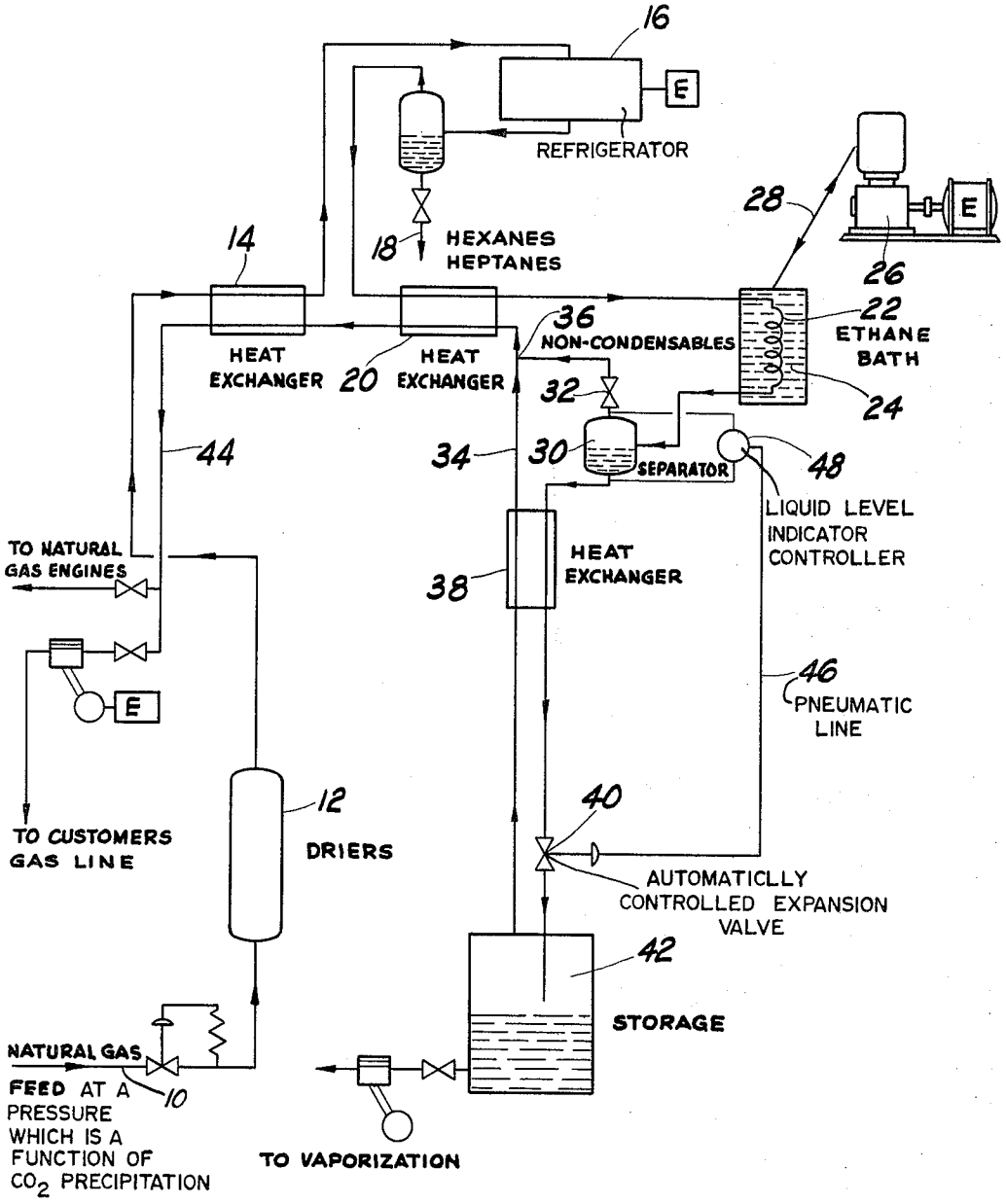
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NATURAL GAS LIQUEFACTION AND STORAGE

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NATURAL GAS LIQUEFACTION AND STORAGE

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This invention relates to a method and apparatus for liquefying natural gas and more particularly to liquefying a natural gas mixture without the occurrence of solid carbon dioxide which tends to block and plug the cold lines. Previously it was necessary to pretreat natural gas for carbon dioxide removal prior to liquefaction.

