United States Patent

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[72] Inventor Frank De Luca
Thompsonville, Conn.
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[73] Assignee Ambac Industries, Inc.
Springfield, Mass.
a corporation of New York

[54] FUEL INJECTION NOZZLE WITH AUXILIARY SPRAY ORIFICE
1 Claim, 8 Drawing Figs.

[52] U.S. Cl. **239/533,** 239/601
[51] Int. Cl. **B05b 1/30**
[50] Field of Search 239/533, 601

[56] **References Cited**
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Primary Examiner—Lloyd L. King
Assistant Examiner—John J. Love
Attorney—Howson and Howson

ABSTRACT: A fuel injection nozzle assembly comprising an elongated holder, a nozzle assembly having an axial bore mounted at one axial end of the holder, a valve mounted in said axial bore in the nozzle, said nozzle including an elongated shank having a conical valve seat at its lower terminal end and a sac hole below the seat, said valve including a tip end in the closed position engaging the valve seat, said tip end including a conical portion and a pintle adapted to engage in said sac hole in the nozzle, means defining a main fuel discharge orifice on the nozzle communicating at its inner end with the sac hole, means defining an auxiliary orifice of smaller cross section than said main orifice communicating at its inner end with said conical valve seat.

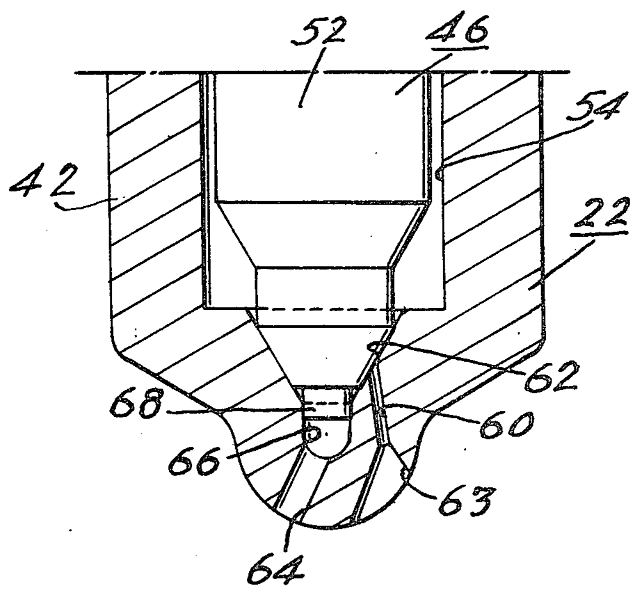


FIG.4.

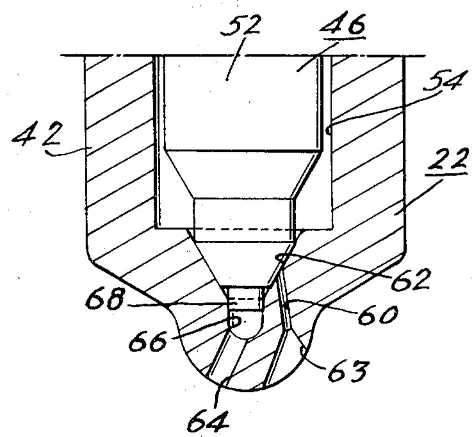


FIG.1.

