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[54] **BLENDING APPARATUS FOR VAPORIZING PROPANE**

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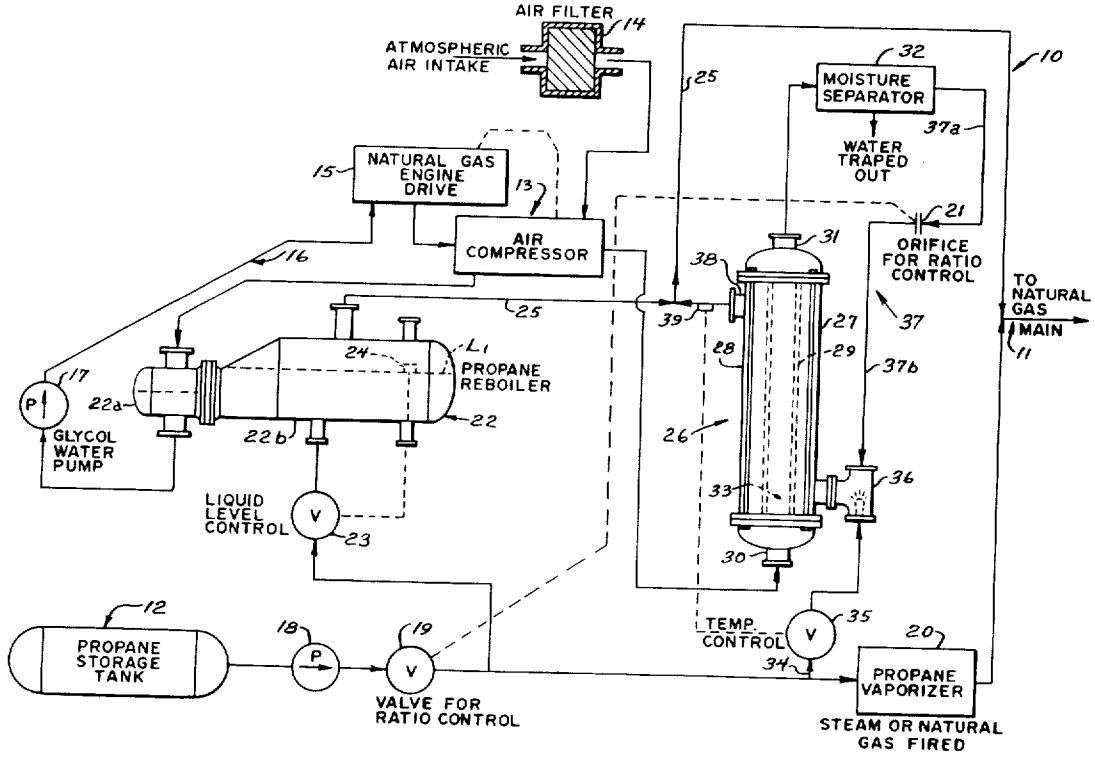
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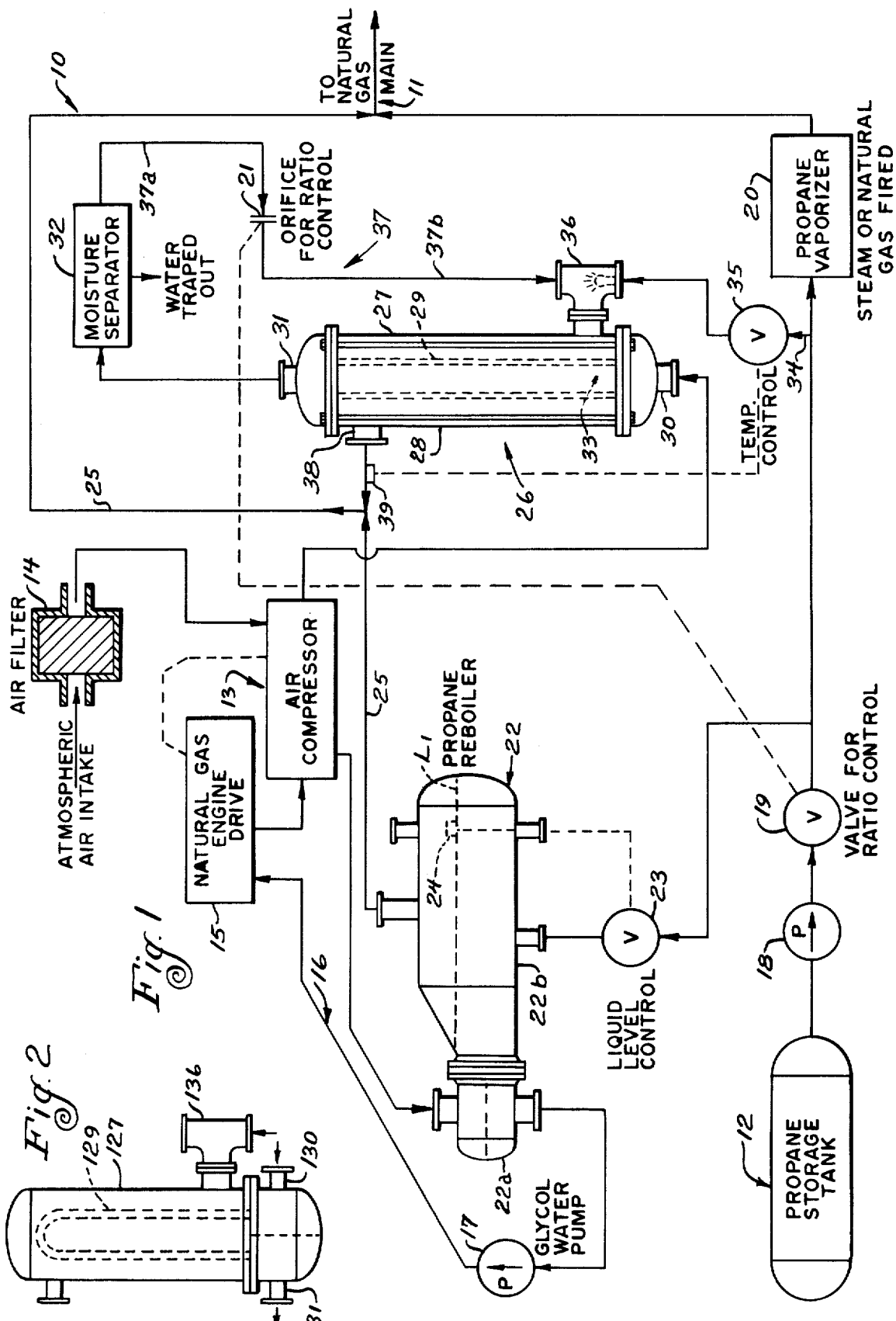
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[57] **ABSTRACT**

