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Stary et al.

[11] **3,926,230**

[45] **Dec. 16, 1975**

[54] **RECOVERY OF FLAMMABLE VAPORS**

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[21] Appl. No.: **478,519**

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[51] **Int. Cl.**[2] **B65B 31/06**

[58] **Field of Search** ..... 141/41–45, 141/52, 59, 287, 290, 98; 55/387, 88, 62, 74, 316, 182, 385 NS; 220/85 VR, 85 US, 86 R; 62/50–54; 123/133, 136

[56] **References Cited**

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3,087,291	4/1963	Jackson et al.	55/62
3,543,484	12/1970	Davis	55/387
3,581,782	12/1968	Onufer	141/52
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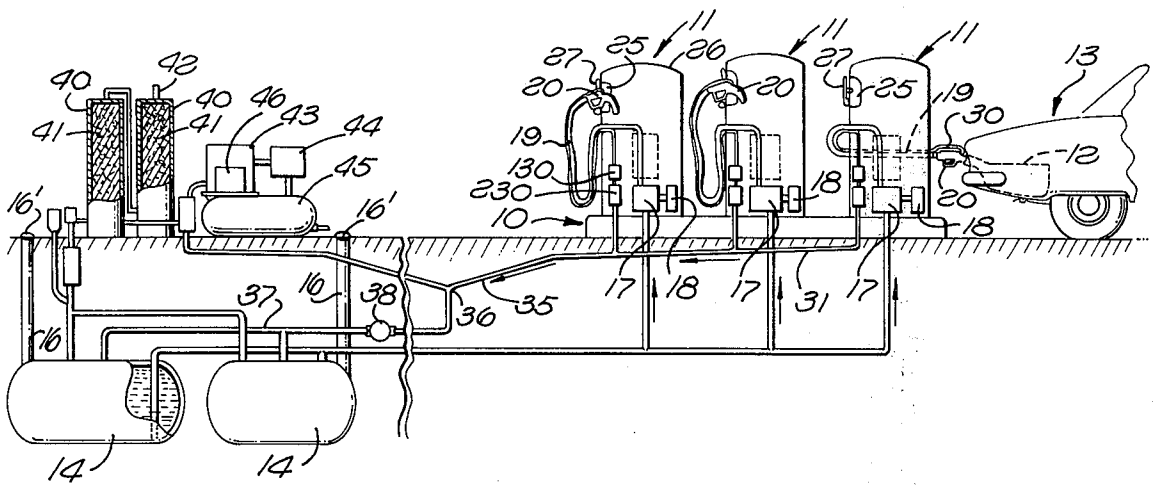
Primary Examiner—Houston S. Bell, Jr.

Attorney, Agent, or Firm—William P. Green

[57] **ABSTRACT**

A system for preventing escape of vapors into the atmosphere when filling gasoline or the like into a tank, and including means for collecting vapors from the vicinity of the filling nozzle, or nozzles, adsorbing the vapors onto an adsorbent substance such as activated charcoal, and then utilizing the vapors in admixture with air as the sole fuel for driving a combustion engine. The engine may be started intermittently, preferably in response to each actuation of the dispensing nozzle.

33 Claims, 5 Drawing Figures



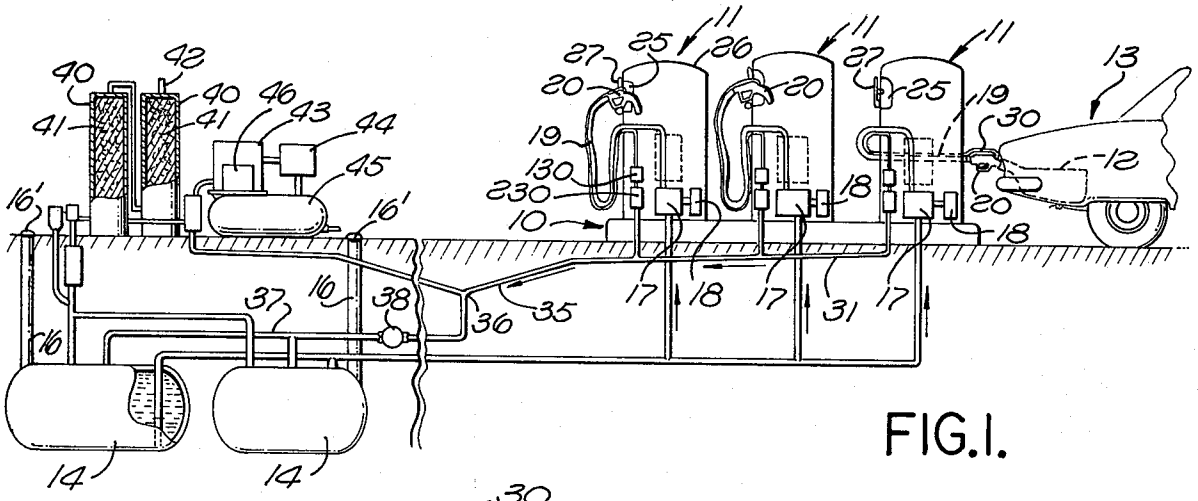


FIG.1.

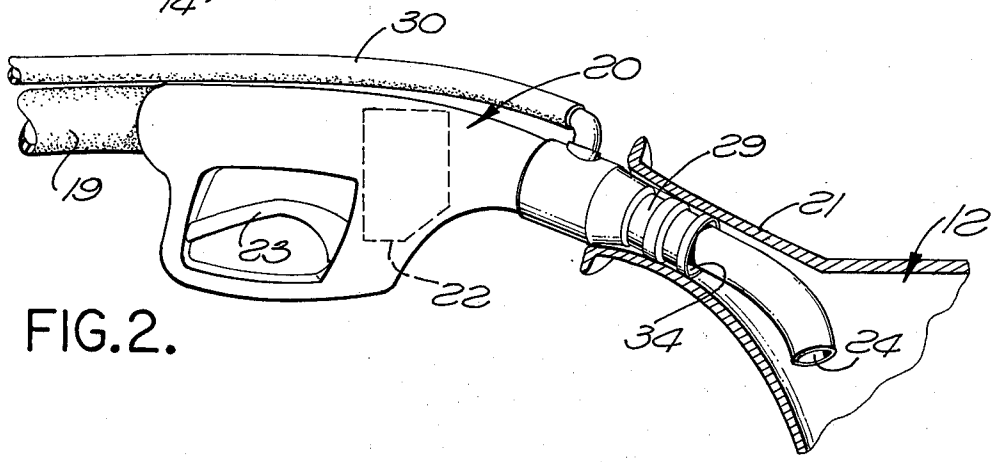


FIG.2.

