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Doncer et al.

[11] **3,861,890**

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[54] **GASOLINE VAPOR RECOVERY SYSTEM AND METHOD**

[75] Inventors: **Alex J. Doncer**, Burbank; **Harold R. White**, New Lenox, both of Ill.

[73] Assignee: **Alar Engineering Corporation**, Burbank, Ill.

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[52] **U.S. Cl.** **55/88**
[51] **Int. Cl.** **B01d 53/14**
[58] **Field of Search** .... 55/68, 84, 88, 89; 62/54; 220/85 VR, 85 VS

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Primary Examiner—Charles N. Hart
Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

Gasoline vapor recovery system particularly adapted for bulk flow plants. The system includes an absorber into which raw gasoline vapor is introduced, as by a connection from a tank truck while the tank truck is loaded with gasoline. Light oil, such as kerosene, is pumped into the absorber and acts as a carrier, carrying the gasoline vapor through a heat exchanger and trim heater to adjust the temperature and then through a stripper, from which the gasoline is stripped from the kerosene as a vapor. The gasoline vapor is drawn from the stripper to a gas cooler by a vacuum pump and then compressed and condensed in the form of a liquid blendable into a desired grade of gasoline. The lean oil from the system may be pumped back to the absorber and reused.

5 Claims, 2 Drawing Figures

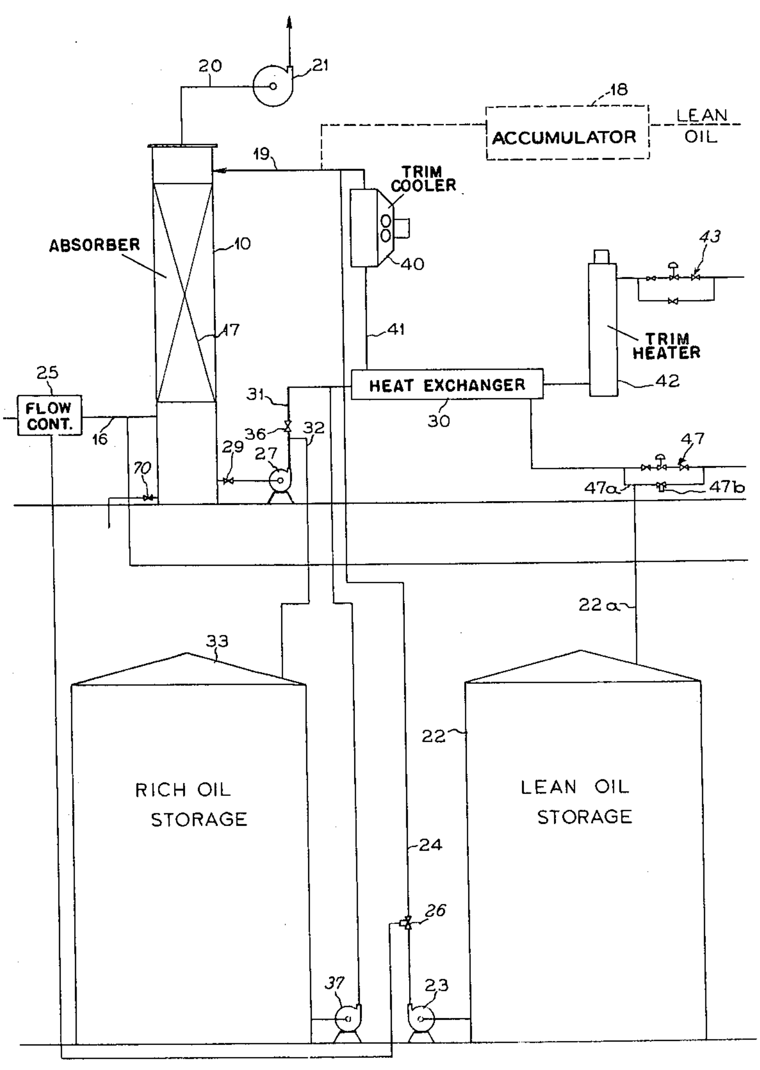


Fig. 1

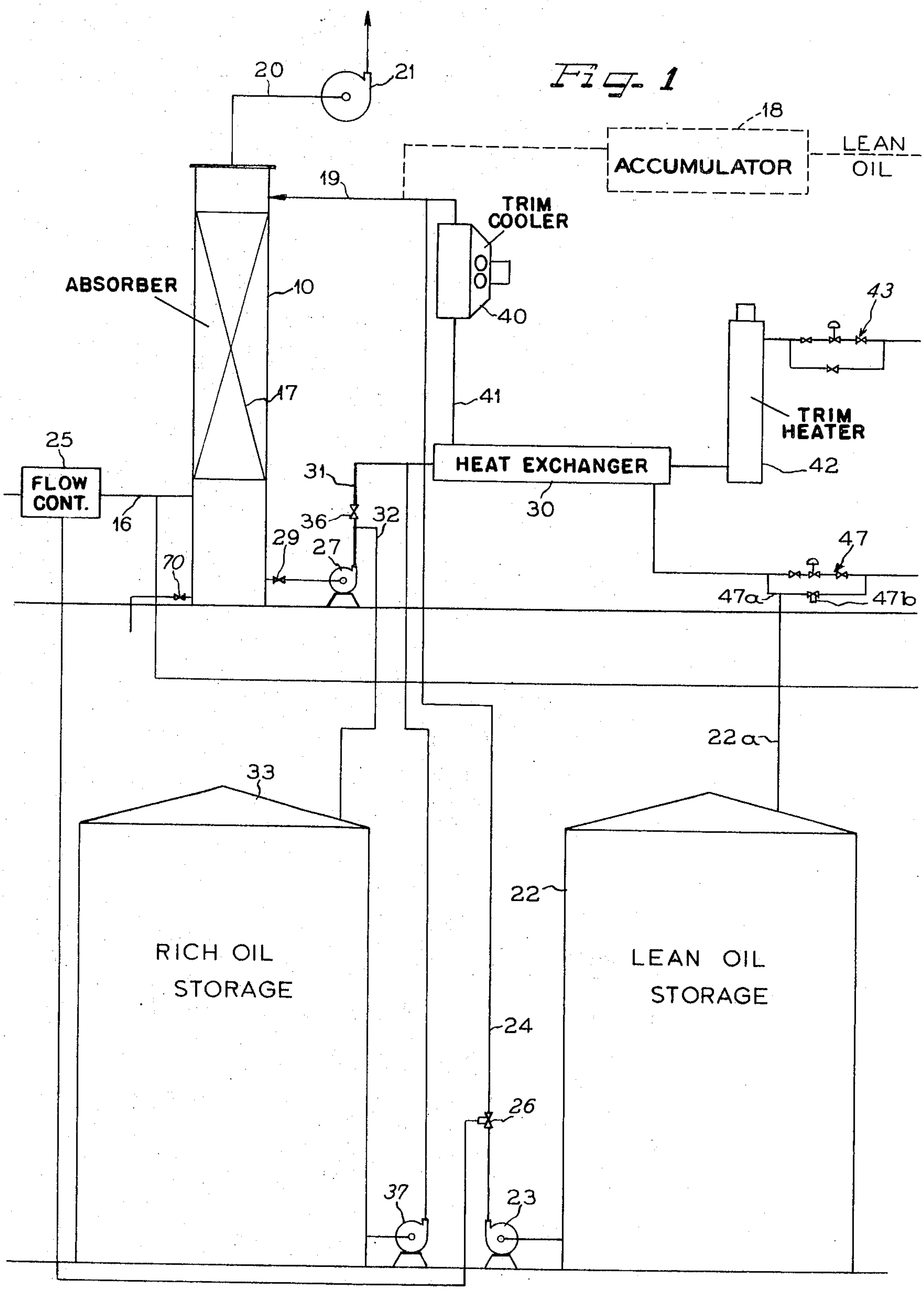
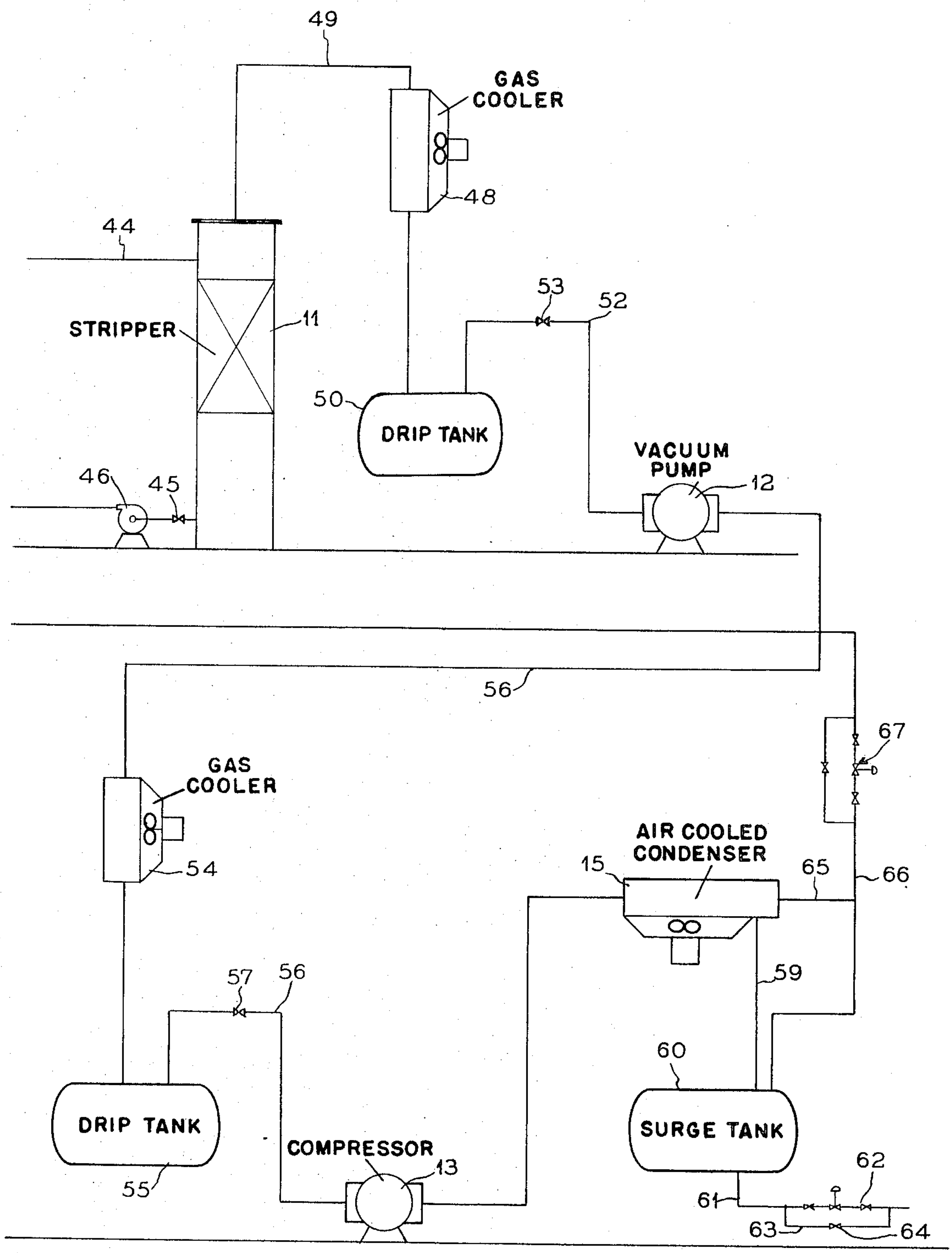

