

- [54] **DIRECT CONTACT LIQUID GASIFIER AND METHOD**
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- [58] Field of Search **48/190, 196, 93, 107, 180 R, 48/212, 144; 261/16, 141, 147, 148, 152, 158, 161, 116, 117, 127, 128, 18 R; 23/259.5; 123/119 A; 60/39.71, 261, 39.06, 39.52, 39.74; 62/52**

[56] **References Cited**

UNITED STATES PATENTS

3,107,482	10/1963	Fono.....	60/39.16 R
3,413,810	12/1968	Kaufmann	60/261 X
3,417,563	12/1968	Loprete	60/39.71 X
3,524,319	8/1970	Stockel.....	60/261 UX
2,609,282	9/1952	Hang et al.	48/190 X
2,767,025	10/1956	Griffith.....	261/39 X
3,414,247	12/1968	Sama.....	26/118
3,232,726	2/1966	Eagle et al.....	48/196
1,715,775	6/1929	Lewitt et al.	48/93

2,129,269	9/1938	Fwilong.....	48/93 UX
2,921,004	1/1960	Wood.....	126/350 X
3,204,629	9/1965	Newton, Jr.	126/350 UX
3,014,705	12/1961	Colucci.....	261/16
2,541,569	2/1951	Born et al.....	48/190 UX

