# United States Patent

**Griffiths**

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[54] **FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES**


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[52] **U.S. Cl.**.....**239/557,** 123/32 JV, 239/595, 239/601

[51] **Int. Cl.**.....**B05b 1/14**

[58] **Field of Search**...239/552, 556, 557, 590.5, 592, 239/595, 601; 123/32 JV



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[57] **ABSTRACT**

A multi-outlet fuel injection nozzle is formed from metal tube which at one end is inwardly-deformed so that portions of the wall of the tube are compressed together and divide the interior of the end of the tube into two or more passages which extend longitudinally of the tube and form tubular injection outlets of the nozzle each having a cross-section which tapers laterally of the tube.


**8 Claims, 5 Drawing Figures**

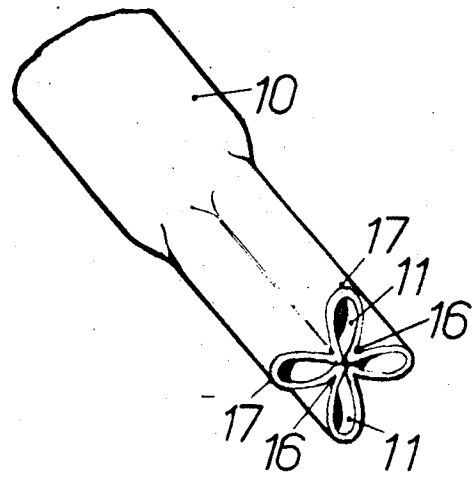


Fig. 1.

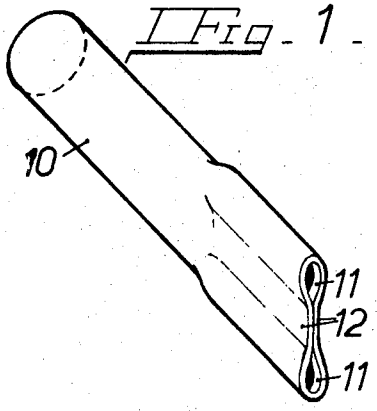



Fig. 2.

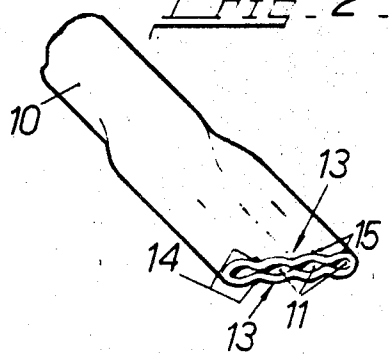



Fig. 3.

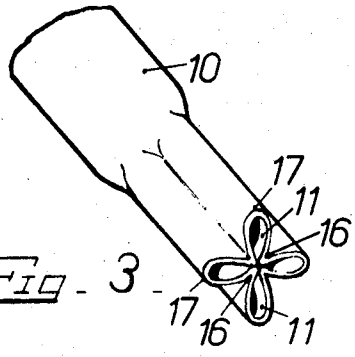



Fig. 4.

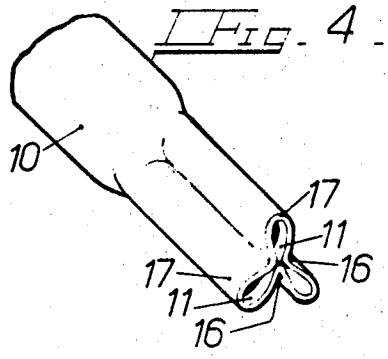
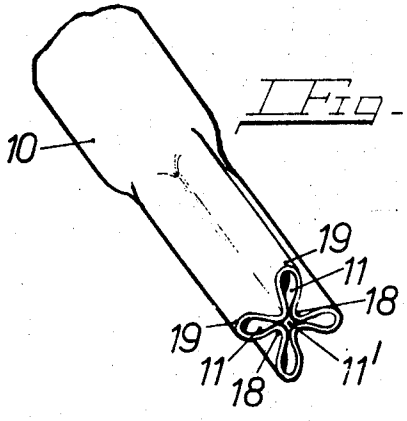



Fig. 5.



# FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES

This invention relates to fuel injection apparatus for internal combustion engines, and in particular to fuel injection nozzles.

