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FUEL INJECTION NOZZLES

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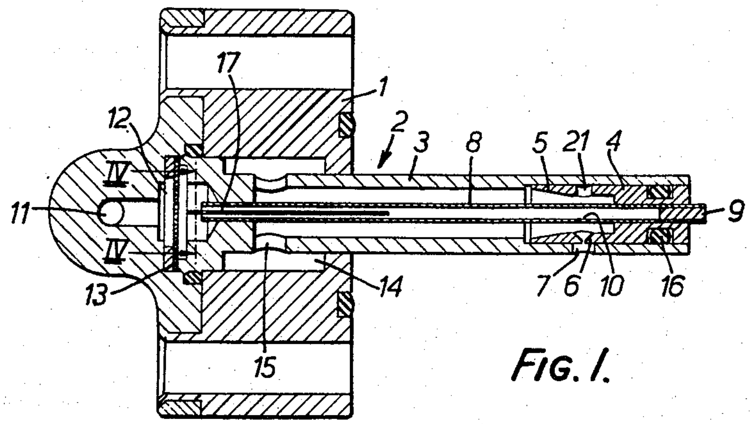


FIG. 1.

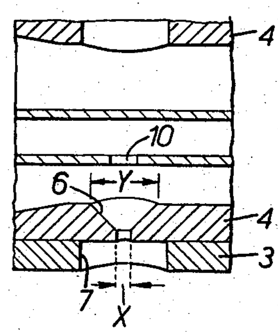


FIG. 2.

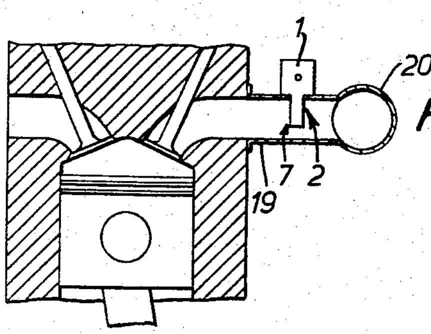


FIG. 3.

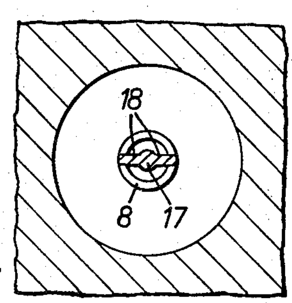


FIG. 4.

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# FUEL INJECTION NOZZLES

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8 Claims. (Cl. 239—588)

## ABSTRACT OF THE DISCLOSURE

A fuel injector device for an internal combustion engine, which is a discrete unit having a nozzle (in use located in the inlet manifold of the engine) which includes a fuel tube communicating with a fuel inlet in the body of the device and, surrounding the fuel tube, a jacket which is vented to atmosphere through the body. The fuel tube has an outlet aperture aligned with an outlet orifice in the jacket, which orifice includes a funnel shaped portion to direct all fuel from the fuel tube to the exterior of the jacket and to prevent vacuum conditions in the engine inlet manifold affecting the interior of the jacket. The fuel tube includes a flow restriction device in the form of a wire.

This invention relates generally to injector devices for use in fuel injection systems for internal combustion engines. In particular, it provides an injector device having an improved form of open nozzle from which atomised fuel can be sprayed continuously into the inlet manifold of an internal combustion engine, being drawn into the engine cylinders upon opening of their respective inlet valves.

The injector devices normally are located with their open nozzles situated in branch pipes leading from the inlet manifold to the respective engine cylinders and consequently the interiors of the injector devices are exposed to variations in the inlet manifold vacuum level. When the injector nozzles form part of a fuel injection system in which metering of fuel to the injector devices is accurately related to engine operating conditions, the exposure of the interiors of the injector devices to inlet manifold vacuum level changes can give rise to difficulties since the effect of increasing vacuum depression is to increase the amount of fuel flow from the injector devices. In a fuel injection system of the type mentioned above, this results in fuel being supplied to the engine cylinders in excess of the existing engine operating conditions. The effect of unwanted increase in fuel flow is most marked when the inlet manifold vacuum depression is large, e.g. at engine idling speeds when the fuel requirements of the engine are low.

