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METHOD OF STORING AND VAPORIZING LIQUEFIED GASES

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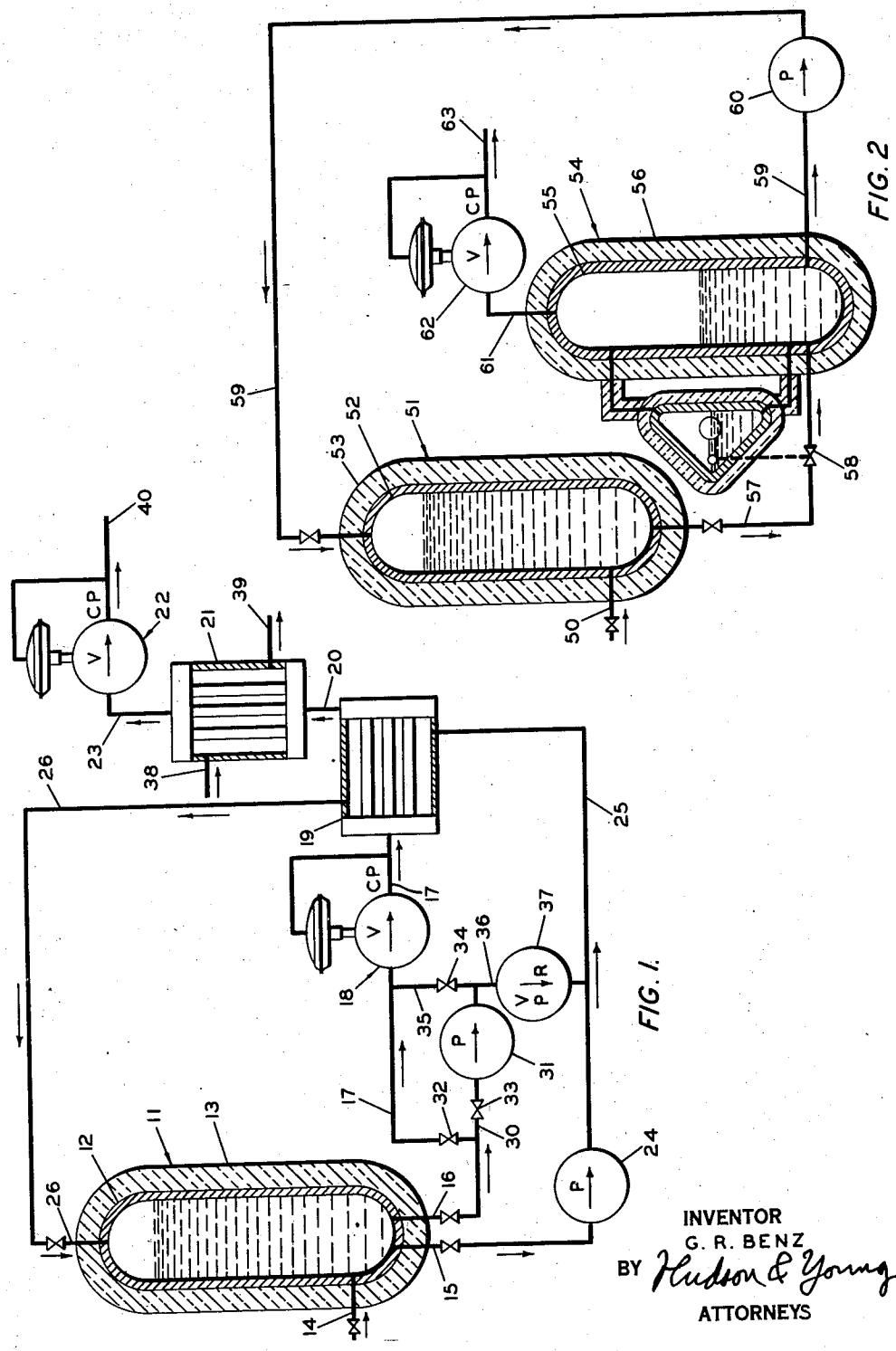


FIG. 2

FIG. 1.

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METHOD OF STORING AND VAPORIZING LIQUEFIED GASES

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This invention relates to the storage and vaporization of liquefied gases. In one of its more specific aspects it relates to a method for the storage of liquefied petroleum gases whereby the liquefied gas is maintained at a relatively low temperature to facilitate storage.