An apparatus for providing from a supply of liquefied fuel fluid, such as propane, an aerated, gaseous fuel fluid to be added to a natural gas distribution system from supplementation, standby or peak shaving service. The apparatus includes means for vaporizing a portion of the liquid fuel as a result of absorption of thermal energy developed in the process of compressing ambient air to be mixed with the supply fuel fluid in the aeration thereof. The apparatus further includes means for dehumidifying the compressed air utilizing a flashing of another portion of the liquid fuel into the compressed air so as to cool the air and permit subsequent removal of the condensed moisture by a separator apparatus.

17 Claims, 2 Drawing Figures




TO NATURAL GAS MAIN
11
10
MOISTURE SEPARATOR
32
37a
WATER TRAPED OUT
21
ORIFICE FOR RATIO CONTROL
37
37b
36
PROPANE VAPORIZER
20
STEAM OR NATURAL GAS FIRED
35
TEMP. CONTROL
34
31
27
29
28
33
30
38
39
26
25
AIR FILTER
14
ATMOSPHERIC AIR INTAKE
AIR COMPRESSOR
13
NATURAL GAS ENGINE DRIVE
15
16
PROPANE REBOILER
L1
22
24
22b
LIQUID LEVEL CONTROL
23
VALVE FOR RATIO CONTROL
19
18
P
PROPANE STORAGE TANK
12
GLYCOL WATER PUMP
17
22a
Fig. 1
Fig. 2
129
127
136
130
131

BLENDING APPARATUS FOR VAPORIZING PROPANE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to fluid supply apparatus, and in particular, to apparatus for providing from a supply of liquefied fuel fluid a gaseous fuel fluid.

