United States Patent [19]

Senger

[11] **3,892,218**

[45] **July 1, 1975**

[54] **COLD START METHOD AND APPARATUS FOR CARRYING OUT SAME**

[75] Inventor: **John F. Senger**, Berkeley, Calif.

[73] Assignee: **Chevron Research Company**, San Francisco, Calif.

[22] Filed: **Nov. 12, 1973**

[21] Appl. No.: **415,070**

Related U.S. Application Data

[63] Continuation of Ser. No. 295,041, Oct. 4, 1973, abandoned.

[52] **U.S. Cl.** .... **123/127**; 123/135; 123/180 R

[51] **Int. Cl.** **F02m 1/16**

[58] **Field of Search** ... 123/3, 133, 135, 127, 179 G, 123/180 R, 180 A, 180 T

[56] **References Cited**

UNITED STATES PATENTS

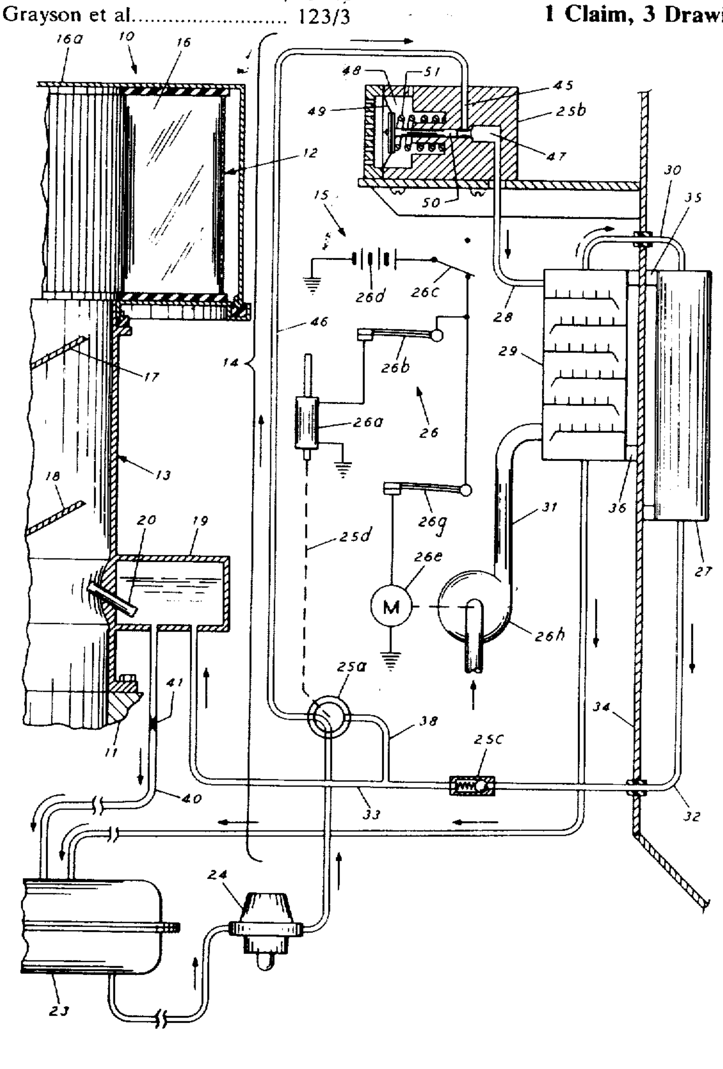
565,828	8/1896	Best	123/135 X
1,490,192	4/1924	Anderson	123/127
1,559,214	10/1925	Woolson	123/3
1,619,612	3/1927	Grudzinski	123/180 T
1,744,953	1/1930	Dienner	123/3
2,768,496	10/1956	Stamm et al.	123/127 X
3,688,755	9/1972	Grayson et al.	123/3
3,783,841	1/1974	Hirschler et al.	123/127
3,783,849	1/1974	Bramfitt	123/123

Primary Examiner—Charles J. Myhre
Assistant Examiner—W. Rutledge, Jr.
Attorney, Agent, or Firm—Harold D. Messner; Ralph L. Freeland, Jr.

