Nov. 14, 1961 J. N. MORRIS ET AL 3,008,653

FUEL INJECTION NOZZLE

Filed May 8, 1959

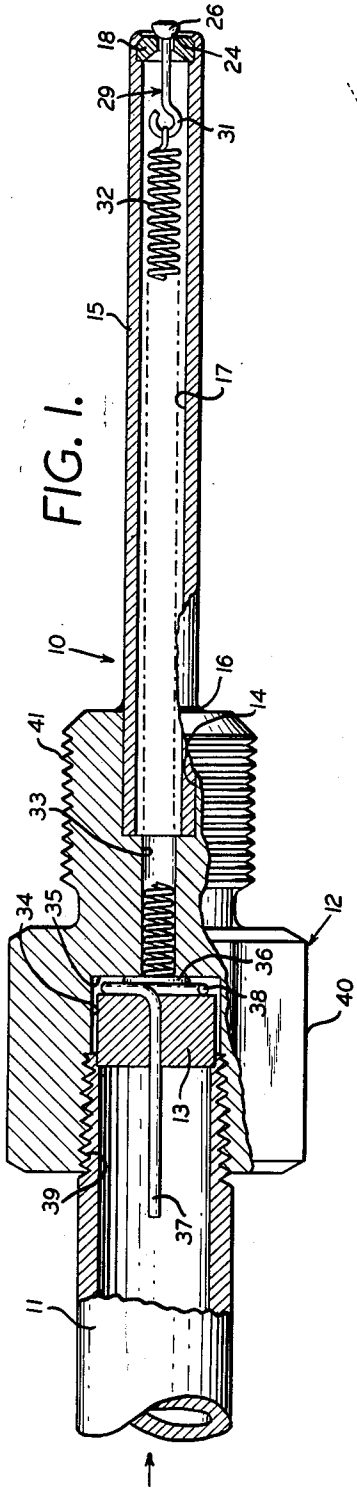


FIG. 1.

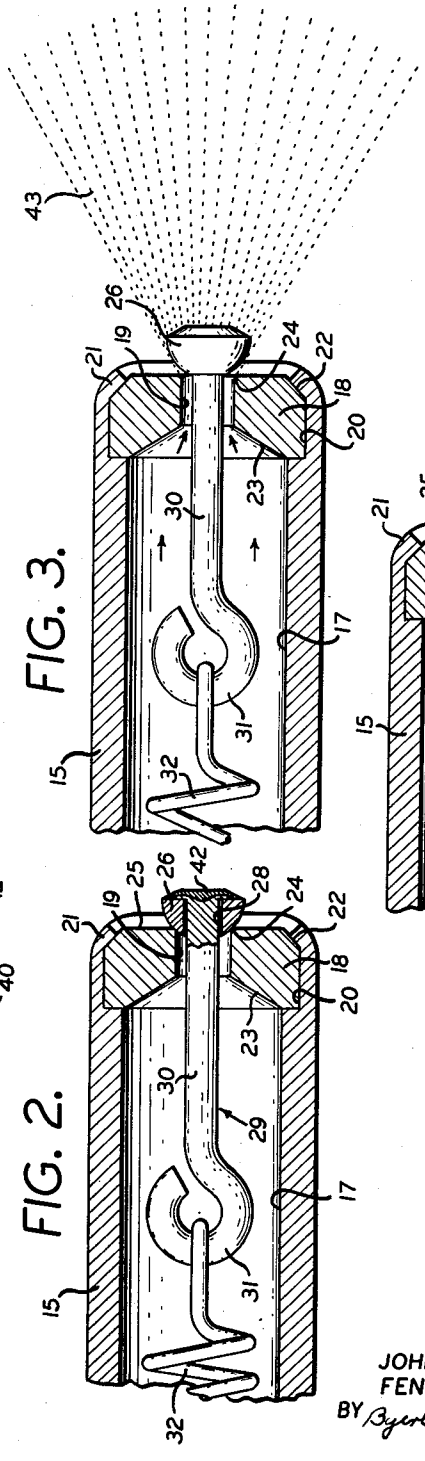


FIG. 3.

FIG. 2.

