

[54] FUEL SYSTEM FOR INTERNAL COMBUSTION ENGINE

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[22] Filed: **Nov. 8, 1973**

[21] Appl. No.: **413,955**

[52] U.S. Cl. .... **261/145, 261/154, 261/79 R, 261/39 D, 261/105, 261/DIG. 6, 123/122 R, 123/135**

[51] Int. Cl. .... **F02m 15/02**

[58] Field of Search ..... **261/145, 105, 106, 153, 261/154, 144, 79 R, 39 D, DIG. 6, 36 A; 123/135, 122 R; 55/240**

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[57] **ABSTRACT**

A fuel processing unit replacing the usual carburetor provides passage means maintained at sub-atmospheric pressure through which an airstream flows from an air-intake port of the unit to intake manifold of the engine. A heating coil wound helically to a cylindrical configuration is embraced by a cylindrical fine mesh wire screen which is heated by the heating coil and is continuously sprayed from the outside with volatile liquid fuel. The airstream that flows through the passage means flows radially inwardly through the cylindrical screen and through the closely spaced turns of the helical heating coil to produce a completely dry gaseous stream of air and fuel vapor which is then subjected to turbulence to result in a uniform mixture. When the engine is started while cold a thermostatic valve feeds liquid fuel into the air-vapor stream, and when a throttle valve is opened to accelerate the engine, additional air is fed into the turbulent zone of the fuel mixture stream.

**4 Claims, 8 Drawing Figures**

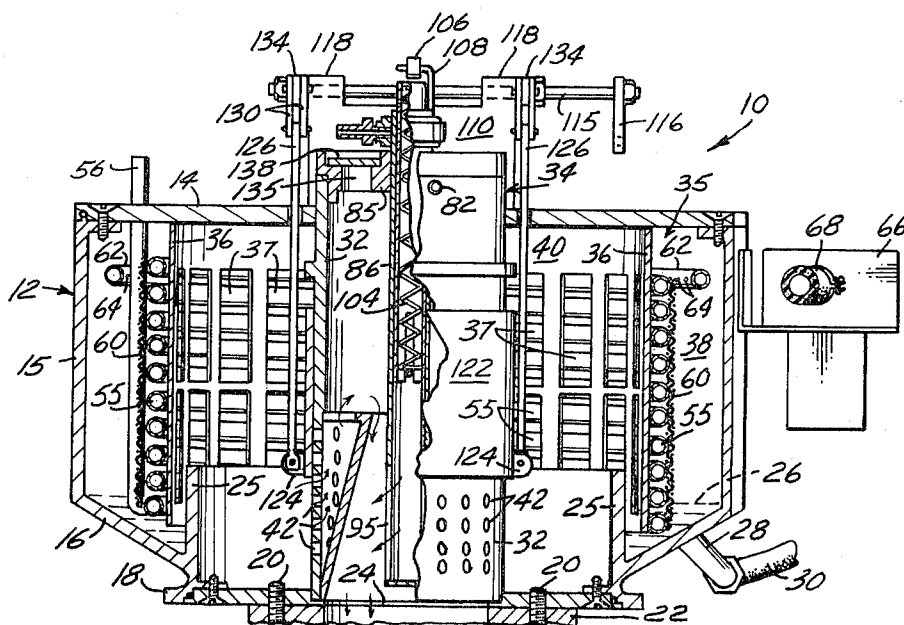


FIG. 1.