2. Description of the Prior Art

In the distribution of natural gas, variations in demand have required reserve supply means. The reserve supplies have been provided by blenders which are thusly operated mostly in intermittent service and, thus, little consideration has heretofore been given as to maximizing the efficiency thereof. Conventionally, the reserve gas supply has been in the form of a blend of propane and air in a conventional ratio of approximately 53 percent propane and 47 percent air. The propane is conventionally provided in the form of liquefied propane and is provided as a by-product of conventional oil refining.

The suppliers of such liquefied propane have recently begun to require that the natural gas distribution companies purchase the propane on a continual basis and it has become economically desirable to provide a continuous blending of the propane-air mixture with the natural gas.

In the past, the peak requirements for natural gas have been in the coldest winter weather when heating units are operated at maximum level. Under these conditions, the compressed air is relatively low in humidity and presents no moisture problem in the mixing thereof with the propane.

The compression of the air has conventionally been effected by air compressors utilizing natural gas engine drives and again, as these drives are operated primarily in the coldest weather, minimum cooling of the air compressor drives has been required. Further as the ambient air was conventionally of extremely low temperature, no after-coolers were conventionally provided for cooling the compressed air.

SUMMARY OF THE INVENTION

The present invention comprehends an improved apparatus for providing from a supply of liquefied fuel fluid, such as liquid propane, butane, etc., a gaseous fuel fluid suitable for blending into a natural gas distribution supply.

More specifically, the invention comprehends providing such an apparatus wherein a portion of the fuel delivered to the natural gas supply is vaporized as a result of heat exchange with the means for compressing ambient air to be mixed with another portion of the fuel. In the illustrated embodiment, the air compressor is powered by a natural gas engine drive and the liquid fuel is vaporized by heat exchange with a coolant liquid flowed in heat exchange relationship with the engine drive and the liquid fuel.

The compressed air is dehumidified by cooling through a heat transfer surface so as to condense moisture therein. The condensed moisture is separated from the air in a conventional moisture separator apparatus. After the moisture separator, a liquid fuel stream is flashed into the dry air stream to provide the low temperature sink required for the heat exchange service.

A third means for vaporizing the liquid fuel may be provided which may utilize a conventional thermal energy source such as steam or natural gas burners and the vaporized fuel is delivered from each of the different vaporizing means such as the air compressor drive cooling means, the dehumidifying means, and the main vaporizing means to a delivery means defining the connection to the natural gas distribution system.

Resultingly, the vaporized power required may be reduced substantially to zero depending on the ambient air conditions. The use of the liquid fuel vaporizer for cooling the air compressor drive affords a substantial saving in the cost of the apparatus and the operation. The direct injection of liquid fuel into the air system results in a fuel vapor pressure that is compatible to dehumidification of the compressed air without having to pressure boost to the natural gas distribution as would be required by a single phase or indirect means. The portion of the fuel fluid vaporized in the air compressor drive cooling means and the dehumidifying means may be subtracted from the requirements of the main vaporizer so as to further increase the efficiency of the system.

The apparatus of the present invention is extremely simple and economical of construction while yet providing the highly desirable advantages discussed above.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. **1** is a schematic flow diagram of an apparatus embodying the invention; and

FIG. **2** is a fragmentary schematic illustration of a modified portion of the apparatus for dehumidifying the compressed air.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as disclosed in FIG. **1** of the drawing, an apparatus generally designated **10** is provided for delivering a supply of fuel fluid, such as propane, to a delivery means generally designated **11** comprising a connection to a natural gas distribution system main. The fuel fluid is provided from a supply **12** of liquefied fluid and is converted in the apparatus **10** to a gaseous fuel fluid suitable to be mixed with the natural gas. Illustratively, the gaseous fluid may comprise a blend of approximately 53 percent propane and 47 percent air.

In the illustrated embodiment, air is compressed by a conventional air compressor **13** utilizing ambient air delivered thereto through a suitable conventional filter **14.** The compressor may be driven by suitable power means, such as a natural gas engine drive **15,** and compressor **13** and drive **15** may be suitably cooled by a recirculating glycol-water system generally designated **16** utilizing a conventional pump **17** for effecting the desired circulation.

Liquid fuel is delivered by a conventional pump **18** from supply **12** through a suitable valve **19** to a vaporizer **20** which may utilize a conventional source of thermal energy such as steam or natural gas-fired means. The vaporized fuel is delivered from vaporizer **20** to the delivery means **11** for mixture with air delivered from the compressor **13.** The ratio of the air and fuel is controlled by regulation of valve **19** by means of an orifice control **21** in the air flow path as will be brought out more fully hereinafter.