Because of their high vapor pressure at atmospheric temperature, liquefied gases such as liquefied petroleum gases require high pressure storage vessels or low pressure insulated storage vessels plus refrigeration to keep the stored material in the liquid state until needed for use in the gaseous form. Investment in storage equipment and cost of vaporization of these gases, particularly in large industrial and utility company installations, are therefore major items of expense.

One object of my invention is to provide a low cost method of storage of such liquefied gases using low pressure insulated tanks in place of the normally used high pressure uninsulated vessels.

Another object of my invention is to provide for low pressure storage apparatus wherein the vaporization unit permits uniformity in quality of vaporized gas from a mixture of stored gases.

Still another object of my invention is to provide a vaporization unit in conjunction with the storage vessel wherein the sensible heat of the stored liquid is utilized for its vaporization.

Still other objects and advantages of my invention will be apparent to those skilled in the art from a careful study of the following description and drawing which respectively describes and illustrates preferred embodiments of my invention.

In the drawing, Figure 1 illustrates one form of my storage and vaporization apparatus particularly adapted to the storage and vaporization of either individual hydrocarbons or mixtures of normally gaseous hydrocarbons.

Figure 2 illustrates a second embodiment of my invention which is especially adapted to the storage and vaporization of a single liquefied gaseous hydrocarbon.

Referring now to the drawing and especially to Figure 1, a tank assembly 11 is composed of an inner steel shell or tank 12, and an exterior insulation 13. The tank is equipped with four inlet or outlet lines 14, 15, 16 and 26. Pumps 24 and 31 are for transfer of liquefied gas while a vaporizer 18 is used for transforming the liquefied gas into its normally gaseous form, and a pressure regulator 22 controls final outlet pressure. 19 and 21 are heat exchangers.

In the operation of the embodiment of Figure

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1, a liquefied petroleum gas such as propane or butane or a mixture of these gase under sufficient pressure to insure that they are liquids at existing temperature, may be pumped into the tank assembly 11 through an inlet line 14 from any source, for example, a transport truck or tank car. Because of their high vapor pressure if these hydrocarbons are stored at atmospheric temperature thick walled high pressure vessels are required. I propose to cool these high vapor pressure liquids so that they may be stored at considerably lower pressures.

In relatively large installations, such as required by public utilities or in industrial installations, considerable heat is absorbed, or conversely, considerable cooling is available when these liquefied gases are vaporized for plant or utility use. I make use of this available cooling for maintaining the liquefied gas in the storage tank 11 at a low temperature.

In utility and industrial installations liquefied gas is most always continuously removed, vaporized and passed to the gas mains for transportation to points of consumption, and cooling is therefore nearly always available. For transfer to a gas main, as for example line 40, liquid is passed through an outlet line 16 and through a line 17 to a vaporizer 18. From this mechanism the hydrocarbon which is cooled in the vaporization step through vaporizer 18, passes on through line 17 into one end of the heat exchanger 19, out the opposite end and through the auxiliary heater 21, line 23 and pressure regulator 22 and finally into the gas main 40.

An additional and relatively large quantity of liquefied gas is withdrawn from the storage vessel 11 through the outlet line 15, and under pressure from a pump 24 passes on through a line 25 through the heat exchanger 19 in indirect heat exchange with the above mentioned cooled gas, and through a transfer line 26, is passed back into the storage tank 11. In this manner sensible heat from the liquefied gas passing through the exchanger 19 from line 25 furnishes heat for the evaporation of the liquefied gas passing through the exchanger from evaporator 18 and line 17. Liquid then emerging from the exchanger in line 26 has been cooled and this cooled liquid then passes on into the main storage vessel 11.

By continuously operating in this manner the body of liquid in vessel 11 is appreciably cooled and since the vessel is intended to be well insulated the liquid, once cooled, will remain cool

for considerable periods of time even during warm summer days.

Since the latent heat of evaporation of a compound or mixture of compounds is so much greater than the specific heat of the corresponding material, I have found that by operating a system in the manner just described, the liquefied gas in storage may be cooled to quite a low temperature and maintained at that low temperature with comparative ease.

