July 7, 1970 S. G. HILBORN 3,519,407

FUEL INJECTION NOZZLE

Filed June 27, 1966

Fig. 1

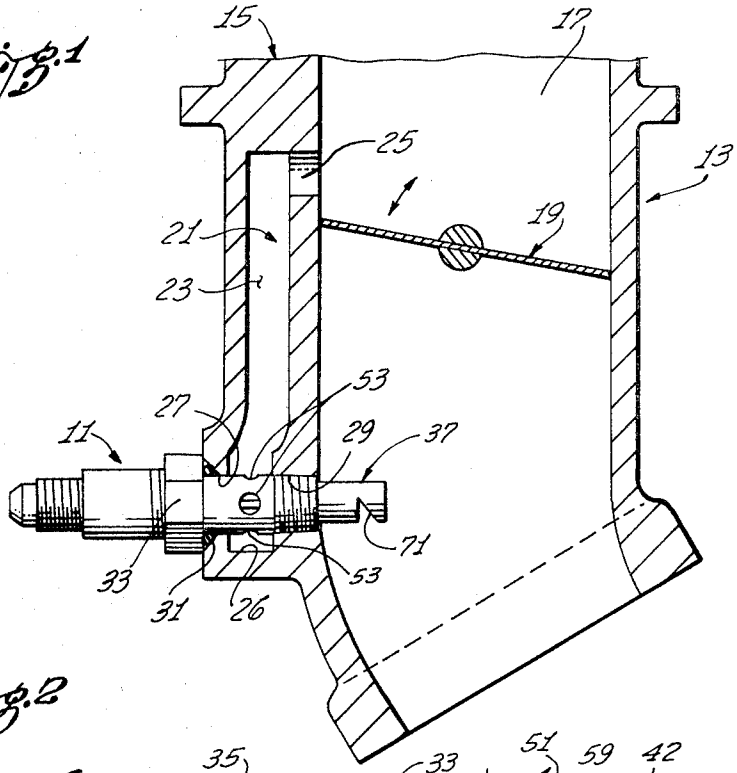


Fig. 2

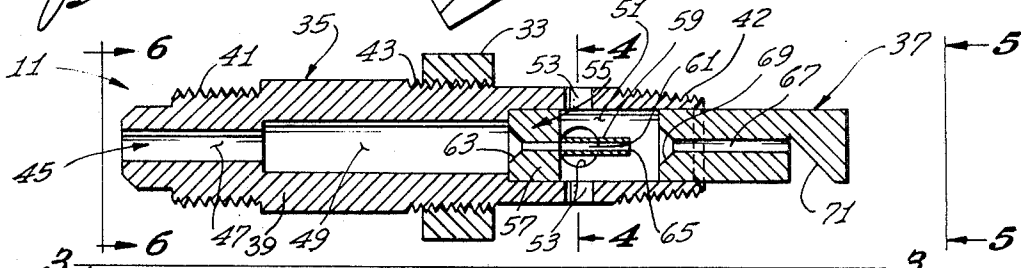


Fig. 3

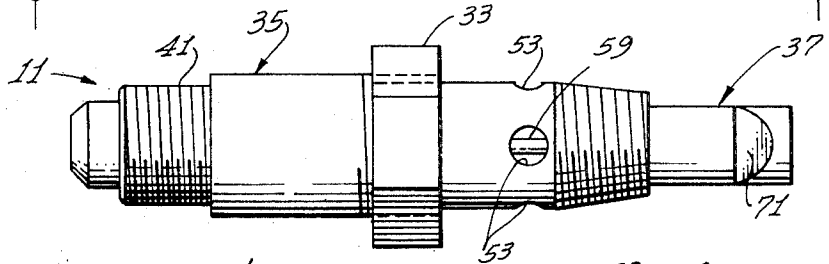


Fig. 4

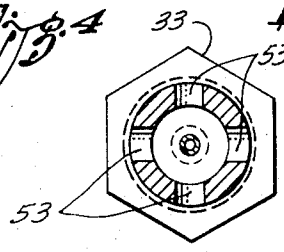


Fig. 5

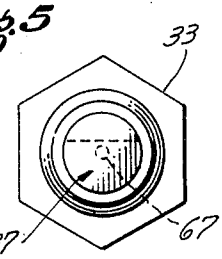
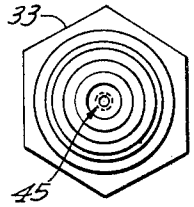


