

May 26, 1970

E. A. HAASE

3,514,082

FUEL SUPPLY SYSTEM FOR COMBUSTION ENGINES

Original Filed Dec. 7, 1964

3 Sheets-Sheet 1

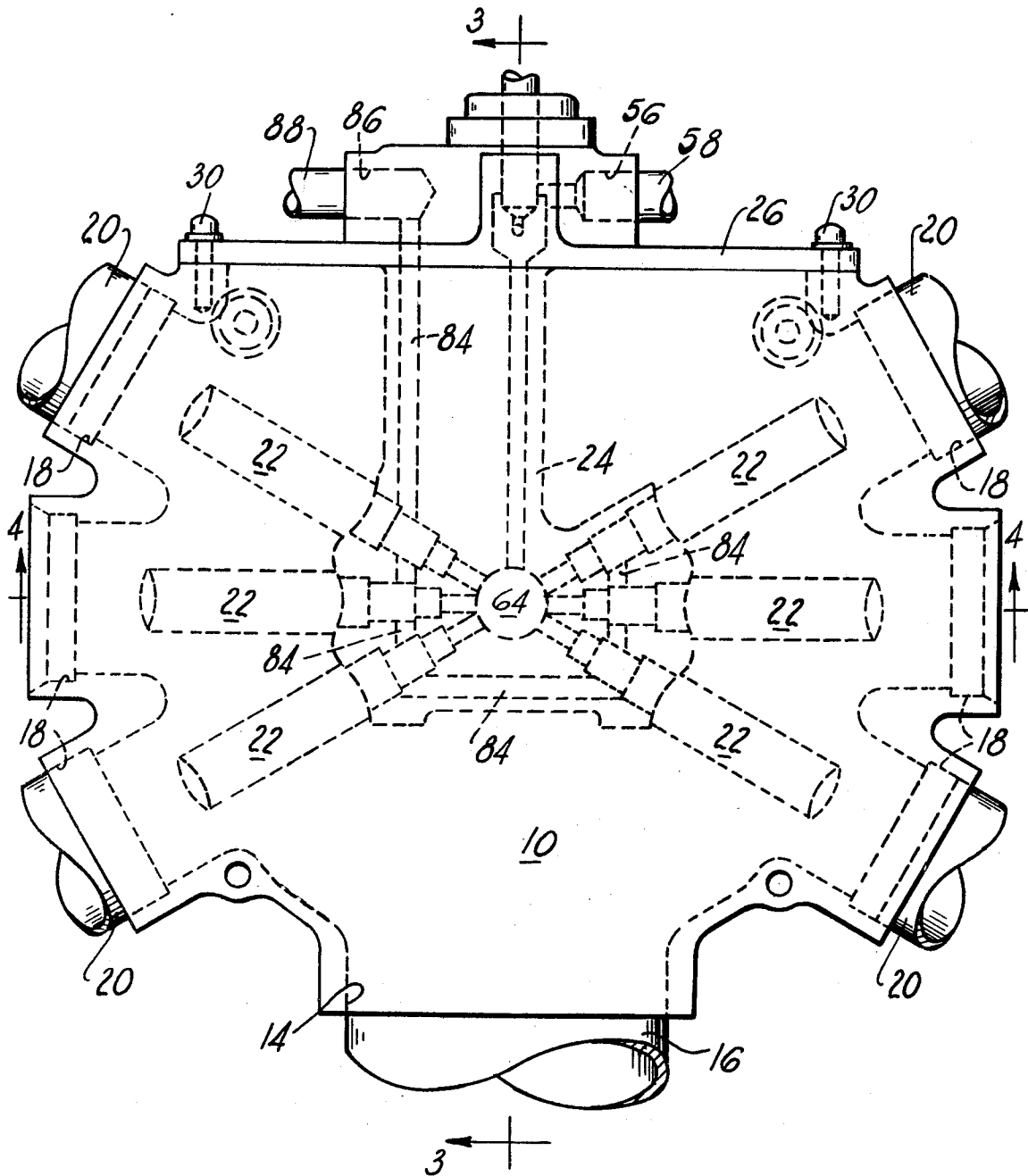


Fig. 1

INVENTOR
ELMER A. HAASE

BY

Jordan H. Cheney
AGENT

May 26, 1970

E. A. HAASE

3,514,082

FUEL SUPPLY SYSTEM FOR COMBUSTION ENGINES

Original Filed Dec. 7, 1964

3 Sheets-Sheet 2

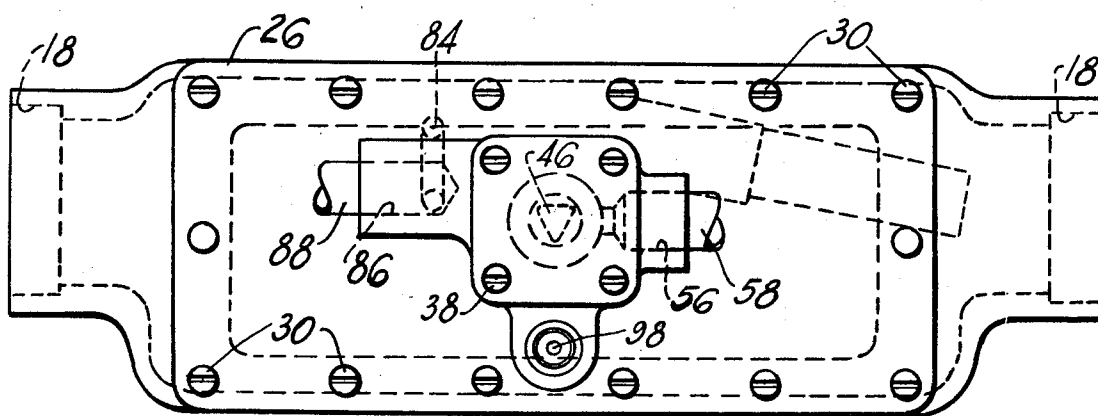


Fig. 2

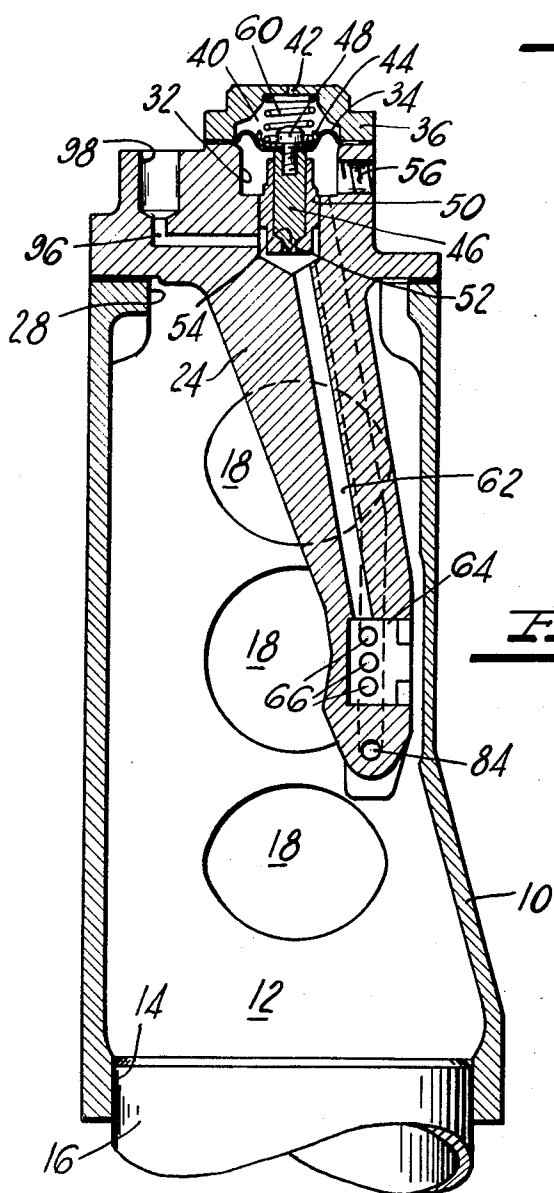


Fig. 3

INVENTOR.
ELMER A. HAASE

BY

Frederick W. Cheney
AGENT

May 26, 1970

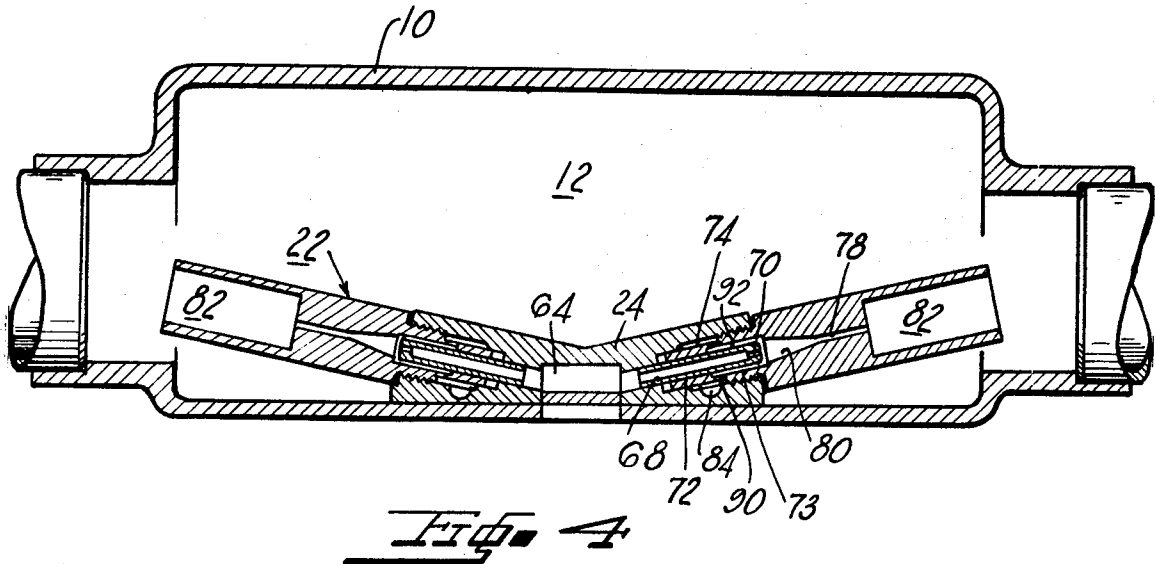
E. A. HAASE

3,514,082

FUEL SUPPLY SYSTEM FOR COMBUSTION ENGINES

Original Filed Dec. 7, 1964

3 Sheets-Sheet 3



INVENTOR.
ELMER A. HAASE

BY

Gordon H. Cheney
AGENT

1

3,514,082

FUEL SUPPLY SYSTEM FOR COMBUSTION ENGINES

Elmer A. Haase, South Bend, Ind., assignor to The Bendix Corporation, a corporation of Delaware
Continuation of application Ser. No. 654,658, July 19, 1967, which is a continuation of application Ser. No. 416,358, Dec. 7, 1964. This application May 23, 1968, Ser. No. 732,498

Int. Cl. F02d 7/02; F02m 67/02
