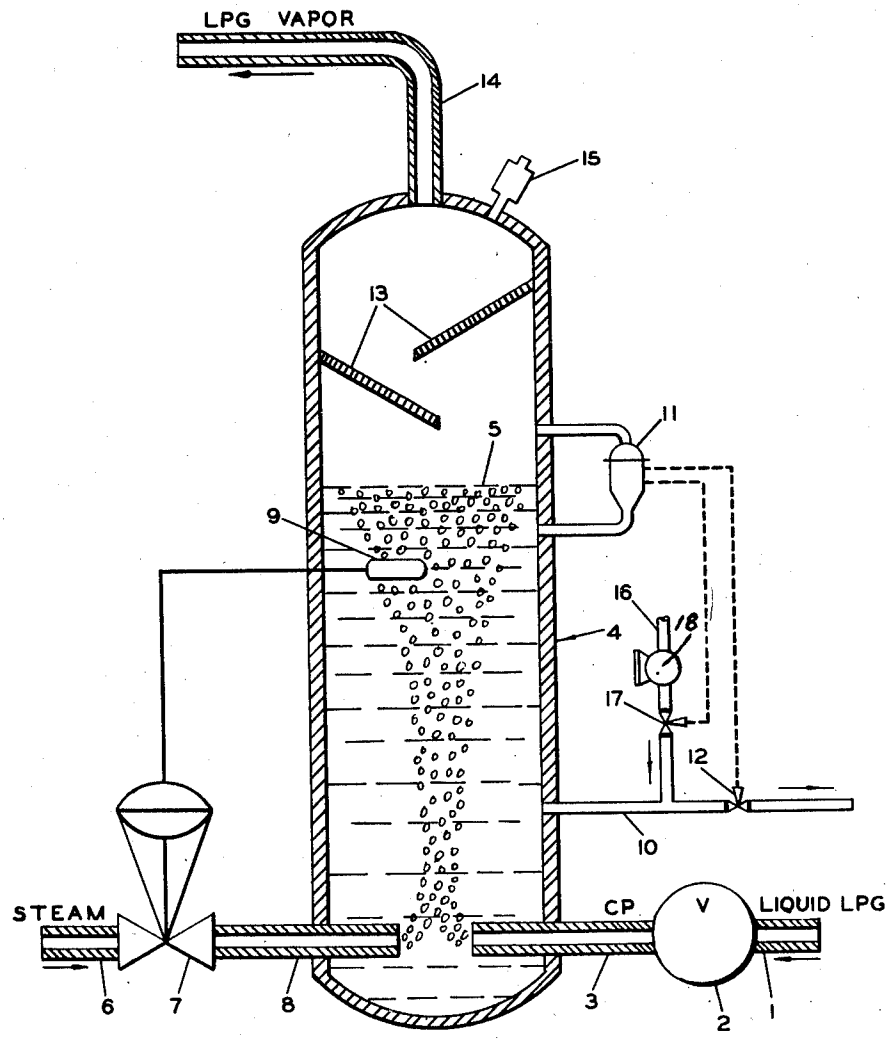
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APPARATUS FOR VAPORIZING LIQUEFIED GAS

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APPARATUS FOR VAPORIZING LIQUEFIED GAS

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This invention relates to evaporators. In one of its more specific aspects it relates to evaporators for use in the evaporation of liquefied normally gaseous materials. My evaporator has special utility in the liquefied petroleum gas field and in many installations relatively large quantities of such material need to be transformed from the liquid state to the gaseous state. Such hydrocarbons as propane or butane are compressed and liquefied and transported and stored in the liquefied condition. Then prior to use of the hydrocarbon as fuel, it must be vaporized. It is in this vaporization step that my particular evaporator finds special utility.

Further, such hydrocarbon gases are usually processed and handled in a dry condition, that is, substantially free from moisture. Public utilities distributing propane, either in the diluted or undiluted form, complain that because propane as conventionally vaporized is extremely dry, and because their metering and rate schedules are based on a water saturated gas, there is a loss of about 3% in volume. To state the problem conversely, the consumer receives a dry gas whereas the B. t. u. requirements are based upon a water saturated gas.