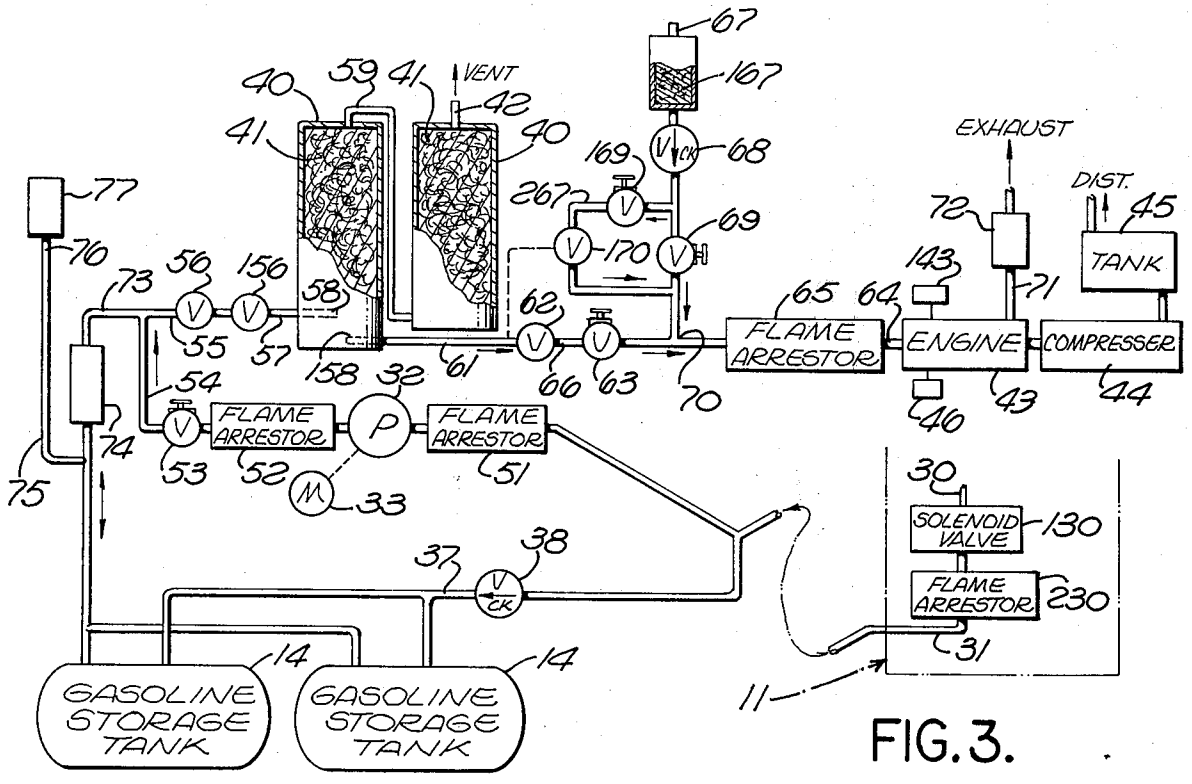


FIG.3.