U.S. Cl. 261—23

3 Claims 10

ABSTRACT OF THE DISCLOSURE

Multiple cylinder combustion engine fuel injection apparatus wherein a plurality of fuel injection nozzles corresponding to the number of engine cylinders is encased by an air manifold having a separate outlet connected to supply air as well as fuel injected thereto by an associated one fuel injection nozzle to each of the engine cylinders. All of the fuel injection nozzles encased by the air manifold received metered fuel flow from a remotely located fuel meter via a common fuel passage having its inlet connected to the fuel meter and its outlet connected to the air manifold. A casing is secured to the air manifold for supporting the fuel injection nozzles. The fuel nozzles are of the continuous flow type. A plurality of spaced apart openings are formed in the casing and each communicates with an associated one of the fuel injection nozzles. A fuel inlet is formed in the casing externally of the air manifold. A first conduit including a circular cavity is formed in the casing and is provided with circumferentially spaced-apart outlet ports in a curved wall which defines the plurality of openings. The fuel injection nozzles are each aligned with an associated one of the spaced-apart outlet ports and extends radially outwardly from the circular cavity toward an associated air induction pipe. A second conduit connects a source of metered pressurized fuel with the fuel inlet. The first and second conduits have series flow relationship and operate to supply a continuous flow of metered pressurized fuel to the plurality of fuel injection nozzles connected thereto simultaneously. The casing locates the circular cavity in the midportion of the air manifold. The first conduit includes a fuel pressurizing valve upstream from said circular cavity and in series flow therewith. A spring is connected to the fuel pressurizing valve for urging the same towards a closed position. A diaphragm exposed to atmospheric pressure and metered pressurized fuel is connected to the fuel valve for actuating the valve. The diaphragm urges the fuel valve toward an open position in response to metered pressurized fuel in opposition to the spring and the atmospheric air pressure.