Such public utilities frequently have occasion to vaporize these liquefied hydrocarbons at rather rapid rates and under such conditions heat exchange problems may be acute. Vaporization of liquids is, of course, endothermic. For a conventional evaporator or heat exchanger there is a definite limitation on the rate of heat transfer through metal tubes. A further limitation exists on the rate of heat transfer through metal tubes due to the formation of an insulating film of vapor adjacent exchanger tube surfaces when certain temperature differentials are exceeded.

An object of my invention is to provide an evaporator which overcomes the above mentioned difficulties.

Another object of my invention is to provide a liquefied gas evaporator which is capable of evaporating such liquid at high rates.

Still another object of my invention is to provide a liquefied petroleum gas evaporator which is adapted to the evaporation of such liquids at high rates and at the same time is adapted to moistening the gases for metering purposes.

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

The drawing illustrates in sectional elevation a preferred form of my apparatus.

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Referring now to the figure of the drawing, a liquefied gas from a source, not shown, and flowing through a line 1 and a pressure reducing valve 2, enters my evaporator by way of an inlet line 3. The evaporator body is merely a cylindrical tank 4, vertically disposed and about half filled with water 5. The liquefied gas inlet tube 3 extends into the lower portion of the tank some little distance so that liquid entering the tank may be discharged well into the body of the water.

Steam from a source, not shown, and flowing through a line 6 passes a flow control valve 7 and enters the tank through an inlet line 8. The steam, also, is preferably discharged well into the body of the water and at a point more or less near the inlet point of and substantially countercurrent to the flow of liquid from conduit 3. To prevent overheating or underheating of the water, a temperature responsive device 9 is inserted into the body of water as shown. A connection from this temperature responsive device connects with the motor valve 7 for controlling the flow of steam. This device is so operated that as the water in the vessel becomes cooled to below a certain predetermined temperature more steam is admitted through valve 7. In case the water becomes too warm or is heated to a temperature higher than a predetermined value, the temperature responsive device operates to throttle or to close off the flow of steam. Such a condition as the latter might exist at times when the flow of liquefied gas to be evaporated stops for one reason or another.

An outlet pipe 10 is provided for removing excess water from the vessel at times when condensation of steam to water is more rapid than the evaporation of the water into the vaporized gas. A liquid level controller 11 is responsive to the level of the water within the vessel and functions to open or to close a motor valve 12 in the water line 10. This assembly is so adjusted that when the water level reaches a certain maximum height the float controller 11 operates to open the motor valve 12 and permit water to flow in the direction indicated by the arrow since the pressure within the vessel is at all times greater than atmospheric. In like manner when the water level reaches a certain minimum stage the float 11 operates to close valve 12. As a second minimum level is reached controller 11 operates to open valve 17 to admit additional water into the system through line 16, pump 18 and line 19. As the desired water level within the tank is reached controller 11 once more actuates valve 17 to close it.

At least several baffles 13 are provided in the upper gas containing portion of the vessel to as-

sist in preventing or at least minimizing entrainment of liquid in the vapors or gas passing out from the top of the vessel. A gas outlet line 14 leads from the vaporizer tank above the baffles to a gas main, service lines, or other disposal or use, not shown.

In the operation of my apparatus and system as herein described, liquid propane, or other liquefied petroleum gas, enters my evaporator by way of line 1, pressure reducer 2 and inlet line 3 from such a source as a storage tank or transportation tank car, not shown. Liquid propane has a vapor pressure of about 180 to 190 pounds per square inch at about 100° F., and in the summer season storage pressure may frequently approach this value or even exceed it depending upon the location of storage tanks. The liquefied gas at storage pressure then passes through the pressure reducer 2 in which pressure may be reduced to that necessary to force the gas through a gas main or even a network of gas mains, as in the case of a municipal distribution system. Such gas main pressures are comparatively low, as for example from a few pounds pressure up to as high as 10 to 20 or even 25 pounds per square inch. The exact value of a given gas main pressure for pressure reduction purposes through reducer is immaterial since the pressure reduction may be to any desired value.

Any pressure reduction in valve 2 will cause considerable cooling, and under some conditions it might be advisable to supply heat to the valve.