20
21
18
ACCUMULATOR
LEAN OIL
19
TRIM COOLER
ABSORBER
10
40
43
17
41
TRIM HEATER
25
FLOW CONT.
HEAT EXCHANGER
42
31
16
36
32
30
29
27
47
70
47a
47b
22a
33
22
RICH OIL STORAGE
LEAN OIL STORAGE
24
26
37
23

Fig. 2


49
GAS COOLER
48
44
STRIPPER
11
53
52
50
DRIP TANK
VACUUM PUMP
12
46
45
56
67
GAS COOLER
54
AIR COOLED CONDENSER
15
65
66
57
56
59
60
DRIP TANK
SURGE TANK
55
COMPRESSOR
13
62
61
63
64

GASOLINE VAPOR RECOVERY SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

Recovery system for gasoline vapor by the use of a lean oil as a carrier.

2. The Prior Art

Heretofore air gasoline vapors, generated by bulk loading operations have been recovered by refrigeration. Such methods of recovering gasoline vapors are expensive and complicated and usually require a high degree of maintenance and, therefore, are uneconomical for the average bulk gasoline terminal operation.

The present invention provides a simple and economical system for recovering gasoline vapors generated by bulk loading operations by the use of a light oil as a carrier, which may be kerosene, and then stripping the light oil from the vapor by vacuum, and recovering the gasoline by compressing and condensing the stripped vapor.

An advantage of the present invention is in the simplification in the recovery of gasoline vapors or other hydrocarbons by using a light oil as a carrier for the hydrocarbons and stripping the oil from the hydrocarbon vapor enabling the hydrocarbon vapor to be compressed and condensed for reblending for storage and reuse.

Another advantage of the present invention is in the simplification of the recovery of gasoline vapors without the need for the complicated and expensive refrigeration systems heretofore necessary for such purposes.

Still another advantage of the invention is the provision of a recovery system for gasoline vapors utilizing kerosene as a carrier, which may be recovered for reuse and recycled as stripped from the gasoline vapor.

A further advantage of the invention is in the efficiency and low operating cost of the gas vapor recovering system, making it particularly adapted for bulk terminal operations.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic view diagrammatically illustrating one-half of the recovery system; and

FIG. **2** is a diagrammatic view forming in effect a continuation of FIG. **1** and illustrating the balance of the system.

DESCRIPTION OF PREFERRED EMBODIMENTS OF INVENTION

In the embodiment of the invention illustrated in the drawings, the system of recovering the gasoline from the gasoline vapors consists essentially of an absorbing column **10**, a stripping column **11**, a vacuum pump **12**, a compressor **13** and a condenser **15**, all connected in series.

The absorber **10** may be of any conventional form and has an inlet line **16** for gasoline vapor shown as being disposed beneath packing **17** of the absorber. A suitable connection (not shown) may be provided from a tank truck (not shown) at the bulk station to the inlet line **16** to admit gasoline vapor at atmospheric pressure to the absorber beneath the packing **17** thereof of a volume, for example, of the order of 50 cubic feet per minute for the present system.

The components of the vapor may, for example, be:

Component	Summer	Winter
C_3	1%	1%
iC_4	11%	15%
nC_4	9%	12%
C_5	10%	10%
C_6	2%	2%
C_7	2%	2%
Air	65%	58%

where C_3 is propane; iC_4 is isobutane; nC_4 is N butane; C_5 is pentane; C_6 is hexane; and C_7 is heptane.

An inlet **19** for light oil, such as kerosene, enters the top of the adsorber and passes downwardly through the packing therein and mixes with the gas vapor and acts as a carrier therefor. An outlet **20** may lead from the top of the absorber to a pump **21,** for essentially removing air from the absorber and discharging the air to atmosphere.

As shown in FIG. **1,** a lean oil storage tank **22** is provided for storing a lean oil such as kerosene, to be delivered to the lean oil inlet **19** through a pump **23** connected with a pipeline **24** leading from said pump to the inlet line **19.** A flow control **25** is provided in the inlet line **16** for gas vapor. Said flow control may be a flow sensor and may have control connection with a control valve **26** in the inlet line **24** for lead oil, to admit lean oil into the absorber at a rate proportionate to the admission of gasoline vapor into the absorber.

While we have herein shown a lean oil storage tank in the system, it should be understood that if desired the lean oil storage tank and pump may be dispensed with and that an accumulator **18** may be instead used to supply the lean oil to the adsorber. The accumulator **18** is diagrammatically shown by broken lines in FIG. **1** to indicate it may be an alternative form of the invention, and may be of any suitable conventional form so need not herein be shown or described in detail.

The air gas mixture mixed with the light oil in the absorber will result in a rich oil at the bottom of the absorber, which may be pumped from the absorber by a pump **27** under the control of a valve **29.** From the pump **27** the rich oil may be pumped to a heat exchanger **30** through a line **31,** at which point the components, for example, may be as follows:

	Mol.%
C_3	0.16
iC_4	2.06
nC_4	1.71
C_5	2.05
C_6	0.65
C_7	1.04
Sol.	92.32

The resultant mixture, therefore, may contain 92.32 percent of solvent rich oil passing to the heat exchanger at a temperature which may be of approximately 100° and a pressure of approximately 14 pounds per square inch at the rate of 254 cubic feet per minute in an exemplary system of the capacity described.