This application is a continuation of my application Ser. No. 654,658, filed July 19, 1967, now abandoned, and application Ser. No. 654,658 was a continuation of application Ser. No. 416,358, filed Dec. 7, 1964 now abandoned.

This invention relates, in general, to fuel supply apparatus for a combustion engine and, in particular, to a fuel injection system of the type shown in U.S. Pat. No. 3,140,324 issued July 7, 1964, to E. A. Haase.

A conventional fuel injection system for an engine having a plurality of cylinders includes a separate fuel injection nozzle and associated fuel line for delivering a flow of metered pressurized fuel from a fuel flow regulator to the air induction passage leading to each of the various cylinders. In aircraft engine installations, in particular, the engine compartment space available for engine accessories including the fuel injection is somewhat limited

2

and items such as the abovementioned plurality of fuel lines constitute a significant problem for obvious reasons. For instance, a six-cylinder engine requires six fuel lines of sufficient length to extend from the fuel flow regulator to the cylinder air induction pipes which may be located at some distance from the air induction pipes depending upon installation conditions. The fuel lines must be suitably routed to avoid obstacles and, at the same time, be spaced from the engine to avoid undue heat transfer to the fuel flowing through the fuel lines. Each fuel line is susceptible to leakage as a result of rupture and/or seal failure at fittings thereof with the attendant fire hazard increasing proportionally with the number of fuel lines.

Furthermore, turbocharged engines equipped with conventional air bleed fuel nozzles require an air line for supplying pressurized air to each of the fuel nozzles for reasons obvious to those persons skilled in the art. In such a case of turbocharged engines, the requirement for a plurality of air lines in addition to the aforementioned plurality of fuel lines aggravates the space and routing problems heretofore mentioned of the engine compartment.

The fuel and/or air lines heretofore mentioned constitute a significant material cost which, in addition to attendant labor costs for assembly of the lines to the engine results in a corresponding higher production cost as well as subsequent maintenance costs for replacing deteriorated or questionable parts.

It is an object of the present invention to provide a fuel injection system having a single fuel supply line for supplying metered fuel to a plurality of fuel injection nozzles;

It is another object of the present invention to provide a fuel injection system having a plurality of fuel injection nozzles located within an air induction manifold and arranged to inject fuel to an associated plurality of air induction pipes leading from the manifold to a plurality of engine cylinders;

It is an important object of the present invention to provide a fuel injection system including a plurality of fuel injection nozzles housed within an air induction manifold and supplied metered pressurized fuel via a single fuel line;

It is a further object of the present invention to provide a fuel injection system including a plurality of air bleed fuel injection nozzles having a common fuel supply line and a common air supply line for supplying metered pressurized fuel and pressurized air thereto;

It is an additional object of the present invention to provide a fuel injection system for a multiple cylinder combustion engine wherein a plurality of fuel injection nozzles are so located as to be easily removed as a unit and serviced and which are compactly arranged thereby requiring relatively small space allocation.

It is still another object of the present invention to provide a fuel injection system having a plurality of fuel injection nozzles for a multiple cylinder combustion engine wherein the number of fuel lines supplying the fuel nozzles is reduced to a minimum thereby reducing the possibility of fuel leakage and attendant fire hazard to a minimum.

Other objects and advantages of the present invention will become apparent to those persons skilled in the art from the following description taken with the accompanying drawings wherein:

FIG. 1 represents that portion of a fuel injection system embodying the present invention for a conventional six-cylinder internal combustion aircraft engine;

FIG. 2 is an end view of FIG. 1;

FIG. 3 is a cross sectional view taken on line 3—3 of FIG. 1; and

FIG. 4 is a cross sectional view taken on line 4—4 of FIG. 1.