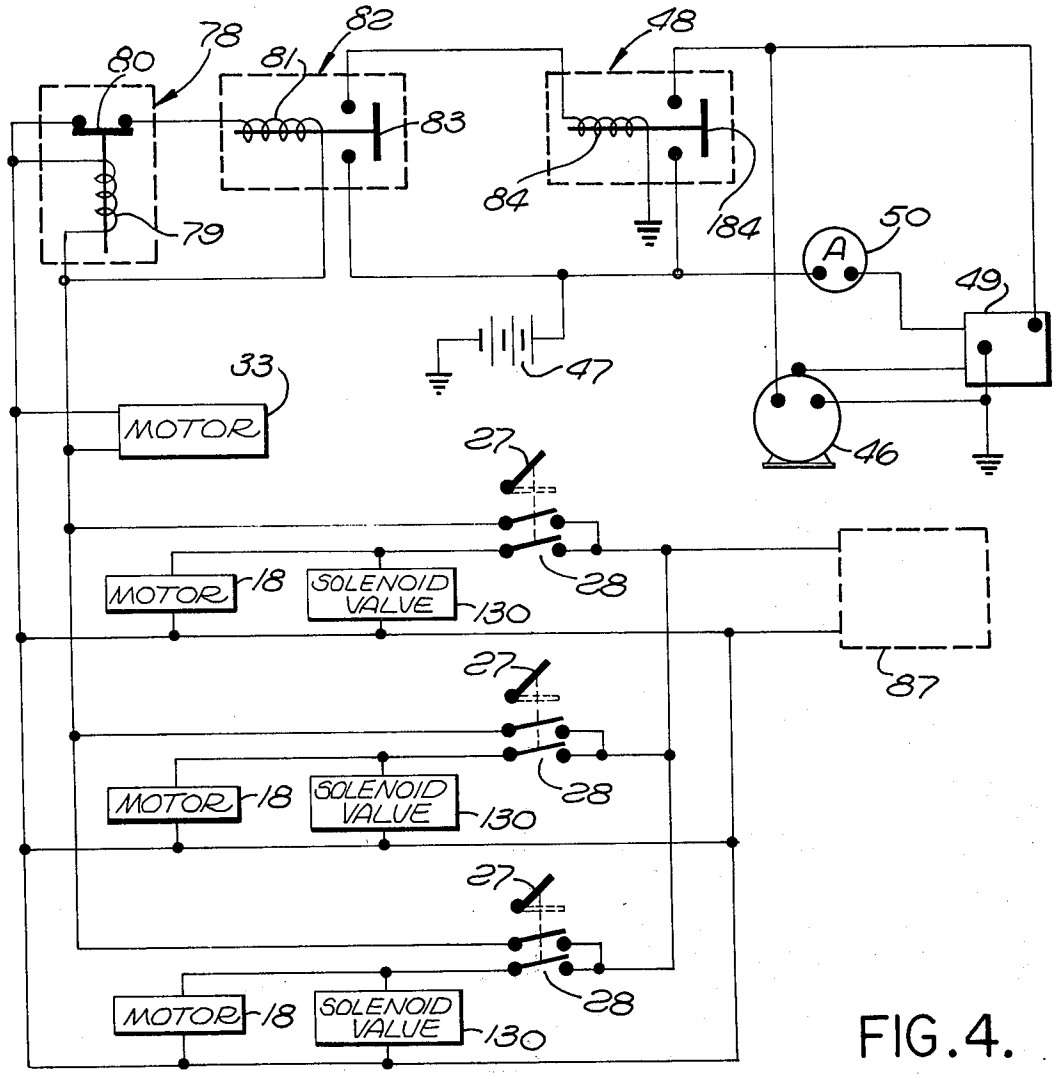

78
80
81
82
83
79
84
48
184
50
A
49
47
33
MOTOR
46
27
28
MOTOR
18
SOLENOID VALVE
130
87
27
28
MOTOR
18
SOLENOID VALVE
130
27
28
MOTOR
18
SOLENOID VALVE
130

FIG.4.

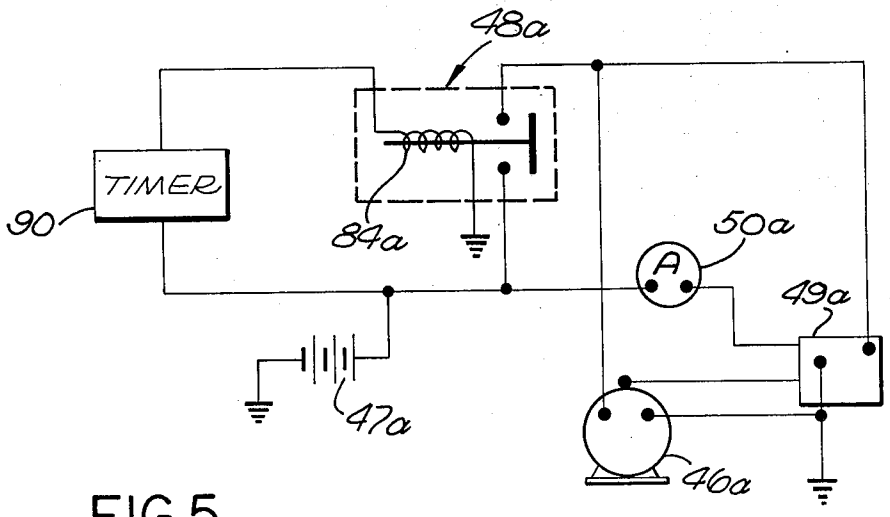

48a
TIMER
90
84a
50a
A
49a
47a
46a

FIG.5.

RECOVERY OF FLAMMABLE VAPORS

BACKGROUND OF THE INVENTION

This invention relates to improved apparatus and methods for filling a flammable liquid such as gasoline into a tank, as for example into the fuel tank of an automobile at a service station, and doing so in a manner preventing escape of vapors from the liquid into the atmosphere.

There have in the past been devised various types of apparatus for preventing escape of vapors while a tank is being filled. These systems usually include a vapor pickup line which takes suction from the location of the dispensing nozzle by which the liquid is being filled into the tank. In some instances, the accumulated vapors are then refrigerated to convert them to liquid form for return to a main storage tank. In other types of equipment, the vapors may be separated from intermixed air by passage over an adsorbent substance, such as activated charcoal, which will selectively adsorb the fuel vapors and permit the cleaned air to escape into the atmosphere.

Certain arrangements of this latter type are shown in U.S. Pat. No. 3,581,782 issued June 1, 1971. One form of the invention shown in that patent is adapted for use on a fuel delivery truck, and ultimately withdraws the adsorbed vapors from the activated charcoal to the intake side of the delivery truck engine for burning in the engine along with its driving fuel.

SUMMARY OF THE INVENTION

The present invention discloses an adsorption type system, in which there is provided an engine which is driven solely by combustion of the recovered vapors. These vapors are intermixed with air in a controlled air-vapor ratio assuring essentially complete conversion of the fuel to carbon dioxide and water, while making available for use in any desired manner the mechanical output power produced by the engine. The means for delivering the vapors and air to the engine may include appropriate valve means for controllably varying the proportions of vapor and air to attain optimum combustion.

A vapor pump initially withdraws the vapors from the vicinity of the dispensing nozzle or nozzles, and delivers the vapors to the adsorptive material, with a return line being provided for return of some of the vapors back into the main storage tank from which the liquid is being withdrawn. A float valve in this return line may serve to prevent flow of liquid therethrough toward the adsorbent material in the event that the storage tank is inadvertently over-filled. A pressure operated valve may also be provided in the line going to the adsorbent material, to prevent the engine from drawing vapors from the main storage tank, and operating on those vapors, during periods when the adsorbent material is being regenerated but no fuel is being dispensed from the discharge nozzle.

A starter is provided for the engine, to intermittently commence operation of the engine if and when enough vapors are present in the adsorptive material to drive the engine. In a presently preferred form of the invention, the starter is energized automatically for a short interval each time that the dispensing equipment is actuated to deliver liquid into a tank.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

FIG. 1 is a representation of a service station installation embodying the invention;

FIG. 2 is an enlarged fragmentary showing of one of the fuel dispensing nozzles of the FIG. 1 apparatus;

FIG. 3 is a flow diagram illustrating the vapor recovery system of the FIG. 1 apparatus;

FIG. 4 shows the electrical control circuitry of the FIG. 1 apparatus; and

FIG. 5 shows a variational circuit for controlling energization of the starter.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, I have represented generally at **10** in that figure a service station 'island' on which a number of fuel dispensing units or pump assemblies **11** are located for filling gasoline or other fuel in measured quantities into a fuel tank **12** of an automobile or other motor vehicle represented at **13.** As is conventional, there may be several such dispensing units at the same station, receiving fuel from one or more underground storage tanks **14** through lines **15.** The tanks **14** are filled from delivery trucks through vertical fill pipes **16,** which extend upwardly to the surface of the earth and have removable caps **16'**.

