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Mulliner

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[54] **APPARATUS FOR ODORIZING LIQUID NATURAL GAS**

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[73] Assignees: **San Diego Gas & Electric Co.**, San Diego; **Dual Fuel Systems, Inc.**, Los Angeles, both of Calif. ; part interest to each

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[51] **Int. Cl.²** **C10L 10/00**

[58] **Field of Search** ..... 48/195; 236/21 R; 44/59, 44/2, 52

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[57] **ABSTRACT**

Liquid natural gas is odorized with an odorant in discrete volumes as the liquid natural gas is being transferred from a bulk storage vessel to a tanker or the like. An odorant vessel containing odorant and a diluent is communicated to an injection vessel to fill the latter, whereupon high pressure gas from a third vessel forces the odorant and diluent through a heat exchanger and into the liquid natural gas. In the heat exchanger, the odorant-diluent mixture is cooled to a predetermined level by liquid natural gas boil-off from the bulk storage vessel. This procedure is repeated as many times as is necessary to odorize the quantity of natural gas being taken from a bulk storage vessel.

13 Claims, 3 Drawing Figures

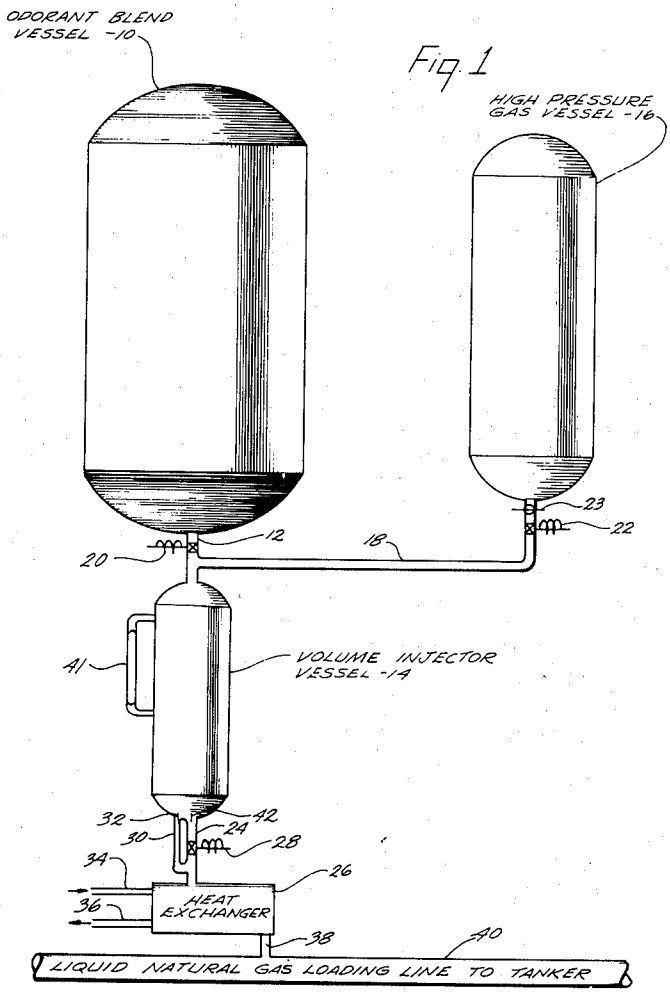
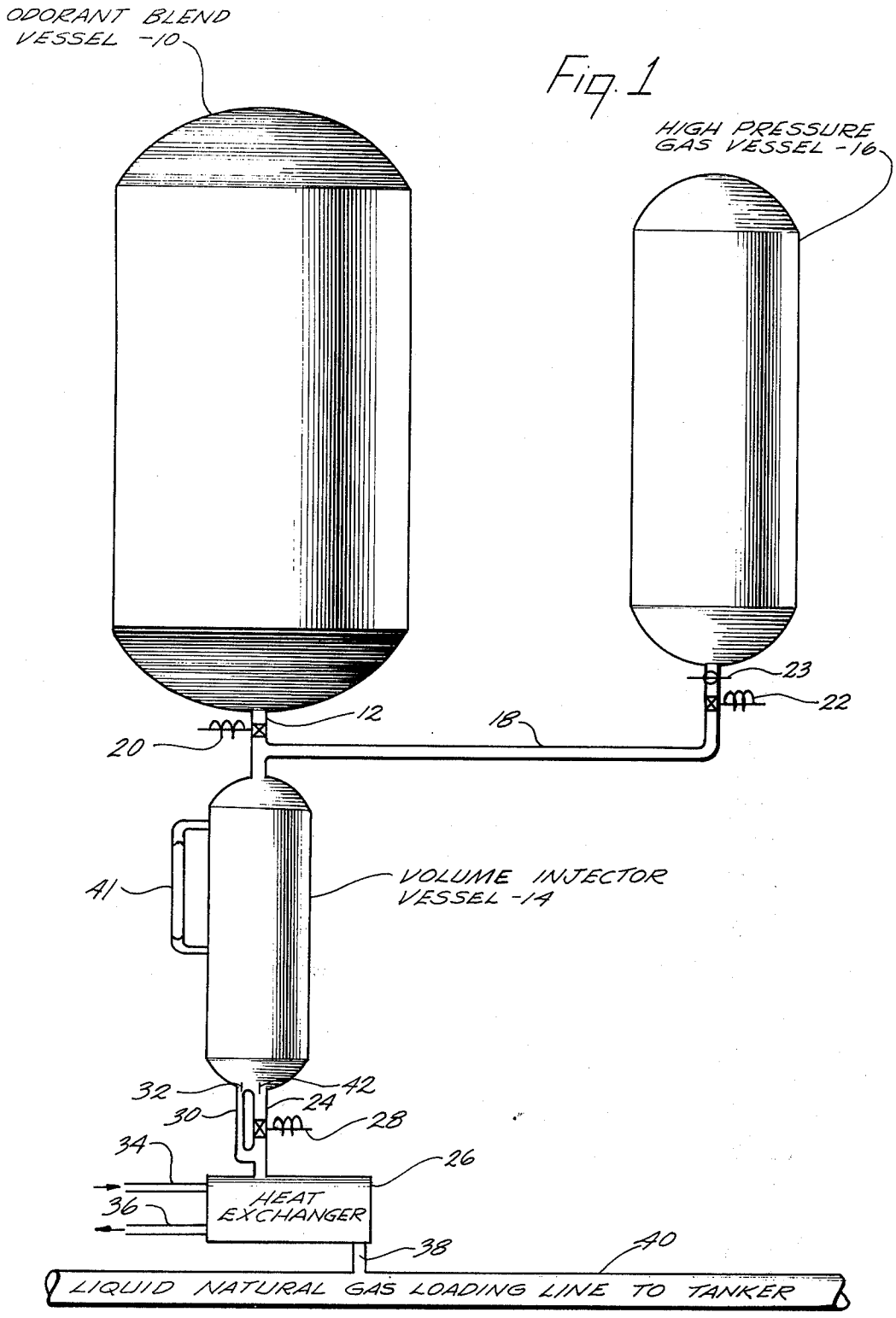