Referring to the drawings, numeral 10 designates a conventional air induction manifold for a typical six-cylinder aircraft engine of the turbocharged type, not shown. The air induction manifold 10 which defines a chamber 12 is provided with an air inlet 14 which is supplied pressurized air via a conduit 16 leading from a conventional turbocharger, not shown, and six air discharge ports 18 each of which is connected to an associated air induction pipe 20 leading to one of the engine cylinders, not shown.

Six fuel injection nozzles 22 of the air bleed type are removably secured within the manifold 10 by means of a casing 24 having an integral plate or flanged portion 26 which seals an access opening 28 in manifold 10 and which is secured in position by any suitable fastening means such as bolts 30 threadedly engaged with manifold 10. The casing 24 is provided with a stepped diameter bore 32 which is closed at one end by a flexible diaphragm 34. The outermost edge of diaphragm 34 is secured to casing 24 by a cup-shaped cap 36 removably secured to casing 24 by suitable fastening means such as bolts 38 and which together with diaphragm 34 defines a chamber 40. A port 42 in cap 36 vents chamber 40 to ambient or atmospheric air pressure P_A . The center portion of diaphragm 34 is clamped between a spring retainer 44 and the end of a triangular shaped valve 46 by a bolt 48 which is threadedly engaged with valve 46 thereby rendering the diaphragm 34 and valve 46 movable as a unit. The valve 46 is slidably carried in a sleeve 50 fixedly secured in the reduced diameter portion of bore 32 and provided with an orifice 52 against which a tapered end portion 54 of valve 46 is adapted to seat to thereby pressurized fuel flow therethrough. An inlet port 56 communicates bore 32 upstream from valve 46 with a fuel conduit 58 which transmits a metered flow of pressurized fuel from a conventional fuel meter, not shown, such as that disclosed in the aforementioned Pat. No. 3,140,324.

The valve 46 is biased to a closed or seated position against orifice 52 by a spring 60 interposed between spring retainer 44 and cap 36. The spring 60 is overcome permitting valve 46 to open in response to a predetermined pressure generated by a flow of metered fuel to bore 32 which acts against diaphragm 34. With valve 46 open, fuel is permitted to flow through orifice 52 to an outlet passage 62 leading from bore 32 to a circular cavity 64 having six radially extending spaced apart stepped diameter bores 66 the axes of which are disposed at an angle relative to the adjacent plane surface of manifold 10 as shown in FIG. 4. An air bleed fuel injection nozzle 22 is removably secured in each of the bores 66. Each nozzle 22 includes a tubular portion 68 which is press fitted in a bore 72 and which has an orifice 70 at one end thereof. The tubular portion 68 extends from bore 72 into an adjacent larger diameter portion 73 of bore 66 thereby defining an annulus 74. The one end of bore 66 is threaded to receive a threaded portion of nozzle 22 which has a centrally located passage 78 provided with a flared portion 80 into which the orifice 70 discharges. The passage 78 is adapted to spray fuel into a relatively large diameter bore portion 82 of nozzle 22 which, in turn, terminates at its open end within the confines of port 18 to which the atomized fuel is discharged. The fuel injection nozzles 22 are conventional and no claim to such nozzles, per se, is made.

Each annulus 74 communicates with a passage 84 formed in casing 24 and connected to a port 86 to which air at atmospheric pressure P_A in the case of a nonsupercharged engine or pressurized air from the turbocharger in the case of a supercharged engine is supplied via conduit 88. Air transmitted to annulus 74 passes through openings 90 in nozzle 22 to an annulus 92 defined by the spaced walls of tubular portion 68 and bore portion 73

and then past the end of tubular portion 68 to the flared portion 80 where the air mixes with the fuel discharged from orifice 70 to atomize the same.

Referring to FIG. 3, numeral 96 designates a passage which connects bore 32 downstream from valve 46 with a port 98 which, in turn, supplies the fuel pressure signal to a conventional flowmeter, not shown.