[57] **ABSTRACT**

Reference is hereinafter had to a cold start system for a spark-ignition, internal combustion engine in which a greater fraction of lower molecular weight constituents can be quickly and easily separated from a full-range gasoline i.e., a hydrocarbon mixture of full-range components, as cold start is initiated. The separation system includes a miniature vertical countercurrent stripping column positioned within the engine compartment. The stripping column has separate inlet and outlet conduits in selective fluid contact with a stream of full-boiling gasoline passing to the stripping column from the gas tank by way of a fuel pump. Entry of the gasoline into the column is regulated by a conduit and valve network under control of a controller circuit initiated by the tripping of an ignition switch.

1 Claim, 3 Drawing Figures



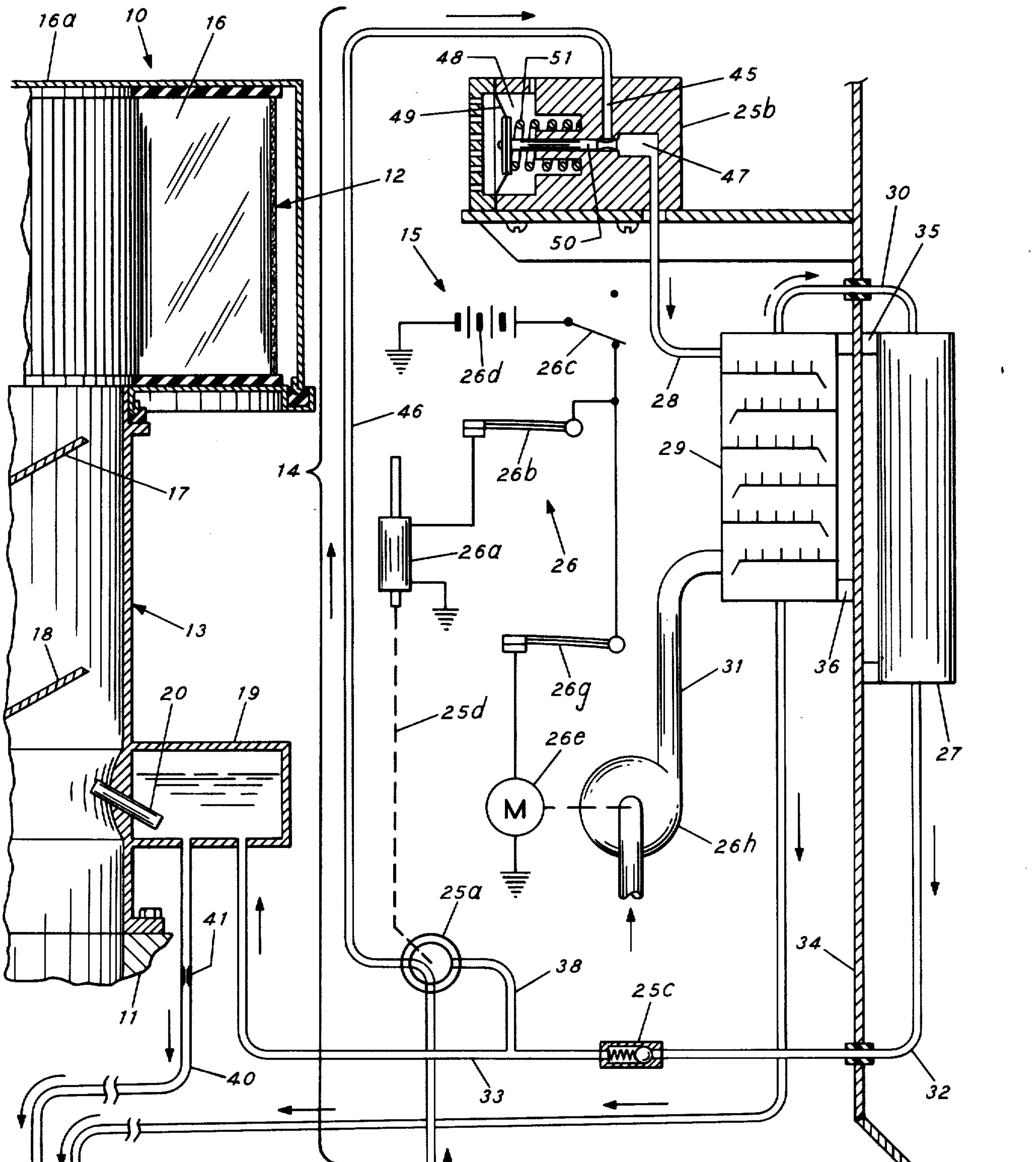


FIG.1

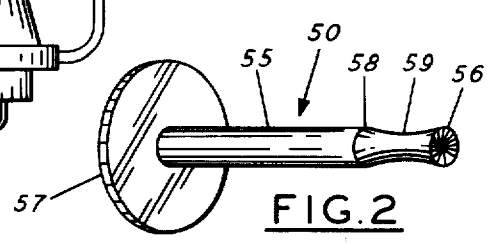


FIG.2

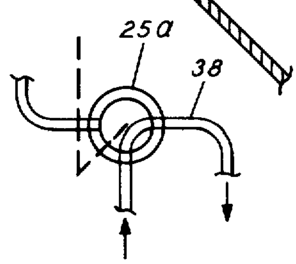


FIG.3

COLD START METHOD AND APPARATUS FOR CARRYING OUT SAME

This is a continuation of Ser. No. 295,041 filed Oct. 4, 1973, now abandoned.

RELATED APPLICATIONS

Applications filled simultaneously with the subject disclosure which are assigned to a common assignee and contain common subject matter but claim distinct inventions, include:

Title	Inventor(s)	Ser. No.
Single-Stage Cold Start and Evaporative Control Method and Apparatus for Carrying Out Same	Sigmund M. Csicsery	295,028 now Pat. No. 3,831,572 "A"
Two-Stage Cold Start and Evaporative Control System and Apparatus for Carrying Out Same	Sigmund M. Csicsery and Bernard F. Mulaskey	295,029 now Pat. No. 3,838,673 "A"
Fuel Injection Cold Start and Evaporative Control Method and Apparatus for Carrying Out Same	Sigmund M. Csicsery	295,040 now Pat. No. 3,838,667 "A"
Two-Stage Fuel Injection Cold Start Method and Apparatus for Carrying Out Same	Sigmund M. Csicsery and Bernard F. Mulaskey	295,030 now Pat. No. 3,826,237 "A"