Each of the dispensing units **11** contains a pump **17** which is driven by an electric motor **18** and acts when energized to force fuel into and through the usual flexible hose **19** to a dispensing nozzle unit **20** adapted to project into the fill tube or neck **21** of the vehicle tank **12,** (See FIG. 2). The nozzle unit **20** is manually manipulated, and contains a dispensing valve **22** which is actuated by a trigger type control element **23** to start and stop the discharge of fuel from the discharge end **24** of the nozzle.

When the nozzle element **20** of a particular one of the dispensing units **11** is not in use, the nozzle is inserted into and supported within a recess **25** in the housing **26** of the unit **11.** The nozzle is locked within this recess and against removal therefrom by a lever **27,** which must be swung manually, as between the full line and broken line positions represented diagrammatically in FIG. **4,** to release the associated nozzle for removal from housing **26.** This swinging movement of element **27** actuates a double pole electric switch (**28** in FIG. **4**) between open and closed positions, to close the electric circuit to the associated pump motor **18,** and thereby commence operation of the pump **17** for delivering fuel through hose **19** to the vehicle tank when the nozzle **20** is opened. As will appear at a later point, this actuation of switch **28** also serves in the present apparatus to energize certain equipment relating to the vapor recovery system with which the present invention is especially concerned.

For preventing the escape of fuel vapors into the atmosphere while fuel is being delivered from nozzle **20** into the vehicle tank, each of the nozzles **20** carries a vapor pickup element **29** (FIG. **2**), which is connected to a flexible suction hose **30** extending alongside and parallel to the main fuel delivery hose **19** for connection to a solenoid valve **130** and flame arrestor **230** within the interior of the associated dispenser unit

housing 26. When a particular one of the solenoid valves 130 is energized and therefore open, it places the connected suction hose 30 in communication with an underground suction line 31 leading to a vapor pump 32 driven by an electric motor 33 to create a sub-atmospheric pressure in line 31 and element 29 on the nozzle, acting to withdraw fuel vapors and some air from the vicinity of nozzle 20 and thereby prevent escape of any of the vapors outwardly past the nozzle during a filling operation. Element 29 on the nozzle contains an appropriate suction passage, which preferably has an annular open end at the locations designated 34 in FIG. 2, so positioned as to be received within the filling tube 21 of the vehicle tank during a filling operation.

At the location 35, the suction line 31 has a downwardly inclined portion leading to a point 36 of communication with a drain line 37 through which any liquid contained within the suction line can drain back into tanks 14 past a swing check valve 38. Vapors in line 31, however, are taken by vacuum pump 32, as indicated previously.

The vapor recovery equipment of FIGS. 1 to 4 includes also one or more adsorption chambers 40, containing beds of an adsorbent substance 41, such as activated charcoal, capable of adsorbing the flammable gasoline vapors and thereby separating the vapors from any air intermixed therewith, and then permitting escape of the cleaned air into the atmosphere at 42. At various times, these adsorbed vapors are withdrawn from the material 41 by reverse flow of clean atmospheric air through the beds, and are then utilized as the sole fuel for driving an internal combustion engine 43, whose power output may typically be utilized for driving an air compressor 44 acting to compress air into an accumulation tank 45. The compressed air from this tank 45 may be withdrawn as needed for driving various types of air actuated equipment normally employed in a service station or the like. Alternatively, the unit represented at 44 in FIG. 1 may be an electrical generator, acting to generate electric power for use at the station. Regardless of whether the driven unit 44 is a compressor, generator, or other piece of equipment, that driven unit is preferably of a type to impose an essentially constant load on the engine at all times when in operation.

The engine 43 may be a conventional reciprocating piston and cylinder type internal combustion engine, except that it does not require a carburetor since the fuel as supplied to the engine is already in vapor form. In most instances, it is contemplated that for a service station installation a relatively small engine, typically a two cylinder four-stroke-cycle engine, will be capable of converting all of the accumulated vapors to water and carbon dioxide to thereby prevent their admission into the atmosphere. The engine is adapted to be started by a starter-generator device 46 which when energized electrically will turn the engine over at starting speed, but when de-energized and driven by the engine will serve as a generator for producing an output voltage and current for recharging the engine battery 47. A conventional starter solenoid 48 is used for energizing the starter, in association with the usual voltage regulator 49 and ammeter 50. A governor represented at 143 may be used to regulate the engine speed.

With reference now to the flow diagram of FIG. 3, there preferably are provided at both the inlet and outlet sides of vapor pump 32 a pair of flame arresters 51 and 52, which may consist merely of canisters containing masses of porous but heat adsorbent material capable of preventing propagation of any flame which may be developed past the locations of these flame arresters. Beyond arrester 52, the slightly pressurized vapor from pump 32 passes first through a trim valve 53 which is manually adjustable to vary the rate of flow through a line 54 and connected line 55 to a pressure regulator valve 56 and pressure opening valve 156, from which the vapors flow through a line 57 into an inlet end of a first of the adsorbent beds 41. The valve 56 maintains a predetermined regulated pressure slightly above atmospheric pressure at its discharge side, so long as vapor at a pressure above atmospheric reaches its intake side. Valve 156 is normally closed when its inlet is at atmospheric pressure, but automatically opens when its inlet pressure increases to a predetermined slightly super-atmospheric value. Regulator 56 maintains a pressure in excess of that opening pressure of valve 156 whenever pump 32 is in operation.

