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Alquist et al.

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[54] **AUXILIARY FUEL VAPORIZER SYSTEM FOR AN INTERNAL COMBUSTION ENGINE**

[75] Inventors: **Henry E. Alquist; Lyle W. Pollock; Glenn H. Dale,** all of Bartlesville, Okla.

[73] Assignee: **Phillips Petroleum Company,** Bartlesville, Okla.

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[52] **U.S. Cl.** .... **123/133,** 60/285, 123/122 H

[51] **Int. Cl.** **F02m 17/18**

[58] **Field of Search** .... 123/179 G, 180 E, 180 P, 123/180 T, 180 R, 133, 122 E, 122 F, 122 H, 121, 127, 3, 35

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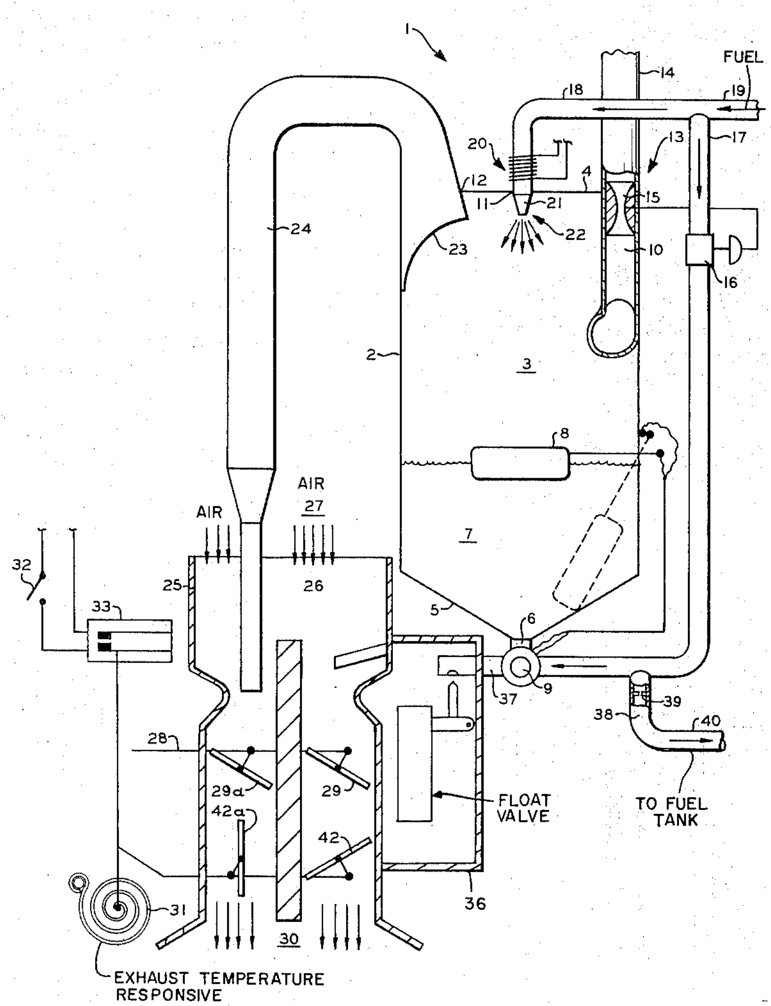
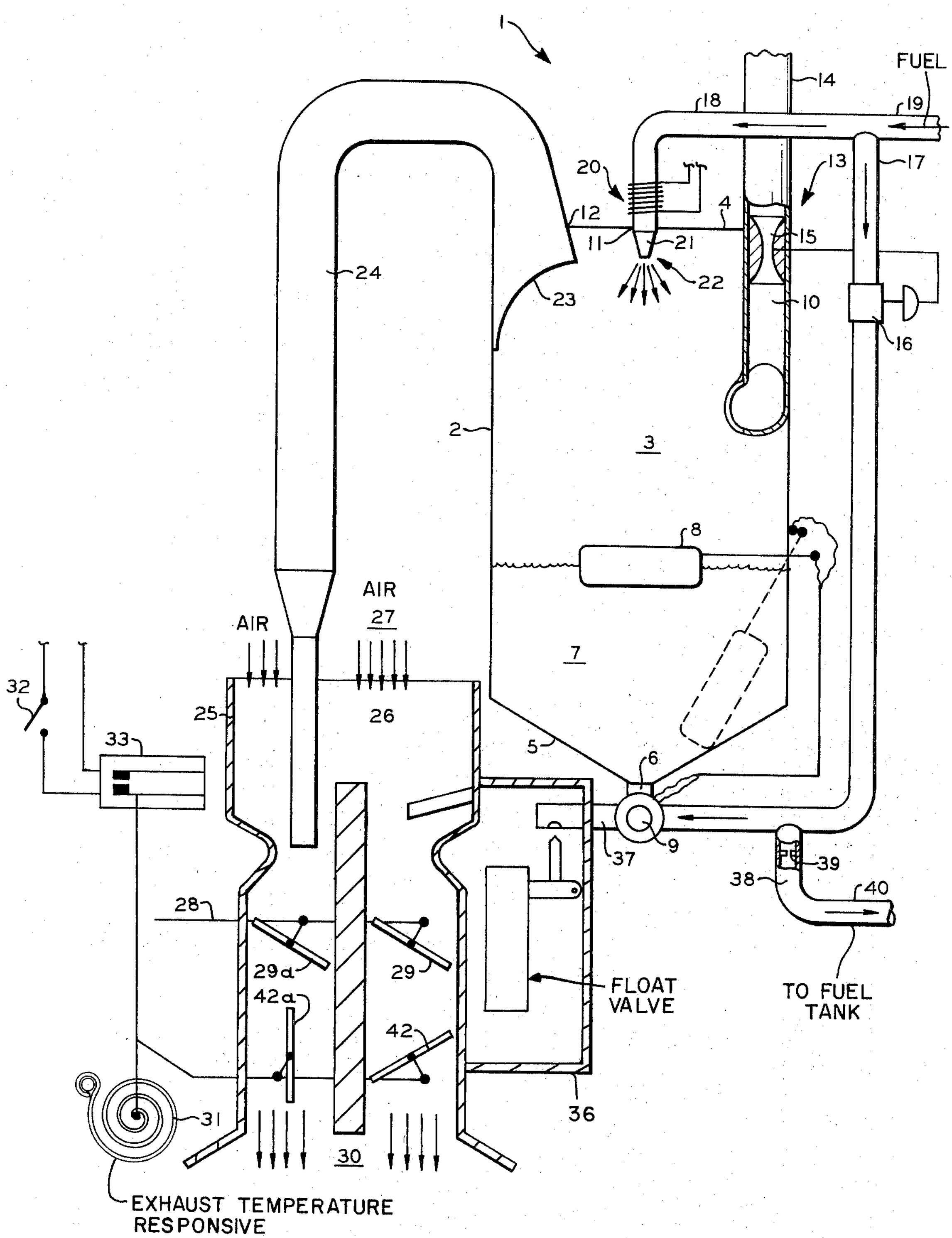
Primary Examiner—Charles J. Myhre
Assistant Examiner—R. H. Lazarus