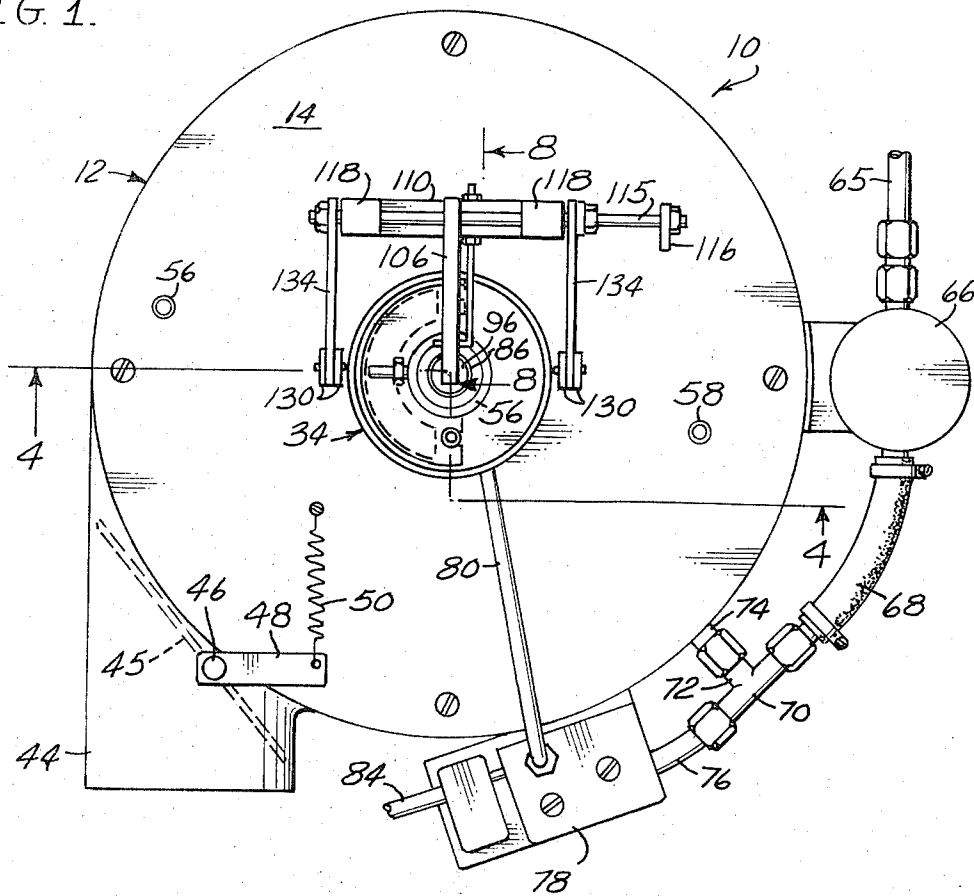


FIG. 2.

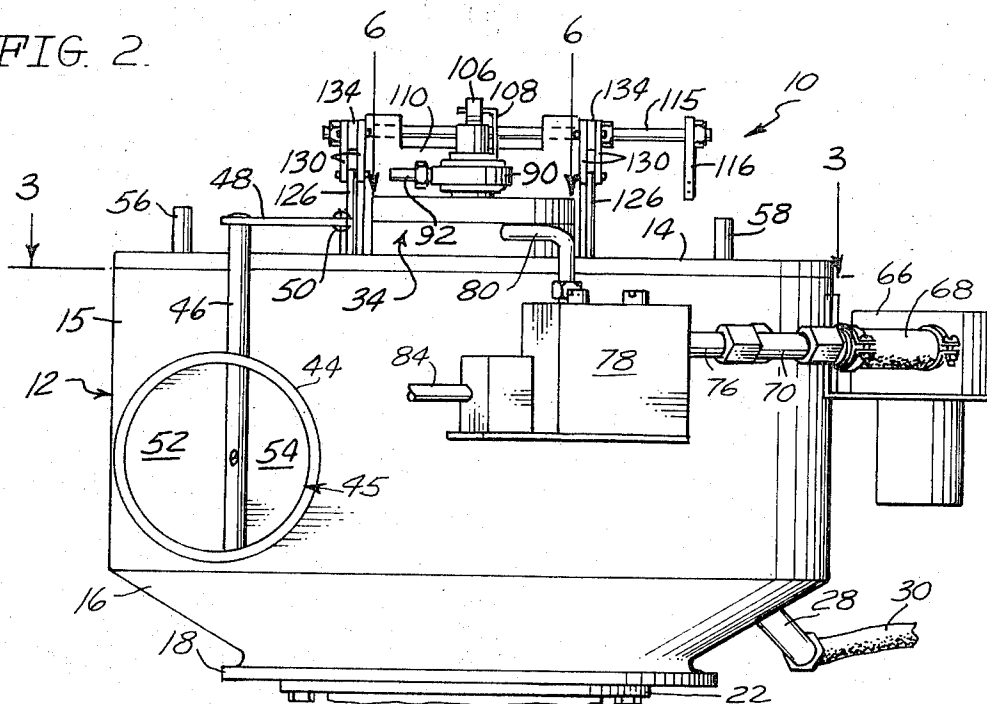


FIG. 3.