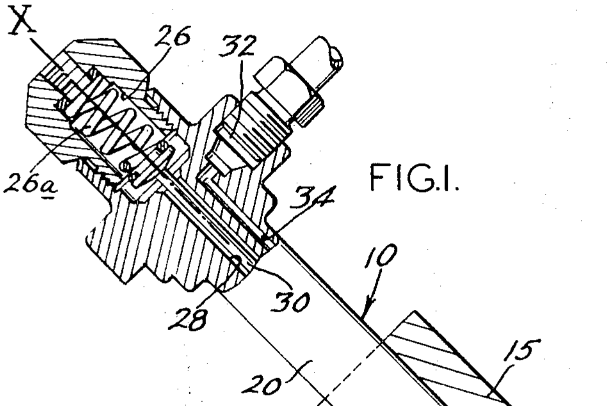
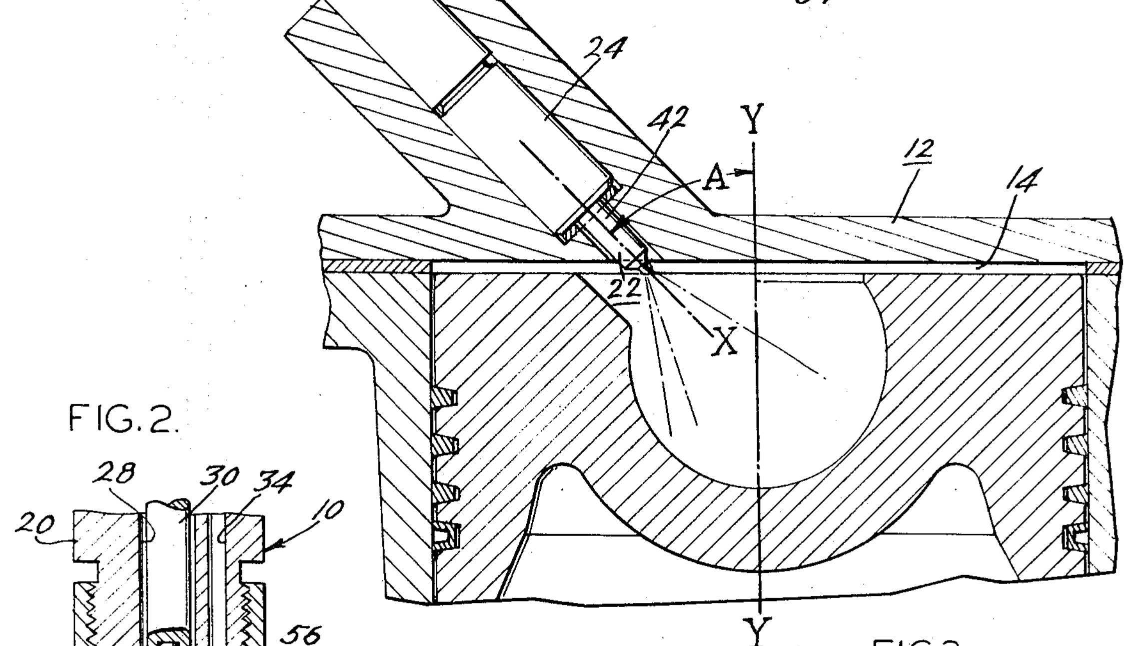



FIG.2.

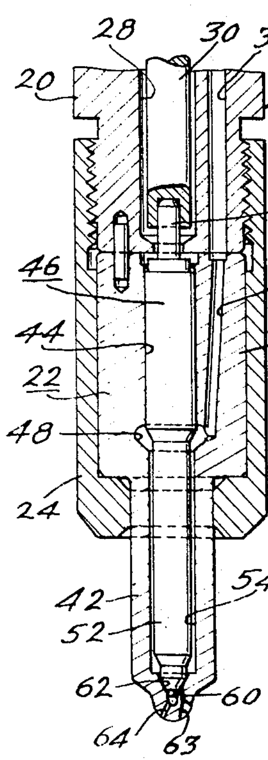


FIG.5.

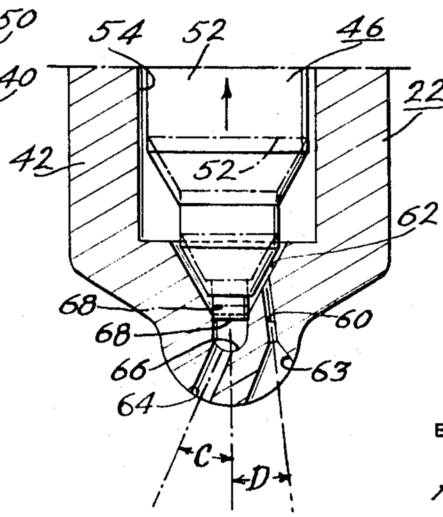
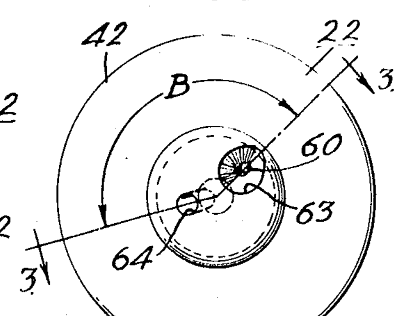


FIG.3.