The liquefied gas then at a reduced pressure enters my evaporator through line 3 and the liquefied gas comes directly in contact with the warm water 5. By maintaining the temperature of the water at any desired value by the addition of steam from the steam inlet line 8, heat exchange directly from the warmed water to the evaporating liquefied petroleum gas is rapid and efficient. In order to maintain the water temperature at any optimum value, I use a temperature responsive device 9 which functions to open the steam valve 7 when the temperature of the water decreases below a predetermined value or to close the valve when the water temperature exceeds this value. Such a temperature controller may be set to control the temperature at any desired value. This type of equipment is standard and commercially available and its use is understood by those skilled in the art.

The desired operating temperature of the water is a result of several considerations. It is obvious that the higher the water temperature the more rapid will be the evaporation of the liquefied gas. A second consideration is the amount or relative proportion of water vapor desired to be added to the gas for metering purposes. The amount of water vapor carried by the evaporating gas is a direct function of temperature, the higher the temperature the faster is the rate of water evaporation. The specific temperature carried will probably be determined largely from the water vapor pressure consideration and the amount of water vapor desired to be added to the gas. The exact amount of water vapor to be added to a gas forms in reality no part of my invention since the water vapor will be added in each installation according to local conditions, and these may vary from place to place and even in one location from time to time. One important function of my apparatus is that I can add water vapors to the gas in substantially any desired amount by merely controlling the heat exchanger water temperature.

In my evaporator I accomplish a direct heat exchange between the water and the evaporating liquefied gas which type of exchange operation is very efficient. Indirect heat exchange through metal is at best considerably slower than the direct exchanging as herein described. Other disadvantages of indirect exchanging have been hereinbefore mentioned. Under certain conditions, as for example, at summertime temperatures, steam condensation may not provide sufficient water to maintain a desired liquid level in tank 4, and water may need be added through a water inlet line 16, pump 18, and by the float controller 11—valve 17 assembly.

The particular means as herein described for carrying out the heat exchange-evaporation process of my invention is not critical since variations and modifications may be made and yet employ direct heat transfer. For example, the water may be withdrawn from the evaporator tank and passed through a heating coil, then back to the tank again. In this case no steam condensate will increase the water volume as in my detailed example, and water will then need be added to maintain a constant level within the evaporator vessel. A float controller-motor valve-water pump assembly can be used. When the water level drops as indicated by the float, this latter opens a valve and starts a pump. Then as the water level increases to a predetermined value, the float operates to stop the pump and close the valve so the water will not back flow in any manner.

A safety valve 15 of any desired type and adjustable to flow off at any desired pressure should be used for obvious reasons.

Still other means of heating the water may be employed, as for example, use of a steam coil in the bottom of the vessel 4, but even in this case the hot water is the medium for transferring heat to the vaporizing gas.

Apparatus and materials to be used in such an installation is standard and may be purchased on the market. No special equipment is needed.

From the above explanation it will be obvious to those skilled in the art that many variations and modifications of my preferred embodiment 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 simultaneously vaporizing a liquefied petroleum gas and adding moisture to the extent of a maximum of approximately 3% by volume of the evaporated gas comprising passing the liquefied petroleum gas into direct heat exchange relation with steam and water at such a temperature as will evaporate the liquefied gas and will vaporize sufficient water to produce about 3% moisture in the vaporized petroleum gas; and removing the vaporized gas containing moisture as the product of the process.

2. A method for vaporizing and humidifying liquefied petroleum gas comprising passing the liquefied petroleum gas into direct heat exchange with water at a temperature to provide rapid evaporation of the gas; maintaining the temperature of said water by direct heat exchange with steam; and removing the evaporated gas.

3. An improved process for vaporizing a liquefied petroleum gas and controllably humidifying the resulting vapor in a confined vaporizing zone containing a body of water, which comprises the steps of continuously introducing into said body of water in the lower portion of said vaporizing zone a stream of liquefied petroleum gas; simul-

taneously and continuously introducing into said body of water in said zone a stream of steam in an amount sufficient to provide latent heat for vaporizing said liquefied petroleum gas and maintaining the temperature of said body of water and said vaporized hydrocarbon at such a point that effluent vapors contain about 3% by volume of water vapor; and removing from said body of water and vaporizing zone resulting vaporous humidified petroleum.