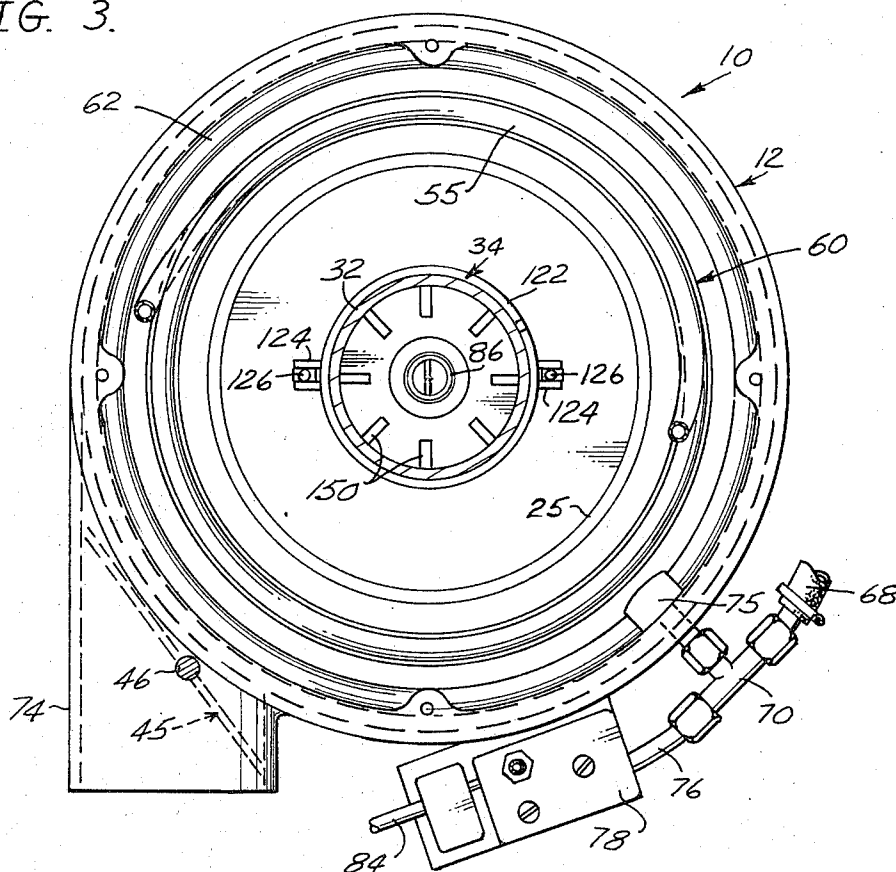


FIG. 4.

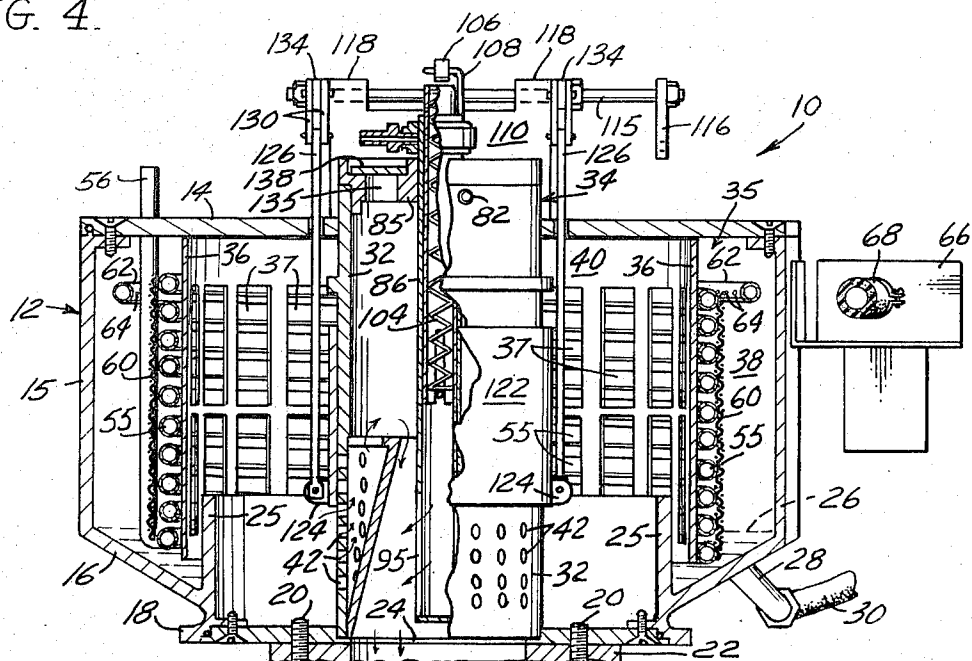


FIG. 5.