FOREIGN PATENTS OR APPLICATIONS

1,158,934 7/1969 Great Britain

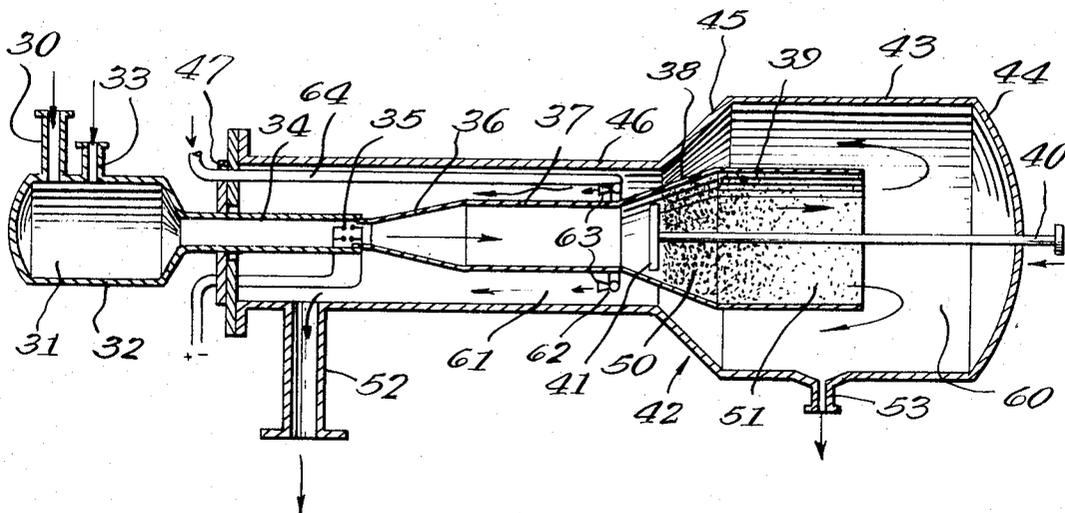
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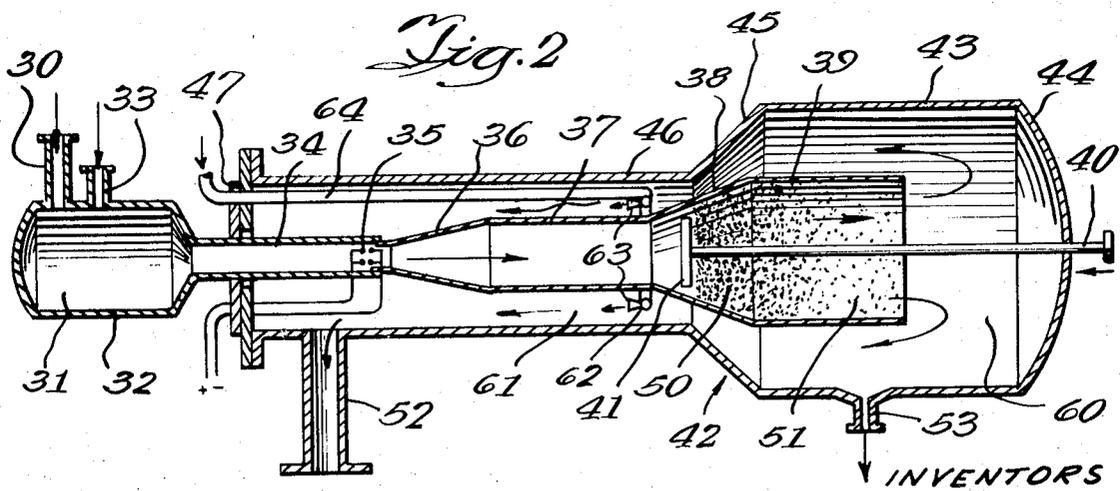
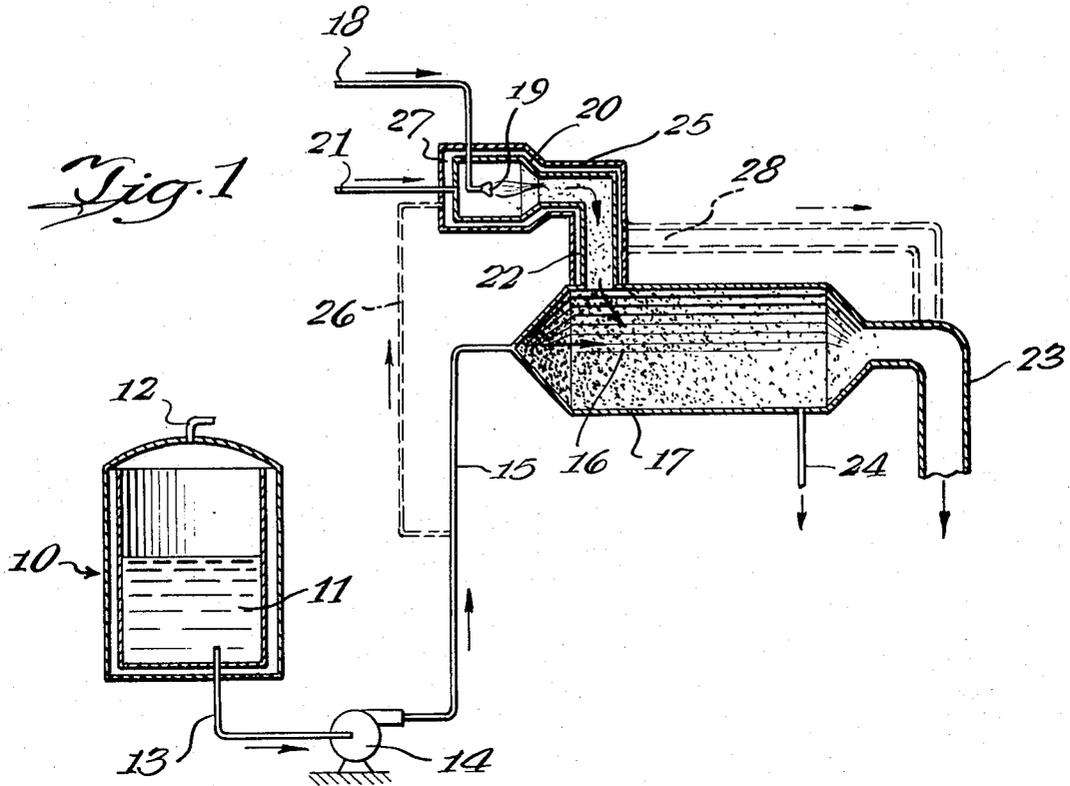
[57] **ABSTRACT**

A method of gasifying a liquid by feeding the hot products of combustion of a combustible material into intimate direct contact with a stream of the liquid at a rate to provide sufficient heat content to gasify the liquid stream and form a stream of the liquid in gaseous or vapor form diluted by the said products of combustion. The method is useful in gasifying substances which are liquid at ambient temperatures and pressures and liquefied gases. The liquid can be combustible or noncombustible. The method is specifically useful for gasifying liquefied natural gas by burning natural gas to form the hot combustion products.

Apparatus for gasifying a liquid comprising a burner for burning a combustible material with air, oxygen or oxygen-enriched air to form hot combustion products, a gasifying chamber for gasifying a liquid, an inlet conduit for directly feeding the hot combustion products from the burner to the gasifying chamber, an inlet conduit for feeding a stream of liquid to be gasified to the gasifying chamber, and an outlet conduit leading from the gasifying chamber for delivering an admixture of the gasified liquid and the combustion products to a gas outlet.