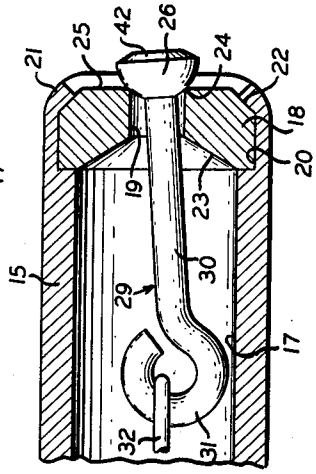


FIG. 4.

INVENTORS
JOHN NEVILLE MORRIS
FENO H. TRUAX
BY Byerly, Townsend Watson & Churchill
ATTORNEYS.

United States Patent Office 3,008,653 Patented Nov. 14, 1961

3,008,653

FUEL INJECTION NOZZLE

John Neville Morris, Birmingham, England, and Feno H. Truax, Vergennes, Vt., assignors of one-half to The S.U. Carburetter Co. Ltd., Birmingham, England, a British company, and one-half to Simmonds Precision Products, Inc., a corporation of New York

Filed May 8, 1959, Ser. No. 811,902
1 Claim. (Cl. 239—453)

This invention relates to fuel injection apparatus for internal combustion engines, and in particular, to a novel and improved form of injection nozzle adapted to deliver a hollow, conical, mist-like spray of fuel particularly suitable for automotive uses.

The injection nozzle of the present invention contemplates use with a special type of fuel pump to form a fuel system which does away with the conventional carburetor. The pump is adapted to supply metered quantities of fuel under pressure intermittently to the injection nozzle. The nozzle is actuated to discharge the fine mist-like spray of fuel. The spray is picked up by air to form an intimate mixture of finely atomized droplets and air for combustion in an internal combustion engine wherein each cylinder of the engine is serviced by a respective injection nozzle. As part of a fuel supply system, the injection nozzle may be adapted to discharge the atomized fuel directly into the individual cylinders of an engine, for example an engine normally employed for automotive applications. As an alternative, the injection nozzle may be adapted to discharge the atomized spray into ports interconnecting the air intake manifold with the respective cylinders.

For automotive applications contemplating driving conditions normally confronting the average driver, optimum and efficient operation of the aforesaid fuel system requires a fine mist-like spray of fuel to produce the admixture with air for combustion, in contrast to a non-atomized spray consisting of globules or slugs of fuel. The most suitable spray pattern to achieve optimum combustion is a spray having an annular cross section with air inside and outside the annulus, that is to say a hollow, cone-shaped spray pattern.

The injection nozzle of the instant invention employs a substantially right-angled and annular-edged valve seat operatively associated with a hemispherical valve member to produce the desired conical spray in a mist-like dispersion. Installed in an automobile and operated under average driving conditions normally confronting the average automobile driver, injection nozzles employing the instant invention have shown marked improvements in fuel consumption efficiencies in contrast to comparable prior art injection nozzle structure.

Accordingly, it is the principal object of the instant invention to provide a novel and improved injection nozzle for developing a mist-like fuel spray in the form of a hollow conical pattern which is brought about by a substantially right-angled and annular-edged valve seat operatively associated with a spherical-surfaced valve member biased by a preloaded spring. The valve member is adapted to undergo movement from its closed seated position to a fuel dispersible position in response to the development of a crack pressure in the supply line of the injection nozzle by an interconnected fuel pump. The spring is preloaded slightly below the over-riding crack pressure in order to effect sharp, quick opening of the valve upon development of such pressure.

It is a further object of the instant invention to provide an injection nozzle capable of providing a mist-like atomization of fuel conducive to a good admixture with air in which the fineness, pattern, and penetration of the spray may be predetermined and easily and accurately

controlled by the design of the injection nozzle structure in order to arrive at an optimum admixture for combustion in an internal combustion engine.

It is a further object of the instant invention to provide a novel and improved fuel injection nozzle characterized by good seating and closure qualities over the range of engine operation, thus eliminating the possibility of leaking resulting in the admission of raw fuel to the cylinder and minimizing draining of fuel lines during shut off; and which injection nozzle over the range of engine operation is further characterized by sharp and quick opening of its valve in order to develop a mist-like spray of fuel in response to the development of an opening crack pressure in the supply line of the injection nozzle.