A return line **32** for the rich oil is shown as leading to the top of a rich oil storage tank **33.** The storage tank for rich oil need only be provided where the system does not use an accumulator. A valve **36** controls the return of rich oil to the rich oil storage tank, while a pump **37** is provided to pump rich oil from the rich oil storage tank to the inlet line **31** to the heat exchanger **30.**

A trim cooler **40** is connected with the heat exchanger **30** adjacent the inlet end thereof through a line **41.** The trim cooler **40** serves as an additional heat exchanger to adjust the temperature and may pump the gas vapor and the solvent mixture to the absorber **10** through the inlet line **19** to the top of the absorber. The components of this mixture, for example, may be as follows:

	Mol.%
C_3	0.00
iC_4	0.24
nC_4	0.25
C_5	0.58
C_6	0.36
C_7	0.80
Sol.	97.77

The trim cooler **40** may be a conventional form of cooler well-known to those skilled in the art, so need only be shown diagrammatically herein, and, for example, may have a capacity of 53,000 B.T.U. per hour at an operating temperature of 112°F.

The gasoline vapor mixed with oil passes from the heat exchanger to a trim heater **42,** which may be in the form of a second heat exchanger which for a basic unit of 50 cfm may have an operating capacity of 100,000 B.T.U. per hour and an operating temperature of 208°F. with a design capacity of 112,000 B.T.U. per hour and a design temperature of 600°F. and a design pressure of 125 psi.

The solution of gasoline and kerosene is passed through the trim heater **42** under the control of a system of valves **43** through a line **44** to the top portion of the stripper column **11,** where the kerosene or light oil is separated from the gasoline vapor. A valve **45** and pump **46** may return the kerosene or light oil to the heat exchanger, adjacent the outlet end thereof, under the control of the valve **45** and a system of valves **47,** to thereby recirculate the light oil.

A gas cooler **48** is connected with the top of the stripper **11** through a line **49** to withdraw the gasoline vapor removed from the light carrier oil and cool the vapor and allow the cooled vapor to drop into a drip tank **50.** The gas cooler **48** may be similar in construction to the trim cooler **40** with an air rate capacity in the order of 6,500 B.T.U. per hour.

The vacuum pump **12** is connected with the drip tank through a line **52** under control of a valve **53** and withdraws the gasoline vapor and passes the vapor to a second gas cooler **54** having a second drip tank **55** disposed therebeneath and connected therewith through a line **56.**

The compressor **13** is connected to the second drip tank **55** through a line **56** having a valve **57** therein. Said compressor compresses the gasoline vapor conducted from the vacuum pump **12** to the air cooled condensor **15** where it is discharged in the form of a liquid through a line **59** leading to a surge tank **60.** A discharge line **61** leads from the bottom of the surge tank **60** and may conduct the gasoline for reblending under the control of a series of valves **62** including a bypass line **63** having a valve **64** therein, for bypassing the valves **62** where desired or required.

With the present system, the gasoline recovered may be at the rate of 0.4 gallons per minute and may, for example, have the following composition:

Comp.	Mol.Fr.
C_3	Nil
iC_4	0.3163
nC_4	0.2580
C_5	0.3006
C_6	0.0623
C_7	0.0620

Vapors from the condenser **15** may be recycled to the absorbing column through a line **65** leading from the condenser **15** and connected with a line **66** having fluid connection with the intake line **16.** A system of control and bypass valves **67** is connected in a recycling line **66** to control the recycling of the vapors not condensed. The line **66** is also connected to the top of the surge tank **60,** to recycle vapors in said tank.

Where an accumulator such as the accumulator **18** is provided in the system, the same components are in the system except the lean oil storage tank **22** and the rich oil storage tank **33** need not be used. The light oil is thus applied from a suitable source of supply through the accumulator **18** to the lean oil inlet line **19,** connected from the trim cooler **40** to the top part of the absorber **10,** which line also transmits oil and gasoline vapor from the heat exchanger **30** and trim cooler **40** to be absorbed by the lean oil.

In this system, the flow controller **25** and pumps **23** and **37** may be dispensed with, and the gasoline vapor may be compressed in the compressor to pressures in the order of 200 psi and condensed as a liquid suitable for blending into regular grade gasoline, as previously described. Vapors from the condenser may also be recycled to the absorbing column to insure the maximum possible recovery, as previously described.