Fig. 6



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FUEL INJECTION NOZZLE

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Int. Cl. B01f 3/02; C10j 1/12
U.S. Cl. 48—180 5 Claims

ABSTRACT OF THE DISCLOSURE

Fuel injection nozzle which includes tubular body means defining a passageway extending through said body means. The passageway has an inlet section connectible to a fuel supply system and a discharge section for injecting fuel into the intake manifold of an engine. The discharge and inlet sections are separated by a chamber section and means are provided in the chamber section for directing a stream of fuel thereacross into the discharge section. The body means has an air passage therein for conducting air into the chamber section and such air may be supplied from the upstream side of the butterfly valve in the manifold. An impingement surface is provided adjacent the outlet of the discharge section against which the air and fuel traveling through the discharge section can impinge.

This invention relates to fuel injection nozzles and, more particularly, to a fuel injection nozzle of the air gap type which is particularly adapted for use with supercharged automobile racing engines.

The fuel requirements of an automobile racing engine vary rapidly over a wide range. For example, the speed of a supercharged racing engine may vary from 1000 r.p.m. to over 10,000 r.p.m. in a few seconds. The throttle position may change from closed, to fully open, to partly open, and back to fully open within seconds. Each slight variation of throttle position and of engine speed will produce a corresponding fluctuation in manifold pressure which might range, for example, from zero to 120 inches Hg positive boost, then down to 25 inches of Hg vacuum. These extreme changes in manifold pressure may occur in just a few seconds as during an acceleration or "drag" race in which a racing vehicle may accelerate from zero to 200 miles per hour in less than eight seconds.

Each change in engine r.p.m. or air flow to the engine requires a corresponding and accurately controlled change in fuel flow. If the fuel injection system fails to produce these changes or fails to produce them accurately and without excessive time delay, power is lost, engine performance is poor, and damage to the engine may occur.

Generally, prior art fuel injection systems attempt to vary the amount of fuel supplied to the engine in response to various engine conditions. However, the prior art fuel injection systems are generally unsatisfactory and not sufficiently flexible to efficiently operate over the wide range of fuels, engine r.p.m., and engine air flows required in the racing engine.

One important fuel injection problem is presented during deceleration or closing of the throttle valve and during idling. In these situations, the throttle may be suddenly closed or partially closed. Because the fuel pump is driven by the engine, the output thereof continues at nearly maximum until the engine speed is reduced. If all of the fuel pumped by the fuel pump during this period were fed to the engine, excessive richness of the fuel-air mixture would result. To solve this problem, one or more bypass lines may be provided for feeding fuel from the area of the fuel pump back to the fuel supply tank during periods of deceleration. One such system is described and claimed in applicant's copending patent application, Ser. No. 545,748 filed on Apr. 27, 1966, entitled "Fuel Injection System" and now abandoned.

Notwithstanding the use of these several bypasses, additional fuel injection problems are created by the low air pressure which exists in the intake manifold when the throttle is being closed. These low air pressures which may be below atmospheric pressure draw fuel from the fuel supply system into the intake manifold. Stated another way, the low or vacuum pressure in the intake manifold moves through the fuel injection nozzle and into the fuel supply system to suck or withdraw the fuel therefrom.

This results in poor engine operation for several reasons. First, during idling or deceleration, engine fuel requirements are low and therefore drawing of the fuel from the fuel supply system into the engine creates excessive richness of the fuel-air mixture and wasted fuel. As is well known, overly rich fuel-air mixtures do not allow proper operation of the engine. In addition, because fuel has been wasted, additional fuel stops may be required during long distance races. This, of course, could result in losing a race that might otherwise have been won.

Perhaps the primary disadvantage of allowing fuel to be drawn from the fuel supply system during closing of the throttle is that when the throttle is again open and sudden power is desired, there is a short delay period required for the fuel to reach the intake manifold. That is, if a substantial portion of the fuel supply system contains low pressure air rather than fuel, this low pressure air must first be forced from the fuel supply system before fuel can reach the intake manifold. This short delay period can be very costly, particularly during a race in which the engine of the racing car must frequently accelerate and decelerate.