[57] **ABSTRACT**

A fuel vaporizer apparatus and method for an internal combustion engine has a hydrocarbon separator incorporated into the engine fuel supply system. Fuel is heated and injected into a vessel chamber, admixing therein with air under controlled volume flow rates resulting in the passage of a vaporous lighter end hydrocarbon and air admixture to the carburetor for a preselected period. Thereafter contacting means synchronously terminates the introduction of said admixture, and initiates the passage of a liquid fuel into the carburetor.

8 Claims, 1 Drawing Figure




FUEL
AIR
AIR
FLOAT VALVE
TO FUEL TANK
EXHAUST TEMPERATURE RESPONSIVE

AUXILIARY FUEL VAPORIZER SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

This invention relates to a method and apparatus for providing a controlled start-up fuel vapor-air blend. In another aspect this invention relates to a method and apparatus for lowering engine start-up emissions. In yet another aspect this invention relates to an alternative to the internal combustion engine choke.

The causes of poor starting under cold conditions are related and interdependent; thus elimination of any one cause will often result in elimination of the problem of poor starting. The present invention is designed to eliminate the chief cause of poor starting, which is poor fuel vaporization, by providing an auxiliary source of heated fuel vapor-air admixture to be used in starting the engine. If a sufficient amount of dry fuel vapor-air admixture is available to the engine immediately upon the initiation of starting operations, the engine will start even though the cranking speed is slow and the spark weak.

In gasoline engines, poor fuel vaporization results from the low volatility of gasoline at low temperatures. Since gasoline is not a pure substance, but a mixture of hydrocarbons of varying molecular weights and properties, vaporization takes place over a wide temperature range with complete vaporization occurring at approximately 400°F. At an ambient temperature of 0°F., for example, only about 10 percent of the gasoline flow into the carburetor is converted into a vapor. Even this small amount of vapor will frequently not reach the cylinders since much of it rapidly condenses when it comes in contact with the cold engine. Under these conditions, over 90 percent of the gasoline passing through the carburetor remains in liquid form and does not mix with the incoming air to form a combustible fuel vapor-air mixture. If combustion of the limited amount of gasoline vapor does not occur within a few turns of the engine, the engine will flood and become impossible to start until the flooding condition is cleared.

New challenges for cold engine starting have arisen from the emission standards now being imposed, for example, on the 1975 automobile. The 1975 automobile exhaust emission standards, based upon a 23-minute driving cycle from a cold start, are proving to be most difficult to meet because of the high emissions which occur within the first few minutes of engine operation. Approximately 46 percent of the total hydrocarbon and carbon monoxide emissions in a 7.5 mile simulated trip are released in the first 2 minutes, during which time an exhaust catalytic converter is warming up and ineffective. These high emissions during early engine operation are primarily due to engine choking which is vital to satisfactory automobile performance during start and warm-up. The start-up situation presents a problem wherein a desirable fuel would be a liquid that approaches the warm-up performance and emission characteristics of propane, but is not so volatile as to cause fuel handling and evaporative problems.

Choking during cold start-ups for the internal combustion engine is required for adequate performance and has been an established procedure for many years. Regardless of ambient or engine operating temperatures, an automobile engine delivers, for example, maximum power at a vapor-air mixture of 110 percent stoichiometric fuel. With a cold intake manifold, the ordinary carburetor must meter a liquid fuel-to-air mixture much richer in order to achieve this 110 percent stoichiometric fuel "best power" vapor-air mixture. The choke achieves this best power mixture by throttling the air supply and by reducing the pressure in the vicinity of the fuel nozzles to help vaporize the liquid fuel. A suitable alternative for the automobile choke is to provide a vapor-fuel supply during a start and warm-up period.

The basic incompatibility of the modern choke system with the 1975 exhaust emission standards and the high costs involved in making a more volatile fuel demand that alternative approaches to the start-up problem be explored. Furthermore, summer motor fuel volatility must be considered as well as cold climate fuel requirements. One approach to minimizing the choke is to start and warm up the engine on the hydrocarbons containing mainly butanes (C_4) and pentanes (C_5) which are in present gasolines and then, at the time when the choke normally ceases its operation, to operate the engine from the normal carburetor with a slightly debutanized and dependentanized fuel. Although this approach represents a departure from present fuel system designs, it has the advantage of requiring only one liquid fuel supply and may reduce the need for a gasoline of 250°F., maximum 90 percent distillation temperature. This means that 90 percent of the fuel is evaporated at 250°F. ASTM specification **D439** for current gasoline specifies a maximum temperature of 365°F. for 90 percent of fuel evaporated. This alternative to the choke would require a device for stripping light hydrocarbons from the gasoline under controlled admixing conditions for preselected periods.

The present invention provides a method and apparatus which is an alternative to the internal combustion engine choke. Our invention comprises a small debutanizer vessel incorporated into the fuel supply system wherein the vessel receives an internal spray of fuel through a heated nozzle during engine start and warm-up periods. An air stream flowing through the vessel carries lighter constituents, butanes and pentanes, for example, to the carburetor. Debutanized fuel accumulates in the vessel and flows to the carburetor at the end of a preselected warm-up period.