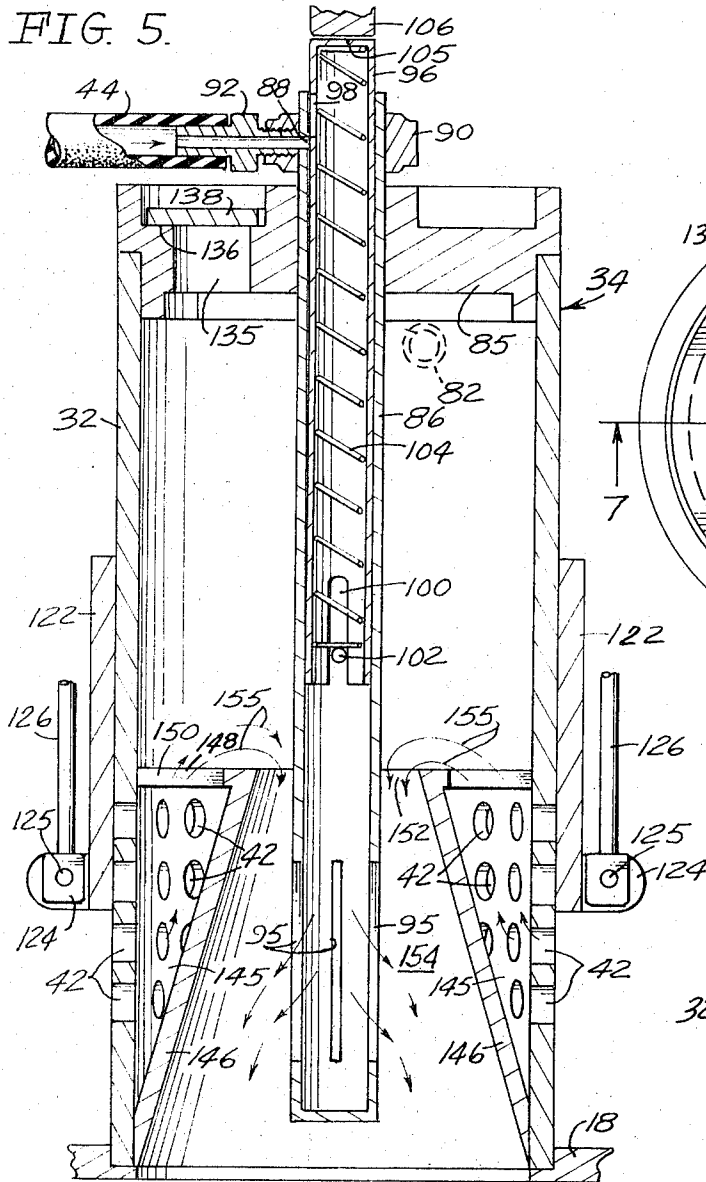


FIG. 6.

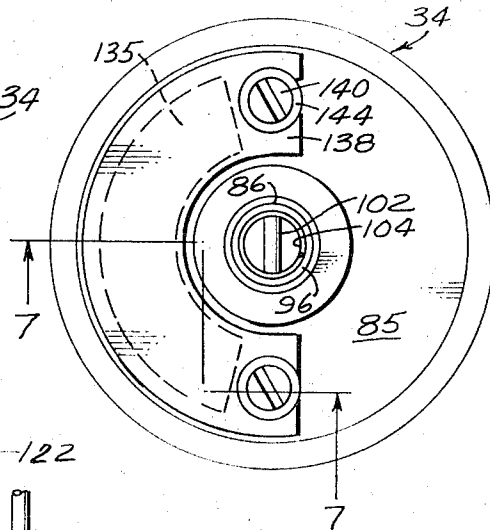


FIG. 7.

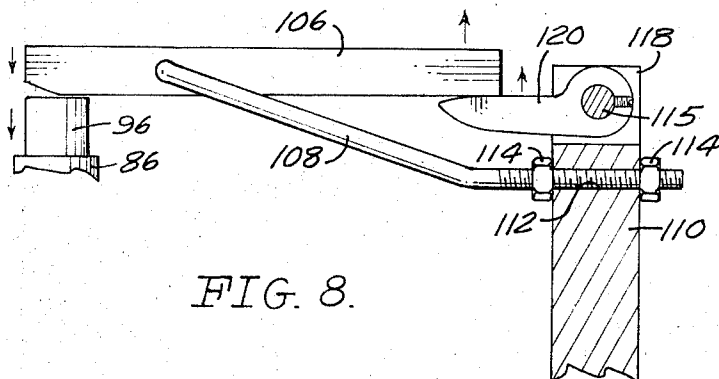
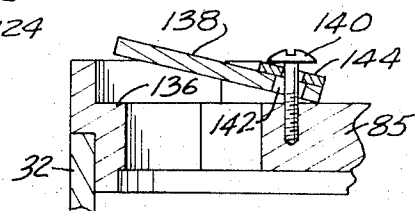


FIG. 8.

## FUEL SYSTEM FOR INTERNAL COMBUSTION ENGINE

### BACKGROUND OF THE INVENTION

Carburetor systems for internal combustion engines have been developed to a highly advanced state by decades of intensive engineering but, nevertheless, prevalent types of carburetors inherently operate to produce mixtures of air and fine fuel mist or minute droplets of liquid fuel. The fact that the combustion of a fine droplet of liquid fuel is progressive, starting at the surface of the droplet, has two results, namely, incomplete combustion of the liquid fuel and attenuation of the combustion.