The heat transfer liquid utilized for cooling the compressor drive **15** and compressor **13** is placed in heat transfer association with a portion of the liquid fuel fluid in a reboiler generally designated **22.** The coolant liquid is delivered from air compressor **13** to a first portion **22***a* of the reboiler. Liquid propane is delivered through a liquid level control valve **23** to a second portion **22***b* of the reboiler in heat transfer association with the coolant liquid in portion **22***a*. A liquid level control **24** is provided for maintaining the level of liquid propane at level L1 in reboiler portion **22***b*.

Heat transfer from the coolant liquid in portion **22***a* causes vaporization of the propane liquid in portion **22***b* and the vaporized propane is delivered through a conduit **25** to the outlet connection **11.** The vaporization of a portion of the liquid fuel delivered to delivery means **11** in cooling the air compressor means reduces the load on vaporizor **20** thereby increasing the efficiency of apparatus **10** and further permitting the apparatus to be used over a wide range of ambient temperature conditions. If desired, however, where the compressor drive utilizes an electric motor or the like, the reboiler means may be omitted for minimizing the cost of the apparatus.

The compressed air may include moisture which preferably should be removed before delivery of the air to the delivery means **11.** To this end, apparatus **10** includes a dehumidifying means generally designated **26** including a regeneration air chiller **27** comprising a shell and tube heat exchanger including an outer shell **28** and tube **29.** Compressed air is delivered through an inlet **30** and is passed through tubes **29** to an outlet **31** connected to a conventional moisture separator **32.** The air is cooled to a low temperature, such as approximately 37° F. by flashing propane from a spray nozzle counter flow into conduit **37.**

More specifically, a portion of the liquid propane is delivered from valve **19,** through a conduit **34** provided with a temperature controlled valve **35,** and an inlet connector **36** to chamber **33** and conduit **37.** Air is delivered to connector **36** by conduits **37***a* and **37***b* connected in series through orifice **21** from moisture separator **32.** A portion of the propane vaporizes at connector **36** and conduit **37***b* and the remainder vaporizes within chamber **33** as a result of the mixture of the propane with the air in accordance with the partial pressure law of fluid pressures. The blending of the air and propane lowers the vapor pressure of the propane to provide an excellent low temperature heat transfer means without requiring that the vapor pressure be subsequently boosted to permit delivery thereof through the delivery means **11** to the natural gas main.

Illustratively, the aerated fuel mixture delivered from the outlet **38** of chamber **33** may have a temperature of approximately 32° F., which temperature may be maintained by means of a control **39** sensing the temperature at outlet **38** and controlling valve **35.** The air-fuel mixture is delivered to conduit **25** from outlet **38** for delivery with the vaporized propane from reboiler **22** to delivery means **11.**

Thus, three separate deliveries of propane gas are effected to delivery means **11** in the illustrated apparatus **10.** The vaporization of the propane in the air compressor cooling means and the dehumidifying means effectively reduces the load on the vaporizer **20,** thus not only providing the highly desirable improved functioning of the apparatus, but further increasing the efficiency thereof.

Where the temperature of the compressed air delivered through inlet **30** to chamber **33** is approximately 120° F. or less, it has been found advantageous to provide a parallel fluid flow, as shown in the drawing, wherein the air flow through the tubes **29** and the flow of blended fluid through the chamber **33** are in the same direction through the air chiller. As will be obvious to those skilled in the art, where a higher temperature compressed air is provided, a 2 pass channel down counterconcurrent flow system, such as illustrated in FIG. **2,** may be utilized. As shown in FIG. **2,** where a counter-current flow system is utilized both the inlet **130** and outlet **131** may be disposed at the lower end of shell **127.** The tubes **129** would comprise conventional return bend tubes having both an inlet and outlet at the lower end of the shell for connection to the inlet **130** and the outlet **131,** respectively. Under extreme conditions, a conventional counter-flow system (not shown) may be suitable.