The vapors from line 57 may be injected into the adsorbent material through an elongated hollow screen element 58 or the like, projecting into the interior of the adsorbent material and capable of discharging the vapors over a somewhat extended area into the bed. From the location of screen 58, the vapors and some intermixed air flow first upwardly through one of the beds of adsorbent material, and then through a line 59 into the lower portion of the next successive bed and surrounding chamber or tank 40, to flow upwardly therethrough to the discharge line 42 leading to the atmosphere. By the time the air has reached line 42, all of the vapors have been completely adsorbed onto the activated charcoal or other adsorbent material, and the air in line 42 is therefore completely clean of such vapors.

When engine 43 is in operation, atmospheric air is drawn from line 42 through the beds of material 41, to desorb the vapors progressively from that material, and then deliver the vapors and some intermixed air through a preferably elongated outlet screen 158, a line 61, a pressure regulator valve 62 and a manually actuated shut off valve 63 to the intake 64 of engine 43. A flame arrestor 65 may be provided at the intake of the engine, again to prevent propagation of any flame in either direction past this location, while still permitting free and unobstructed flow of the vapors to the engine. The pressure regulator valve 62 maintains an essentially constant pressure at its discharge side 66, to assist in controlling the delivery of a proper air-vapor mixture to the engine. The inlet 58 and outlet 158 in the first bed 41 are offset or spaced from one another so that vapors can not flow directly between the inlet and outlet without passing through some of the adsorbent material. The provision of this buffer zone of adsorbent material between the inlet 58 and outlet 158, in conjunction with the various automatic pressure controls, permits simultaneous adsorption and desorption on the same carbon bed, and also permits the engine to keep running with or without dispensing, and even while tanks 14 are being filled.

For intermixture with the vapors, a second intake line to the engine is provided at 67, taking suction from the atmosphere. The air from line 67 passes first through an air filter 167, then through a check valve 68 acting to permit air flow only downwardly in FIG. 3 (but to prevent reverse flow or loss of vapor when the engine is not running), and then through a manually adjustable

trim valve 69, before intermixture at 70 with the vapor in line 61. Additional air can be supplied to the engine through a by-pass line 267, past a trim valve 169 and a pressure operated valve 170 responsive to the pressure at the intake side of valve 62. Valve 170 is normally closed during operation of the equipment, but may be automatically opened by a predetermined increase in pressure in beds 41 to pass additional air to the engine.

The two valves 63 and 69 are so adjusted manually as to deliver to engine 43 a combustible mixture of vapors and air, having a proper air-fuel ratio for efficient burning within engine 43, when valve 170 is closed and the pressure in beds 41 is at its normal valve. Under these conditions, it is found that, once the valves 63 and 69 have been properly set for an appropriate air-fuel ratio, say between about 11 to 1 and 13 to 1, this ratio will automatically remain fairly constant, regardless of the amount of accumulated vapor which may be present on the material 41. So long as any vapor remains in the beds, the engine will continue to operate efficiently, and will then automatically cease operation when all of the adsorbed vapors have been removed from the material 41.

If the pressure in the beds at any time becomes excessive, valve 170 opens automatically to pass increased air to the engine, in a metered amount determined by the setting of trim valve 169, and just sufficient to compensate for the increased vapor flow and maintain essentially the same predetermined air-fuel ratio to the engine.

As a final assurance against discharge of any unwanted substances into the atmosphere, the exhaust line 71 from engine 43 may contain a catalytic exhaust purifier represented at 72, for oxidizing any small amount of unburned hydrocarbons or carbon monoxide which may remain in the exhaust, and thereby discharging to the air only carbon dioxide and water vapor.

During any interval when fuel is being withdrawn from one or both of the underground storage tanks 14 by one of the units 11, and is being filled into a vehicle tank 12, some of the vapor discharged by pump 32 is fed back into the storage tanks through a line 73, to take the place of the removed liquid. A float valve 74 may be connected into this line 73, to prevent reverse flow of liquid through line 73 and toward beds 41 in the event that the storage tanks 14 are at any time accidentally over-filled. This valve 74 normally permits vapor flow in either direction through the valve, but automatically closes by float action if liquid reaches the level of valve 74 from the tanks, to thereby protect material 41 from the liquid.

Valve 74 may be connected to the storage tanks most expeditiously by connecting valve 74 to a vent line 75, which is connected to the upper portions of the tanks 14 and extends upwardly to an upper end 76 at which a pressure-vacuum vent valve 77 communicates with the atmosphere. This valve 77 is normally closed, but will open as a pressure relief valve in response to the attainment of an excessive pressure in the tanks 14 and line 75, to thereby discharge fuel and vapors to the atmosphere and prevent damage to the system as a result of such excessive pressure.

In addition to the various electrical components already discussed, the circuitry of FIG. 4 includes also a time delay relay 78 whose coil 79 is connected in parallel to the vapor pump motor 33, as shown, and whose movable contact 80 is normally closed but adapted to be opened by energization of coil 79 to break the circuit to a coil 81 of a second rleay 82, whose normally open contact 83 is adapted to close the circuit from battery 47 to the coil 84 of the starter solenoid unit 48.

To now describe a cycle of operation of the illustrated equipment, assume first of all that the underground tanks 14 have been filled with a flammable fuel to be dispensed, and that the engine 43 is initially not running. If, then, it is desired to fill the tank 12 of a motor vehicle with fuel from one of the dispensing units 11, an operator first actuates the lever or arm 27 of that particular unit 11 to free the associated nozzle 20 for removal from its position of confinement within recess 25, and then places the nozzle into the fill tube 21 of the vehicle tank. The actuation of lever 27 also closes an associated switch 28 of that particular unit 11 (FIG. 4), to thereby close a circuit from a power source 87 (typically 115 volt-60 cycles) through the switch 28 to an associated one of the solenoid valves 130 and the associated fuel delivery pump motor 18. The motor 18 commences to drive its connected fuel pump 17, to pressurize the fuel within hose 19, and to cause delivery of the fuel into tank 12 when trigger element 23 of the nozzle assembly is actuated.