I have further found especially under heavy vaporization load conditions that the liquid in the storage vessel may be cooled to such an extent that the stream passing through line 25 to the exchanger 19 will not contain sufficient sensible heat to complete the vaporization of the material passing through line 17 into the exchanger. Under these conditions line 20 may then contain some vapor or gas and some liquid and to complete the vaporization I have provided the auxiliary heat exchanger 21. I am able to use hot water or steam as a hot heat exchange medium for passing from line 38 into this latter exchanger and out through line 39. By supplying extraneous heat in this manner the hydrocarbon gas passing from this exchanger in line 23 is fully vaporized and ready for pressure reduction to gas main pressure in the regulator 22.

In the event that it is desired to maintain the pressure and temperature of the product in the storage vessel 11 as low as possible or near to the normal boiling point of the hydrocarbon stored, it may then be necessary to operate a pump 31 by closing valve 32 in line 17 and opening valves 33 and 34. Under these conditions liquid from tank 11 will pass through line 16, line 30, valve 33, pump 31, valve 34 and line 35 into the regulator or vaporizer 18 and exchangers 19 and 21 for complete vaporization. It will, of course, be necessary under such conditions to supply that amount of heat not supplied from the sensible heat of the product in storage by steam or hot water through the connections 38 and 39 on the exchanger 21 in order to secure final and complete vaporization of the gas prior to passing through the regulator 22 into the gas main.

In order to handle varying requirements for gas from the system the back pressure regulator 22 is used to permit flow of gas from the exchanger 21 to the gas main 40 as the pressure on the downstream side of regulator 22 tends to decrease. In this manner pressure on the system upstream of this regulator is accordingly held at least 10 to 20 pounds per square inch greater than on the downstream side. When using regulator 22 with pump 31, an excess of liquid hydrocarbon builds up between pump 31 and said regulator. The excess hydrocarbon liquid will enter the recirculation system through line 36. Thus this excess liquid put out by pump 31 will merely pass through line 36, regulator 37, line 25, exchanger 19, line 26 into the storage vessel 11.

Regulator 37 may be set at a pressure 10 to 20 pounds per square inch greater than the setting of regulator 22 so that there will always be a potential supply of liquefied gas ready to be vaporized for passage into the gas main 40.

In case the liquefied petroleum gas in storage tank 11 is one individual hydrocarbon, as for example, butane or propane, then the apparatus illustrated in Figure 2 of the drawing may be used. Under these special conditions it may well be advantageous to use this flow plan since such apparatus is very simple, and less expensive to install and to operate than the apparatus of Figure 1.

When employing a single hydrocarbon, there cannot be a change in composition of the liquefied gas during evaporation from a body of the liquid. Thus, the liquefied gas may be transferred from a tank car or transport truck, not shown, through a line 50 into a storage tank 51. This tank may be similar in all respects to tank 11 of Figure 1, and may be composed of steel walls 52 and a layer of insulation 53. An auxiliary tank or evaporator 54 may be of similar construction as tank 51 and accordingly composed of steel wall 55 and insulation 56.

A line 57 conveys liquefied gas from storage tank 51 into the evaporator tank 54. A liquid level controller device is installed as shown to operate a valve 58 for maintenance of a desired liquid level in the evaporator. A line 59 is adapted to convey liquefied gas from evaporator 54 to the storage tank 51 by action of a pump 60. A line 61 leading from the top of the evaporator 54 conducts vaporized hydrocarbon from the vapor space in said evaporator to a back pressure regulator 62 which discharges the gas at a lower pressure to a gas main 63 for transportation to points of distribution or use.

In this embodiment the pump 60 operates at substantially a constant capacity and circulates liquid from the evaporator 54 to the storage tank 51. As the liquid level in the evaporator drops below a predetermined point, the liquid level controller operates to open valve 58 and permit entry of liquefied gas from vessel 51. As the pressure in the gas main drops below a predetermined gas main pressure, the back pressure controller 62 opens and permits passage of gas from the vapor space in the evaporator 54 through line 61 into the gas main 63. When pressure in the vapor space in the evaporator 54 decreases below a certain point the liquid boils until the pressure increases sufficiently to cause an increased gas flow through line 61 into the gas main. Then at a time when the gas main pressure reaches a predetermined value the regulator 62 closes and flow through line 61 stops.

The evaporation of liquid in the evaporator 54 absorbs latent heat of evaporation and accordingly cools the liquid remaining in the evaporator so that it is cooled liquid which is pumped through line 59 back into the storage vessel 51. In this manner the stored liquid in vessel 51 becomes cooled and remains cool so that its vapor pressure or storage pressure is relatively low, and a less expensive storage vessel may be used.