It is well known that incomplete combustion produces exhaust gases that contain excessive unburnt hydrocarbons and excessive carbon monoxide to pollute the atmosphere. It is also well known that incomplete combustion causes deposits of carbon on interior engine surfaces. It is further well known that attenuation of the combustion period requires that the ignition be substantially advanced to provide peak combustion pressure in each cylinder when the piston in the cylinder reaches the top of its compression stroke.

In contrast, it is well known that a purely gaseous fuel mixture such as produced by propane fuel burns cleanly with minimum pollution and burns so rapidly that ignition may be set to occur at or close to the top of the compression stroke.

Considerable development work has been undertaken to modify carburetor-equipped engines to lower the production of pollutants by more complete combustion of the fuel. I have found that a more promising approach, however, is to avoid a conventional carburetor system and to use, instead, a fuel system that employs liquid fuel, but in doing so produces a completely dry, uniform, gaseous mixture of air and fuel vapor.

### SUMMARY OF THE INVENTION

The primary object of this invention is to provide a fuel system in the form of a compact fuel processing unit for attachment to the intake manifold of an internal combustion engine, wherein conventional liquid hydrocarbon fuel, such as gasoline, is employed to produce a completely dry and uniform gaseous mixture of air and fuel vapor for complete, clean and rapid combustion on the power stroke of each cylinder. Such a fuel system inherently results in increased horsepower, greater engine efficiency, substantially more mileage per gallon of fuel, better engine operation at lower operating temperatures and striking reduction of pollutants in the engine exhaust. Unburned hydrocarbons are practically nil and the production of carbon monoxide is drastically reduced.

Briefly described, the object of the invention is attained by spraying volatile liquid fuel onto a cylindrical, fine mesh screen that is heated by a contiguous heating coil. The airstream created by the engine intake is swirled against the outer circumference of the screen to flow radially inwardly through the screen into intimate contact with the hot surfaces of the turns of the heater coil to result in complete vaporization of the fuel that is picked up by the airstream. The vapor-laden airstream is then passed through a turbulence zone for conversion into a completely uniform gaseous mixture of air and fuel vapor. For cold start of the engine, liquid fuel is introduced into the air-fuel stream and when the

engine is accelerated by opening the throttle valve, additional air is introduced into the turbulence zone of the airstream.

These and other objects and advantages of the fuel system may be understood by the following detailed description of the preferred form of my invention, taken with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of the presently preferred embodiment of the fuel processing unit;

FIG. 2 is a side elevation of the unit;

FIG. 3 is a horizontal section as indicated by the line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken as indicated by the angular line 4—4 of FIG. 1;

FIG. 5 is an enlarged fragmentary sectional view, showing the construction of an axial chamber in the center of the unit;

FIG. 6 is an enlarged plan view of the top of the axial chamber, as seen along line 6—6 of FIG. 2;

FIG. 7 is a fragmentary sectional view taken along line 7—7 of FIG. 6, showing the construction of a relief valve at the top of the axial chamber; and

FIG. 8 is a fragmentary sectional view taken along line 8—8 of FIG. 1, showing mechanism controlled by the throttle linkage for introducing additional air into the axial chamber when the throttle valve is open to accelerate the engine.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

The drawings show a fuel processing unit, designated in its entirety by the reference numeral 10, which incorporates the fuel system of the present invention. Unit 10 has a cylindrical casing 12 with a top wall 14, an outer cylindrical wall 15 formed with a conical lower portion 16, and a bottom wall 18, which may be attached by screws 20 to an intake manifold 22 of an internal combustion engine. The bottom wall 18 has a circular opening 24 for direct communication with the intake manifold. The casing 12 has an internal, upstanding cylindrical flange 25 which together with the lower conical portion 16 of the outer cylindrical wall 15 forms an annular receptacle to collect residual liquid fuel, designated 26, for appropriate disposal. In this instance the annular receptacle is provided with a drainage nipple 28 which is connected to a return hose 30 for recycling of the collected residual liquid fuel.

The outer cylindrical wall 15 of the casing, together with the cylindrical wall 32 of the upright axial chamber 34 in the casing, forms an annular processing chamber 35, and an upright cylindrical cage 36 of open construction divides the annular processing chamber into an outer annular compartment 38 and an inner annular compartment 40.

Unit 10 forms a passage means for air flow there-through to the intake manifold 22, and, in effect, the passage means is enlarged to form the annular processing chamber 35. From the inner annular compartment 40 of the annular processing chamber, the passage means is continued by the interior of the axial chamber 34, the lower portion of the cylindrical wall 32 of the axial chamber being provided with a plurality of vertical and circumferentially distributed apertures 42 to admit the gaseous fluid. The lower end of the axial

chamber continues the passage means to the intake manifold 22.