The closure of any of the switches 28 also acts to close a circuit to the vapor pump motor 33, to commence withdrawal of a mixture of vapors and air from the nozzle location through one of the suction lines 30 and through the associated solenoid valve 130 which has been energized and opened by actuation of the switch 28. In addition, the closure of switch 28 closes the circuit to coil 79 of the time delay relay 78, which is so designed as to open the normally closed contact 80 of that relay after a predetermined delay interval of say fifteen seconds. During that interval, the contact 80 of time delay relay 78 closes a circuit from the power soruce 87 to coil 81 of the second relay 82, to thereby pull the normally open contact 83 of that relay to its closed condition, energizing starter solenoid coil 84 from 12-volt battery 47, and closing the contact 184 of the solenoid in a manner energizing starter motor 46 from battery 47. Thus, as soon as any one of the switches 28 is closed, starter motor 46 commences to turn engine 43 over at starting speed, and continues to turn it over until expiration of the timed delay period for which relay 78 is set, at which time coil 79 of relay 78 opens contact 80 of that relay, to deenergize relay 82, starter solenoid 48, and the starter 46 itself.

If at the time of this actuation of the engine by starter 46, there is sufficient vapor accumulated in chambers 40 to drive the engine, the rotation of the engine will create a vacuum in line 64 (FIG. 3) acting to draw vapors and some air from chambers 40 through line 61 to the engine, and simultaneously drawing air through line 67 to the engine. Assuming that valve 170 is closed, the settings of valves 63 and 69 are such that the air-fuel mixture which reaches the engine is within the proper range to cause the engine to run by combustion of the fuel vapor within the cylinders of the engine. During this operation, some air is drawn downwardly through line 42 into and through the adsorptive material 41, for delivery from the bottom of the second bed of adsorptive material into line 61 leading to the engine. The air thus flowing downwardly desorbs the flammable vapors from the material 41 progressively, in a proportion which, it is found, does not vary substantially in spite of variations in the amount of vapors present in the bed. The air-fuel ratio to the engine

therefore remains within a proper range to continue operation of the engine, once started, until substantially all of the adsorbed vapors have been removed from the material **41**. Thus, if there are enough vapors to commence operation of the engine on any particular timed actuation of the starter, the engine will continue to run until substantially all of the vapors have been desorbed from the beds of activated charcoal or the like. When all of the accumulated vapors have been removed, the engine automatically stops for lack of further fuel, and remains stopped unitl the next successive dispensing operation, at which time the closure of one of the switches **28** causes the starter to again operate for a timed interval, and start the engine if at that time enough vapors have accumulated to run the engine. If as previously indicated the pressure in beds **41** and line **61** ever reaches the predetermined excessive value for which valve **170** has been set, this valve opens and admits enough extra air to compensate for the increased vapor concentration in line **61** and thereby still maintain a properly combustible air-fuel ratio in the engine intake.

During the entire time that any one of the liquid dispensing pumps **17** is in operation, the vapor pump **32** is driven continuously to withdraw vapors from the vicinity of the dispensing nozzle **20**, and to force those vapors, slightly compressed, past valves **56** and **156** and into the adsorptive beds **41**. Any air which is withdrawn from the nozzle region with the vapors flows upwardly through the chambers **40** for discharge to the atmosphere as clean air through line **42**, with all of the flammable vapors being adsorbed onto the material **41** before reaching line **42**. The pressure opening valve **156** prevents negative pressure being drawn on the storage tanks **14** when engine **43** is in operation and tending to draw a vacuum but fuel is not being dispensed through any of the nozzles **20**. As soon as any of the nozzles is opened and dispensing commences, the resultant slightly positive or super-atmospheric pressure at the inlet to valve **156** opens that valve to permit vapor flow to beds **41**.

When fuel is being filled into the tanks **14** through the fill lines **16**, it is preferred that the delivery trucks be of a type having built-in vapor recirculation systems, to themselves withdraw from the tanks at least some of the vapor being displaced by the added liquid. Any excess vapor may then pass through the float valve **74** and valves **56** and **156** into the carbon beds, for adsorption onto the beds and discharge of clean air to the atmosphere. If the gasoline storage tanks are overfilled, the float check valve **74** automatically closes to prevent the flow of liquid gasoline into the carbon beds or vapor pump. If the gasoline delivery is made with a truck which does not have a vapor return, excessive pressure may build up in the vent line **75**, but pressure regulator **56** will prevent more than the normal vapor flow to beds **41**, and the excess vapor will be discharged to atmosphere through relief valve **77**.

The intermittent operation of engine **43** acts through compressor **44** to build up a supply of compressed air in tank **45**, which may be used as needed in a distribution system at the service station or other facility. Any other power takeoff system, such as a generator or alternator driven by the engine, may similarly utilize substantially all of the energy of the collected vapors for useful purposes, without discharge of any pollutants into the air.

FIG. **5** shows diagrammatically a changed portion of the electrical circuit of a variational form of the invention, which form may be considered as identical with that of FIGS. **1** through **4** except that the two relays **78** and **82** are deleted, and in lieu of these relays there is provided a timer **90** for controlling operation of a starter-generator **46***a* corresponding to the starting unit **46** of FIG. **4**. Timer **90** may include a clock which acts at predetermined timed intervals to close the circuit to coil **84***a* of starter solenoid **48***a* (corresponding to solenoid **48** of FIG. **4**), and thereby energize the starter **46***a* for a predetermined interval (say fifteen seconds), following which the timer breaks the circuit leaving the engine operating if sufficient vapor is present, and with the engine then continuing to operate until depletion of all adsorbed vapors. At that time, the engine stops until the next energization of the starter by timer **90**. As an example, timer **90** might perhaps be set to start the motor once each day, so that the vapors would accumulate in the activated charcoal for a full day and then be desorbed by operation of the engine, then accumulate for another day, etc. In lieu of the timer **90** or the relays of FIG. **4**, it is also contemplated that other means may be provided for intermittently starting the engine, which means may include manually actuated switches for starting the engine under the direct control of an operator if desired. If at any time in any of the forms of the invention the starter is energized when the engine is already running, the operation of the engine is not affected by such energization of the starter.

In the presently preferred form of the invention, the operational pressures at different points in the system, and the operating pressures of the various automatic valves, may be as follows:

1. Intake pressure to pump **32** is preferably between about **−5**″WC and **−20**″WC desirably about **−10**″WC.

2. Discharge pressure from pump **32** is preferably between about **+5**″WC and **+20**″WC, desirably about **+10**″WC.

3. Pressure maintained by regulator valve **56** at its outlet side is slightly positive (above atmospheric), preferably between about **1**″WC and **3**″WC, and optimally about **2**″WC.