Certain of the valves and controls for the pumps and other components may be electrically operated and controlled to enable suitable control means (not shown) of a form known to those skilled in the art to make the system fully automatic. With a basic unit having an accumulator, without the rich oil and lean oil storage tanks, at the start of the day, the operator may start the system by depressing a start button (not shown). The vacuum pump **12,** oil circulating pump **27** and heat exchangers **30** and **42** start and the system remains in a warm-up condition until normal operating conditions are established. The trim coolers **40,48,54,** compressor **13** and condenser **15** will also start. As normal operating conditions are established, a "ready" light (not shown) on a control panel (not shown) may flash and the operator may open a valve **70** which may be a safety valve of a well-known form, to admit the air-gasoline mixture to the adsorber. No further operator attention is required, as the system is self-adjusting over the entire range of operating conditions. At the end of the operating day, the operator may depress a "stop" button (not shown). The safety valve **70** will then close and the system will purge any gas vapors remaining by the pump **21,** prior to actual shut down.

Other controls of a conventional form and no part of the present invention may also be provided to cause the system to shut down and purge upon a malfunction of the system, which may be indicated on an annunciator panel (not shown) and the sounding of an alarm (not shown).

Where an accumulator is not in the system, the lean oil storage tank **22** and rich oil storage tank **33** take the place of the accumulator. The operation of the system is, however, similar to the operation of the system using the accumulator, except the scrubbing system controls and the recovery system controls are separate. The scrubbing system may be started by depressing a "scrubber start" button (not shown). The lean oil pump **23,** trim cooler **40** and control system therefor may start and the loading operations may begin. When sufficient rich oil has accumulated in the storage tank **33,** the operator may start the recovery system by depressing a "recovery start" button (not shown). This will circulate the oil back to the rich oil tank until normal operating conditions are established. The valve **45,** which may be a solenoid operated valve, may then transfer the oil from the bottom of the stripper **11** to the heat exchanger under the control of the pump **46.** The series of valves **47** may also include a bypass line **47***a* having a valve **47***b* therein which may be solenoid operated, to enable the lean oil leaving the heat exchanger to be pumped to the lean oil storage tank through a line **22***a*, for recirculation over the adsorber. It is, of course, understood that when lean oil is returned to the lean oil storage tank, the valves **47** are closed. The cooler **40,** vacuum pump **12,** cooler **48,** compressor **13** and condenser **15** are then in operation to deliver the recovered gas from the surge tank **60** and recycle any remaining gasoline vapors back to the inlet line **16.**

It should be understood that the system just described in exemplary only and may be of various sizes and capacities, with the resultant varying volumes and pressures from those mentioned herein.

It should also be understood that the system is adaptable for various hydrocarbons with different components from those mentioned in the examples and the percentages of components of the vapor may vary under different outside temperature conditions.

We claim as our invention:

1. In a method of recovering gasoline from gasoline vapor, including

the provision of a lean oil storage tank and a rich oil storage tank,

establishing a constant feed of lean oil from the lean oil storage tank to an absorber,

withdrawing rich oil from the bottom of the absorber and passing to the rich oil storage tank,

passing the rich oil from the rich oil storage tank through a heat exchanger,

passing part of the oil from the heat exchanger to a trim cooler,

forcing the oil by the trim cooler to the absorber, and

passing the oil from the first heat exchanger through a second heat exchanger to a stripper and stripping the gasoline vapor from the the rich oil, removing the gasoline as a vapor by vacuum,

and then compressing and condensing the vapor and withdrawing the condensed vapor by blending in the form of a required gasoline mixture.

2. The method of claim **1,** including

the sensing of the flow of gasoline vapor to the absorber, and

controlling the flow of lean oil to the absorber and thereby balancing the flow of lean oil to the absorber in accordance with flow of gasoline vapor thereto.

3. The method of claim **1,** wherein the vapor remaining after the condensing operation is recycled through the absorber.

4. The method of claim **1,** wherein the heavy oil is passed through a plurality of heat exchangers in series with the stripper and the oil stripped from the gasoline in the stripper is recirculated through the heat exchanger.

5. The method of claim **1,** wherein the gasoline vapor is supplied to the absorber through an accumulator at atmospheric pressure and at a temperature in the order of 90°.

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