It is a further object of the instant invention to provide a novel and improved fuel injection nozzle employing a substantially right-angled and annular-edged valve seat operatively associated with a spring biased hemispherical valve member whereby the valve member always finds its seat and assumes an annular-line fluid tight seating in respect to the valve seat.

It is a further objection of the instant invention to provide a fuel injection nozzle of the type wherein a spring loaded hemispherical valve member is operatively associated with a substantially right-angled and annular-edged valve seat. The valve member undergoes a small longitudinal movement from its closed seated position on the exterior face of said valve seat to a fluid dispersible position spaced axially from and confronting said valve seat in response to the development of a crack pressure in the supply line of the injection nozzle overriding the closing force acting upon the valve.

It is a further object of the instant invention to provide a novel and improved injection nozzle structure to be used in conjunction with a fuel pump furnishing fuel under pressure to said nozzle for providing accurate quantities of metered fuel which may be readily duplicated from one nozzle to another for respective engine cylinders. Such fuel system is particularly adaptable for automotive uses contemplating speeds and loads encountered during normal automobile driving conditions.

It is a further object of the instant invention to provide novel and improved injection nozzle structure capable of minimizing wetting of manifold or cylinder block walls by furnishing a mist-like spray of fuel for admixture with air to provide an optimum admixture for combustion in respective cylinders of the internal combustion engine.

Further objects and advantages will become apparent from the following description of the invention taken in conjunction with the figures, in which:

FIG. 1 is a longitudinal view partly in section, showing an injection nozzle employing the improvements of the instant invention;

FIG. 2 is a fragmentary view partly in section, of the nozzle tip end of the embodiment of FIG. 1, showing the valve seated on the valve seat;

FIG. 3 corresponds to FIG. 2, but shows the valve in open position for effecting an atomized conical spray; and

FIG. 4 is a fragmentary and magnified view of the nozzle tip end illustrating the feature that the valve member will always assume annular-line valve seating notwithstanding departure from coincidence of the longitudinal axis of the valve seat, which is an advantage provided by the structure of the instant invention.

Reference is now made to the figures illustrating a fuel tight injector nozzle **10** incorporating the principles of the improvements. Fuel under pressure is supplied by a supply line **11** to the intake end of a head member **12**. The fuel is caused to flow through a filter **13** and discharge at the other end of nozzle **10**. Head member **12** has a centrally disposed through bore composed of differ-

ent diametered sections. Bore section 14 is dimensioned to receive the recessed end of a longitudinal tubular or barrel member 15 integrally joined to head 12 by soft soldering at the annular joint 16. The opposed ends of tubular member 15 are joined by a centrally disposed through bore 17. A nozzle tip 18 is provided with a centrally disposed and uniform diametered orifice bore 19. Tip 18 substantially encloses the fuel dispersible end of tubular member 15. Nozzle tip 18 is recessed against a shoulder within an enlarged diametered bore 20 and held therein by the swaged peripheral edge 21 folded over an annular bevelled surface 22 of tip 18 and soft soldered. The aforementioned bores are in axial alignment. The interior surface 23 of tip 18 is concave-shaped to minimize turbulence of fluid flow into orifice 19, and to allow the hanger 29 to vibrate freely without striking the adjacent sides of nozzle tip 18.