4. Pressure opening valve **156** opens at a slight positive pressure, not greater than, and preferably somewhat less than the regulated outlet pressure of valve **56**, the opening pressure of valve **156** desirably being between about **0.5**″WC and **1.5**″WC, optimally about **1**″WC.

5. Pressure maintained by regulator valve **62** at its outlet side is desirably between about **0**″WC and **−4**″WC, and for best results about **−2**″WC.

6. Valve **170** preferably opens at a positive pressure between about **0**″WC and **1**″WC, for best results about **0.5**″WC.

7. Relief valve **77** opens at a pressure above the normal discharge pressure of pump **32**, and above the normal pressure at the outlet side of valve **53**, the opening pressure of valve **77** desirably being between about **10**″WC and **18**″WC, for best results about **14**″WC.

While certain specific embodiments of the present invention have been disclosed as typical, the invention is of course not limited to these particular forms, but rather is applicable broadly to all such variations as fall within the scope of the appended claims. As one example of a possible variation, there may be substituted for the individual fuel delivery pumps in the various dispensing units **11** a single pump delivering fuel to a number of the dispensing units **11** and typically located

near one of the tanks **14.**

We claim:

1. Apparatus comprising:

a liquid dispensing system including tank means for holding a flammable liquid, hose means for dispensing said liquid, and discharge nozzle means on said hose means;

means for collecting flammable vapors of said liquid from said dispensing system and including collection line means for withdrawing vapors from the vicinity of said nozzle means during a dispensing operation;

adsorption chamber means through which said collected vapors and intermixed air are passed and containing a substance adapted to adsorb said vapors;

an engine;

means for feeding said collected vapors to the intake of said engine as its only fuel in a quantity sufficient to drive said engine solely by the combustion of said vapors, said vapor feeding means acting to progressively desorb vapors from said substance for delivery to the engine; and

means for delivering air to the intake of said engine with said collected vapors in a controlled total air-vapor ratio which is combustible in the engine to drive it solely by burning of said vapors.

2. Apparatus as recited in claim **1,** including an air compressor driven by said engine.

3. Apparatus as recited in claim **1,** in which said vapor feeding means include a line through which said vapors are delivered to said engine, and a pressure regulator in said line.

4. Apparatus as recited in claim **1,** in which said vapor feeding means include a first line for delivering vapors from said chamber means to the engine, said air delivering means including a second line for delivering air to said engine, there being valve means for controllably varying the proportions of vapor and air delivered through said first and second lines to produce said combustible air-vapor mixture.

5. Apparatus as recited in claim **1,** including a starter for turning over said engine, and means for energizing said starter intermittently.

6. Apparatus as recited in claim **1,** including a pressure opening valve adapted to pass an increased amount of air to said engine in response to a predetermined increase in pressure of said vapors.

7. Apparatus as recited in claim **1,** in which said vapor feeding means include a first line for delivering vapors from said chamber means to the engine, and a pressure regulator in said line; said air delivering means including a second line for delivering air to said engine, adjustable metering valve means in said second line, a third line bypassing said metering valve means, and a pressure opening valve in said third line adapted to open and pass an increased amount of air to said engine in response to an increase in the pressure of said vapors upstream of said pressure regulator of the vapor feeding means.

8. Apparatus as recited in claim **7,** including a check valve in said second line upstream of said third line and metering valve means, and additional metering valve means in said third line.

9. Apparatus as recited in claim **1,** in which said vapor collecting means include vacuum pump means for drawing vapors through said collection line means and delivering said vapors to said adsorption chamber means.

10. Apparatus as recited in claim **1,** in which said vapor collecting means include vacuum pump means for drawing vapors through said collection line means and delivering said vapors to said adsorption chamber means, there being a return line for delivering vapors from said pump means back to said tank means.

11. Apparatus as recited in claim **1,** in which said vapor collecting means include vacuum pump means for drawing vapors through said collection line means and delivering said vapors to said adsorption chamber means, there being a return line for delivering vapors from said pump means back to said tank means, and a valve connected into said return line adapted to permit flow of vapor but prevent flow of liquid therethrough in a direction away from said tank means.

12. Apparatus as recited in claim **1,** in which said vapor collecting means include vacuum pump means for drawing vapors through said collection line means and delivering said vapors to said adsorption chamber means, there being a pressure regulator valve between said pump means and said adsorption chamber means.

13. Apparatus comprising:

a liquid dispensing system including tank means for holding a flammable liquid, hose means for dispensing said liquid, and discharge nozzle means on said hose means;

means for collecting flammable vapors of said liquid from said dispensing system and including collection line means for withdrawing vapors from the vicinity of said nozzle means during a dispensing operation;

adsorption chamber means through which said collected vapors and intermixed air are passed and containing a substance adapted to adsorb said vapors;

an engine;

means for feeding said collected vapors from said chamber means to the intake of said engine to burn therein;

a vapor flow line through which vapor may flow between said tank means and said adsorption chamber means; and

a valve connected into said vapor flow line and adapted to permit flow of vapor but prevent flow of liquid therethrough toward said chamber means.

14. Apparatus comprising:

a liquid dispensing system including tank means for holding a flammable liquid, hose means for dispensing said liquid, and discharge nozzle means on said hose means;

means for collecting flammable vapors of said liquid from said dispensing system and including collection line means for withdrawing vapors from the vicinity of said nozzle means during a dispensing operation, and vacuum pump means for drawing vapors through said collection line means;

adsorption chamber means to which said vapors are discharged by said vacuum pump means and containing a substance adapted to adsorb said vapors;

a pressure opening valve between said pump means and said adsorption chamber means adapted to be opened by the pressure of said pump means but to close under a reduced pressure when the pump means are not operating;

an engine;

means for feeding vapors from said chamber means to the engine to burn therein; and

means for delivering air to the intake of said engine.