Fig. 1


ODORANT BLEND VESSEL -10
HIGH PRESSURE GAS VESSEL -16
23
22
12
18
20
VOLUME INJECTOR VESSEL -14
41
32
42
24
30
28
34
26
HEAT EXCHANGER
36
38
40
LIQUID NATURAL GAS LOADING LINE TO TANKER

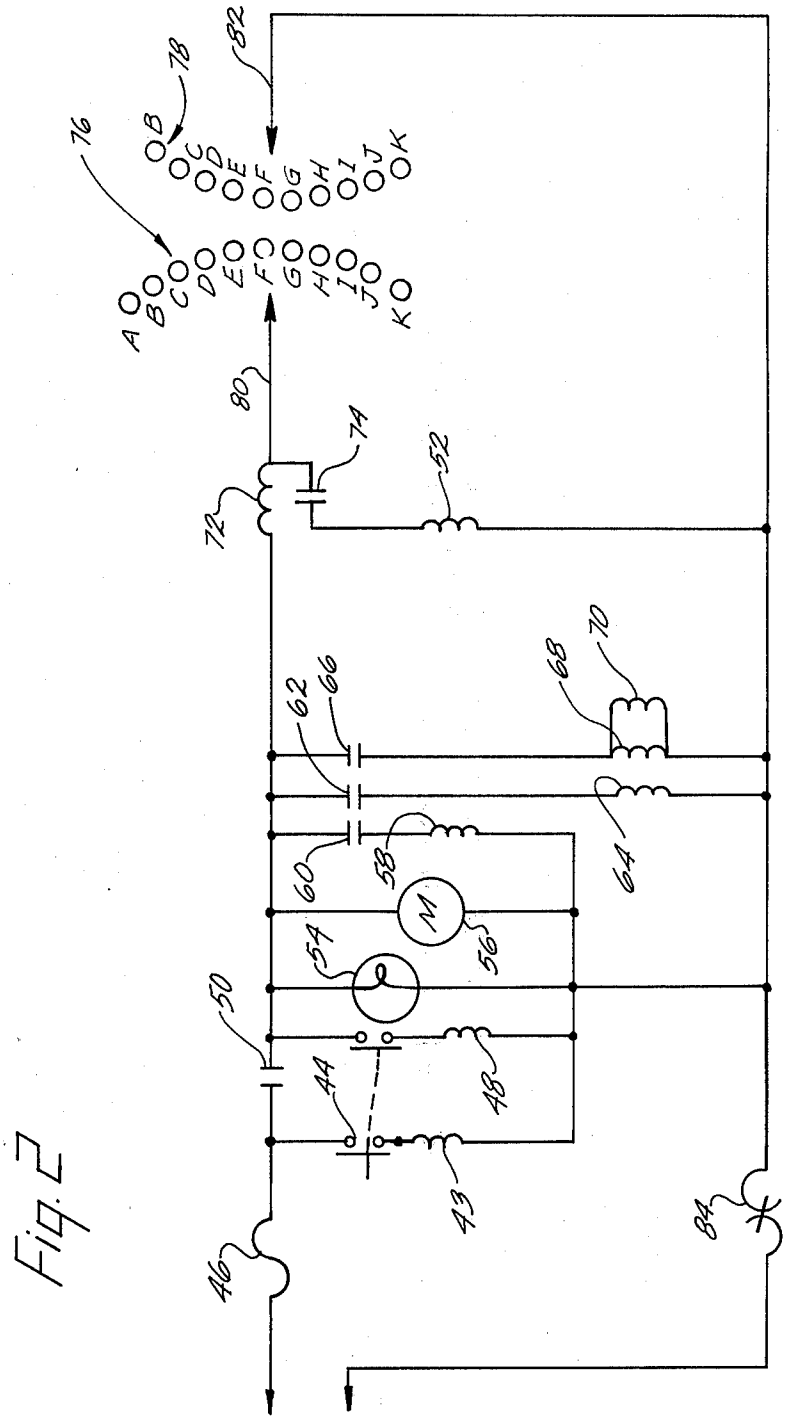

76
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Fig. 2

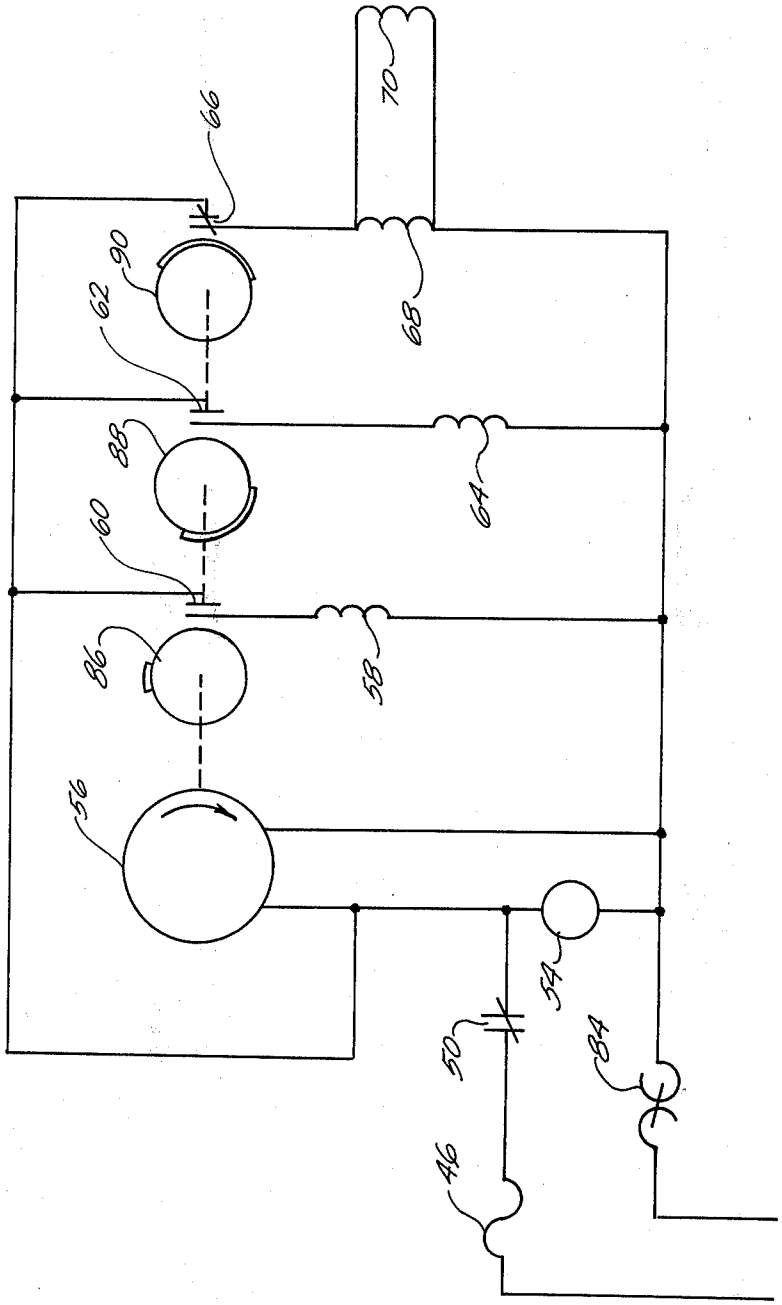


Fig. 3

APPARATUS FOR ODORIZING LIQUID NATURAL GAS

BACKGROUND OF THE INVENTION

The present invention relates to the odorization of natural gas and, more in particular, to an apparatus and method for odorizing liquid natural gas.

Natural gas in its pure state is odorless. Obviously, because of the hazards associated with this combustible gas, it is desirable to have some means to detect leaks in storage vessels, pipelines and the like. The accepted manner of leak detection is to odorize the natural gas and through odor note the presence of a leak.

If has long been recognized that an effective amount of odorant is an amount sufficient to warn of a leak but not very much more. Over-odorization is not desirable because the odor can be present even absent a leak. For example, a pilot flame may not burn all the odorant.