A valve seat 24 is provided on an exterior face 25 of nozzle tip 18 and is shown in enlarged detail in FIGS. 2, 3, and 4 with its associated valve member 26. Valve seat 24 is formed by boring a uniform diametered orifice 19 in tip 18 after which the tip member is hardened and the exterior face 25 is lapped to a fine finish to produce a substantially right-angled, annular and sharp-edged valve seat 24 in the plane of exterior face 25. The hemispherical valve 26 may be made of a ball bearing cut in half. Valve 26 is disposed so that its spherical face confronts valve seat 24. After the ball is cut in half, it is provided with a centrally disposed bore 28, the spherical surface hardened and then highly polished. Valve 26 is suspended by a hanger 29 for movement from a seated closed position (FIG. 2) on valve seat 24 to a fluid dispersible position (FIG. 3) spaced axially from and confronting valve seat 24 in response to forces acting upon valve 26. Hanger 29 includes a longitudinal stem 30 which extends from the interior of bore 17 and passes through orifice 19 and through bore 28 of valve member 26. The forward end of stem 30 is anchored to valve 26, as shown in detail in FIG. 2, by peening same over the flat face of the hemisphere and soft soldering at 42. The amount of solder used should be minimized to avoid condensation of fuel at 42. The other end of hanger 29 is provided with an eye 31 hooked to a turned end of a preloaded distensible tension spring 32. Spring 32 extends along bore 17 and into a small diametered section 33 of head 12. Section 33 communicates with a larger diametered section 34 at the fluid intake end of head 12. An annular shoulder 35 is formed in the plane where bore sections 33, 34 join. Spring 32 terminates with a large-diametered coil 36 bearing against shoulder 35. A puller wire 37 pierces filter 13 and terminates with a large-diametered coil 38 bearing against the interior surface of filter 13. Filter 13 prevents impurities flowing into the fuel passage of nozzle 10 and scouring valve seat 24. Puller wire 37 facilitates replacement of the filter. Section 34 is threaded at 39 in order to anchor the nozzle of supply line 11 to the intake end of nozzle injector 10. Filter 13 and coil 36 of spring 32 are clamped against annular shoulder 35 upon threaded advancement of supply line 11 along threaded portion 39. The exterior wall of head member 12 is hexagonally shaped at 40 and threaded at 41 to effect threaded attachment to manifold or cylinder block structure. Bore section 33 is dimensioned so that spring 32 fits snugly therein to provide a substantially non-vibrating anchorage of the preloaded spring at the intake end of nozzle injector 10. Bore 17 is of larger diameter to prevent interference with motion of the spring at the spray dispersible end of injector 10. In addition the adjacent portions of nozzle tip 18 and the spring loaded hanger 29 are suitably chosen to permit hanger 29 to vibrate freely without striking the adjacent sides of nozzle tip 18.

In operation, valve 26 undergoes movement through a short axial distance from its closed seated position, FIG. 2, to a second position, FIG. 3, spaced from and confronting valve seat 24 in response to forces acting thereon. Such forces include the restraining force exerted by spring 32, the pressure generated in supply line 11 and nozzle 10 by a fuel pump (not shown) and the pressure on the back face 42 of valve member 26. The fuel pump is interconnected to the other end of supply line 11. In describing such mode of operation, reference will be made to a specific installation of an injection nozzle 10 in an internal combustion engine employed in an automobile. Injection nozzle 10 was mounted to spray fuel into the intake ports of an intake manifold. During the non-injection period, a pressure in the order of 8 to 10 p.s.i. (pounds per square inch) normally existed in supply line 11 and injection nozzle 10. Spring 32 was preloaded to exert a force in the order of 10 to 15 p.s.i. below the crack pressure. Spring 32 is designed to hold valve 26 in closed position until development of a crack pressure in the fuel line by the pump. The term crack or opening pressure as used herein means the pressure at which valve 26 is designed to open, that is to say, the pressure overriding the restraining force of preloaded spring 32. In the foregoing installation spring 32 was designed to respond to a crack pressure of approximately 120 p.s.i. It will be understood that for automative uses lower or higher crack pressures, from about 100 p.s.i. to about 200 p.s.i., may be used. The higher the crack pressure, the more closely compact will be the particles of the fuel spring, which results in a denser type of spray pattern. The intake manifold pressure acting on back face 42 of valve 26 is approximately atmospheric pressure.

Prior to the development of the crack pressure, the fuel line is completely filled with fuel without air pockets or space between supply line 11 and valve seat 24. The overriding crack pressure is developed on the injection stroke of the next cycle of operation of the fuel pump, thereby forcing more fuel into supply line interconnecting injection nozzle 10. The output of the pump causes almost a vertical rise of pressure up to crack pressure or higher. Valve 26 responds by suddenly and sharply opening valve seat 24 as valve member 26 is caused to move forwardly through a short distance as shown in FIG. 3. A small axial displacement is desired for automotive uses. The rapid and responsive opening establishes the fine spray-like mist 43 as the fuel breaks down upon discharge into the relatively low pressure region of the manifold port. The quick opening is accomplished by preloading spring 32 as hereinbefore noted slightly below crack pressure. A hollow conical spray pattern develops as the fuel discharges into the relatively low pressure region and flows around and past valve member 26. The atomized spray or vapor is picked up by the air in the intake ports of the manifold to form a combustible admixture of vapor and air which is conducted into the cylinder.