The present invention relates to cold starting of a spark-ignition internal combustion engine and has for an object the provision of a simple, effective and novel cold start system for use in such engine for selectively separating from a full-range fuel flowing to the engine, an increased fraction of lower molecular weight constituents so as to allow quick starting of the engine without producing excessive amounts of unoxidized hydrocarbons at the exhaust. The stripped higher molecular weight fractions during cold start are recycled to the gas tank for later use in the engine fuel system, say after the engine has been warmed and the full range fuel is being utilized.

During cold start of spark-ignition internal combustion engines, the fuel-air ratio is generated by the air-fuel intake system, say a conventional carburetion system. At cold start, the air-fuel ratio can be varied (enriched) to assure adequate amounts of low molecular weight constituents of the fuel at the intake manifold. By operation of a plurality of interrelated well-known parts, the lower molecular weight constituents become more easily vaporized to form combustible vapor-fuel/air ratios to allow starting of the engine even at low operating temperatures. However, since remaining higher molecular weight constituents are not oxidized even if the start is rapid, such remaining constituents contribute to the formation of unburned hydrocarbons at the exhaust.

Although a more volatile fuel having a lower boiling point, would permit faster starts and warmup as well as reduce exhaust pollutants including unburned hydrocarbons and carbon monoxide emissions at the exhaust, experience shows that the full range engine performance using the more volatile fuel would be adversely affected. In this regard, fuel consumption would be greatly increased over all ranges of driveability.