It is an object of this invention to provide an alternative to the internal combustion engine choke. It is another object of this invention to lower start-up and warm-up emissions. It is yet another object of this invention to provide a method and apparatus for improving start-up fuel vapor-air blends.

The principal features of the method and apparatus according to the invention required to accomplish the objectives set out hereinabove provide a start-up and early warm-up fuel vapor-air mixture for a standard car (12 miles per gallon) which requires three choke-assisted starts per day and operates for about 21 miles per day. During urban operation, such a vehicle would use air at an average rate of 0.0406 lbs/sec., but said rate can vary between 0.013 and 0.095 lbs/sec. during the warm-up period.

The method and apparatus according to the invention is presented herein using a realistic gasoline composition representative of gasolines now on the market. An example gasoline was chosen which was defined by the American Petroleum Institute as being representative, in terms of both physical properties and composition, of the average summer gasoline marketed in the

United States. Inspection data on this fuel is shown in Table I.

TABLE I

PHYSICAL PROPERTIES AND COMPOSITION OF U.S. AVERAGE SUMMER GASOLINE

Distillation, °F*	
Initial boiling point	91
10 pct evaporated	126
20 pct evaporated	144
30 pct evaporated	164
40 pct evaporated	185
50 pct evaporated	210
60 pct evaporated	231
70 pct evaporated	252
80 pct evaporated	279
90 pct evaporated	328
End point	409
Pct evap. at 160°F	28.0
Average RVP**	9.1
Sp. Gr. °API	63.5
Specific gravity	0.7256
Octane No.	
Research	99.6
Motor	92.0
TEL, ml/gal	3.0

* ASTM D 86
**Reid Vapor Pressure, lb., ASTM D 323

The principal features of the method and apparatus according to our invention required to accomplish the start-up and warm-up objectives as stated hereinabove are shown schematically in the drawing. Referring in detail to the drawing, there is shown an auxiliary fuel vaporizer system **1** for an internal combustion engine (not shown). The fuel vaporizer system **1** has a vessel **2** having a chamber **3.** The vessel has an upper end **4** and a lower end **5.** The vessel lower end **5** has an opening **6.** The chamber **3** has a lower portion **7** and a float control means **8** located therein. The float control means **8** is connected to a solenoid drain valve **9** which is in communication with the vessel lower end opening **6.**

The vessel's upper end **4** has a first opening **10,** a second opening **11,** and a third opening **12.** The vessel upper end first opening **10** communicates with an air intake means **13** which is connected through conduit means **14** to an air filter, not shown. The air intake means **13** has a venturi inlet **15** in communication with valve **16** on fuel conduit **17.** The valve **16** in communication with the venturi inlet **15** provides a control means for the fuel flowing to the vessel **2** through conduit **18.**

Fuel is provided from a fuel tank and pump, not shown, through fuel conduit **18, 19** to a heated spray nozzle **20** in communication with the vessel upper end second opening **11.** The heated spray nozzle **20** has a spring loaded nozzle **21** which is inserted into the chamber **3.** The fuel inlet spray means **22** is controlled by the venturi inlet **15** which controls valve **16** located on fuel conduit **17** thereby providing a controlled fuel flow through conduit **18** and nozzle **21** in proportion to air flow through conduit **14.**

An air-fuel vapor outlet **23** communicates with the vessel upper end third opening **12** and an air-fuel vapor conduit **24.** The air-fuel vapor conduit **24** communicates with a carburetor **25** through the primary carburetor section **26.** Additional air is provided to the carburetor through carburetor air intake **27** and is controlled by the carburetor throttle rod **28** and butterfly valves **29.** The carburetor communicates with the intake manifold **30** of an internal combustion engine, not shown. An exhaust gas thermostat **31** communicates with an electro-mechanical relay system **33** providing control means for the auxiliary fuel vaporizer system **1.**

The carburetor bowl **36** communicates through fluid conduit **37** with solenoid drain valve **9.** Fluid conduit **38** provides a fuel return through fuel conduit restricor **39** to the fuel supply tank, not shown.