According to the present invention, an air gap fuel injection nozzle is provided which overcomes the above-noted problems. More particularly, excessive richness of the fuel-air mixture during closing of the throttle caused by substantially evacuating a portion of the fuel supply system is eliminated. With the air gap nozzle of the present invention, no fuel is wasted and no additional fuel stops are required as a result of unnecessarily allowing the low manifold pressures to draw fuel from the fuel supply system. Furthermore, with the present invention there is no lag in acceleration as a result of substantially evacuating a portion of the fuel supply system. The air gap nozzle maintains fuel under pressure within the nozzle so that when the throttle valve is open fuel is immediately injected into the intake manifold. Another advantage of the air gap nozzle is that it assists in producing an intimate fuel-air mixture.

The air gap nozzle of this invention is particularly designed for connection to a fuel supply system and to an intake manifold of an engine. Usually, the air gap nozzle will be secured to the manifold downstream from a throttle valve so that the nozzle can discharge fuel into the air stream in the main manifold passage.

Briefly stated, the air gap nozzle may include body means having a passageway therethrough, the passageway having an inlet connectible to the fuel supply system and a discharge orifice spaced from the inlet for directing fuel

into the intake manifold. Means are provided for at least substantially preventing the low-pressure air within the intake manifold from entering the fuel supply system via the body means. This allows fuel to be maintained within the body means during all phases of the operation of the engine.

Such means preferably includes conduit means for providing communication between a point in the passageway of the body means intermediate the inlet and the discharge orifice and a main manifold passage upstream from the throttle valve. Thus air is supplied from the main manifold passage to the air gap nozzle through the conduit means regardless of the position of the throttle valve. As the air pressure of the upstream side of the throttle valve will normally be higher than the air pressure downstream of the throttle valve when the throttle valve is closed, a correspondingly greater pressure is maintained within the passageway of the air gap nozzle. The air gap nozzle of this invention is particularly designed for use with a supercharged engine. The supercharger of the engine maintains relatively high air pressure in the manifold upstream of the throttle valve. This relatively high pressure air is supplied by the conduit means to the air gap nozzle to prevent excessive reduction in fuel pressure within the nozzle and to prevent sucking of fuel from the air gap nozzle and the fuel supply system into the intake manifold. Thus, excessive richness, wasted fuel, unnecessary fuel stops, and the time delay following opening of the throttle valve are eliminated.

More particularly, the conduit means includes an auxiliary manifold passage formed in the wall of the manifold and bypassing the throttle valve. The conduit means also includes a plurality of generally radially extending ports in the wall of the body means to provide communication between the auxiliary manifold passage and the passageway of the body means.

The passageway of the air gap nozzle provides two axially aligned passageway sections of relatively small cross-sectional areas separated from each other by a chamber section of larger cross-sectional area than either of the passageway sections. The radial ports preferably terminate in the chamber section. Fuel is directed from one of the passageway sections through a relatively short axial length of the chamber section to the other of the passageway sections.

Preferably, one of the passageway sections includes a restrictor member positioned in the chamber section. The restrictor member has a discharge tube of smaller external cross-sectional area than the cross-sectional area of the chamber section and extends generally axially through a portion of the chamber section in general axial alignment with the other passageway section.

The invention, both as to its organization and method of operation, together with further features and advantages may best be understood by reference to the following description taken in connection with the accompanying illustrated drawings, in which:

FIG. 1 is a fragmentary elevational view partially in section showing an air gap nozzle constructed in accordance with the teachings of this invention and secured to a manifold having an auxiliary manifold passage therein;

FIG. 2 is an enlarged longitudinal sectional view of the air gap nozzle;

FIG. 3 is a bottom view of the air gap nozzle taken along line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 1 and showing the circumferential distribution of the ports in the body means;

FIG. 5 is an end view of the air gap nozzle taken along line 5—5 of FIG. 2; and

FIG. 6 is a view of the other end of the air gap nozzle end taken along line 6—6 of FIG. 2.

Referring to the drawing, and in particular to FIG. 1 thereof, reference numeral **11** designates an air gap nozzle constructed in accordance with the teachings of this invention. The air gap nozzle **11** is secured to an intake manifold **13** of an engine (not shown) of a vehicle, such as a racing car.

The intake manifold **13** includes a manifold wall **15** defining a main manifold passage **17** of relatively large diameter for supplying air to the engine. A throttle valve **19** of conventional construction is suitably pivotally mounted within the main passage **17** for controlling the flow of air to the engine. The throttle valve **19** is illustrated in FIG. 1 as being in the closed position. Air is supplied to the main passage **17** upstream of the throttle valve **19** by a supercharger (not shown).