In accordance with the present invention, rather than

use a more volatile fuel under a multiplicity of operating conditions of a spark-ignition internal combustion engine (particularly during cold start), a greater fraction of lower molecular weight constituents can be separated from a full-range gasoline i.e., a hydrocarbon mixture of full-range components, as cold start is initiated. The separation system includes a miniature vertical countercurrent stripping column positioned within the engine compartment. The stripping column has separate inlet and outlet conduits in selective fluid contact with a stream of full-boiling gasoline passing to the stripping column from the gas tank by way of a fuel pump. Entry of the gasoline into the column is regulated by a conduit and valve network under control of a controller circuit initiated by the tripping of an ignition switch. The column includes a series of interconnected stacked trays, each provided with, say, a plurality of side-by-side baffles for bringing downwardly traveling full-boiling gasoline into intimate contact with upwardly traversing air. In that way, successive vaporizations of the downwardly cascading fuel occurs at each tray. As a result, an enriched overhead vapor product containing a greater fraction of lower molecular weight components is provided at the outlet of the column. From the stripping column, the overhead product passes into a condenser (say positioned at the firewell of the engine adjacent the stripping column) and, after liquefaction, thence into a fuel well of the carburetor. The fuel is then mixed with passing air to form a combustible air-fuel ratio. The air-fuel mixture is then passed through an inlet manifold into the combustion chambers of the engine and consumed. Since the overhead product comprises an abundance of lower molecular weight components, the result is easier starting of the engine under a variety of conditions without formation of undue pollutants at the exhaust. The bottom product of the column containing stripped higher molecular weight fuel components is simultaneously recycled to the gasoline tank. After being mixed with the full-range fuel within the gas tank, the bottom product is available for later use, say when the engine has warmed.

Construction of the countercurrent stripping column within the engine compartment can vary. Preferably, the arrangement resembles that provided in a stripping tower wherein feed gasoline--during cold start--passes downwardly through the column as countercurrent air is conveyed upwardly relative to the cascading fuel. Selective separation of the higher molecular weight constituents vis-a-vis lower molecular weight components occurs so that during start-up, the greater concentration of the latter constituents makes up the overhead product and passes into the fuel well of the carburetor to be mixed with air in a selected air-fuel ratio for later combustion within the combustion chambers of the engine. Since the starting cycle of an internal combustion engine is quite short, say from less than 1 to 15 seconds (exclusive of starting problems), the required quantity of overhead product to initiate starting can be surprisingly low (say from 400–500 milliliters per cold start).

Further objects, features and attributes of the present invention will become apparent from a detailed description of a selected embodiment, the description to be taken in conjunction with the following drawings in which:

FIG. 1 is a schematic view of a portion of an engine and fuel system illustrating a typical carburetor and air cleaner assembly interconnected between a cold start system separation (stripping) column housed within the engine compartment in fluid contact with a full-boiling gasoline passing from a gasoline tank via a fuel pump and a valve and conduit network under control of a controller circuit;

FIG. 2 is a fragmentary view of a metering pin useful in the valve and conduit network of FIG. 1;

FIG. 3 is a fragmentary view of the valve and conduit network of FIG. 1 illustrating the position of a cold start valve after cold start has been achieved and the engine is at running temperature.

Referring now to FIG. 1, there is illustrated in the engine fuel system **10** connected to an engine intake manifold **11** of a spark-ignition internal combustion engine. Fuel system **10** includes an air intake system **12**, a carburetor **13**, a fuel intake system **14** which includes cold start sytem **15** of the present invention.

To form a combustible air-fuel mixture, air enters by way of air intake system **12**, say by an air inlet line (not shown) and is filtered at an air filter **16** interior of an air filter housing **16*a***, before entry into carburetor **13**. Carburetor **13** includes choke and throttle valves **17** and **18**, respectively, a fuel well **19** and a discharge nozzle **20**. Fuel well **19** contains a metered amount of gasoline to be mixed with air passing discharge nozzle **20**. The resulting air-fuel mixture passes through intake manifold **11** into the engine combustion chambers (not shown) where combustion occurs.