In either embodiment, once the liquid is cooled, in large installations or in any installation wherein there is withdrawal of sufficient gas to maintain the remaining stored liquid well cooled, then the storage vessels may be of the less expensive low pressure type.

A further advantage of my invention is that a major part of the heat for the evaporation of the liquid is furnished by the sensible heat of the remaining stored liquid.

The tanks 11 and 51 may be of any shape or form desired, and of any construction desired. They need only to withstand such pressure as results from the liquefied gas as after being cooled according to my invention. The tanks 11 and 51 and the evaporator 54 of Figure 2 should be well insulated and such type of insulation is well known in the liquefied petroleum gas industry.

The pumps used herein may be any type de-

sired, and may be selected from among those commercially available, as long as they are capable of transferring cooled liquefied petroleum gases in a satisfactory and economic manner.

The pressure reducer 37 and the pressure reducer vaporizers 18 of Figure 1 and the back pressure regulators 22 of Figure 1 and 62 of Figure 2 may likewise be selected from among those commercially available and suited to the problem at hand.

In like manner the exchangers 19 and 21 of Figure 1 may be selected from among those available to perform such heat exchange as necessary. Likewise, hot water or steam or other heat exchange medium may be selected as desired for use in the exchanger 21 of Figure 1.

This invention is applicable, not only to the storage of propane or butane or mixtures of these as mentioned hereinbefore, but may also be used for the storage and vaporization of methane, ethane, as well as propane and butane, and the corresponding olefins and diolefins, as well as mixtures containing practical combinations of these gases.

Valves, safety valves, controllers and other auxiliary devices as might be deemed useful by those skilled in the art have been omitted for purposes of simplicity. Only those essential have been shown.

It will be obvious to those skilled in the art that many alterations and variations of my invention may be made and yet remain within the intended spirit and scope of my invention.

Having disclosed my invention, I claim:

1. A method for storing and dispensing liquefied gases in a gas dispensing system which comprises withdrawing a portion of said liquefied gas from the lower portion of a storage vessel and passing said portion to a heat exchange zone; vaporizing a first portion of said liquefied gas therein; removing said vaporized first portion from said heat exchange zone and passing it to a distribution zone; removing an unvaporized second portion from said heat exchange zone; mechanically maintaining said second portion under pressure; and returning said second portion to the upper portion of said storage vessel.

2. A method for storing and dispensing liquefied gas in a gas dispensing system which comprises withdrawing a first portion of said liquefied gas from a storage vessel and vaporizing said portion; withdrawing a second and larger portion of liquefied gas from said vessel and mechanically maintaining said second portion under pressure; passing said second portion of liquefied gas in heat exchange relation with said vaporized first portion in a heat exchange zone, whereby said second portion is cooled; passing said vaporized portion to a gas distribution zone; and returning said second liquefied gas portion to the upper portion of said storage vessel.

3. A method of storing and dispensing liquefied petroleum gas in a gas dispensing system which comprises withdrawing a first portion of liquefied petroleum gas from a storage zone; passing said first portion of liquefied gas through a pressure reducing zone to a primary heat exchange zone; withdrawing a second portion of liquefied petroleum gas from said storage zone; passing said second portion of liquefied petroleum gas under mechanical pressure through said primary heat exchange zone in indirect heat exchange with said first portion of liquefied petroleum gas, whereby said second portion is cooled; returning

said second portion to the upper portion of said storage zone; passing said first gas portion through an auxiliary heat exchange zone in indirect heat exchange with a hot fluid heat exchange material wherein additional vaporization of said first portion of liquefied gas is accomplished; and passing said vaporized gas portion through a pressure control zone to a gas distribution zone.

4. A method of storing and dispensing liquefied petroleum gas in a gas dispensing system which comprises withdrawing a first portion of liquefied petroleum gas from a storage vessel; passing said first portion of liquefied gas through a pump, whereby pressure is maintained on said first portion; withdrawing a second portion of said liquefied gas from said storage vessel; pumping said second portion under pressure into a primary heat exchanger; passing a first portion of said first liquefied gas portion through a pressure reducer vaporizer and through said primary heat exchanger in indirect heat exchange with said second portion of liquefied gas; passing a second portion of said first liquefied gas portion through a pressure regulator into said second liquefied gas portion; passing said second liquefied gas portion through said heat exchanger and returning said portion to the upper portion of said storage vessel; passing said first gas portion through an auxiliary heat exchanger in indirect heat exchange with a hot fluid heat exchange material, wherein additional vaporization of said first portion of liquefied gas is accomplished; and passing said vaporized gas portion through a pressure regulator to a gas distribution zone.