According to the present invention it is proposed to alleviate the above discussed difficulties by use of a fuel injector device having an open nozzle assembly including a fuel tube disposed in and spaced from an outer jacket vented to atmosphere, a side outlet aperture in the wall of the fuel tube being disposed in alignment with an outlet orifice in the outer jacket shaped to direct to the exterior of the jacket fuel emergent from the fuel tube outlet aperture that impinges on the orifice walls and to maintain atmospheric pressure conditions within the outer jacket regardless of pressure conditions to which the outlet orifice is exposed. In particular, the outlet orifice is so shaped that in use of the injector device as part of a fuel injection system, with the injector device outlet orifice exposed to engine inlet manifold vacuum conditions, changes in the vacuum level have no material effect on the pressure inside the outer jacket of the injector device and hence has no detrimental effect on the discharge of fuel from the injector device.



For example, the injector device outlet orifice can include a funnel shaped inlet portion which converges in a direction from the interior to the exterior of the outer jacket, the walls of the funnel shaped inlet portion being so inclined to the flow path of fuel from the fuel tube that fuel impinging on the convergent walls is directed towards the exterior of the outer jacket. Preferably the funnel shaped portion has walls inclined at an angle of 45° to the flow path of fuel from the fuel tube.

Typically, the fuel tube can have a bore diameter of several ten thousandths of an inch and the aperture in the fuel tube can have a diameter of several thousandths of an inch, the diameter of the exit mouth of the outlet orifice being of the order of several ten thousandths of an inch.

When the nozzles of the injector devices are intended to be located in branch pipes leading from the inlet manifold of an internal combustion engine to the respective engine cylinders, it is preferable that the devices are adapted to discharge fuel to the cylinders in a direction perpendicular to the axes of the fuel tubes.

The fuel tube may also include a fuel flow restrictor. This may for example be a fine wire disposed in the bore of the fuel tube, the restriction presented by the fuel tube then depending on the length and diameter of the wire.

By way of example, a fuel injection device incorporating a nozzle constructed in accordance with the invention will be described with reference to the accompanying drawings in which:

FIG. 1 is a cross-section of the fuel injection device,

FIG. 2 is an enlarged view of part of FIG. 1,

FIG. 3 is a diagrammatic view of the inlet manifold of an internal combustion engine, showing a fuel injection device in position, and

FIG. 4 is a view on line IV—IV of FIG. 1.

The injector device shown in detail in FIGS. 1, 2 and 4 has a body portion **1** from which projects a nozzle assembly **2**. The nozzle assembly has a tubular jacket formed by a tube **3** the distal end of which is closed by a closely fitting removable plug member **4**. The inner end of the plug member has a recess **5** in the wall of which is formed an outlet orifice **6** the walls of which converge towards the outside of the jacket tube **3** and terminate in a cylindrical walled outlet portion (see FIG. 4). A circular aperture **7** in the wall of the tube **3** surrounds the outlet orifice **6**.

The nozzle assembly also includes a fuel tube **8** extending along the jacket tube **3** and being centralised therein by the plug member **4** through which the fuel tube extends. The distal end of the fuel tube is closed by a plug **9**. An aperture **10** is formed in the wall of the portion of the fuel tube passing through the recess **5**, the aperture being aligned with the outlet orifice **6**.

The body portion has a fuel inlet port **11** which communicates with the fuel tube **8** via a passage **12** containing a fuel filter **13**. The body portion **1** also has a port **14** communicating via apertures **15** in the jacket tube **3** with the interior of the jacket tube to vent it to atmosphere.

Fuel flowing along the fuel tube **8** passes through the aperture **10** and is directed towards the outlet orifice **6**, either passing straight through the orifice or impinging on the walls of the funnel shaped inlet portion thereof, the angle of convergence of the funnel shaped portion being such that any fuel impinging on its convergent walls is redirected towards the exterior of the nozzle. A suitable angle of convergence for the funnel shaped portion is 45°. Thus, all fuel emergent from the fuel tube aperture **10** passes through the outlet orifice **6**, emerging therefrom as an atomised stream. The aperture **7** in the jacket tube

3 is of relatively large diameter compared with the outlet orifice 6 and serves to permit an unimpeded flow of fuel from the outlet orifice. In a particular embodiment, the fuel tube has bore diameter of 0.042 inch with the diameter of the aperture 10 being 0.0106 inch; the exit diameter of the outlet orifice 6 is 0.02 inch and the inlet diameter of the funnel portion is 0.08 inch.