Hitherto the practice has been to provide fuel injection nozzles with outlets of circular cross-section. Usually the outlets have simply been orifices formed by holes drilled into the end of the nozzle body. In general with the known injection nozzles fuel which is ejected under pressure from the circular outlets continues some distance from the outlets in virtually unbroken streams before breaking up and becoming diffused, the streams being of a diameter substantially similar to that of outlets from which they have emerged. If free to do so the streams could travel as far as 6 to 12 inches from the outlets before breaking up. In practice, however, they do not travel that far because of the confined space of the cylinders into which the fuel is injected from the nozzles, and the streams in fact are caused to break-up by contact with surfaces in the cylinders. This does not give good diffusion of the fuel, with the result that there is inefficient combustion.

An object of the present invention is to provide a multi-outlet fuel injection nozzle formed from elongate metal tube an end portion of which is inwardly deformed so that portions of the wall of the tube are compressed against one another and divide the interior of the tube into two or more longitudinally extending passages which form tubular injection outlets of the nozzle each having a cross-section which tapers laterally of the tube.

With the injection nozzle in accordance with the present invention it is possible to achieve break-up and diffusion of fuel supplied under pressure to the nozzle as soon as the fuel emerges from the outlets of the nozzle. This results from the fact that because of the laterally tapering cross-sectional shape of each of the outlets the pressure of the fuel passing along the outlet varies across the cross-section of the outlet. Hence at different parts of the outlet's section fuel is travelling at different velocities which gives rise to the break-up of the fuel stream. A fine, well dispersed spray can be achieved and this results in improved and more complete combustion.

The nozzle has been designed principally for the injection of fuel supplied to the nozzle under relatively low pressures, for example of the order of 15 to 30 pounds per square inch, and it is when operating under these conditions that the best results are obtained. It is possible, however, that satisfactory results might be obtained from a nozzle in accordance with the invention to which in use fuel is supplied at a higher pressure.

The length of the tubular outlets effects the form of the sprays in which the fuel emerges from the outlets. If the outlets are only short in length, say less than three-sixteenths inch long, widely spread sprays are produced. If the outlets are fairly long, say more than one-fourth inch in length, then the resultant sprays tend to be narrow, the sprays becoming narrower and approaching stream form as the length of the outlets is increased. The ideal length for most applications is a compromise between these two forms, and hence it is normally desirable for the outlets to be of the order of three-sixteenths to one-fourth inches in length.



The tube from which the nozzle is formed may have a bore of any desired diameter. The selection of the tube bore diameter will normally be determined by the number of outlets with which it is to be formed and the fuel delivery requirements of the nozzle. In general a minimum bore diameter of one-fourth inch is required.

A thin-walled tube will normally be used. The wall thickness is preferably in the order of 0.020 to 0.030 inches.

The tube may be of any suitable metal. Stainless steel is particularly suitable.

The tube may be deformed by pressing rolling or in any other appropriate way.

Any number of outlets may be formed, as desired, the maximum number which it is possible to form depending upon the cross-sectional size of the tube used and the cross-sectional sizes of the outlets required. The outlets may be of similar or different cross-sectional sizes and shapes.

The wall of the tube may be deformed so that the tubular outlets thus formed extend parallel to one another in a row, or so that the outlets are angularly disposed about the main, longitudinal, axis of the tube.

Where there are three or more outlets disposed in a row the end ones of the row are preferably of generally tear-drop shape in cross-section, although they may possibly be of other shapes such as, for example, substantially arrow or diamond shaped. The other outlet or outlets intermediate the end ones of the row may be substantially oval shape in cross-section. They may taper to sharp points at the narrower ends of their cross-sectional shape. The sides of the outlets may converge linearly to meet at the narrower ends of their cross-section, or they may converge in concave curves to the narrower ends, or converge in convex curves so that the narrower ends are cuspidated. Alternatively the outlet or outlets intermediate the end ones of the row may be of generally diamond shape in cross-section, or possibly be bicuspid.

Where there are three or more outlets angularly disposed about the main axis of the tube they are preferably of tear-drop shape in cross-section, the taper being towards the main axis of the tube. However, they may possibly be of other shapes such as of a row of outlets.