It is an object of the present invention to liquefy natural gas at a pressure high enough whereby the CO_2 present therein will also be in a liquid state. The mixture is then expanded to storage pressure, which is usually atmospheric, and the solid CO_2 that will form can either be removed by filtration or may be simply sent to storage where it will occupy a volume of about ½%. Heretofore, it has been necessary to remove the carbon dioxide content of a gas mixture prior to liquefaction by such costly methods as monethanolamine scrubbing. However, in order to minimize labor and capital costs the present apparatus and method has been devised in order to eliminate the danger of CO_2 plugged lines or fouled heat transfer surfaces.

The present invention is of particular importance in colder locations where it is desirable for the utility company supplying gas to its customers to engage in the practice known as peak load shaving.

A principal object of the present invention is to liquefy the natural gas at a pressure high enough so that the CO_2 will also be in the liquid state.

The above and other features, objects and advantages of the present invention will be fully understood from the following description considered in connection with the accompanying illustrative drawing in which the sole figure is a flow sheet of the natural gas liquefication plant and the method according to the principles of the invention.

Referring more particularly to the drawing the natural gas which has been previously compressed to a suitable pressure, is fed into the apparatus through the line **10**. It is to be noted that the natural gas received by a utility company is a complex mixture. A typical composition is:

Component:	Composition, vol. percent
Methane	95.32
Ethane	2.66
Carbon dioxide	0.69
Propane	0.57
Nitrogen	0.43
Iso-butane	0.12
Normal butane	0.09
Iso-pentane	0.04
Normal pentane	0.03
Hexane, Heptane	0.05
Water, −15°.[1]	

[1] Dew point.

The natural gas mixture is conducted through chemical driers **12** and then through heat exchanger **14** to a refrigerator **16**, the latter being at a −40° F. level. The refrigerator **16** may be a conventional propane or Freon refrigerator. The heavy hydrocarbons, which have been condensed from the main gas stream are removed from the system as shown in the drawing and from the main gas stream at **18** since they may ultimately freeze and block the flow passages and foul heat transfer surfaces.

The gas stream is cooled by heat exchange in heat exchanger **20** and is further cooled and condensed in a coil **22** immersed in a boiling refrigerant in receptacle **24**. A suitable refrigerant for receptacle **24** is ethane with a normal boiling point of −127.6° F. Other refrigerants may be used, however, the particular refrigerant used is dependent upon the pressure chosen for the system. As is shown, a refrigerator such as a cold gas refrigerator **26**, is connected through line **28** to the receptacle **24** having the ethane bath therein wherein the ethane that is vaporized by the natural gas is recondensed by the refrigerator **26**. The non-condensibles, such as nitrogen, are separated from the liquefied natural gas in the separator vessel **30**. The non-condensibles are throttled in valve **32** to a low pressure and join the returning low pressure gas in line **34** at junction **36**. The liquefied natural gas, after being subcooled by returning low pressure gas in heat exchanger **38** is throttled to storage pressure in valve **40** and sent to storage in storage tank **42**. The carbon dioxide content of the liquefied natural gas mixture will precipitate as a solid at the throttle valve **40**. The solid CO_2 may either be filtered at this point or sent to storage with the remainder of the liquefied natural gas. The solid CO_2 may also be filtered out of the liquefied natural gas should that be desirable. Other solids that may form upon expansion of the high pressure liquefied natural gas, such as butanes, may be removed with the solid CO_2. The vapors formed on throttling, comprising about 48% of the feed, are rewarmed by heat exchange with the incoming natural gas feed. A pneumatic line **46** is connected at one end to the automatically controlled expansion valve **40** and is connected at the other end to liquid level indicator controller **48**, the latter being in turn connected to the separator **30**.

It should be noted that the natural gas formed on throttling may be fed to the consumers gas line by means of pipe line **44**. The flash vapors from the storage tank **42** are drawn off to the consumers gas line through heat exchangers **38**, **20** and **14** respectively.

Thus, the liquefied mixture may be expanded to storage pressure, which is usually atmospheric, and the solid CO_2 that will form can either be removed by filtration or sent to storage where it will ocupy a volume of ½%.