4. An improved process for vaporizing a liquefied petroleum gas and controllably humidifying the resulting vapor in a confined vaporizing zone containing a body of water, which comprises the steps of continuously introducing into said body of water in the lower portion of said vaporizing zone a stream of liquefied petroleum gas; simultaneously and continuously introducing into said body of water in said zone, at a point substantially opposite the petroleum gas introduction point and in close enough proximity that the introduction will be substantially counter-current to the flow of said petroleum gas stream, a stream of steam in an amount sufficient to provide latent heat for vaporizing said liquefied petroleum gas and maintaining the temperature of said body of water and said vaporized hydrocarbon at such a point that effluent vapors contain about 3% by volume of water vapor; and removing from said body of water and vaporizing zone resulting humidified vapor.

5. An improved process for vaporizing liquid propane and controllably humidifying the resulting vaporous propane in a confined vaporizing zone containing a body of water, which comprises the steps of continuously introducing into said body of water in the lower portion of said vaporizing zone a stream of liquid propane; simultaneously and continuously introducing into said body of water in said zone, at a point substantially opposite the propane introduction point and in close enough proximity that the introduction will be substantially counter-current to said liquid propane stream, a stream of steam in an amount sufficient to provide latent heat for vaporizing said liquid propane and maintaining the temperature of said body of water and said vaporized hydrocarbon at such a point that effluent vapors contain about 3% by volume of water vapor; and removing from said body of water and vaporizing zone resulting vaporous humidified propane.

6. A liquefied gas vaporizer device comprising in combination a confined chamber; a body of water in a substantial portion of said chamber; a steam conduit protruding substantially into said body of water in said chamber; a liquefied gas conduit protruding into said body of water in said chamber on substantially the same level as said steam conduit and to a point so that the outlet for said gas conduit is in relatively close proximity to the outlet of said steam conduit, whereby liquefied gas and steam are emitted from their respective conduits into said body of water to form a mixture of gas and steam; control means responsive to temperature within said chamber; a valve in said steam conduit regulating steam flow therethrough and operatively connected to said temperature responsive control means; a pressure reducing valve in said liquefied gas conduit; control means communicating with said chamber and responsive to the liquid level therein; means for draining water from said chamber; a valve in said drain means operatively connected to said liquid level responsive control means; means for introducing water into said chamber; a valve in said water introducing means operatively connected to said liquid level responsive control means; a gas outlet from the upper portion of said chamber; and means for reducing entrainment of liquid in the gas passing out of said chamber.

7. A liquefied gas vaporizer device comprising in combination a confined chamber; a body of water in a substantial portion of said chamber; a steam conduit protruding substantially into said body of water in said chamber; a liquefied gas conduit also protruding into said body of water in said chamber; control means responsive to temperature within said chamber; a valve in said steam conduit regulating steam flow therethrough and operatively connected to said temperature responsive control means; a pressure reducing valve in said liquefied gas conduit; control means communicating with said chamber and responsive to the liquid level therein; means for draining water from said chamber; a valve in said drain means operatively connected to said liquid level responsive control means; means for introducing water into said chamber; a valve in said water introducing means operatively connected to said liquid level responsive control means; a gas outlet from the upper portion of said chamber; and means for reducing entrainment of liquid in the gas passing out of said chamber.

8. A liquefied gas vaporizer device comprising in combination a confined chamber; a steam conduit protruding substantially into the lower portion of said chamber; a liquefied gas conduit protruding into said chamber from a direction other than that in which said steam conduit is maintained and on substantially the same level as said steam conduit, the outlets of said conduits being in relatively close proximity to one another; control means responsive to temperature within said chamber; a valve in said steam conduit for regulating steam flow therethrough and operatively connected to said temperature responsive control means; a pressure reducing valve in said liquefied gas conduit; control means communicating with said chamber and responsive to liquid level within said chamber; drain means in the lower portion of said chamber; a valve in said drain means operatively connected to said liquid level responsive control means; liquid inlet means communicating with the lower portion of said chamber; a valve in said liquid inlet means operatively connected to said liquid level responsive control means; a gas outlet in the upper portion of said chamber and baffle members in the upper portion of said chamber and below said gas outlet therein.

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