The manifold wall **15** also defines an auxiliary manifold passage **21** of relatively small diameter which bypasses the throttle valve **19**. The auxiliary manifold passage **21** has a generally axially extending portion **23** and a relatively short radially extending portion **25**. The passage **21** has a lower wall **26** which lies slightly below the nozzle **11**. As clearly shown in FIG. 1, the auxiliary manifold passage **21** provides communication between the main manifold passage **17** upstream of the throttle valve **19** and the air gap nozzle **11**.

As shown in FIG. 1, the intake manifold **13** is provided with aligned radially extending openings **27** and **29**, the latter of which is threaded to receive the air gap nozzle **11**. Thus, the air gap nozzle passes through the auxiliary manifold passage **21** and is sealed to the manifold wall **15** by an O-ring seal **31**.

The air gap nozzle **11** includes a nut **33** for securing the air gap nozzle to the manifold **15**. The air gap nozzle also includes a body member **35** and an injector member **37**, which together constitute tubular body means. The body member **35** has a wall **39**, the end portions of which have screw threads **41** and **42**, respectively, and a central portion thereof has screw threads **43**. The nut **33** is held on the body member **35** by threads **43** and the threads **42** are received by the threads of the opening **29**.

The body member **35** has a stepped axial passageway **45** extending therethrough. The passageway **45** has an inlet section **47**, a first intermediate section **49**, and a chamber section or second intermediate section **51** of progressively increasing diameter. Each of the sections of the passageway **45** is preferably cylindrical. The inlet section **47** may be held in communication with a fuel supply system (not shown) by the threads **41**.

As best shown in FIGS. 2 and 4, four radially extending ports **53** extend outwardly from the chamber section **51** and terminate at the outer periphery of the body member **35**. The threads **42** and the nut **33** mount the air gap nozzle **11** so that the ports are in communication with the auxiliary manifold passage **21** and are positioned at the lower end thereof.

A resistor member **55** is mounted in the chamber section **51**. The restrictor member **55** includes a block **57** of relatively large diameter secured within the chamber section **51** at the upstream end thereof and a discharge tube **59** projecting from the block. The block **57** snugly fits within the upstream portion of the chamber section **51**. The block **57** and the discharge tube **59** define a small diameter passageway section **61** that extends axially therethrough. The inlet end of the passageway section **61** has a flared portion **63**. The passageway section **61** is of considerably smaller diameter than the chamber section **51** or the intermediate section **49** and is preferably of smaller diameter than the inlet section **47**.

As clearly shown in FIG. 2, the passageway section **61** extends axially through a substantial portion of the chamber section **51** and the ports **53** terminate in the chamber section intermediate the downstream end of the block **57** and an outlet **65** of the discharge tube **59**.

The injector member **37** has a small diameter generally cylindrical passageway section **67** extending axially therethrough in axial alignment with the passageway section **61**. The upstream end of the passageway section **67** has a flared portion **69**, and as shown in FIG. 2, the injector member **17** has an impingement surface **71**

which extends across the outlet or discharge orifice of the passageway section **67** at an acute angle relative to the axis of the section **67**. The impingement surface **71** illustrated in FIG. 2 extends completely across the diameter of the passageway section **67** and lies closely adjacent the outlet thereof. The injector member **37** is suitably rigidly secured within the chamber section **51** as shown in FIG. 2.

During normal operation of the engine with the throttle valve **19** in an open position, fuel is supplied by the fuel supply system to the passageway **45** of the air gap nozzle **11**. The fuel flows through the inlet section **47**, the intermediate section **49**, and the passageway section **61**, to the chamber **51**. Air is supplied from the main manifold passage **17** through the auxiliary manifold passage **21** to the chamber **51** even if the throttle **19** is closed. Fuel is ejected from the outlet **65** of the passageway section **67** in a small diameter stream which traverses the gap between the outlet **65** and the passageway section **67** and enters the passageway section **67**. Air in the chamber section **51** surrounds and contacts the stream and also enters the passageway section **67**. The fuel and air leaving the passageway section **67** impinge against the surface **71**, and then are directed downwardly thereby into the main manifold passage.

When the throttle valve **19** is moved toward the closed position, the engine causes low pressures less than atmospheric to exist in the main manifold passage **17** downstream from the throttle valve **19**. If the auxiliary manifold passage **21** and the ports **53** were not provided, this low pressure would tend to draw fuel remaining in the air gap nozzle **11** and from the fuel supply system secured thereto into the engine. As explained hereinabove, this results in excessively rich fuel-air mixture and wasted fuel.