In the method of this invention, prior to the time that the internal combustion engine is to be started, an operator places the automobile engine ignition system switch **32** in the "on" position, thereby starting the electric fuel pump in the supply tank and closing the solenoid drain valve **9** at the bottom of the vaporizing vessel chamber **3.** By virtue of the valve arrangement as shown, cranking the engine causes air to be pumped through the debutanizer vessel **2** via the venturi inlet **15** to the debutanizer chamber **3.** Needle valve **16,** which is normally open, is partially closed by the vacuum generated by air flow through the venturi **15** into the debutanizer. The aforementioned combination of events forces a fuel spray into the debutanizer through the spring-loaded nozzle **21.** Regardless of the quantity of air flowing through the debutanizer, about 3 mols of fuel are admitted for each 2.5 mols of air by virtue of control valve **16.** Fuel in excess of the quantity required by-passes the debutanizer vessel back to the tank by way of conduit **40.** When the ignition switch is turned on and the exhaust gas thermostat **31** is in a cold position, the electrical heating element **20** is activated through the action of the electro-mechanical relay **33** to compensate for the temperature drop at the nozzle caused by the vaporizing fuel. Heating element **20** releases approximately 25 BTU/min., requiring approximately 440 watts.

An exemplary operation of the apparatus according to the method of the invention would provide a total of about 830 grams of gasoline to be sprayed into the debutanizer through the nozzle during approximately 100 seconds of operation. About 103 g. (15.7 weight percent) of this sprayed liquid is vaporized and swept overhead by the air flow. The overhead vapor-air mixture consists of about 18.7 mol percent hydrocarbon and about 81.3 mol percent air with about 73.5 mol percent of the hydrocarbon being butanes and pentanes.

Initially there is no liquid gasoline in the debutanizer and the float rests at the bottom of the chamber. Tank fuel is available to the carburetor bowl until the debutanized gasoline raises the float to its top position in the lower portion of the chamber which, in turn, rotates valve **9** so that only debutanized gasoline can flow to the carburetor bowl. The normal carburetor bowl needle valve permits liquid flow in accordance with the engine needs. After about 420 g. of debutanized gasoline have accumulated in the debutanizer chamber, and about 60 seconds have elapsed, the butterfly valve **42** begins to open in the normal carburetor air horn and the butterfly valve **42A** in the fuel vapor-air supply horn **26** begins to close. These valves are thermostatically and simultaneously controlled by exhaust bas thermostat **31** in the same fashion as present automatic chokes, but are located below throttle plates **29** and **29**A. The effect of this pair of valves is to cause the engine to operate progressively on a decreasing portion of the debutanized overhead product and an increasing portion of debutanized gasoline from vessel **2** by way of bowl **36.** This " transfer mode" requires a period of about 40 seconds. Thermostat **31** which initiates the transfer mode also turns off the heater **20** on the fuel injector nozzle.

Upon completion of the "transfer mode", air no longer flows through the debutanizer, the fuel spray is stopped, and the fuel supplied by the pump by-passes the debutanizer and returns to the tank by conduit **40.** The carburetor relies completely for its fuel supply on the debutanized gasoline until the float **8** drops to the bottom of the debutanizer. The dropping of the float to the bottom of the debutanizer switches the position of valve **9** so that the carburetor receives tank fuel.

At the completion of use of the engine, the ignition is turned off. The exhaust cools and the butterfly valves **42** and **42**A in the carburetor air horns begin to return to their cold positions. The fuel heater relay is set to turn the heater on when the ignition is turned to an "on" position through the electro-mechanical relay means. Should a start be attempted before the engine is completely cold, the engine will start in some stage of the "transfer mode" with a portion of the fuel being supplied as vapor from the debutanizer. Valve **9** remains in a position where tank fuel is supplied to the carburetor bowl until the debutanizer float lifts to its top position, thus activating valve **9** and providing further operational results as discussed hereinabove.