Supplying fuel well **19** with a metered quantity of gasoline is by way of fuel intake system **14** including a gas tank **23** containing a reservoir of full-range fuel (i.e., a full-boiling mixture of hydrocarbons), a fuel pump **24** and cold start system **15** of the present invention. Cold start system **15** includes a valve and conduit network **25** having a cold start rotary valve **25*a*** in fluid contact with discharge sides of fuel pump **24** and condenser **27**. Valve and conduit network **25** is under operative control of a controller circuit **26**. Valve and conduit network **25** also includes a valve metering unit **25*b*** connected to the discharge side of rotary valve **25*a*** and a spring loaded one-way valve **25*c*** located at the discharge side of condenser **27**. The valve metering unit **25*b*** meters selected amounts of gasoline via conduit **28** to stripping column **29**. Cold start rotary valve **25*a*** is controlled by relay means **26*a*** of controller circuit **26**, the rotary valve **25*a*** being mechanically controlled through mechanical transducer **25*d*** and electrically controlled through bimetal temperature switch **26*b***, ignition switch **26*c*** and battery **26*d***. Transducer **25*d*** converts rectilinear travel of the relay means **26*a*** to rotational movement for activating rotary cold start valve **25*a*** as explained below. In shunt with relay means **26*a*** is seen to be motor **26*e***, electrically controlled through bimetal temperature switch **26*g***. When activated, motor **26*e*** drives air blower **26*h*** to pass air via conduit **31** into stripping column **29** and thence upwardly through stripping column **29** countercurrent to the downward flow of the full-boiling gasoline.

Construction of the stripping column **29** can vary. Preferably, the column **29** includes a series of horizontally extending, stacked trays, each tray including a multiplicity of side-by-side baffles to allow the cascading feed gasoline entering by way of conduit **28** to flow downwardly and be place in intimate contact with the upwardly traveling air. As the downwardly flowing feed gasoline is spread horizontally up on each tray in rather thin sections, the area of exposure to evaporation is enhanced to allow increased evaporation (stripping) of lower molecular weight constituents from the full-range fuel. Temperature differences existing between the upwardly moving air saturated with hydrocarbons can cause each tray (in addition to acting as a vaporizer) to also act as a partial condenser; i.e., ascending vapor comes into intimate contact with cooler downwardly traveling liquid wherein the less volatile components can be partially condensed as more volatile components from the liquid are vaporized. From column **29**, the overhead comprising an increased concentration of lower molecular weight constituent product is conveyed via conduit **30** through condenser **27** and thence from condenser **27** via conduit **32** and **33** to fuel well **19** of the carburetor **13**. The column **29** is seen to be supported at the fire wall **34** of the engine compartment by support straps **35** and **36** adjacent to condenser **27**. The condenser **27** is modified, of course, to include a vapor-liquid separator so as to provide a liquid fraction which exits from the condenser **27** via conduit **32** for travel to the fuel well **19**, and a vapor fraction which is recycled through the pump **31** to the condenser **27**.

Note that the method of the present invention contemplates operation at rather low operating temperatures (i.e., at operating temperatures encountered in the normal operation of an automobile). Thus, the design engineer must take the anticipated temperature conditions as well as the following other design factors into consideration in designing column **29**: the pressure of operation, the feed rate, the number of trays, (or character of the packing material should a packed column be used), the properties and composition of the desired overhead and bottom products, (i.e., stripping and absorption factors), the column and tray capacity, and the separation period per starting cycle. In this regard, the complexity of such operations in analogous process equipment is set forth in general in Science of Petroleum, Oxford University Press (1938) Vol. II, Section 25, pages 15, 43 et seq, and in Kirk-Othmer Encyclopedia of Chemical Technology, 2nd Ed., Vol. I, "Absorption" page 43, et seq and Vol. 7, "Distillation" page 43 et seq. With regard to the last-mentioned factor, it is apparent that the separation cycle must be short in order to provide adequate amounts of overhead product at the fuel well **19** to effect starting of the engine. In this regard, for a quite short separation cycle of say less than **1** second, the cold start system of the present invention provides sufficient amounts of overhead product containing increased lower molecular weight concentration to assure cold starting of the engine under a variety of operating conditions. These amounts can be surprisingly low, say in the range 400–600 milliliters per starting cycle.