7 Claims, 2 Drawing Figures





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DIRECT CONTACT LIQUID GASIFIER AND METHOD

This invention relates to apparatus and methods for gasifying liquids. More particularly, this invention is concerned with apparatus and processes for gasifying liquids which are gases at ambient temperatures and pressures.

Although many products are stored and transported as liquids, it is often necessary for the liquids to be gasified for various intended uses. This pertains both to materials or products which are normally liquid at ambient temperatures and pressures as well as materials which are normally gases under such conditions but have been converted to liquids by cooling with or without the application of pressure. The gasification of such liquids is normally conducted by indirect heat exchange such as by the use of conventional shell-and-tube heat exchangers. While such apparatus and methods are useful for gasifying such liquids, the gasification of large quantities of liquids, and particularly of liquefied gases, requires large capital investments in gasifying apparatus of the shell-and-tube type. The volume of gas or vapor to be produced of course has a substantial effect on the size of the equipment but also playing a significant part is the low heat transfer coefficient between the liquefied gas and the heating media. Also, the large numbers and lengths of heat transfer tubes causes gasifiers as presently employed to be expensive and difficult to operate. There is thus a need for improved apparatus and methods for gasifying liquids, particularly liquefied gases and especially liquefied gases which are combustible.

According to the present invention, there is provided a method of gasifying a liquid which comprises feeding the hot products of combustion of a combustible material into intimate direct contact with a stream of the liquid at a rate to provide sufficient heat content to gasify the liquid stream and form a stream of the liquid in vapor or gaseous form diluted by the said products of combustion. The method is useful in gasifying a liquefied gas, particularly a combustible liquefied gas. The products of combustion are readily controlled to essentially lacking in oxygen or contain insufficient oxygen to form a combustible mixture with the gasified liquid stream. Furthermore, the method is especially suitable for gasifying liquefied natural gas by burning natural gas with air, oxygen or oxygen-enriched air to form hot products of combustion and bringing them into direct contact with liquefied natural gas to gasify it.

The invention also provides apparatus for gasifying a liquid comprising a burner for burning a combustible material with air, oxygen or oxygen-enriched air to form hot combustion products, a gasifying chamber for gasifying a liquid, an inlet conduit for directly feeding the hot combustion products from the burner to the gasifying chamber, an inlet conduit for feeding a stream of liquid to be gasified to the gasifying chamber, and an outlet conduit leading from the gasifying chamber for delivering an admixture of the gasified liquid and the combustion products to a vapor outlet. The inlet conduit for feeding the liquid to the gasifying chamber is generally placed in communication with a reservoir for storing the liquid to be gasified. In addition, means can and usually are provided for removing any condensed water from the gasified material in the gasifying

chamber. Furthermore, when desired, the burner can be suitably cooled by passing the liquid to be gasified through a cooling jacket associated with the burner. The liquid, after cooling the burner and as a result thereof, can be gasified and the resulting gas or vapor fed to a suitable line for distribution. The resulting gas, when natural gas, can be fed to a gas line for distribution to users.

The invention will now be described further in conjunction with the attached drawings in which:

FIG. 1 is an elevational view partially in section showing apparatus useful in gasifying a liquid according to the invention; and

FIG. 2 is an elevational view, mostly in section, showing another embodiment of apparatus which can be employed for gasifying a liquid according to the invention.

With reference to FIG. 1, storage tank 10 of the insulated type is used for storing a liquefied gas and in this case liquefied natural gas 11. The tank is provided with a suitable venting pipe 12 for removing vapors formed by heat leak through the tank. The vapors can be fed to a gas line for disposal or be reliquefied. Liquefied natural gas can be withdrawn by pipe 13 from tank 10 and fed by means of pump 14 to pipe 15 and from it to the gasifying chamber 16 defined by gasifying vessel 17. Conduit 18 supplies a suitable fuel through nozzle 19 to the internal space of burner 20. The fuel may be any oxidizable material, but normally will be natural gas or a petroleum oil. Oxygen, air, or oxygen-enriched air can be fed by conduit 21 into burner 20 to burn the fuel emitted from nozzle 19.

Gasifying chamber 16 is supplied with the hot products of combustion from burner 20 by means of inlet conduit 22. The hot products of combustion mix with the liquid to be gasified in gasifying chamber 16, gasify it and at the same time admix with it to dilute it. Outlet 23 leads from gasifying chamber 16 and conveys the admixture of gasified liquid and the products of combustion to a suitable destination. Pipe 24 communicates with gasifying chamber 16 and drains condensed water from the chamber.