The spray pattern may be readily controlled by varying the size of orifice 19, the shape of valve 26, or both. A small sized orifice is desirable for automotive uses. In the nozzle embodiments employed in the aforementioned installation, orifice bores of .038 inch and .048 inch were used, and valve 26 was made from a standard 1/16 inch ball bearing. A small orifice prevents a mass damping of fuel out from seat 24 immediately upon valve opening. In addition, the pressure in the fuel line flattens out and is sustained during the injection period so that a continuous spray continues for such time.

Upon delivery of a metered quantity of fuel by the pump, the supply line pressure drops. Valve member 26 promptly shuts upon collapse of the pressure overriding the closing force of spring 32 to interrupt fuel flow. The hemispherical-shaped valve 26 automatically finds its seat with relationship to the right-angled and annular-edged orifice 19. The foregoing structure will always insure a positive fuel tight annular closure at valve seat 24 to prevent drainage notwithstanding that in seating, hanger 29 may be deviating from coincidence with the axis of the valve bore 19, as illustrated in FIG. 4. A failure of positive seating during the non-injection period

would permit dribble or leakage of fuel via valve seat 24 and empty part of the fuel line to cause on the next cycle of operation, a discharge less than a full metered quantity of fuel, with the result of ragged engine operation.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

An injection nozzle providing an atomized, hollow-cone-shaped spray pattern comprising, a fluid intake member having opposed ends joined by a through bore provided with a plurality of different diametered sections, a longitudinal tubular member having opposed ends joined by an inner bore, one end of said tubular member being joined to and recessed in one of said different diametered sections at one end of said intake member, a nozzle tip having an exterior face substantially enclosing the other end of said tubular member, said tip having an orifice through bore defining a substantially right-angled and annular-edged valve seat in the plane of said exterior face, a valve member suspended for axial movement and having a substantially hemispherically-shaped surface confronting said valve seat, a rigid hanger member secured to the hemispherical valve member and having a stem extending through said tip orifice bore and into said tubular member, the stem of said hanger being of substantially less diameter than said tip orifice bore, said valve member providing with said valve seat an annular fluid-tight line contact at said annular edge when seated in said valve seat irrespective of angular displacement of the hanger, the other end of said intake member provided with a relatively large diametered bore section joined to said first-mentioned section by a small diametered bore section, said large and small diametered bore sections terminating in a common plane defining an annular shoulder, a tension spring suspended in said tubular bore and having opposed ends, one end of said spring being connected to said hanger member and the other end of said spring passing snugly through said small diametered section of said intake member and terminating with an enlarged diametered coil bearing against said annular shoulder, and filter means removably mounted in said large diametered section, said large diametered section adapted to receive a fluid input line for fluid under pressure to effect fluid flow toward said nozzle tip via said bores, said filter and enlarged end of said spring being clamped against said annular shoulder upon insertion of the fluid input line into said large diametered section, said spring normally maintaining said valve member in closed seated position to prevent discharge of said fluid, said valve member being adapted to move from its seated position to a fluid dispersible position spaced axially from and confronting said valve seat in response to an over-riding pressure acting upon said valve member, and said spring being preloaded slightly below said over-riding pressure to effect quick opening upon development of such pressure, whereby an atomized hollow-cone-shaped pattern is developed as the fluid is dispersed around and past said valve member, said valve member returning to its closed seated position under the influence of said spring upon absence of said over-riding pressure.

References Cited in the file of this patent

UNITED STATES PATENTS

1,112,416	Sargent	Sept. 29, 1914
2,749,181	Maxwell et al.	June 5, 1956
2,756,106	Schenk	July 24, 1956
2,860,780	Ziesche et al.	Nov. 18, 1958

FOREIGN PATENTS

367,014	Great Britain	Feb. 12, 1932
866,597	France	May 26, 1941
909,177	France	Dec. 10, 1945

UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 3,008,653 November 14, 1961

John Neville Morris et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 59, for "damping" read -- dumping --.

Signed and sealed this 24th day of April 1962.

(SEAL)
Attest:

ESTON G. JOHNSON
Attesting Officer

DAVID L. LADD
Commissioner of Patents