The passage means through the unit has a cylindrical intake port 44 which is positioned tangentially of the outer, annular compartment 38 of the processing chamber, to cause the incoming airstream to swirl around the entire circumference of the cage 36.

Air flow into the intake port 44 is controlled by a butterfly valve 45 which is mounted eccentrically, i.e., off-center, on an upright valve stem 46 that extends through the top wall 14 of the casing. Valve stem 46 is provided on its outer end with a radial arm 48 connected to a tension spring 50 that biases the butterfly valve 45 towards its closed position. The off-center location of the valve stem 46 divides the butterfly valve into a major wing 52 and a minor wing 54 of substantially smaller area than the major wing. It is apparent that because of the difference in area of the two wings 52 and 54, butterfly valve 45 functions as a normally closed check valve which opens when a predetermined pressure differential exists across the butterfly valve. Under normal operating conditions, the butterfly valve 45 functions to maintain sub-atmospheric pressure inside the casing 12, with the magnitude of the sub-atmospheric pressure determined by the tension spring 50.

The cylindrical cage 36 supports and is embraced by a heating coil 55 that is helically wound to cylindrical configuration. Heating coil 55 is in the form of a tube through which circulates a suitable heated fluid, such as hot water from the radiator, or hot exhaust gases from the engine, and for this purpose the heating tube has an upwardly extending intake end 56, shown in FIGS. 2 and 4, and an outlet end 58 shown in FIG. 2.

The heating coil 55 heats a cylindrical, fine mesh wire screen 60 which snugly embraces the heating coil and which is continuously wetted by suitably supplied volatile liquid hydrocarbon fuel, such as conventional gasoline. Liquid fuel may be supplied to the wire screen 60 by a fuel manifold in the form of a circular tube 62 that has numerous spaced small apertures to direct liquid jets 64 onto the wire screen.

The arrangement for supplying liquid fuel to the circular tube 62 is best shown in FIGS. 1 and 2, where a supply tube 65 from a suitable electric fuel pump (not shown) is connected to a pressure regulator 66, which reduces the pressure of the liquid to approximately 1 psi. The liquid fuel at reduced pressure flows from the pressure regulator 66 through a short hose 68 to one arm of a T-fitting 70. The stem 72 of the T-fitting 70 is connected by a short tube 74 to a T-fitting 75, shown in FIG. 3, that is incorporated in the circular fuel tube 62.

The second arm of the T-fitting 70 is connected by a short tube 76 to a thermostatic valve 78 of well-known construction, which supplies liquid fuel to a choke tube 80 that terminates at an inlet port 82 (FIG. 5) in the upper end of axial chamber 34. The thermostatic valve 78 is responsive to the temperature of the engine, and for this purpose a tube 84 may supply the thermostatic valve with either hot gases from the engine exhaust or hot water from the cooling system of the engine.

The axial chamber 34 extends upward through the upper end wall 14 of the casing 12 and has a relatively thick upper end wall 85 through which an axial tube 86 extends to the bottom region of the axial chamber to

supply additional air thereto when the throttle valve of the engine is opened for acceleration of the engine. As best shown in FIG. 5, the upper exterior end of the axial tube 86 has a radial inlet port 88 and is embraced by a collar 90 into which a nipple fitting 92 is screwed in alignment with the inlet port. The nipple fitting 92 is connected by a hose 94 to the intake filter (not shown) of the engine to receive clean air therefrom. The bottom of the axial tube 86 is closed, but the lower portion of the axial tube is provided with a plurality of longitudinal slots 95 for discharging the additional air therefrom into the lower portion of the axial chamber 34.

Slidably mounted in the upper open end of the axial tube 86 is a sleeve valve 96 that has a radial port 98 of substantially greater vertical dimension than the inlet port 88 in the axial tube. The lower end of sleeve valve 96 is formed with a pair of diametrically opposite end slots 100 that straddle a fixed diametrical pin 102 to prevent rotation of the sleeve valve, and thereby keep the inlet port 98 of the sleeve valve in alignment with the inlet port 88 of the axial sleeve 86. A suitable coiled compression spring 104 inside the sleeve valve 96 acts under compression between the diametrical pin 102 and the upper end wall 105 of the sleeve valve to urge the sleeve valve upwardly towards a normal upper limit position, at which the upper end of the sleeve valve abuts an overhanging arm of a control lever 106. When the throttle valve of the engine is opened for increased fuel flow to accelerate the engine, the throttle linkage of the engine actuates the lever 106 to depress the sleeve valve 96, causing the inner port 98 of the sleeve valve to register with the inlet port 88 of the axial tube 86, to admit the desired additional air into the axial tube.