It is apparent that if the fuel well **19** contained residual full-flow gasoline at cold start, a deluted cold start fuel charge would result. In this regard, consider the function of drain conduit **40** connected between fuel well **19** and gas tank **23** in FIG. **1.** When the engine is in an inactive state, fuel within the fuel well **19** drains therefrom via the drain conduit **40** to the gas tank. As shown, conduit **40** is provided with an orifice valve **41** so as to control the rate of drainage of the fuel, say at a rate which will allow total removal of resident fuel within a 6–12 hour period. Thus, when the engine is inactive overnight, the drain conduit **40** in cooperation with orifice valve **41** provides for total removal of the fuel-range fuel from the fuel well **19.** It should also be apparent that if the drainage conduit **40** is mounted at the side well of the fuel well **19** (not at the bottom wall as shown) not all the full-range fuel would be so drained. Instead, a residual reservoir remains, the amount of which is a function of the connector position relative to the top wall of the fuel well. For example, if the connector between the side wall of the fuel well and the conduit **40** is at a location say about two-thirds of the way from the top wall, the residual fuel therein would be one-third of the total fuel well capacity. During initial starting of the engine, the position of the discharge nozzle **20** and the connector could be arranged, depthwise, so that a selected, compatible mixture of the residual and separated fuels would enter the carburetor at cold start and allow starting of the engine.

Since successful separation of the low and high molecular weight components within stripping column **29** is based on, inter alia, the flow rate of the feed gasoline therethrough, consideration of metering valve unit **25*b*** between the discharge side of fuel pump **24** and the inlet side of stripping column **29,** is in order. As indicated in FIG. **1,** the valve unit **25*b*** includes a vertical passageway **45** intersecting a horizontal bore **47.** Passageway **45** connects exteriorly to cold start rotary valve **25*a*** by way of conduit **46.** At a remote end, the horizontal bore **47** is seen to be enlarged to form central chamber **48.** Within the chamber **48** is a bimetallic diaphragm **49.** The diaphragm **49** is attached, at an outer edge, to the side wall of the chamber **48,** and at an inner edge to metering pin **50.** The spring force provided by the diaphragm **49** is seen to be in opposite direction to the spring force provided by compression spring **51** so as the rectilinear travel of the metering pin **50** within opening **47** can be controlled as a function of temperature. In that way, the amount of full-boiling gasoline appearing at the inlet side of the stripping column **29** (i.e. at conduit **28**) can be carefully controlled as a function of temperature.

FIG. **2** illustrates the metering pin **50** in more detail. As indicated, the pin **50** includes an enlarged head **51** at one end and an elongated shank portion **55** at the other end tapered to form a reduced segment **56.** Reduced segment **56** is seen to be swedged as a function of length. That is to say, the reduced segment **56** is reduced in diameter starting at a beginning section **58** and ending at a mid-portion section **59.** Accordingly, the amount of fuel which can be conveyed into the column **29** is dependent upon whether or not minimum section **59** or the beginning section **58** is in registry with the passageway **45,** when the pin is positioned as depicted in FIG. **1.**

Reference should now be had to FIGS. **1** and **3** illustrating the method aspects of the present invention. In more detail, it should be apparent that the initiation of the cold start cycle automatically occurs when the driver closes ignition switch **26*c*** of the controller circuit **26.** As a driver closes the ignition switch **26*c*,** assume that the fuel well **19** has been emptied of full-range fuel. Closure of ignition switch **26*c*** activates control relay **26*a*** of the controller circuit **26** so as to cause the cold start valve **25*a*** to be reoriented from the position shown in FIG. **3** to the position shown in FIG. **1.** Simultaneously, motor **26*e*** is activated which in turn activates air blower **26*h*.** Air is conveyed upwardly through the stripping column **29.** As the engine turns over, the fuel pump **24** conveys full-range fuel via cold start valve **25*a*** and inlet metering unit **25*b*** to stripping column **29.** Within the column **29,** the full range fuel cascades from tray to tray countercurrent with upwardly moving air, which culminates in the production of an overhead product at conduit **30** rich in lower molecular weight components. From the exit conduit **30,** the enriched overhead product is conveyed through condenser **27** then after liquefaction, via conduits **32** and **33** to the fuel well **19** and thence into carburetor **13** where the fuel charge and air are properly mixed for consumption within the combustion chambers of the engine. After a selected rise in engine temperature, as measured, say by bimetal switch **26*b*** of the controller circuit **26** positioned at the water jacket or exhaust manifold of the engine, the control relay **26*a*** is deactivated resulting in rotary valve **25*a*** returning to a relaxed position as shown in FIG. **3.** After the cold start valve **25*a*** returns to a relaxed position depicted in FIG. **3,** the fuel intake system of the present invention is switched over to full utilization of the full-range gasoline. That is to say, fuel conveyed from fuel pump **24** then passes via inlet rotary valve **25*a*,** conduits **38** and **33** to the fuel well **19.** In this regard, one-way valve **25*c*** is seen to prevent escape of the fuel in the direction of condenser **27.**