Assuming the engine to be self-sustaining in operation, the metered flow of fuel passing into bore 32 pressurizes diaphragm 34 thereby holding valve 46 in an open position which permits the metered flow to pass through orifice 52 to cavity 64 which supplies the plurality of fuel injection nozzles 22 simultaneously. The fuel passes from cavity 64 through orifices 70 from which it is injected into flared portion 80 where the fuel mixes with air and the resulting atomized fuel forced through passage 78 into the enlarged diameter bore 82 which, in turn, discharges to the air flow passing through port 18 to the corresponding engine cylinder. It will be noted that the fuel from nozzle 76 is injected into port 18 substantially at the center thereof where the air velocity is greatest to thereby promote dispersion of the fuel in the air flow. Prior art nozzle installations where the fuel is injected at a point relatively close to the internal wall of an air induction pipe is not entirely satisfactory due to the boundary layer effect of the air flow within the air induction pipe.

Furthermore, it will be noted that applicant's novel fuel injection nozzle location results in fuel injected into the air flow to a given cylinder at a point upstream from the cylinder to permit a longer travel of the air and fuel which, in turn, results in a better air-fuel mixture whereas prior art fuel injection nozzle locations which are in the air induction pipes at a point relatively close to the cylinder intake valve fed thereby result in a corresponding relatively short travel of the air and fuel subsequent to injection of fuel into the air and thus relatively poor mixture mixing.

It has been found that applicant's nozzle location also results in a reduced temperature of the air-fuel mixture at the cylinder inlet in comparison to that obtained with the abovementioned prior art nozzle locations.

Various changes and modifications of the structure described heretofore and disclosed in the drawings may be made by those persons skilled in the art without departing from the scope of applicant's invention. For instance, the present invention is not limited to fuel injection nozzles of the air bleed type but may include other types of fuel injection nozzles without the air bleed feature in which case the abovementioned reduction in fuel lines is the same. Also, the number of engine cylinders and thus fuel injection nozzles may be greater or less than the above mentioned six with suitable modifications to the above described structure as will be recognized by those persons skilled in the art.

What is claimed is:

1. Fuel injection apparatus for a multiple cylinder combustion engine comprising:

means defining an air induction manifold having an air chamber and a plurality of air induction pipes connected to supply an air fuel mixture to the multiple cylinders of the combustion engine, each cylinder being supplied by a separate induction pipe;

support means secured to said manifold and extending into said chamber;

a plurality of continuous flow fuel injection nozzles secured to said support means and supported thereby within said chamber;

a source of metered pressurized fuel;

a plurality of spaced-apart openings formed in said support means, each of said spaced-apart openings communicating with an associated one of said plurality of fuel injection nozzles;

a fuel inlet formed in said support means externally of said air chamber;

5

a first conduit including a circular cavity formed in said support means and provided with circumferentially spaced-apart outlet ports in the curved wall thereof defining said plurality of spaced-apart openings;

said fuel injection nozzles each aligned with an associated one of said spaced-apart outlet ports and extending radially outwardly from said circular cavity toward an associated one of said air induction pipes;

a second conduit connecting said source of metered pressurized fuel with said fuel inlet;

said first and second conduits having series flow relationship and operative to supply a continuous flow of metered pressurized fuel to said plurality of fuel injection nozzles connected thereto simultaneously.

2. Fuel injection apparatus as claimed in claim 1 wherein:

said first conduit includes fuel pressurizing valve means upstream from said circular cavity and in series flow relationship therewith;

resilient means operatively connected to said pressurizing valve for urging the same toward a closed position; and

fluid pressure responsive means exposed to atmospheric air pressure and the metered pressurized fuel opera-

5

10

15

20

25

6

tively connected to said pressuring valve means for actuating the same;

said fluid pressure responsive means urging said pressurizing valve means toward an open position in response to said metered pressurized fuel in opposition to said resilient means and said atmospheric air pressure.

3. Fuel injection apparatus as claimed in claim 1 wherein:

said support means extends into said air chamber to locate said circular cavity in a midportion of said air chamber.

References Cited

UNITED STATES PATENTS

2,119,879	6/1938	Hoffman et al.
2,893,365	7/1959	Haefner.
2,957,682	10/1960	Cameron et al.
3,007,684	11/1961	Haase.
3,140,324	7/1964	Haase.

RONALD R. WEAVER, Primary Examiner

U.S. Cl. X.R.

123—55, 119; 261—69