INVENTOR:
FRANK DE LUCA

BY

Howson & Howson

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FIG.6.

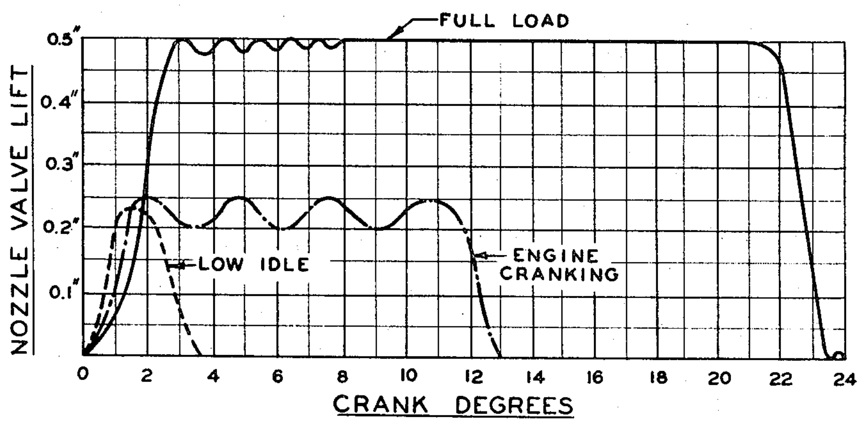


FIG.7.

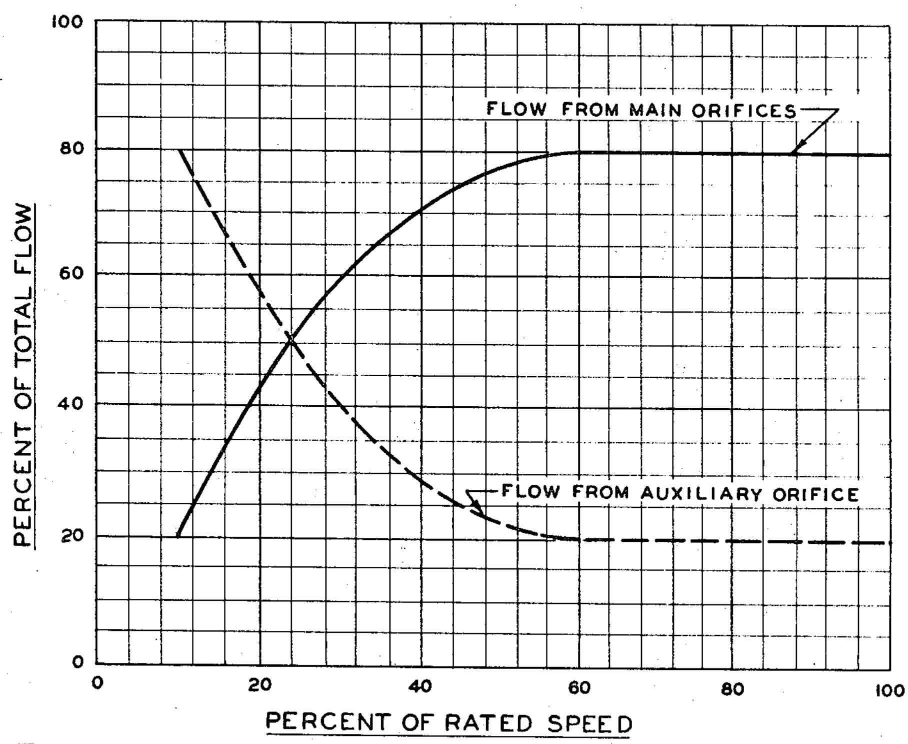
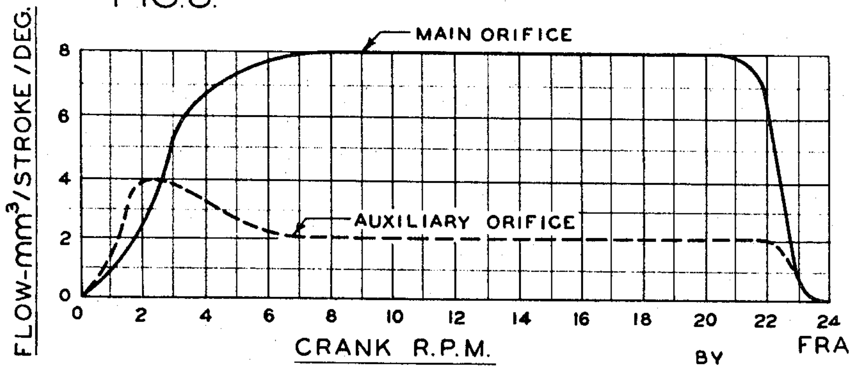