However, the auxiliary manifold passage **21** and the ports **53** supply air to the chamber section **51** of the air gap nozzle **11** regardless of the position of the throttle valve **19**. Thus, the pressure in the chamber section **51** is substantially the same as the pressure within the main manifold passage **17** upstream from the throttle valve **19**. Because the supercharger (not shown) supplies air under pressure to the main manifold passage **17** upstream from the throttle valve **19**, the pressure there is greater than the pressure downstream from the throttle valve. Thus, the pressure in the chamber section **51** is greater than it would be if the auxiliary manifold passage **21** were not provided. Accordingly, there is less tendency for the relatively low pressure downstream of the throttle valve **19** to draw fuel from the nozzle **11** and from the fuel supply system. The result is that fuel under some pressure remains in the intermediate section **49** and as far downstream as the outlet **65** of the restrictor member **55**. Thus, when it is desired to accelerate, fuel is instantly made available to the engine and there is no need for the fuel to first fill the fuel supply system and nozzle **11**. This materially reduces the time between opening of the throttle and production of an increased level of power by the engine. Of course, the air flowing from the ports **53** into the chamber section **51** can exhaust through the passageway section **67** into the main manifold passage **17** downstream of the throttle valve **19**.

The air gap nozzle **11** is particularly adapted for use with a supercharged engine. Although other means may be used to supply air under pressure to the chamber section **51**, it is preferred to utilize air from the main manifold passage **17** upstream of the throttle valve **19** because of the simplicity of design. One or more of the ports **53** may be utilized. However, it is preferred to use a plurality of these ports to facilitate entry of air into the chamber section **51**. Although the auxiliary manifold passage **21** is preferred, other types of conduits could be used to interconnect the nozzle **11** and passage **17** upstream of the throttle valve.

Although an exemplary embodiment of the invention has been shown and described, it will be apparent to those having ordinary skill in the art that many changes, modifications and substitutions may be made to the exemplary embodiment illustrated without departing from the spirit and scope of this invention.

What is claimed is:

1. In a fuel injection system for use with a supercharged engine and connectible to a source of fuel, the combination of:

an intake manifold having a manifold wall defining a main manifold passage for supplying air to the engine;

a throttle valve in said main manifold passage for controlling the flow of air to the engine;

tubular body means having a wall defining a generally axial passageway extending through said body means, said passageway having an axially extending inlet section and an outlet section separated by an intermediate section of greater cross sectional area then either of the inlet or outlet sections, said intermediate section having a peripheral surface, said inlet section being connectible to the fuel supply and said outlet section having an outlet through which fuel can pass and be injected into the intake manifold;

means in said intermediate section defining a fuel conduit terminating in an outlet spaced from the outlet section, said fuel conduit forming the fuel passing therethrough into a stream which traverses the space between the outlet of the fuel conduit and the outlet section in spaced relationship to the peripheral surface of the intermediate section;

means for mounting said tubular body means on said intake manifold to permit said body means to inject fuel into said intake manifold;

said tubular wall of said body means having a port therein terminating in said intermediate section;

means formed integrally with said intake manifold defining an auxiliary manifold passage for conducting air from the upstream side of said throttle valve to said port; and

said body means defining an impingement surface extending across the outlet of the outlet section at an acute angle relative to the axis of the outlet section and closely adjacent the outlet of the outlet section so that the fuel and air exiting from the outlet of the outlet section will strike the impingement surface.

2. A combination as defined in claim **1** wherein said means for mounting includes a nut threadedly received on said tubular body means.

3. A combination as defined in claim **1** wherein at least a portion of said fuel conduit is spaced radially inwardly from the peripheral surface of the intermediate section and is mounted within the intermediate section by a block member which is mounted within said passageway at the downstream end of the inlet section.

4. A combination as defined in claim **1** wherein the outlet section has an inlet and a central portion with the central portion being intermediate the inlet and the outlet of said outlet section, the cross sectional area of said outlet of said outlet section being no greater than approximately the cross sectional area of the central portion.

5. A combination as defined in claim **4** wherein said tubular body means extends through said auxiliary manifold passage and is removably mounted on said intake manifold, said tubular body means having a plurality of circumferentially spaced ports providing communication between the auxiliary manifold passage and said intermediate section, and said auxiliary manifold passage surrounding the tubular body means at the region thereof containing said ports.

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JOSEPH SCOVRONEK, Primary Examiner

U.S. Cl. X.R.

123—139; 261—78