It is becoming increasingly recognized that natural gas storage in liquid form is an effective and economical way of transporting large quantities of the gas and for storing it for use, as in peak demand applications. Liquid natural gas may be used and transported by tankers to remote locations where pipelines for natural gas are not economically feasible. Liquid natural gas is also being used as a fuel for motor vehicles.

It is preferred, when liquefying natural gas, that all impurities be removed from the gas so that it is stored in liquid form in a substantially pure state. With this removal of impurities, any natural or added odorants are removed. If odorants are not removed, they will freeze in the process of liquefication. The reasons for the purification are well known and include the avoidance of frozen substances which foul liquefication equipment and subsequent vaporization equipment.

However, it is extremely desirable, if not mandatory, to odorize the liquefied natural gas taken from bulk storage for subsequent use, as in the transport in a tanker or the liquid natural gas fuel tank of a motor vehicle. The liquid natural gas must, moreover, be odorized to within prescribed limits.

The apparatus and method for odorizing liquid natural gas should be economical, easy to use and very accurate.

SUMMARY OF THE INVENTION

The present invention provides an apparatus and method for odorizing liquid natural gas which is especially useful in odorizing the liquid natural gas during its transfer from bulk storage to, for example, a tanker or a smaller storage vessel.

Briefly, the present invention contemplates forcing a predetermined volume of an odorant-diluent solution from a source thereof into liquid natural gas by means such as a high pressure gas. The high pressure gas keeps the pressure in the environment of the diluent above the vapor pressure of the diluent at the prevailing temperature and, therefore, keeps the diluent as a liquid and as a solvent for the odorant. If the pressure on the diluent is lower than the vapor pressure of the diluent, the diluent will evaporate leaving an insufficient quantity of diluent to keep the odorant from freezing at the temperature of the liquid natural gas.

In a copending application by the same inventor and assigned to the same assignee, a process of odorizing liquid natural gas with a thiophene odorant is described. In this copending application, the use of a diluent, preferably propane, for the thiophene odorant has been found very effective in keeping the thiophene odorant from freezing at the −260°F. temperatures typically associated with liquid natural gas storage. More in particular, the propane is mixed with the odorant with at least 20 parts by volume propane for each part odorant to form a true solution. The solution, before injection into the liquid natural gas, is cooled to a temperature of at least −20°F. and no more than about −60°F. The upper temperature of −20°F. is a practical limit for keeping the propane from boiling away at the pressure of injection, thus losing the freezing point depression it produces on the odorant and allowing the odorant to precipitate out of solution with the liquid natural gas and be rendered ineffective. The lower limit of −60°F. is the limit of sufficient thermal agitation to effectively mix the odorant-diluent solution with the liquid natural gas.

Liquid natural gas is typically transferred from a bulk storage vessel to a tanker or other vessel at pressures of from about 15 to 20 p.s.i.g. At these pressures propane, unless sufficiently cooled, will boil. Propane at room temperature has a vapor pressure of about 160 p.s.i.g. Thus it is clear that for accurate metering of the diluent-odorant solution into liquid natural gas, while maintaining the propane as a liquid, requires the use of some means to keep the propane at a sufficiently high pressure during the injection that it does not boil.

These problems are resolved in accordance with a particular form of the present invention. An odorant-diluent storage vessel is provided which is in selective communication with an injection vessel of predetermined volume. A high pressure gas source, such as a vessel, is also in selective communication with the injection vessel in parallel with the odorant-diluent vessel. A normally closed valve normally prevents communication between the odorant-diluent vessel and the injection vessel. In like manner, a normally closed valve normally keeps the high pressure gas vessel out of communication with the injection vessel. The injection vessel is in selective communication with a bulk liquid loading line through a heat exchanger. The heat exchanger cools the odorant-diluent solution about to be injected into the liquid natural gas to within the predetermined temperature range noted above. A normally closed valve normally prevents communication between the injection vessel and the liquid natural gas bulk loading line.

A unique control circuit is provided to ensure the sequence of events required to effectively odorize liquid natural gas with the requisite volume of the odorant-diluent solution within the proper temperature range without excessive operator attention. For example, the circuit automatically turns the injection apparatus off at the end of a desired volume of odorant-diluent injection.

These and other features, aspects and advantages of the present invention will become more apparent from the following description, appended claims, and drawings.

DESCRIPTION OF THE FIGURES

FIG. 1 is a line schematic diagram illustrating the apparatus of the present invention;

FIG. 2 is a circuit diagram illustrating the control circuit of the present invention; and

FIG. 3 is a detail of the control circuit of FIG. 2 in an intermediate portion of an injection cycle.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides an apparatus and method for injecting an odorant-diluent solution into liquid natural gas to odorize the latter. The odorant-diluent solution is introduced into an injection vessel having a predetermined volume and is forced into liquid natural gas in a bulk transfer line by high pressure gas. The high pressure gas is at a pressure above the vapor pressure of the diluent at the prevailing temperatures in the injection vessel. The injection vessel is filled and the odorant-diluent solution injected into the liquid natural gas in the bulk loading line as many times as is necessary for effective odorization of the quantity of gas being transferred through the bulk loading line. The odorant-diluent solution is cooled prior to its injection to within a predetermined temperature range. Odorization is prevented unless such cooling has been accomplished.