Other modifications and alterations of this invention will become apparent to those skilled in the art from the foregoing discussion and accompanying drawing, and it should be understood that this invention is not to be unduly limited thereto.

What is claimed is:

1. Apparatus to supply fuel-air mixtures to an internal combustion engine comprising:

a carburetor having first and second sections, each adapted to convey fuel and air to the engine;

a first valve in said first section and a second valve in said second section;

first fuel supply means connected to said first section to deliver liquid fuel thereto from a fuel tank;

an evaporation vessel having a first outlet in the upper region thereof and a second outlet in the lower region thereof;

second fuel supply means connected to said vessel to deliver liquid fuel thereto from the fuel tank;

inlet means in said vessel to permit introduction of air into said vessel;

conduit means extending between said first outlet and the second section of said carburetor to convey vaporized fuel and air from said vessel to said second section;

a temperature sensing means adapted to sense the temperature of exhaust gases from the engine; and

means responsive to said temperature sensing means to control said valves to open said first valve and close said second valve when the measured temperature reaches a predetermined value.

2. The apparatus of claim **1,** further comprising a float positioned to detect a liquid level in said vessel, and means responsive to said float to pass liquid fuel from said vessel to said first chamber when the liquid level in said vessel reaches a preselected height.

3. The apparatus of claim **1** wherein said inlet means comprises a conduit having a venturi therein, said first fuel supply means comprises second conduit means adapted to extend from the fuel tank to said first section, a valve in said first conduit means, said second fuel supply means comprises third conduit means extending between an upper region of said vessel and said second conduit means upstream of said valve, and further comprising means to move said valve toward a closed position in response to flow of air through said venturi.

4. The apparatus of claim **3,** further comprising a heater connected to said second fuel supply means to elevate the temperature of the fuel to facilitate vaporization thereof in said vessel.

5. The apparatus of claim **2** wherein said first fuel supply means includes a fuel bowl which receives fuel and from which the fuel is delivered to said first section of said carburetor.

6. An auxiliary fuel vapor system for an internal combustion engine, comprising:

a vessel having a chamber and upper and lower ends, said upper end having a first, second, and third opening into the chamber and said lower end having an opening into the chamber;

an air intake element in communication with the chamber through the upper end first opening of the vessel;

a fuel intake element in communication with the chamber through the upper end second opening of the vessel;

a spray nozzle on the discharge end of the fuel intake element within the vessel;

first means for heating and passing fuel through the fuel intake element, the spray nozzle, and into the vessel;

second means for passing air through the air intake element and into the vessel;

a carburetor having first and second sections;

a fuel bowl in communication with said first section;

third means for passing vapors from the vessel chamber, through the upper end third opening of the vessel, and into the second section of the carburetor;

fourth means for passing fuel into the bowl;

means for controlling the passage of fuel into the vessel in response to the flow of air into said vessel;

means to sense the temperature of exhaust gases from the engine and to terminate the flow of vapors to said second section and initiate the flow of fuel from the bowl into said first section when the sensed temperature reaches a predetermined value;

a float within the vessel; and

means responsive to the float rising to a predetermined level to pass collected liquid fuel from said vessel to said first section.

7. A method of supplying fuel to an internal combustion engine from a single source of liquid fuel comprising:

initially spraying liquid fuel from the source into a stream of air to partially vaporize the fuel;

passing the stream of air containing the vaporized fuel into the engine;

collecting the remainder of the liquid fuel which is not vaporized from the spraying step;

sensing the temperature of the exhaust gases from the engine;

terminating the spraying step when the sensed temperature reaches a preselected value;

thereafter passing the collected fuel to the engine in place of the vaporized fuel resulting from the spraying step; and

passing fuel to the engine from said source after the collected fuel has been used.

8. The method of claim 7 wherein the fuel sprayed into the air stream is heated to facilitate vaporization of the lower boiling constituents thereof.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,845,749 Dated November 5, 1974

Inventor(s) Henry E. Alquist et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line [22], delete "Filed: July 30, 1972" and insert therefor -- Filed: July 3, 1972 --.

Signed and sealed this 4th day of February 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents