the distance between the nozzles and the throttle valve is increased. Also, by keeping the distance between the nozzles and the throttle valve relatively large, the negative pressure at deceleration has less influence on the nozzles so that fuel is not sucked into the intake cylinder. Furthermore, the present invention provides equal or better efficiency than the fuel injection systems heretofore known, without the use of complicated fuel injection pumps and highly accurate injection nozzles.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

We claim:

1. Fuel-injection apparatus for use with an internal combustion engine having an air-intake conduit and a throttle valve for controlling the flow of air along an air-flow path through said conduit, said apparatus comprising:

a fuel pump;
an air pump;
a fuel nozzle having an exit opening into said air-intake conduit;
an air nozzle having an exit opening into said intake conduit;

said exit openings being aligned so that air and fuel exiting from said exit openings collide in said air-flow path of said conduit at a collision zone;

means for conveying fuel from said fuel pump to said fuel-nozzle exit opening;

means for conveying air from said air pump to said air-nozzle exit opening; and,

air pressure regulating means for regulating the pressure at which air is supplied from said air pump to said air nozzle exit opening and thereby regulating the pressure in said collision zone and the fuel flowing from said fuel-nozzle exit opening.

2. Fuel-injection apparatus as claimed in claim 1 wherein said air pressure regulating means comprises:

first and second pressure controllers;

means for conveying to said controllers the pressure in said air-intake conduit;

said first pressure controller being responsive to the pressure in said air-intake conduit for controlling the pressure of air supplied to said air-nozzle exit opening; and,

means connected to said second controller for venting the discharge of said air pump to the atmosphere as said second controller is actuated by the pressure in said air-intake conduit.

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