The apparatus for odorizing will now be described.

With specific reference to FIG. **1**, an odorant-diluent storage vessel **10** is in series communication through a line **12** with an injection vessel **14.** The injection vessel has a predetermined volume. The predetermined volume of injection vessel **14** is determined by the particular type of odorant used, the odorant-diluent ratio, and typical amounts of liquid natural gas to be odorized. A discussion of these parameters will be undertaken subsequently. A high pressure gas storage vessel **16** is also in series communication with the injection vessel through a line **18** and line **12.** A normally closed, solenoid-operated valve **20** in line **12** is selectively operable to admit the odorant-diluent solution into the injection vessel from vessel **10.** Valve **20** is upstream from a junction between lines **12** and **18.** A normally closed, solenoid-operated valve **22** in line **18** is operable to admit high pressure gas from vessel **16** into injection vessel **14.** A regulator **23** in line **18** insures that the pressure of injection of the solution of odorant and diluent is constant.

A line **24** from injection vessel **14** leads to a heat exchanger **26.** A normally closed, solenoid-operated valve **28** in line **24** normally maintains injection vessel **14** out of communication with heat exchanger **26.** A bypass relief line **30** having a pressure relief orifice **32** is in parallel with and bypasses normally closed valve **28** and serves to vent the injection vessel after odorant and diluent have been ejected therefrom. Line **30** meets line **24** downstream of valve **28.** An inlet line **34** from a liquid natural gas bulk storage vessel provides liquid natural gas boil-off to the heat exchanger to cool odorant-diluent solution therein. A return line **36** from the heat exchanger returns warmed liquid natural gas boil-off to the bulk storage vessel. A line **38** between heat exchanger **26** and a bulk loading line **40** provides the communication between the heat exchanger and the bulk loading line. The bulk loading line is the transfer line between a bulk storage vessel and a vessel, such as a tanker, being filled with liquid natural gas. A metering orifice **42** in line **24** insures the accurate metering of the odorant-diluent solution from injection vessel **14** through the heat exchanger and ultimately into the bulk loading line at a flow rate sufficiently low to get good mixing of the odorant-diluent solution with the liquid natural gas.

A sight glass **41** is provided for operator convenience in determining the volume of odorant-diluent solution in the injection vessel.

When odorant is to be injected into the bulk loading line, the sequence of events is generally as follows. Normally closed valve **20** is opened while normally closed valves **22** and **28** are closed. The injection vessel is filled with the odorant-diluent solution. After the injection vessel has been filled with the odorant-diluent solution, normally closed valves **22** and **28** are opened and valve **20** is closed. High pressure gas, preferably methane, forces the volume of odorant-diluent in injection vessel **14** from injection vessel through line **24,** heat exchanger **26** and into the bulk loading line to odorize liquid natural gas flowing from the bulk loading vessel to, for example, a tanker. The odorant-diluent solution is cooled in heat exchanger **26** to within a predetermined temperature range. The cycle is repeated as is required for the effective odorization of the quantity of liquid natural gas being transferred through the bulk loading line.

The sequence of events described in general with reference to the line diagram of FIG. **1** is controlled by the circuit illustrated in FIGS. **2** and **3.**

In FIG. **2** a coil **43** of a latching relay is in series circuit with a source of alternating current through a normally open momentary switch **44** and a circuit protecting fuse **46.** Momentary switch **44** also controls a series circuit between a stepping relay coil **48** and the source of alternating current. Stepping relay coil **48** and latching relay coil **43** are in parallel circuit with respect to each other. Momentary switch **44** has two ganged switching elements to control the circuits to coils **43** and **48** of the latching and stepping relay.

Latching relay coil **43** controls normally open holding contacts **50** which function upon the energization of coil **43** to close and enable the circuit elements in series circuit with it to be in circuit with the power source. Contacts **50** once closed are maintained closed by a mechanical latch. The latch is freed and contacts **50** open when a coil **52** of the latching relay is energized.

A pilot light **54** is in parallel circuit relationship with stepping relay coil **43** and latching relay coil **48** and is in series with the source of alternating current, with fuse **46** and holding contacts **50** between them.

A timer motor **56** is also wired parallel with the aforementioned coils and also with the pilot light. The timer motor is in series with the source of alternating current through holding contacts **50** and fuse **46.**

A fifth parallel branch is made up of a second coil **58** of the stepper relay and normally open timer motor contacts **60.** Contacts **60** and coil **58** are in series with each other.