In the case of the outlets being disposed angularly about the main axis of the tube, a central outlet may also be formed at or near the main axis of the tube, its shape depending upon the number and form of the surrounding outlets. Where the surrounding outlets are of tear-drop shape, the central outlet will normally be of substantially star shape in cross-section with three or more points.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which,

FIG. 1 is a perspective view of a fuel injection nozzle in accordance with the present invention having two injection outlets;

FIG. 2 is a fragmentary perspective view of the discharge end of a fuel injection nozzle having four injection outlets disposed side-by-side in a row;

FIG. 3 is a fragmentary perspective view of the discharge end of another fuel injection nozzle which has four injection outlets but in which the outlets are disposed in a square, and

FIGS. 4 and 5 are further fragmentary perspective views of the discharge ends of fuel injection nozzles having respectively three and five injection outlets.

In all of the embodiments illustrated by the accompanying drawings the fuel injection nozzles are made of thin-walled metal, preferably stainless steel, tubing. The end forms of the injection nozzles are exaggerated in the drawings in order that they may be clearly understood. The tubes are in each case designated generally be reference **10**.

The fuel injection nozzle shown in FIG. **1** has just two tubular injection outlets **11** which are disposed side-by-side. The outlets **11** are formed by compressing tightly against one another diametrically opposite portions **12** of the tube **10** at the end of the tube, so that passages are formed at opposite ends of a diameter of the tube **10**, which passages extend longitudinally of the tube and constitute the outlets **11**. The end of the tube **10** may be compressed by any convenient means. The outlets **11** thus formed are of similar size and shape. They could be of disimilar sizes if desired. In this instance the outlets are tear-drop shaped in cross-section, the narrow ends of their cross-sections being directed inwardly towards the main, longitudinal, axis of the tube **10**.

In the embodiment shown in FIG. **2** the fuel injection nozzle has four tubular injection outlets **11** extending parallel to one another in a row. The outlets **11** are produced by compressing the end of the tube **10** from opposite sides so/longitudinally extending /that corrugations **13** are formed. The valley portions **14** of the corrugations **13** of the one side of the compressed tube end meet the valley portions **14** of the corrugations of the opposite side along a diameter of the tube **10**. The injection outlets **11** are defined by the passages left between opposed ridge portions **15** of the corrugations **13** of the two sides of the compressed tube end. Three or more than four parallel injection outlets **11** may be formed in this manner, if required. As will be seen in FIG. **2** the end outlets **11** of the row are of substantially tear-drop shape in cross-section with their narrower ends directed inwardly towards the main axis of the tube **10**. The other two, intermediate, outlets **11** are of modified oval shape in cross-section, their narrower ends being cuspidated.

In FIGS. **3** and **4** the fuel injection nozzles shown respectively have three and four tubular injection outlets **11** which are angularly disposed about the main axis of the tube **10**. In each case the outlets **11** are formed by passages produced by pressing angularly spaced apart portions **16** of the wall of the tube **10** inwardly so that the portions **16** meet and are compressed together at the center of the tube. The outlets **11** thus formed are of tear-drop shape in cross-section with their narrower ends towards the center of the nozzle. In these two examples the portions **16** of the wall which are pressed inwardly are spaced at equal angles apart so that the resultant outlets **11** are of similar cross-sectional size. The portions **16** need not necessarily be equally spaced apart. They could be unequally spaced apart if outlets of different cross-sectional sizes are required. As viewed from their discharge ends, the tubes **10** shown in FIGS. **3** and **4** each respectively have three and four lobes **17** of tear-drop shape radiating from the main axis of the tube, each with an outlet **11** in the outer, bulbous, portion of the lobe **17**. The axes of the outlets **11** in each of the two embodiments extend parallel to the main axis of the tube **10**. More than four lobes, and hence more than four outlets could, if required, be formed in similar manner in a nozzle.

The nozzle shown in FIG. **5**, which has five outlets **11,11'**, is formed in a generally similar manner to the nozzle shown in FIG. **4** except that in this case equally-angularly spaced portions **18** of the wall of the tube **10** which are pressed inwardly do not meet at the center of the tube. Instead the portions **18** meet a short distance from the center so that the center of the tube is left open to provide a central outlet **11'**. This is surrounded by four outlets **11**, one in the bulbous outer portion of each of four equally-angularly spaced tear-drop shaped lobes **19**. The axes of all five outlets **11, 11'** are parallel to one another. Again there could be more than four lobes **19**, and thus outlets**11**, surrounding the central outlet **11**. The four surrounding outlets **11** each, as in the embodiments of FIG. **4**, have a tear-shaped cross-section with the narrower end towards the center of the tube. The central outlet **11'** is of a generally four-pointed star shape in cross-section.