5. A method for storing and dispensing liquefied petroleum gas in a gas dispensing system which comprises withdrawing a portion of said liquefied gas from a storage vessel and passing said portion to a heat exchange zone; maintaining a predetermined liquid level in said heat exchange zone; vaporizing a first portion of said liquefied gas therein; removing an unvaporized portion from direct heat exchange relation with said vaporized portion in said heat exchange zone; mechanically maintaining said second portion under pressure and returning it to the upper portion of said storage vessel; and passing said vaporized portion through a pressure control zone to a gas distribution zone.

6. A liquefied gas storage and dispensing system comprising an insulated storage vessel; a primary heat exchanger; a first conduit communicating between the lower portion of said storage vessel and said primary heat exchanger; a second conduit communicating between the lower portion of said storage vessel and said primary heat exchanger; a pump disposed in said first conduit intermediate its ends; a pressure reducer vaporizer disposed in said first conduit intermediate said pump and said primary heat exchanger; a second pump disposed in said second conduit intermediate its ends; a third conduit communicating between said first conduit, intermediate said pump and said pressure reducer vaporizer and said second conduit, downstream of said pump; a pressure regulator disposed in said third conduit intermediate its ends; a fourth conduit communicating between said primary heat exchanger and the upper portion of said storage vessel, adapted so as to convey fluid from said second conduit to the upper portion of said storage vessel; an auxiliary heat exchanger; a fifth conduit communicating between said primary heat exchanger and said auxiliary heat exchanger,

adapted so as to convey fluid from said first conduit to said auxiliary heat exchanger; a heating material inlet and outlet in said auxiliary heat exchanger; a sixth conduit communicating between said auxiliary heat exchanger and a gas disposal point, adapted so as to convey gaseous fluid from said fifth conduit to a gas disposal point; and a pressure regulator disposed in said sixth conduit intermediate its ends.

7. A liquefied gas storage and dispensing system comprising an insulated storage vessel; a primary heat exchanger; a first conduit communicating between the lower portion of said storage vessel and said primary heat exchanger; a pressure reducer vaporizer disposed in said first conduit intermediate its ends; a second conduit communicating between the lower portion of said storage vessel and said primary heat exchanger; a pump disposed in said second conduit intermediate its ends; a third conduit communicating between said primary heat exchanger and the upper portion of said storage tank, adapted to convey fluid from said second conduit to the upper portion of said storage vessel; an auxiliary heat exchanger; a fourth conduit communicating between said primary and auxiliary heat exchangers, adapted so as to convey fluid from said first conduit to said auxiliary heat exchanger; a heating material inlet and outlet in said auxiliary heat exchanger; a fifth conduit communicating between said auxiliary heat exchanger and a gas disposal point, adapted so as to convey gaseous fluid from said fourth conduit to a gas disposal point; and a pressure regulator disposed in said sixth conduit intermediate its ends.

8. A liquefied gas storage and dispensing system comprising an insulated storage vessel; heat exchanger means; conduit means communicating between the lower portion of said storage vessel and said heat exchanger means; a second conduit means communicating between said heat exchanger means and a gas disposal point; a pressure regulator disposed in said second conduit means intermediate its ends; a third conduit means communicating between said heat exchanger means and the upper end of said storage vessel, adapted so as to convey liquid from said heat exchanger to the upper portion of said storage vessel; and pump means adapted so as to maintain pressure on liquid recycled from said heat exchanger to said storage vessel.

9. A liquefied gas storage and dispensing system comprising an insulated storage vessel; a heat exchange vessel provided with a liquid level control means; a first conduit communicating between the lower portion of said storage vessel and said heat exchange vessel; a flow control valve provided in said first conduit and communicating with said liquid level control; a second conduit communicating between the upper portion of said heat exchange vessel and a gas disposal point; a pressure regulator provided in said second conduit intermediate its ends; a third conduit communicating between the lower portion of said heat exchange vessel and the upper portion of said storage vessel; and a pump provided in said third conduit intermediate its ends.

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