Still another parallel branch circuit includes series wired normally open contacts **62** of the timing motor and a coil **64** of solenoid-operated valve **20,** the latter being shown in FIG. **1** in line **12** between odorant-diluent vessel **10** and injection vessel **14.**

A third set of contacts **66** are also controlled by the timing motor and are in series circuit with parallel wired coils **68** and **70** of solenoid valves **22** and **28.** These valves control the flow of fluid from the high pressure gas vessel and the injecting vessel, respectively. Contacts **66** and coils **68** and **70** are in parallel

circuit with the other branch circuits previously described and in series with the source of alternating current, fuse **46** and holding contacts **50.**

A time delay branch of the circuit consists of a time delay relay coil **72** in series circuit with time delay contacts **74,** which are normally open, and second coil **52** of the latching relay. Contacts **74** are controlled by coil **72** and their time delay, to close, is produced by their bimetal construction. The branch circuit of coil **72,** contacts **74** and relay coil **52** is in parallel with the other branch circuits described and in series with the source of alternating current, fuse **46** and holding contacts **50.**

Stepper relay contacts and switching element **76** and a rotary switch **78** are provided in series circuit with each other to determine how many cycles the injection apparatus of the present invention goes through in any given injection process. The stepping relay is operative to progress from contact to contact until the contact matches or is in circuit with the contact of the selector switch, at which time the stepping sequence of the stepper relay ends and the injection cycle also ends.

In FIG. **2,** contacts of the stepper relay are indicated by reference characters A through K and the switching element is indicated by reference numeral **80.** The switching element is controlled by stepper relay coil **58** and functions to progress from character to character, say from A to B, each time timing motor contacts **60** are closed. Coil **48** of the stepper relay resets switching element **80** at contact A at the beginning of a new injection cycle.

Selector switch **78** has a plurality of contacts B through K which correspond to contacts B through K of stepper relay contacts and switching element **76.** Thus when the selector switch switching element, indicated by reference numeral **82,** is set at B, switching element **80** of the stepper relay advances only from A to B and only one complete injection cycle is effected.

Switching element **80** is in series circuit with coil **72** of the time delay relay and through fuse **46** and holding contacts **50** with the source of alternating current. Switching element **82** of selector switch **78** is normally out of circuit with switching element **80,** as previously described, but when in circuit with switching element **80** is in series circuit with it.

In series circuit with all the circuit elements just described in a thermal switch **84** which senses the temperature of the diluent-odorant solution in the heat exchanger and opens the circuit if this temperature is too high. As previously mentioned, the temperature range of introduction of a thiophene-propane odorant-diluent solution into liquid natural gas is done within a temperature range of between about −20°F. and about −60°F. It is preferred that thermal switch **84** have a setting of, say, −40°F. such that when the temperature of the odorant-diluent solution rises above that value, the circuit opens and no injection takes place.

With reference to FIG. **3,** a more detailed depiction of the timing motor's circuit is illustrated. As previously mentioned, timing motor **56** is in series circuit with a source of alternating current through contacts **50** of the latching relay. The timing motor controls three sets of contacts **60, 62** and **66** which are in branch circuits parallel to each other and parallel to the timing motor, as previously described. Cams **86, 88** and **90** of the timing motor are set to progressively close contacts **60, 62** and **66,** respectively. The branch of the circuit having contacts **60** controls the coil of the stepper relay. The branch of the circuit having contacts **62** controls the coil of solenoid valve **20.** And finally, the branch of the circuit which includes contacts **66** controls the circuit to coils **68** and **70** of solenoid valves **22** and **28.** The cams of the timer motor are set such that a predetermined time is allowed after initiation of a cycle by the closing of the momentary switch **44** for injection vessel **14** to depressurize. After that vessel is depressurized, cam **88** of the timing motor closes normally open contacts **60** to energize coil **64** of the solenoid of valve **20** to admit odorant-diluent from vessel **10** into the injection vessel. After sufficient time for filling the injection vessel has passed, valve **20** is closed through cam **88** passing off the movable contact and opening the circuit to coil **64.** At this point cam **90** of the timing motor closes contacts **66** to coils **68** and **70** of solenoid valves **22** and **28.** This is the orientation shown in FIG. **3** but it should be appreciated that contacts **66** are normally open.

In any event, contacts **66** control the circuit to coils **68** and **70** of solenoid valves **22** and **28** so the duration that cam **90** maintains the contacts closed is determined by the time required for high pressure gas in vessel **16** to force the volume of odorant-diluent in injection vessel **14** into bulk transfer line **40.**

As previously mentioned, the odorant is put into solution with a diluent. The preferred odorant and diluent combination used with the present invention is thiophene and propane, with the propane-thiophene ratio on a volume basis being at least **20** parts propane to one part thiophene. The thiophene is selected from the class of thiophenes consisting of one or more of tetrahydrothiophene (C_4H_8S), 2-methylthiophene (C_5H_6S), and 3-methylthiophene (C_5H_6S). The specific thiophenes just listed have a freezing point well above the boiling point of liquid natural gas and consequently tend to freeze when introduced into the liquid natural gas. Upon the freezing of the odorant, odorization of liquid natural gas is not effective, for solid odorant does not dissolve in the liquid natural gas at a rate sufficient to be effective. The diluent-propane in the volume ratio specified is very effective in lowering the effective freezing point of the thiophene. In fact, freezing point depressions on the order of −300°F. have been noted with the propane-thiophene solution.