FIG.8.



INVENTOR:
FRANK DE LUCA

BY Howson & Howson

ATTYS

FUEL INJECTION NOZZLE WITH AUXILIARY SPRAY ORIFICE

The present invention relates to a fuel injection nozzle for injecting fuel into the cylinders of internal combustion engines, and more particularly to a fuel injection nozzle assembly including an auxiliary spray orifice whereby engine characteristics are improved considerably, particularly during cranking and low-idle speeds.

As is conventional in some internal combustion engines, a fuel injection nozzle is provided for each cylinder of the engine to discharge fuel directly into the engine cylinder. These nozzle assemblies generally comprise an elongated, generally cylindrical nozzle holder having a fuel passageway therein to direct fuel from a suitable source to the nozzle mounted at one end of the holder. The nozzle and holder are mounted in the engine block so that the nozzle tip projects into the combustion chamber. Further, the nozzle has an axial bore which mounts therein a valve element normally biased to close the spray orifices in the nozzle tip by means of a spring housed in the holder. By this arrangement, as fuel pressure develops in the fuel passageway, the valve element is raised against the bias of the spring to permit discharge of fuel through the spray orifices in the nozzle tip into the engine cylinder. It is noted that the delivery of fuel to each fuel injection nozzle assembly is controlled by a conventional metering pump.

In most conventional fuel injection nozzle assemblies, full discharge of fuel through the spray orifices occurs when the valve element is initially raised from its seat. This produces certain disadvantages and drawbacks in engines with combustion chambers where fuel is sprayed on the piston cavity wall. For example, it has been found that on initial starting of the engine, particularly in cold weather, the pistons are cold and when the full charge of fuel is sprayed on the piston cavity wall, the fuel does not vaporize readily so that combustion can hardly sustain itself and results in white exhaust smoke. The present invention is designed to improve combustion, particularly during cold starting and low low-idle speeds by producing more complete vaporization of the fuel under these conditions. To this end the nozzle valve is provided with a cylindrical extension which fits closely in the sac hole in the nozzle and the nozzle is provided with one or more main orifices communicating with the sac hole and an auxiliary orifice of smaller cross section angularly disposed relative to the main orifice and communicating at its inner end with the nozzle seat. By this arrangement, during initial lift of the valve element, the main fuel discharge orifices are still closed and fuel is discharged through the auxiliary spray orifice. Thus, most of the fuel is sprayed through the auxiliary orifice during engine cranking into the interior of the combustion chamber where the air is heated by compression so that it ignites the fuel readily. Injecting into the heated air improves vaporization and facilitates fuel ignition and starting. At low-idle speeds also a high percentage of the fuel may be sprayed through the auxiliary orifice with improved vaporization and idle operation. Furthermore, by reason of the fact that the auxiliary orifice originates at the valve seat, when full valve lift occurs at normal engine operation, the flow through the main discharge orifice will be unrestricted whereas the high rate of fuel flow across the valve seat will reduce the effective pressure at the auxiliary orifice so that the discharge through the auxiliary orifice will be considerably reduced. In this manner combustion is controlled and smooth engine running is assured over the whole operating range of the engine.