While I have shown and described the preferred embodiment of my invention, it will be understood that the latter may be embodied otherwise than as herein specifically illustrated or described and that in the illustrated embodiment certain changes in the details of construction and in the arrangement of parts may be made without departing from the underlying idea or principle of the invention within the scope of the appended claims.

What I claim is:

1. A method of liquefying a natural gas mixture having heavy hydrocarbons without the occurrence of solid carbon dioxide comprising supplying natural gas at a pressure above a predetermined minimum pressure, said predetermined minimum pressure being a function of the inlet carbon dioxide concentration of the natural gas, dehydrating said gas mixture, passing said gas mixture through a first heat exchanger and a refrigerator to cool the same, removing said heavy hydrocarbons in the mixture from the main gas stream, cooling said gas mixture in a second heat exchanger, further cooling and liquefying said gas mixture in an ethane bath, recondensing the ethane vaporized by said natural gas, separating out the non-condensables from said natural gas mixture, throttling said non-condensables to a low pressure and joining the same with the low pressure natural gas returning to the consumers gas line, further cooling the liquefied natural gas in a heat exchanger, throttling said natural gas mixture to storage pressure, and precipitating out the

carbon dioxide from the gas mixture as a solid, the vapors formed on throttling of said natural gas mixture being rewarmed by heat exchange with the incoming natural gas feed.

2. A method of liquefying a natural gas mixture having heavy hydrocarbons without the occurrence of solid carbon dioxide comprising supplying natural gas at a pressure above a predetermined minimum pressure dehydrating said gas mixture, passing said gas mixture through a first heat exchanger and an approximately —40° F. level refrigerator to cool the same, removing said heavy hydrocarbons in the mixture from the main gas stream, cooling said gas mixture in a second heat exchanger, further cooling and liquefying said gas mixture in an ethane bath, recondensing the ethane vaporized by said natural gas by means of said cold gas refrigerator, separating out the noncondensables from said natural gas mixture, throttling said non-condensables to a low pressure and joining the same with the low pressure natural gas returning to the customers gas line, further cooling said liquefied natural gas by heat exchange, throttling said liquefied natural gas mixture thereby precipitating out the carbon dioxide from gas mixture as a solid, the vapors formed on throttling of said natural gas mixture being rewarmed by heat exchange with the incoming natural gas feed.

3. A method of liquefying a natural gas mixture having heavy hydrocarbons without the occurrence of solid carbon dioxide as claimed in claim 1 wherein said gas mixture is dehydrated in a chemical drier and a pressure of about 588 p.s.i.a. is the operating pressure.

4. An apparatus for liquefying a natural gas mixture having heavy hydrocarbons without the occurrence of solid carbon dioxide, said natural gas mixture being supplied to the apparatus at a pressure above a predetermined minimum pressure comprising: a drier for dehydrating said incoming natural gas mixture, a plurality of heat exchangers through which said natural gas mixture traverses, a —40° F. level refrigerator for cooling said natural gas mixture, means for removing said heavy hydrocarbons from said apparatus, an ethane bath for cooling and condensing said natural gas mixture, a cold gas refrigerator for recondensing the ethane vaporized by said natural gas mixture, means for separating out the non-condensibles from the liquefied natural said gas mixture, and a valve for throttling said non-condensibles to a low pressure and joining the same with the low pressure liquefied natural gas mixture, said liquefied natural gas mixture being cooled and throttled to a low pressure whereby the carbon dioxide in said liquefied natural gas mixture is precipitated out as a solid, the vapors formed on throttling of said natural gas mixture being rewarmed by heat exchange with the incoming natural gas mixture.

5. A method of liquefying a natural gas mixture having heavy hydrocarbons without the occurrence of solid carbon dioxide as claimed in claim 1 wherein the operating pressure chosen is a function of the inlet carbon dioxide concentration of said natural gas, and the condensing temperature is a function of said pressure.

6. An apparatus for liquefying a natural gas mixture having heavy hydrocarbons without the occurrence of solid carbon dioxide as claimed in claim 4 further comprising a liquid level indicator-controller, an automatically controlled expansion valve connected to the system and a pneumatic line connecting said valve and said indicator-controller, the latter in turn being connected to said separating means whereby when the liquid level in said separating means is at a predetermined level said valve operates by air pressure in said pneumatic line.

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