However, the propane dilution of thiophene is not enough to prevent freezing precipitation of the thiophene at liquid natural gas temperatures. In addition, the propane must be cooled sufficiently so that it does not boil off at the pressures typically associated with liquid natural gas storage and transfer, from about 15 to about 20 p.s.i.g. Therefore, the propane-thiophene solution is cooled prior to its introuction to a temperature compatible with introduction at these pressures. It has been found that a minimum temperature of −20°F. is necessary to prevent the boiling off of the propane. If the temperature of the propane-thiophene solution is lowered too much, sufficient thermal agitation to effect the complete blending of the odorant-diluent solution in the liquid natural gas is not present. It has been found that below about −60°F. that sufficient thermal agitation does not take place for the complete blending of the odorant-diluent solution into the liquid natural gas.

In operation, an operator selects the appropriate amount of odorant-diluent solution to be injected into

the bulk loading line on selector switch **78**, say, a quantity corresponding to F on the selector switch. The operator then presses momentary switch **44** to close its contacts. Latching relay coil **43** is temporarily energized. Upon the energization of this coil, latching relay contacts **50** close and are maintained closed by a mechanical latch, a well known expedient. With the momentary closure of switch **44**, coil **48** of the stepper relay is energized to act on the pawl of a ratchet to release it and allow a spring to act on switching element **80** and return it to the A position. With the closure of the latching relay contacts, the pilot lamp and timing motor are energized. With boil-off from the bulk storage vessel passing through heat exchanger **26** and a temperature there of, say, −40°F., thermal switch **84** is closed to close the circuit to all operating elements.

The timing motor is set to run for a predetermined time to allow injection vessel **14** to depressurize. Depressurization occurs by bleeding through pressure relief orifice **32** in line **30**, which bypasses normally closed valve **28** and discharges the vented gasses into the liquid natural gas bulk loading line, the high pressure gas being methane, the major constituent of liquid natural gas.

After the time for depressurization of the injection vessel, cam **88** of timing motor **56** acts on normally open contacts **62** to close them and energize coil **64** of solenoid valve **20**. This admits the odorant-diluent solution into the injection vessel. After the time for filling the injection vessel has been completed, cam **88** moves out of engagement with contacts **62** to open the circuit to solenoid valve **20** and close the valve.

AT this point cam **90** of timing motor **56** acts on contacts **66** to close them and energize coils **68** and **70** of solenoid valves **22** and **28** to open these valves. With the opening of these two valves communication between high pressure gas vessel **16** and the injection vessel is established and communication between the injection vessel and the bulk transfer line is also established.

The high pressure gas will act on the odorant-diluent blend and force the blend slowly through metering orifice **42** with the controlled admission of the odorant-diluent solution into the bulk transfer line. The metering orifice provides for the slow injection of the odorant-diluent blend in order to prevent excessive concentrations of the solution and the precipitation of the odorant. After the emptying of injection vessel **14** contacts **66** open as cam **90** passes out of engagement with them and contacts **60** close to energize stepper relay coil **58**. Stepper relay coil **58** acts on switching element or armature **80** of the stepper relay coil to advance it one position.

The cycle is repeated until the switching element or armature of the stepper relay steps to the set point of the selector switch. When this occurs, the circuit is completed through the coil of time delay relay **72** which acts on time delay contacts **74** to heat them and to close them to energize coil **52** of the latching relay. This coil acts on latching relay contacts **50** to open them and deenergize the entire circuit. The time delay circuit ensures that the timing motor cam has sufficient time to rotate to its initial position for the next odorization sequence.

The present invention has been described with reference to a certain preferred embodiment. The spirit and scope of the appended claims should not, however, necessarily be limited to the foregoing description.

What is claimed is:

1. An apparatus for odorizing liquid natural gas comprising:

a. means for a source of an odorant-diluent solution;

b. an injection vessel having a predetermined volume in selective serial communication with the source means of odorant-diluent solution;

c. a gas vessel for a source of high pressure gas, the gas vessel being in selective serial communication with the injection vessel independently of the source means for the odorant-diluent, the high pressure gas being used to maintain a pressure in the injection vessel while odorant-diluent is in such vessel above the vapor pressure of the diluent and for ejecting the odorant-diluent solution from the injection vessel into the liquid natural gas to be odorized, the gas vessel maintaining the pressure independently of the liquid natural gas;

d. a heat exchanger between the injection vessel and the liquid natural gas to be odorized to cool the odorant-diluent solution to within a predetermined temperature range, the minimum temperature of the range being substantially higher than the boiling point of liquid natural gas;

e. normally closed valve means in the selective serial communication between the source means of odorant-diluent solution and the injection vessel;

f. normally closed valve means in the selective serial communication between the high pressure gas vessel and the injection vessel;

g. normally closed valve means between the injection vessel and the liquid natural gas to be odorized;

h. circuit means including:

i. means coupled to the valve means between the injection vessel and the liquid natural gas to be odorized to prevent the opening of such valve means and communication between the injection vessel and the liquid natural gas to be odorized unless the odorant-diluent solution in the heat exchanger is within the predetermined temperature range;

ii. means to open the normally closed valve between the source means of odorant-diluent and the injection vessel; and

iii. means to open the valve between the high pressure gas vessel and the injection vessel after the injection vessel has been filled with a volume of odorant-diluent from the source means thereof and after the normally closed valve between the odorant-diluent source means and the injection vessel has been closed.