These and other objects of the present invention and various details of the construction and operation of a fuel injection nozzle assembly in accordance with the present invention are more fully set forth with reference to the accompanying drawings wherein:

FIG. 1 is a fragmentary sectional view through an engine block showing a fuel injection nozzle constructed in accordance with the present invention;

FIG. 2 is an enlarged transverse sectional view of the nozzle;

FIG. 3 is a view of the fuel injection nozzle assembly as viewed from the nozzle tip;

FIG. 4 is an enlarged sectional view showing the nozzle tip and the angular relationship between the main spray orifice and the auxiliary spray orifice;

FIG. 5 is a view similar to FIG. 3 showing the valve element in partially open and fully open positions;

FIG. 6 is a chart showing valve lift during idle and cranking as compared to full load;

FIG. 7 is a chart showing fuel flow during cranking and idling; and

FIG. 8 is a chart showing typical rates of fuel discharge.

Referring now to the drawing and particularly to FIG. 1 thereof, the fuel injection nozzle assembly broadly designated by the numeral 10 is shown mounted in an engine cylinder block 12 with the nozzle tip extending into the combustion chamber 14. As illustrated, the nozzle assembly is mounted in a sleeve 15 formed integrally with the engine block and is oriented so that the axis X–X of the nozzle assembly 10 is disposed at an angle A as may be required by the engine design for example between 40° to 120°.

As best illustrated in FIGS. 1 and 2, the fuel injection nozzle assembly comprises an elongated, generally cylindrical holder 20 and a nozzle 22 mounted on one end of the holder and retained by means of a cap nut 24. The holder has a spring chamber 26 at its upper axial end and an elongated central bore 28 which mounts therein a spindle 30. The holder also has a fuel inlet 32 adapted to be connected to a suitable source of fuel supply through a metering pump (not shown) and an elongated fuel passageway 34.

The nozzle 22 comprises an upper generally cylindrical body portion 40 and an elongated nozzle shank 42 of reduced cross section extending from the body portion 40. The nozzle also has an axial bore 44 within which is mounted the valve element 46, the axial bore being enlarged as at 48 to define a sump communicating with the lower end of the fuel passage 50 which in turn is aligned with the fuel passageway in the holder.

The valve element 46 as illustrated is of a stepped configuration, the tip end 52 being spaced from the lower portion of the axial bore 44 and the area between the two defining a fuel chamber 54. The upper end of the valve element is a close, sliding fit in the upper portion of axial bore 44 to provide good seating of the nozzle tip on the valve seat. The upper end of the valve extension 56 engages the lower end of the spindle 30 so that it is normally maintained in a closed position.

In accordance with the present invention, means are provided for improving engine characteristics particularly at cranking and low-idle speeds. More specifically, the nozzle assembly is provided with an auxiliary discharge orifice 60 which, as illustrated in FIG. 5, is disposed in the nozzle tip and terminates at its inner end in the conical seat 62 and at its outer end is flared outwardly as at 63. The main discharge orifice 64 is of a larger cross section than the auxiliary orifice. The auxiliary orifice is disposed at such an angle relative to the main orifice so that the auxiliary spray does not deposit fuel on the sidewall of the piston cavity. Thus, when the nozzle is mounted in an engine block in the position illustrated in FIG. 1, discharge of fuel through the auxiliary orifice is into the center of the hollow portion in the piston as illustrated. For example the angular relationships shown in FIGS. 3 and 5 may be in the following range: angle B, 150° to 165°; angle C, 0° to 45°; and angle D, 25° to 60°. Further, the nozzle tip is provided with a sac hole 66 and the valve element 52 has a short piston-like projection or pintle 68 which is a close fit in the sac hole 66 when the valve is in the closed position. The sac hole 66 is formed by a precise machinery process to provide a very close fit between the pintle 68 and sac hole 66 so that upon initial lifting of the valve, a high percentage of fuel flow is through the auxiliary orifice 60 and only a small amount through the main orifice. However, at higher speeds when the valve lifts to its maximum controlled lift position, most of the fuel will be discharged through the main orifice.