As best shown in FIG. 8, control lever 106 is pivotally mounted on an angular rod 108 that is rigidly mounted on a bracket 110, the bracket being fixed to the top wall 14 of the casing 12. In the construction shown in FIG. 8, a threaded end portion of the angular rod 108 extends through a bore 112 of the bracket and is equipped with a pair of nuts 114 that are normally tightened against opposite sides of the bracket.

Referring to FIGS. 1 and 2, the throttle linkage of the engine includes a shaft 115 having an operating arm 116, which shaft is journaled in a pair of spaced arms 118 of bracket 110. FIG. 8 shows how a short arm 120 on shaft 115 extends under one end of lever 106 to rock the lever counterclockwise when the engine is accelerated, thereby to depress the sleeve valve 96 to admit additional air into axial chamber 34 of the unit.

As heretofore stated, the throttle valve that controls the speed of the engine may be a conventional throttle valve in the intake manifold of the engine, but a feature of the present invention is that such a throttle valve is incorporated in the unit 10. The throttle valve is in the form of a sleeve 122 which, as shown in FIGS. 4 and 5, slidably embraces the axial chamber 34 in the region of the plurality of apertures 42 in the cylindrical wall of the axial chamber. The throttle valve 122 has a pair of diametrically opposite ears 124 which are pivotally connected to corresponding upwardly extending links 126. Each of the links 126 is pivotally connected to a pair of short links 130 that are best shown in FIG. 4, and the short links, in turn, are pivotally connected to corresponding arms 134 on the throttle linkage shaft 115. It is apparent that when throttle shaft 115 is rotated clockwise, as viewed in FIG. 8, the clockwise ro-

tation of the arm 120 causes lever 106 to depress sleeve valve 96 to admit additional air into the axial chamber and at the same time the two arms 134 on the throttle linkage shaft lift the throttle valve 122 to admit additional fuel-laden air into the engine.

Axial chamber 34 is provided with a suitable relief valve to open in response to any abrupt pressure rise caused by back-firing of the engine. The relief valve may be of the construction shown in FIGS. 5, 6 and 7, wherein an arcuate aperture 135 in the thick upper wall 85 of the axial chamber is of stepped configuration to form a continuous shoulder 136 to support a valve member 138 in the form of a C-shaped plate. The valve plate 138 is retained by a pair of screws 140 which extend through corresponding holes 142 in its two ends. As indicated in FIG. 7, the holes 142 are oversized in relation to the screw 140 to permit the valve plate 138 to tilt up to open position in response to an abrupt pressure rise in the axial chamber. Each of the two screws 140 is provided with a suitable washer 144 that is substantially larger than the corresponding hole 142 in the valve plate.

As best shown in FIG. 5, the lower end of the axial chamber 34 is provided with an entrance vestibule 145 which is formed by a wall 146 in the form of a truncated cone, together with a ring-shaped wall 148 that extends radially outwardly from the top of wall 146. The entrance to the vestibule 145 is through the previously mentioned plurality of apertures 42 in the cylindrical wall 32 of the axial chamber, and the exit from the vestibule is through radially extending, slot-like apertures 150 (see FIG. 3) in the radial wall 148. The apertures 150 are shaped and dimensioned to serve as flame-arresters, to prevent ignition of the combustible mixture in the vestibule by back-firing of the engine.

It can be seen in FIGS. 4 and 5 that the axial tube 86 and the surrounding upper edge of the conically shaped wall 146 form a restricted annular throat 152 which discharges into a progressively enlarged annular turbulence zone 154. The annular fuel-laden airstream flowing upwardly through the radial slots 150 makes a sharp reversal of direction to enter the throat 152, as indicated by the curved arrows 155. This sharp reversal of flow direction into the throat 152, followed by expansion in the turbulence zone 154 results in such a high degree of turbulence that the air and dry fuel vapor intermix thoroughly to produce a uniform mixture. When additional air is discharged through the slots 95 of the axial tube 86 into the turbulence zone 154, the new air becomes part of the uniform mixture.