The tubes **10** of all the embodiments described above and illustrated by the accompanying drawings would in practice preferably have a wall thickness of 0.020 to 0.030 inches, a bore of at least one-fourth inch in diameter, and the tubular outlets **11, 11'** would preferably be of the order of three-sixteenths to one-fourth inch in length.

In each case the end of the nozzle tube **10** remote from the outlets **11, 11'** is adapted, in any convenient pipe-jointing manner, to be fitted to the discharge end of a feed pipe, not shown, leading from a fuel injection pump, not shown. Fuel is fed by way of the feed pipe into the tube **10** under pressure.

These nozzles inject only fuel into the engine cylinders with which they are associated in use. Air is introduced into the cylinders independently, for example by normal air suction arrangements separate from the nozzles.

With all of the examples of nozzles described and illustrated, using them with fuel supplied to them at a pressure of the order of 15 to 30 p.s.i., it has been found possible to produce a fine, evenly dispersed spray immediately the fuel emerges from the outlets, and this has resulted in very good combustion and improved performance in the engines to which they have been fitted.

Particularly good results have been obtained from nozzles of the forms described and illustrated used with motor cycle one and two stroke engines.

It will be appreciated that the nozzles can be made with very little difficulty and quite cheaply.

I claim:

**1.** A multi-outlet fuel injection nozzle formed from an elongate metal tube having a continuous circumferential wall, said tube comprising a plain tubular portion and an integral end portion extending from said plain portion in the longitudinal direction thereof, at which said end portion said circumferential wall has integral inwardly deformed portions which are compressed into contact one with another and divide the interior of said end portion into a plurality of parallel, elongated passages which extend longitudinally of said end portion and form tubular injection outlets of the

nozzle extending from the interior of said plain tubular portion, said outlets being of substantially constant cross-section along their lengths, and the cross-section of each said outlet tapering laterally of said tube towards said inwardly deformed portions.

2. A multi-outlet fuel injection nozzle according to claim 1 in which each said outlet has a length of the order of three-sixteenths to one-fourth inches.

3. A multi-outlet fuel injection nozzle according to claim 1 in which said tube has a bore of not less than one-fourth inch in diameter.

4. A multi-outlet fuel injection nozzle according to claim 1 in which said tube has a wall thickness of the order of 0.020 to 0.030 inches.

5. A multi-outlet injection nozzle formed from an elongate metal tube having a continuous circumferential wall, said tube comprising a plain tubular portion and an integral end portion extending from said plain portion in the longitudinal direction thereof, at which said end portion said circumferential wall has integral inwardly deformed wall portions which are compressed into contact one against another and divide the interior of said end portion into a plurality of parallel, elongated passages which extend longitudinally of said end portion and are disposed side-by-side to one another in a row, said passages forming tubular injection outlets of the nozzle which extend from the interior of said plain tubular portion and are of substantially constant cross-section along their lengths, said cross-section of each said nozzle tapering laterally of said tube, and said cross-section of each of said outlets at the ends of said row being of tear-drop shape.

6. A multi-outlet fuel injection nozzle according to claim 5 in which there are at least three of said outlets, an intermediate one of said outlets disposed between said end outlets of the row being of substantially oval shape in cross-section with the ends of said oval shape tapering to shape points.

7. A multi-outlet fuel injection nozzle formed from an elongate metal tube having a continuous circumferential wall, said tube comprising a plain tubular portion and an integral end portion extending from said plain portion in the longitudinal direction thereof, at which said end portion said circumferential wall has integral inwardly deformed wall portions which are compressed into contact one against another and divide the interior of said end portion into at least three parallel, elongated passages which are angularly disposed about the main, longitudinal, axis of said tube, said passages forming tubular injection outlets of the nozzle which extend from the interior of said plain tubular portion and are of substantially constant cross-section along their lengths, said cross-section of each said outlet being of tear-drop shape, tapering laterally of said tube towards said main axis of said tube.

8. A multi-outlet fuel injection nozzle according to claim 7 in which said inwardly deformed wall portions make contact one with another at a distance from said main axis and the center of said end portion is left open and forms an additional injection outlet extending from the interior of said plain tubular portion parallel to said angularly disposed outlets.

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