Illustratively, pump **18** may provide the liquid propane at a pressure of approximately 15 to 25 p.s.i.g. above gas main pressure. Similarly, air compressor **13** is preferably arranged to provide compressed air at 5 to 10 p.s.i.g. above gas main pressure at connector **11** to allow for system losses through the equipment. Typically, the gas main pressure is between 150 and 180 p.s.i.g. The vaporized propane from reboiler **22** may have a temperature illustrative of approximately 100° F. for mixture with the lower temperature blended air-fuel mixture delivered from the dehumidifying means **26.** The coolant system of the air compressor may utilize a 50 percent ethylene glycol and water mixture which may be maintained in the range of approximately 140° to 115° F. by the heat exchange with the liquid propane in reboiler **22.**

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

I claim:

1. Apparatus for providing from a supply of liquefied fuel fluid a gaseous fuel fluid, comprising: delivery means; powered means for compressing ambient air; means providing a heat transfer coolant in heat exchange relationship with said powered means for cooling said powered means; means for providing heat exchange between the liquid fuel fluid and said coolant for cooling said coolant and vaporizing said liquid fuel fluid; and means for delivering to said delivery means a mixture of fuel fluid vaporized by said heat exchange means and air compressed by said powered means.

2. The apparatus of claim **1** wherein said powered means includes a natural gas engine drive means.

3. The apparatus of claim **1** wherein said heat exchange means includes means providing a liquid heat exchange medium for transferring heat from said air compressing means to said liquid fuel fluid.

4. The apparatus of claim **1** wherein said heat exchange means includes reboiler tank and means for maintaining a level of liquid fuel fluid therein for heat exchange with the air compressing means.

5. The apparatus of claim **1** further including means for removing moisture from the compressed air prior to the delivery thereof to said delivery means.

6. The apparatus of claim **1** further including means for vaporizing a second portion of the liquid fuel fluid

and combining the vaporized fuel fluid with the compressed air, said delivery means further defining means for delivering the combined vaporized fuel fluid and compressed air to said delivery means.

7. The apparatus of claim 1 further including means for flashing a second portion of the liquefied fuel fluid into the compressed air to refrigerate the compressed air.

8. The apparatus of claim 1 further including means responsive to a change of condition of a second portion of the liquefied fuel fluid for removing moisture from the compressed air.

9. Apparatus for providing from a supply of liquefied fuel fluid an aerated gaseous fuel fluid, comprising: delivery means; means for providing compressed air; means for flashing the liquefied fuel fluid; means responsive to the flashing of the liquefied fuel fluid for dehumidifying the compressed air; and means for delivering a mixture of the dehumidified compressed air and the flashed fuel fluid to said delivery means.

10. The apparatus of claim 9 wherein said flashing means comprises means for flashing said liquefied fuel fluid into the compressed air, and said dehumidifying means includes means to cool the air suitably to condense moisture therein and means for separating the condensed moisture from the cooled air.

11. THe apparatus of claim 9 wherein the flashing means is arranged to further cool the dehumidified air subsequent to the dehumidification thereof.

12. The apparatus of claim 9 wherein said dehumidifying means comprises means for cooling the air suitably to condense moisture therein, and means for separating condensed moisture from the cooled air, said apparatus further including means for placing the dehumidified air in heat exchange relationship with the flashing liquid fuel fluid for further cooling the dehumidified air prior to delivery to said delivery means.

13. The apparatus of claim 9 wherein said dehumidifying means comprises a shell and tube heat exchanger arranged to cause vaporization of the liquefied fuel fluid into the compressed air within the shell portion thereof and thereby cool compressed air in the tube portion thereof suitably to condense moisture therein, means for separating the condensed moisture from the cooled air, the dehumidified air passing through the shell of the heat exchanger with the vaporizing liquefied fuel fluid further cooling the air prior to the delivery thereof to said delivery means.

14. The apparatus of claim 9 further including controlled valve means responsive to the rate of flow of the dehumidified air for controlling the rate of delivery of liquefied fuel fluid from the supply.

15. The apparatus of claim 14 wherein said controlled valve means includes orifice means in the flow path of the air between said flashing means and said delivery means, and a valve responsive to the flow through the orifice means for controlling the flow of liquefied fuel fluid from the supply.

16. The apparatus of claim 9 wherein said flashing means includes a nozzle for injecting fuel fluid from the supply into the dehumidified compressed air.

17. The apparatus of claim 9 further including means for vaporizing a portion of the liquefied fuel fluid of said supply and means for deliverying said vaporized portion to said delivery means.

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