However, as the full-range fuel is being utilized, the bimetal switch **26*g*** of the controller circuit **26** preferably remains in an activated state, and remains so activated for a period of time determined by the time required to purge the stripping column **29** and condenser **27** of remnant fuel constituents. In that way, blower **26*h*** remains activated to provide the purging air for this aspect of the present invention. The purged materials pass from the column **29** and condenser **27** through one-way spring valve **25*c*** into fuel well **19.** At the end of the purging cycle, the bimetal switch **26*g*** is opened, deactivating the motor **26*e*** and blower **26*h*.**

While certain preferred embodiments of the invention have been specifically disclosed above, it should be understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art. For example, in order to improve column efficiency as well as to reduce the separation cycle time required to produce the enriched overhead product, it may be desirable to utilize the cold start system of the present invention only after the engine has warmed and the warmed air could be utilized at the inlet side of blower **26*h*.** In that way, the warmed air could be conveyed through the column **29** in countercurrent direction to the downwardly cascading full range fuel. However, such modification would require the position of a holding tank between the condenser **27** and one-way spring valve **25***c*. After a holding tank is filled to set point level and so indicated in the manner of U.S. Pat. Nos. 3,498,320 and 3,580,263 assigned to the assignee of the present application for "Pressure Liquid Level Indicator," the retained liquid could be released for cold starting through operation of cold start release valve (not shown) under control of controller circuit **26**. Thus the invention is to be given in the broadest possible interpretation within the terms of the following claims.

I claim:

1. Apparatus for reducing exhaust and inoperative pollutants produced by a spark ignition internal combustion engine of the type including an air intake system, fuel intake system, and a carburetor interconnected therebetween for mixing said full-range fuel with air to form a combustible mixture for delivery to combustion chambers of said engine, comprising:

i. a stripping column adapted to selectively strip higher molecular weight constituents from said full-range fuel at all engine start conditions during flow through said column so as to provide a cold start fuel vapor effluent composed essentially of only low molecular weight constituents and a bottom liquid product composed essentially of only high molecular weight constituents,

ii. valve and conduit network means attached between said stripping column, a reservoir means for said full-range fuel and said carburetor, for providing selective flow conditions, said network means including a first plurality of conduit and valve means including first and second valve means controlling flow of said full-range fuel relative to said stripping column and said carburetor so as to allow, (a) in a first operating state, flow of said full-range fuel from said reservoir means to said stripping column and flow of said cold start fuel vapor effluent to a fuel well of said carburetor to provide for rapid starting of said engine without producing excessive exhaust pollutants and, (b) in a second operating state, full-range fuel to flow directly from said reservoir means to said fuel well of said carburetor bypassing said stripping column after said engine is in a normal running condition,

iii. condenser means positioned between said second valve means and said stripping column in operative contact with said cold start vapor effluent for providing liquefaction thereof,

iv. control means operatively connected to said first valve means of said valve and conduit network for changing operating state thereof so as to direct fuel flow relative to said stripping column, said reservoir and carburetor as a function of engine operating temperature,

v. said network means also including a metering means positioned between said first valve means and said stripping column for metering flow of said full-range fuel to said column as a function of temperature, said metering means including a housing having an inlet opening in fluid contact with said first valve means, movable rod means projecting into said opening and a spring-loaded bimetallic-diaphragm means permanently attached both at a central region to said rod means and at an outer edge to said housing, for controlling movement of said rod means relative to said inlet opening whereby full-range fuel flow to said stripping column is accurately controlled as a function of temperature.

* * * * *