A jacket 25 can be positioned around burner 20 and inlet conduit 22 in spaced apart arrangement to provide a space 27 into which liquid from tank 10 can be fed by pipe 26, shown in phantom, for cooling purposes. The vapor or gas generated from the liquid in such cooling can be fed by conduit 28 to outlet 23 for admixture with the gasified liquid being fed thereto.

FIG. 2 illustrates another embodiment of apparatus provided by this invention and which can be used in gasifying a liquid. Conduit 30 supplies air, oxygen or a mixture of air and oxygen to mixing chamber 31 formed by vessel 32. Conduit 33 supplies oxidizable fuel to mixing chamber 31. The combustible mixture flows from chamber 31 through the conduit section 34 of reduced diameter and is ignited by means of an arc formed by electrodes 35 positioned internally thereof. The products of combustion expand into tapered tubular shell section 36 which mates at its end with tubular shell portion 37 which in turn is joined at its end to conical shell portion 38 which is joined to cylindrical section 39. Pipe 40 supplies liquid to be gasified to spray head 41 positioned in conical shell section 38. The liquid is sprayed from spray head 41 either concur-

rently or countercurrently to the direction of travel of the hot products of combustion from the burner. Walled vessel 42 surrounds the burner and the tubular body, comprising shell section 36, 37, 38 and 39, communicating therewith. Walled vessel 42 is more or less axially positioned relative to the burner and the tubular body. The walled vessel 42 has a cylindrical portion 43 closed at one end by dished end 44. The other end of the cylindrical portion 43 has a tapered or conical section 45 which joins at its mouth with a smaller cylindrical portion 46 which extends to just short of vessel 32. Closure 47 closes the end of the cylindrical portion 46. In operation, the hot products of combustion from the burner mix with the liquid spray in the mixing area 50 and the liquid is more or less gasified in the space 51. The flow of the gasified liquid is then reversed in direction by means of the end 44 of walled vessel 43 and directed around the outside of the burner tubular body where it is further heated and the burner cooled and then directed to conduit 52 through which it exits for delivery to a suitable destination, such as a gas pipeline. Outlet 53 is provided in the cylindrical portion 43 of vessel 42 for removing condensed water which forms during the gasification process. Water condensation is induced since the gasified mixture in space 60 is at a temperature which favors condensate formation, such as about 40°F, while the gasified product stream, after picking up heat in the space 61, is heated to a temperature of about 60°F or higher. Vessel 42 might also be a cyclone type separator which would allow effective vapor-liquid separation at relatively higher vapor velocities, hence the size of vessel 42 could be decreased.

It is also feasible to operate vessel 42 at temperatures lower than 40°F thereby causing hydrates to form rather than a liquid condensate. The salient feature of hydrate formation is that a greater quantity of water could be removed.

A means can be provided to inject a stream of the liquid to be gasified into vapor space 61 to regulate the temperature of the admixture formed in vessel 43 while maintaining the temperature of the admixture flowing from outlet 52 at a constant temperature. As shown in FIG. 2, one means comprises an annular tubular member 62 having nozzles 63 from which liquid is ejected. Pipe 64 supplies liquid to member 62 and this liquid is usually the same liquid supplied by pipe 40 to be gasified. Also, the injection can be accomplished by other methods such as an annular slot on pipe 46 or injection into a jacket or tubes about pipe 37.

Apparatus such as described which can be used in the method of this invention, avoids the use of heat transfer tubes, permits a reduction in gasifier or vaporizer size and provides greater controlability.

The invention is particularly useful for gasifying or vaporizing liquified natural gas for peak-shaving when unusually heavy demands are made for gas consumption, such as in winter in cold climates. Although the gasified or vaporized natural gas is diluted by the hot products of combustion during the direct gasification procedure, the resulting admixture still has sufficient heat capacity to be utilized under most conditions. Furthermore, such dilution is often desirable because the storage of liquefied natural gas over a prolonged period results in a rise in heating value of the stored

product because of the increased concentration of hydrocarbons higher than methane in the liquid. The higher heating value provided by such hydrocarbons as ethane, propane and butane compensates for the reduced heating value that results from dilution with the hot products of combustion supplied by the burner in the direct gasification of the liquefied natural gas. The extent of dilution can of course be kept low by using oxygen instead of air to burn the fuel. When higher dilution is desired, such as when the stored liquefied natural gas has an enriched heat content, the use of air is likely to be more suitable since it aids more in lowering the heating value of the gasified product than the use of oxygen alone. Any in-between dilution can be achieved by using a mixture of air and oxygen.