The manner in which the processing unit functions for its purpose may be readily understood from the foregoing description. The airstream from the intake port 44 swirls circumferentially through the outer annular compartment 38 to pick up fuel vapor from the liquid fuel on the cylindrical screen 60, and the cylindrical screen forms the fuel-laden air into an exceedingly large number of minute, radially inward streams that are directed into intimate contact with the heated surfaces of the heating coil 55. The heat added by the surfaces of the heating coil completely vaporizes any fine droplets of liquid fuel that may be entrained in the minute airstreams, the consequence being that the mixture that flows into the inner annular chamber 40 is a completely dry gaseous mixture of air and fuel vapor. The passage of this mixture through vestibule 145, together with the abrupt reversal in direction through

throat 152 into turbulence zone 154 and the violent turbulence in the turbulence zone, insure that the final mixture that reaches the intake manifold of the engine is a completely uniform mixture. The final mixture burns cleanly with an extremely high speed rate of combustion. In contrast, the usual carbureted mixture contains many fine droplets of liquid fuel, some of which do not vaporize until after they have been discharged through the exhaust valves of the engine.

The complete vaporization of the liquid fuel by the unit 10 results in better combustion, greater engine efficiency, and more mileage per gallon of fuel, with drastic reduction in atmospheric pollution, no unburned liquid fuel whatsoever being discharged into the atmosphere.

It has been found that ignition of the completely gaseous fuel may be advantageously retarded 3°-5° from standard specification because of the faster rate of combustion of the uniform, dry, gaseous vapor-air mixture, which causes the combustion pressure to reach its peak faster than is possible with a conventional carbureted fuel mixture. Thus the invention approaches the ideal of having maximum combustion pressure occur quickly and precisely at top dead center.

It can be readily appreciated that the fuel processing unit is of simple, uncomplicated construction, with nothing to get out of order. The unit is easy to service. The cost of the unit is comparable to the cost of a conventional carburetor, but it accomplishes greater power output than a conventional carburetor, and in fact, produces greater power output than natural gas or propane conversion systems with no greater pollution of the atmosphere.

In a laboratory test, a 392-cubic-inch Cadillac engine (1962) in good mechanical condition was run at 1,500 rpm with the exhaust system connected to an exhaust gas analyzer. The indicator on the analyzer for unburned hydrocarbons registered zero and the indicator for carbon monoxide registered 0.25 percent, which is well below the stringent standards set for automobiles to be produced in 1975.

While I have shown and described in considerable detail what I believe to be the preferred form of my invention, it will be understood by those skilled in the art that the invention is not limited to such details, but may take various other forms within the scope of the following claims.

I claim:

1. In a fuel system for an internal combustion engine having an intake manifold, a source of liquid hydrocarbon fuel, a source of heated fluid, and a throttle linkage, the combination of:

a generally circular housing mounted on the end of said intake manifold and having an inlet opening through one wall thereof;

a cylindrical conduit disposed vertically within said housing at the center thereof, the bottom end of said conduit being attached to the bottom of the housing and communicating with the interior of said intake manifold;

a length of heat-exchange tubing wound into a vertically disposed cylindrical coil surrounding said conduit, the individual turns of the coil being closely spaced apart with respect to one another; the ends of said heat exchange tubing being connected to said source of heated fluid, whereby the

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heated fluid is circulated continuously through the tubing;

a wire mesh screen wrapped around said coil of heat exchange tubing in close, heat-exchange contact therewith, whereby the screen becomes hot by conduction of heat from the tubing;

means for flowing liquid hydrocarbon fuel down over said wire mesh screen from the top edge thereof; the liquid fuel flowing down over said hot wire mesh screen and the coils of heated tubing being vaporized, and the fuel vapor being mixed with air flowing radially inward through the screen;

means for admitting the mixture of vaporized fuel and air into said conduit;

means connected to said throttle linkage for controlling the volume of vaporized fuel and air mixture into said intake manifold; and

means for introducing a controlled amount of additional fresh air into said fuel-and-air mixture as the latter flows downwardly through said conduit into said intake manifold.

2. The combination as set forth in claim 1, wherein said means for admitting the mixture of vaporized fuel and air into said conduit comprises a plurality of apertures in the wall of the conduit at the lower end thereof; said apertures opening into a vestibule formed by an

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upwardly converging, conical inner wall, and an annular top wall; said annular top wall having apertures therein through which the fuel/air mixture enters said conduit, where it reverses direction and flows downwardly through the center opening of said conical inner wall into said intake manifold.

3. The combination as set forth in claim 2, wherein said means for introducing a controlled amount of additional fresh air into said fuel/air mixture comprises a hollow tube extending downwardly through said conduit along the axis thereof and through said center opening of said conduit inner wall; said hollow tube having apertures in the bottom end thereof, below the top of said conical inner wall; and means for admitting fresh air into said tube at the top end thereof.

4. The combination as set forth in claim 3, wherein there is a tubular valve member slidably disposed within said hollow tube; said valve member cooperating with an aperture in the wall of the hollow tube to control the flow of air into the hollow tube; spring means urging said valve member in one direction; and actuating means connected to said throttle linkage for moving said valve member in the other direction against the resistance of said spring means.

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