2. The apparatus claimed in claim **1** including means to vent the injection vessel of high pressure gas after a volume of odorant-diluent has been forced therefrom into the liquid natural gas by the pressure means.

3. The apparatus claimed in claim **1** wherein the circuit means includes:

means to open the valve between the injection vessel and the liquid natural gas to be odorized after the injection vessel has been filled with a volume of odorant-diluent from the source means thereof and after the normally closed valve between the odorant-diluent source means and the injection vessel has been closed.

4. The apparatus claimed in claim 3 including means to vent the injection vessel of high pressure gas after a volume of odorant-diluent has been ejected therefrom by the high pressure gas.

5. The apparatus claimed in claim 3 including selector means for repeatedly filling and emptying of the injection vessel from the source means of odorant-diluent and into the liquid natural gas to be odorized, respectively, a preselected number of times.

6. An apparatus for odorizing liquid natural gas comprising:

a. means for a source of an odorant-diluent solution;

b. an injection vessel having a predetermined volume in selective serial communication with the source means of odorant-diluent solution;

c. a gas vessel for a source of high pressure gas, the gas vessel being in selective serial communication with the injection vessel independently of the source means for the odorant-diluent, the high pressure gas being used to maintain a pressure in the injection vessel while odorant-diluent is in such vessel above the vapor pressure of the diluent and for ejecting the odorant-diluent solution from the injection vessel into the liquid natural gas to be odorized, the gas vessel maintaining the pressure independently of the liquid natural gas;

d. a heat exchanger between the injection vessel and the liquid natural gas to be odorized to cool the odorant-diluent solution to within a predetermined temperature range, the minimum temperature of the range being substantially higher than the boiling point of liquid natural gas;

e. normally closed first solenoid valve means in the selective serial communication between the source means of odorant-diluent solution and the injection vessel;

f. normally closed second solenoid valve means in the selective serial communication between the high pressure gas vessel and the injection vessel;

g. normally closed third solenoid valve means between the injection vessel and the liquid natural gas to be odorized;

h. circuit means including:

i. means coupled to the third solenoid valve means to prevent the opening of the third solenoid valve means and communication between the injection vessel and the liquid natural gas to be odorized unless the odorant-diluent solution in the heat exchanger is within the predetermined temperature range;

ii. means to open the normally closed first solenoid valve means while maintaining the second and third solenoid valve means closed to admit a predetermined volume of odorant-diluent solution into the injection vessel; and

iii. means to open the normally closed second and third solenoid valve means at the same time while maintaining the normally closed first solenoid valve means closed to eject a volume of odorant-diluent solution from the injection vessel into the liquid natural gas to be odorized.

7. The apparatus claimed in claim 6 including selector means for repeatedly filling and emptying the injection vessel from the source means of odorant-diluent and into the liquid natural gas to be odorized, respectively, a preselected number of times.

8. The apparatus claimed in claim 7 wherein the opening means for the solenoid valve means includes:

a. a timing motor having first and second timing cams;

b. a first set of normally open contact means disposed for engagement by the first timing motor cam to close a circuit to the coil of the first solenoid valve means;

c. a second set of normally open contact means disposed for engagement by the second timing motor cam to close a circuit to the coils of the second and third solenoid valve means; and

d. the first and second cams being set so that only one engages its associated contacts at any one time and the first set of contacts is engaged first.

9. The apparatus claimed in claim 7 wherein the means for repeatedly filling and emptying the injection vessel includes:

a. a stepper relay having a plurality of contacts, a switching element and a stepper relay coil, the stepper relay coil being operable when energized to advance the switching element progressively from one contact to another;

b. a selector switch having a plurality of contacts each being in electrical circuit with an associated different one of the contacts of the stepper relay and operable when a switching element of the selector switch is at a selector switch contact corresponding to a desired number of injection cycles to establish a circuit through the contact of the stepper relay associated with such selector switch contact; and

c. means responsive to a circuit through any one of the contacts of the stepper relay to open the entire circuit and stop the injection cycles.

10. The apparatus claimed in claim 9 wherein the means for repeatedly filling and emptying the injection vessel includes:

a. a timing motor having a first and a second cam;

b. a first set of normally open contacts engageable by the first timing motor cam to close a circuit to the coil of the first solenoid valve means;

c. a second set of normally open contacts engageable by the second cam of the timing motor after the first set of timing motor contacts open, the second set of contacts when engaged by the second cam closing a circuit to the second and third solenoid valve means to open these valve means.

11. The apparatus claimed in claim 10 including a third timing motor cam and a third set of timing motor contacts engageable by the third timing motor cam, the stepper relay coil being in circuit with the third set of timing motor contacts to be energized when such contacts close.

12. The apparatus claimed in claim 11 including means to vent the injection vessel of high pressure gas after a volume of odorant-diluent has been ejected therefrom by the high pressure gas.

13. The apparatus claimed in claim 6 including metering means for establishing a predetermined flow rate from the injection vessel into the liquid natural gas, the predetermined flow rate being low relative to a flow rate of the liquid natural gas to prevent overconcentration of odorant in the liquid natural gas and precipitation of odorant therein.

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