At the distal end of the injector device, a fluid tight fit of the plug member 4 in the jacket tube 3 is ensured by an O-ring seal 16. At the inlet end of the fuel tube, a fine wire 17 projects into the bore of the fuel tube, being supported therein by diametrically projecting arms 18 which engage the end of the fuel tube, as shown in FIG. 4, whilst permitting fuel flow from the passage 12 into the fuel tube. The wire 17 has a lesser diameter than the bore diameter of the fuel tube 3 and serves as a restriction to the flow of fuel through the fuel tube, the restriction being dependent, for a given wire diameter, on the length of the wire. The inclusion of the wire device is not essential to the correct functioning of the injector device but provides a useful means of achieving flow equalisation between several injector devices fed, for example, from a common fuel chamber.

In use of the injector device described above, it is located with the nozzle 2 disposed (as shown in FIG. 3) in an inlet branch 19 leading from the inlet manifold 20 to an engine cylinder of an internal combustion engine. Each engine cylinder has such an injector device, the devices forming part of a fuel injection system such as, for example, disclosed in co-pending application No. 8,528/65 or No. 38,394/65. The fuel injection system includes means for metering fuel to the injector devices in dependence on engine operating conditions, the metered fuel being fed to the inlet ports 11 of the injector devices and thence passing via the apertures 10 of the fuel tubes 8 and emerging from the convergent outlet orifices 6 in the form of atomised or finely divided sprays directed towards the inlet valves of the engine cylinders.

In the injector device construction described above, the nozzle outlet arrangement permits required fuel flow characteristics to be obtained without fuel flow from the injector devices being detrimentally affected by changes in the inlet manifold vacuum level. The small dimensions of the exit mouth of the outlet orifice 6, as compared with the entry dimensions of the orifice, prevent the inlet manifold vacuum level having any appreciable effect on the pressure conditions inside the injector devices (even when the inlet manifold vacuum depression is large, as at engine idling speeds), the pressure inside the jacket tube remaining substantially at atmospheric pressure, so that accurate metering of fuel to the engine cylinders can be maintained over the whole of the range of engine operating conditions. As engine speed increases above idling speeds more fuel is metered to the injector devices and when the volume of metered fuel is such that the fuel stream emergent from the fuel tube outlet aperture 10 cannot pass directly through the outlet orifice 6, the convergent walls of the orifice ensure that any fuel impinging on the orifice walls still is directed outwardly of the orifice to be discharged from the injector device into the inlet manifold branch 19.

The device described provides an efficient means for injecting fuel into the inlet manifold of an internal combustion engine, its operation being substantially unaffected by vacuum conditions which may exist in the manifold. Improved performance is therefore particularly noticeable when the engine is idling and inlet manifold vacuum depression is at a high level.

The formation of the outer jacket in two portions is a useful feature having regard to manufacture of the device. Thus, the outlet orifice 6 can be formed in the removable plug member 4 through an aperture 21 (FIG. 1) diametrically opposite the outlet orifice in the wall of the removable portion. This aperture is, however, sealed off by the jacket tube 3 when the injector device has been assembled in the manner shown in FIG. 1.



Injection of fuel in a direction perpendicular to the axis of the fuel tube is also preferable having regard to manufacture of the injector device. As mentioned above, the injector device is usually supported on an inlet branch connecting the induction manifold of an internal combustion engine to an engine cylinder, the nozzle of the device projecting radially into the inlet branch as shown in FIG. 3. Fuel is injected towards the engine cylinder, that is, in a direction parallel to the axis of the inlet branch. If the injector device were formed so that fuel injection took place, for example, from the end of the fuel tube (that is the direction of the axis of the fuel tube), the fuel tube and outer jacket must necessarily be formed with a 90° bend to achieve the optimum direction of fuel injection. This obviously complicates the manufacturing process and the arrangement shown in FIG. 1 is to be preferred from the point of view of simplicity.