15. Apparatus as recited in claim **14,** including a pressure regulator valve between said pump means and said pressure opening valve acting when said pump means are in operation to maintain a regulated pressure at the inlet side of said pressure opening valve high enough to open the latter.

16. Apparatus as recited in claim **14,** including a pressure regulator valve between said pump means and said pressure opening valve acting when said pump means are in operation to maintain a regulated pressure at the inlet side of said pressure opening valve high enough to open the latter, a vapor line extending from a point between said pump means and said regulator valve back to said tank means, and a float valve in said vapor line preventing liquid flow therethrough in a direction away from said tank means.

17. Apparatus as recited in claim **14,** including a pressure regulator valve between said pump means and said pressure opening valve acting when said pump means are in operation to maintain a regulated pressure at the inlet side of said pressure opening valve high enough to open the latter, a vapor line extending from a point between said pump means and said regulator valve back to said tank means, a float valve in said vapor line preventing liquid flow therethrough in a direction away from said tank means, a vent to atmosphere communicating with said tank means, and a pressure relief valve on said vent.

18. Apparatus as recited in claim **17,** in which said vapor feeding means include a first line for delivering vapors from said chamber means to the engine, and a pressure regulator in said line; said air delivering means including a second line for delivering air to said engine, adjustable metering valve means in said second line, a third line by-passing said metering valve means, and a pressure opening valve in said third line adapted to open and pass an increased amount of air to said engine in response to an increase in the pressure of said vapors upstream of said pressure regulator of the vapor feeding means.

19. Apparatus comprising:

dispensing means for delivering a flammable liquid into a tank, and including a dispensing conduit and a discharge nozzle;

manually actuated means for controlling the operation of said dispensing means;

means for withdrawing flammable vapors from the vicinity of said nozzle;

chamber means containing an adsorbent substance through which said vapors are passed in a relation causing adsorption of said vapors onto said substance;

an engine receiving vapors from said substance and within which said vapors are burned;

a starter for starting said engine; and

means for energizing said starter in response to operation of said manually actuated means.

20. Apparatus as recited in claim **19,** in which said dispensing means includes a liquid pump for forcing said flammable liquid through said nozzle and into said tank, said manually actuated means serving when actuated to commence operation of said liquid pump.

21. Apparatus as recited in claim **19,** including delay means acting to terminate energization of said starter after it has been in operation for an interval of time.

22. Apparatus as recited in claim **19,** in which said dispensing means include a liquid pump for forcing said flammable liquid through said nozzle and into said tank, said manually actuated means serving when actuated to commence operation of said liquid pump, there being time delay means acting to terminate energization of said starter after it has been in operation for an interval of time, said means for withdrawing vapors including a vapor suction line, a valve in said line, and a vacuum pump, there being means for opening said valve and energizing said vacuum pump in response to actuation of said manually actuated means.

23. Apparatus comprising:

dispensing means for delivering a flammable liquid into a tank, and including a dispensing conduit and a discharge nozzle;

manually actuated means for controlling the operation of said dispensing means;

means for withdrawing flammable vapors from the vicinity of said nozzle and including a vacuum pump;

chamber means containing an adsorbent substance through which said vapors are passed in a relation causing adsorption of said vapors onto said substance; and

means for activating said vacuum pump to withdraw vapors from the vicinity of said nozzle in response to actuation of said manually actuated means.

24. Apparatus as recited in claim **23,** in which said dispensing means include a liquid pump for forcing said flammable liquid through said nozzle, said manually actuated means serving when actuated to commence operation of said liquid pump.

25. Apparatus comprising:

dispensing means for delivering a flammable liquid into a tank, and including a dispensing conduit and a discharge nozzle;

manually actuated means for controlling the operation of said dispensing means;

means for withdrawing flammable vapors from the vicinity of said nozzle and including a vapor suction line and a valve controlling flow therethrough;

chamber means containing an adsorbent substance through which said vapors are passed in a relation causing adsorption of said vapors onto said substance; and

means for opening said valve in response to actuation of said manually actuated means.

26. Apparatus as recited in claim **25,** in which said dispensing means include a liquid pump for forcing said flammable liquid through said nozzle, said manually actuated means serving when actuated to commence operation of said liquid pump.

27. The method that comprises:

collecting flammable vapors from a flammable liquid dispensing system having a tank and at least one dispensing conduit with a discharge nozzle;

adsorbing at least some of said collected vapors onto an adsorbent material;

delivering said collected vapors and air to an engine in a ratio combustible in the engine; and driving said engine solely by the combustion of said collected vapors.

28. The method as recited in claim **27,** including turning said engine over and attempting to start it intermittently to burn up any accumulated vapors.

29. The method as recited in claim **27,** including returning some of said collected vapors back to said

tank.

30. The method that comprises:

operating a liquid dispensing system at different times to dispense a flammable liquid from a tank through a conduit and nozzle;

collecting flammable vapors from said system;

adsorbing at least some of said collected vapors onto an adsorbent material;

delivering said collected vapors and air to an engine to burn therein; and

turning said engine over and attempting to start it at said times when the dispensing system is operated.

31. Apparatus comprising:

dispensing means for delivering a flammable liquid into a tank, and including a dispensing conduit and a discharge nozzle;

means for withdrawing flammable vapors from the vicinity of said nozzle;

chamber means containing an adsorbent substance through which said vapors are passed in a relation causing adsorption of said vapors onto said substance;

an engine receiving vapors from said substance and within which said vapors are burned;

a starter for starting said engine; and

timer means for automatically energizing said starter at predetermined timed intervals to turn said engine over.

32. Apparatus comprising:

dispensing means for delivering a flammable liquid into a tank, and including a dispensing conduit and a discharge nozzle;

means for withdrawing flammable vapors from the vicinity of said nozzle;

chamber means containing an adsorbent substance through which said vapors are passed in a relation causing adsorption of said vapors onto said substance;

an engine receiving vapors from said substance and within which said vapors are burned;

a starter for starting said engine; and

means for energizing said starter at different times and including means for automatically terminating said energization of the starter after it has been in operation for an interval of time.

33. Apparatus as recited in claim **1**, including an electrical generator driven by said engine.

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