This invention is also useful for vaporizing without superheating liquefied heavy hydrocarbons such as liquefied propane for use in propane-air peak-shaving. In the event that the peak-shaving propane-air mixture is delivered at moderate pressure it would not be necessary to superheat the liquefied propane since vapor state propane can exist without superheating at commonly encountered transmission pressures and temperatures.

The burner cooling system of FIG. 1 is especially useful in conjunction with a high capacity burner which would otherwise require a large amount of excess air to lower the flame temperature. Large amounts of air in the gasified liquid could be hazardous and would also limit the degree of heating value regulation possible in the vaporized product. The use of the cryogenic cooling media precludes the need for excess air and permits heating value adjustments to be made independent of flame temperature constraints.

A tank of stored liquefied natural gas may be 95 percent methane, 4 percent ethane and 1 percent propane, having a heating value of 1057.5 Btu. After gasification according to the invention, it can have a heating value, after dilution by the hot products of combustion, of about 1006.6 Btu or a heating value essentially the same as the 1012 Btu value for methane alone.

This invention is further useful for gasifying a non-combustible liquefied gas, such as nitrogen which is commonly used as a purge gas for large volume storage tanks and process vessels. As often is the case, the need for purging an individual storage tank or process vessel is infrequent, hence, it is uneconomical to permanently install purging equipment at each site. It is more economical to mount the equipment on a transportable trailer. The large size of shell-and-tube gasifiers imposes definite restrictions on the transportability and capacity of such gasifiers, whereas the compactness and large capacity of the apparatus of this invention alleviates these restrictions.

The invention is also useful for gasifying materials which are liquid at ambient temperatures and pressures provided dilution by the products of combustion does not give an admixture which cannot be used. Furthermore, the liquid can be combustible or noncombustible. Also, liquids can be fractionated in this way by subsequently cooling the resulting gasified mixture in stages.

What is claimed is:

1. The method of gasifying liquefied natural gas which comprises burning natural gas in a burner cooled

indirectly by heat exchange with liquefied natural gas which becomes gasified,

feeding the hot products of combustion from the burner into intimate direct contact with a stream of liquefied natural gas at a rate to provide sufficient heat content to gasify the liquefied natural gas stream and form a stream of the liquefied gas in gaseous or vapor form diluted by the said products of combustion, and

feeding the stream of gasified liquefied natural gas, formed in cooling the burner indirectly, into admixture with the stream of gasified liquefied natural gas admixed with the products of combustion.

2. The method of gasifying a liquefied gas which comprises:

withdrawing a liquefied gas from a storage reservoir and feeding a dispersed stream thereof into a gasifying zone,

combusting a combustible material with oxygen, air or oxygen-enriched air in a burner to form hot combustion products essentially lacking in oxygen, feeding the hot combustion products into the gasifying zone for direct contact and heat exchange with the dispersed stream of liquefied gas to gasify the same and form a mixture of gasified gas with the said combustion products at a temperature which condenses out water in the combustion products, removing water from the mixture, and

feeding the mixture to a conduit for delivery to a destination, said burner being cooled by indirect heat exchange

with the liquefied gas and it becomes gasified and the resulting gas is fed to the mixture delivered by the conduit.

3. The method of claim 2 in which the combustible material is a petroleum oil.

4. The method of claim 2 in which the liquefied gas and the combustible material are natural gas.

5. Apparatus for gasifying a liquefied gas comprising: a burner having a tubular body through which hot products of combustion flow to a mouth at the end thereof;

a distribution head, positioned in the tubular body of the burner, having a nozzle through which a liquefied gas can be supplied as a stream into admixture with the hot products of combustion;

a conduit for supplying liquefied gas to the distribution head;

a walled vessel surrounding the burner tubular body and spaced therefrom and from the mouth of the tubular body; and

an outlet conduit communicating with the vessel interior at a location remote from the mouth of the tubular body.

6. Apparatus according to claim 5 in which the walled vessel is cylindrical with an enlarged end portion around an enlarged end portion of the burner tubular body which includes at least the space from the distribution head to the mouth of the burner tubular body.

7. Apparatus according to claim 5 in which the walled vessel has means for removing condensed water.

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