I claim:

1. A fuel injector device having a body portion, an elongated tubular nozzle assembly attached to and projecting from said body portion, said nozzle assembly including a tubular outer jacket and a fuel tube disposed within and extending along said outer jacket, said outer jacket having a sideways facing aperture towards the distal end thereof, a plug having a recess defined therein and an outlet orifice in a wall of said recess, said plug being inserted into the distal end of said outer jacket to provide fluid tight closure thereof with said outlet orifice aligned with the aperture in said plug, said plug further being adapted to locate said fuel tube in spaced relation with said outer jacket, said fuel tube having a sideways facing outlet aperture aligned with said outlet orifice, said body portion having a fuel inlet communicating with said fuel tube and a vent aperture communicating with said outer jacket, said outlet orifice including a funnel shaped portion convergent from the inside towards the outside of said nozzle assembly such that pressure conditions exterior of said outlet orifice have substantially no effect on the pressure conditions inside said outer jacket, the said fuel tube outlet aperture having a smaller cross-sectional area than the exit mouth of the said funnel shaped portions, the said funnel shaped portion serving to direct towards the exit mouth of said outlet orifice any fuel from said fuel tube that impinges on said funnel shaped portion.

2. A device according to claim 1, in which the exit mouth of said outlet orifice has a cross-sectional area approximately four times that of said fuel tube outlet aperture.

3. A device according to claim 1, in which said funnel shaped portion has a maximum cross-sectional area approximately sixteen times that of said exit mouth.

4. A fuel injector device comprising a body portion and an elongated nozzle assembly, which together constitute a discrete assembly, the nozzle assembly projecting from the body portion and including an outer jacket, a fuel tube and a flow restriction device, a fuel inlet and a vent aperture in the body portion communicating respectively with the fuel tube and the outer jacket, the outer jacket having an outlet orifice at the distal end thereof and the fuel tube being located within and extending along the outer jacket and having an outlet aperture aligned with the said outlet orifice, the flow restriction device impeding fuel flow from the fuel inlet to the outlet aperture, the outlet orifice including a funnel-shaped portion having a fuel entry mouth and a fuel exit mouth and being convergent in a direction from the inside towards the outside of the outer jacket, the outlet aperture having a cross-sectional area less than that of the fuel entry mouth and also less than that of the fuel exit mouth, the said funnel-shaped portion substantially preventing pressure conditions exterior of the outlet

orifice from affecting pressure conditions inside the jacket, the funnel-shaped portion directing towards the outside of the outer jacket any fuel from the fuel tube that impinges on the funnel-shaped portion.

**5.** A fuel injector device having a body portion and an elongated nozzle assembly, which together constitute a discrete assembly, the nozzle assembly projecting from the body portion and including an outer jacket and a fuel tube disposed within and extending along the outer jacket, the outer jacket having an outlet orifice formed in a side wall of the outer jacket towards the distal end thereof, and the fuel tube having a sideways facing outlet aperture aligned with the said outlet orifice, a fuel inlet and a vent aperture in the body portion communicating respectively with the fuel tube and the outlet orifice, and a fuel flow restriction device located within the fuel tube to impede fuel flow from the fuel inlet to the said sideways facing outlet aperture, the outlet orifice including a funnel-shaped portion convergent from the inside towards the outside of the outer jacket and substantially preventing pressure conditions exterior of the outlet orifice from affecting pressure conditions inside the jacket, the funnel-shaped portion directing towards the outside of the jacket any fuel from the fuel tube that impinges on the funnel-shaped portion.

**6.** An injector device as claimed in claim **5**, including a plug in the distal end of the outer jacket of the nozzle assembly, in engagement with the fuel tube, the said plug closing the outer jacket and locating the fuel tube in spaced relationship with the outer jacket, the plug having a recess defined therein and the said funnel-



shaped portion of the outlet orifice being defined in the wall of the recess in alignment with an outer aperture in the outer jacket.

**7.** An injector device as claimed in claim **5**, in which the flow restriction device is a wire extending partly along the fuel tube between the fuel inlet and the outlet aperture, the wire having a diameter less than the bore of the fuel tube whereby the impedance presented to fuel flow is dependent on the length of the wire.

**8.** An injector device as claimed in claim **5**, in which the inlet of the funnel-shaped portion of the outlet orifice has a cross-sectional area about sixteen times that of the outlet of the funnel-shaped portion, and the said outlet of the funnel-shaped portion has a cross-sectional area about four times that of the fuel tube outlet aperture, the walls of the funnel-shaped portion being inclined at an angle of about 45° to the fuel flow path from the fuel tube towards the outlet orifice.


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U.S. Cl. X.R.

239—601; 123—119, 139