In order to achieve optimum fuel flow characteristics, the auxiliary orifice is preferably in the range of 12 to 20 percent of the total orifice area; that is, 12 to 20 percent of the combined area of the area auxiliary orifice and the main discharge orifice **64**. For example, for present automotive engines the auxiliary orifice is preferably between 0.20 mm. to 0.35 mm. Additionally, the length of the auxiliary orifice **60** is preferably no greater than four times the diameter thereof To this end, the outer terminal end of the auxiliary orifice is controlled by a recess as at **63**, and the effect is to produce an atomized spray of fuel through the auxiliary orifice. The pintle is of an x axial length, preferably equal to one-half—or slightly greater than—the total valve lift so that when the valve element is partially raised, fuel is discharged mostly through the auxiliary orifice. For example, full valve lift in this type of nozzle is usually in the order of 0.35—0.40 mm. and at cranking and low idle, the valve lift should be approximately one-half of its full lift. Accordingly, in this design, the pintle projection or axial dimension should be in the range of 0.18 to 0.25 mm.

Considering now the operation of a fuel injection nozzle in a typical internal combustion engine, the valve element **52** is normally biased to a closed position by the spring **26**. Now, as fuel pressure in the inlet increases as controlled by the metering valve, the valve element **52** is moved axially upwardly against the bias of the spring to provide an annular clearance between the conical tip of the valve element and the valve seat **62**. In accordance with the present invention during cranking and low idle speeds, the valve element raises to the position shown in broken lines in FIG. **5** whereby the pintle **68** is partially engaged in the sac hole **66** to restrict discharge of fuel through the main orifice **64**. However, during this period the auxiliary discharge orifice is open and fuel is discharged mostly through the auxiliary orifice. This provides a better atomization of the fuel during cranking and low-idle speeds as compared with the prior assemblies wherein the entire fuel discharge was through the main orifice. Chart **6** shows valve lift during idle and cranking as compared to full load. The chart shown in FIG. **7** shown fuel flow during various phases of engine operation.

FIG. **7** shows the relative flows through the main and auxiliary orifices. As illustrated, at cranking speeds at about 100 r.p.m., most of the fuel is discharged through the auxiliary orifice and at idle speeds of 200 r.p.m., a high percentage of flow is still through the auxiliary orifice. At increased speeds the fuel injection pressure increases sufficiently to raise the valve element to its maximum lift whereby the pintle **68** is completely withdrawn from the sac hole **66** thereby opening up the main orifice for discharge of fuel therethrough. As illustrated in the chart of FIG. **7**, under these conditions most of the fuel discharges through the main orifice because of the high flow through the valve seat and the consequent reduced pressure at the entry to the auxiliary orifice.

While a particular embodiment of the present invention has been illustrated and described herein, it is not intended to limit the invention, and changes and modifications may be made therein within the scope of the following claims.

I claim:

1. A fuel injection nozzle assembly comprising an elongated holder, a nozzle assembly having an axial bore mounted at one axial end of said holder, a valve mounted in said axial bore, the lower terminal end of said axial bore terminating in a conical valve seat and a sac hole below said seat, said valve having a tip end including a conical portion and a pintle projecting from said conical portion, means defining at least one fuel discharge orifice in the nozzle communicating at its inner end with said sac hole, means defining an auxiliary orifice of smaller cross section than said main discharge orifice, the inner terminal end of said auxiliary orifice terminating at said valve seat, said auxiliary orifice being in the range of 12 percent to 20 percent of the total discharge orifice area and being of a length no greater than four times its diameter, the outer terminal end of said auxiliary orifice being flared outwardly, said valve operable between a closed position wherein the pintle snugly engages in said sac hole and said conical portion overlies the inner terminal end of said auxiliary orifice to seal the same and an open position permitting fuel flow through said orifices, said pintle being of an axial length equal to at least one-half the total valve lift.