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METHOD OF LIQUEFYING NATURAL GAS

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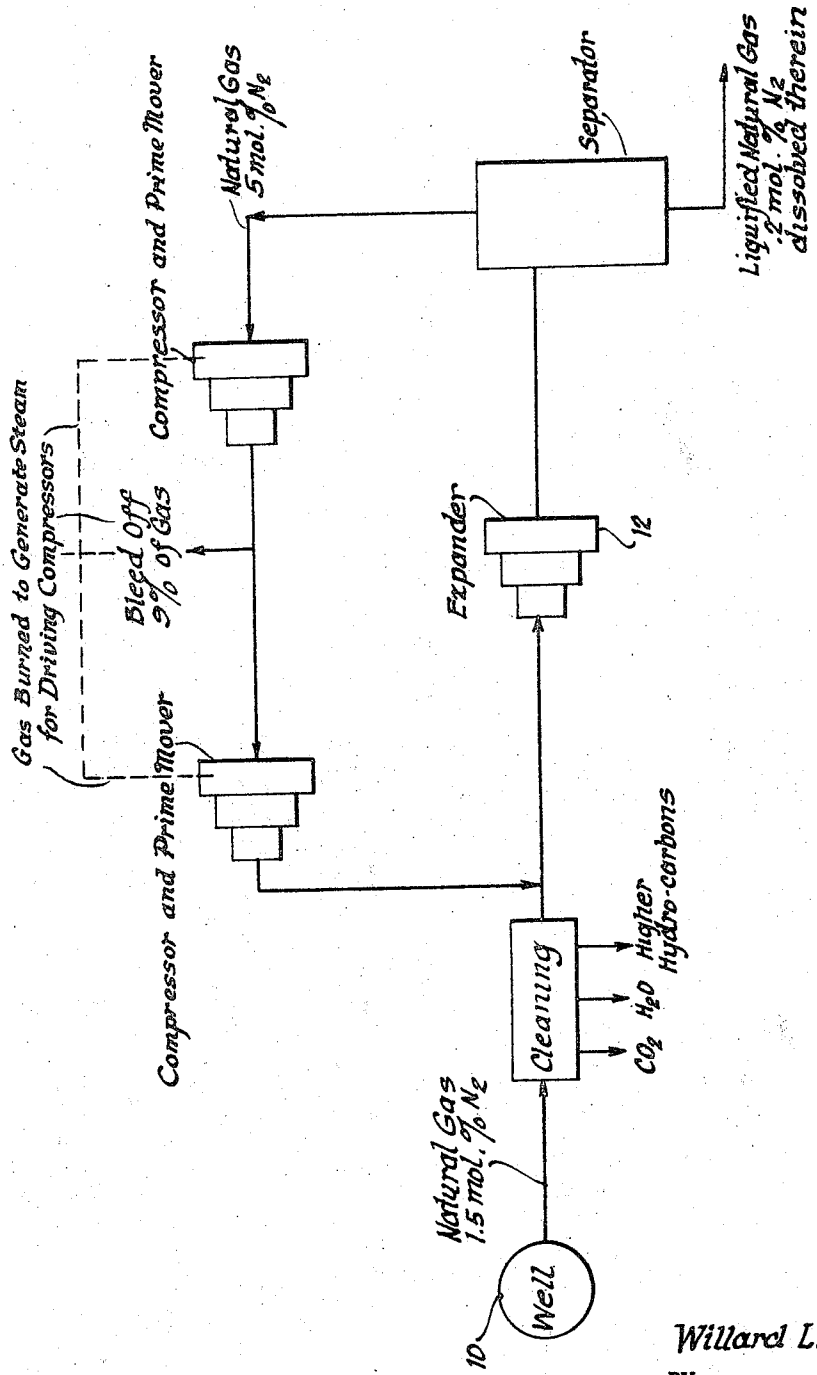

INVENTOR.
Willard L. Morrison

BY
Dorns, MacDougall, Williams & Gerah
Attorneys

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METHOD OF LIQUEFYING NATURAL GAS

Willard L. Morrison, Lake Forest, Ill., assignor, by mesne assignments, to Constock Liquid Methane Corporation, a corporation of Delaware

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4 Claims. (Cl. 62—11)

My invention relates to an improved method of liquefying natural gas.

One object of my invention is to provide means for controlling the concentration of nitrogen, other non-condensibles and inerts, in a liquefying system for natural gas wherein the gas circulates in a closed system, expands and does external work with resultant cooling and liquefaction of a part of the gas and recirculation of the uncondensed portions.

Another object of my invention is continuously to withdraw from such a system after expansion of the gas and withdrawal from the system of the liquefied portion of the gas such quantity of nitrogen and non-condensibles and inerts as will at least compensate for the amount brought into the system by the raw gas for liquefaction.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawing in which the one figure is a flow diagram illustrating the concepts of this invention.

My invention is especially useful in connection with a liquefaction process where the gas is cooled, expands and does work in an expansion turbine, is exhausted from the turbine at substantially atmospheric pressure and at such a low temperature that part of the gas is liquefied. The liquefied gas is separated from the cold unliquefied gas and discharged from the system. The resultant dry gas is compressed, part of the compressed dry gas is discharged from the system for any desired use preferably in part at least to be burned to furnish part of the power to operate the liquefaction system. The remainder of the gas is further compressed for recycling through the system with fresh gas supplied in such quantity as to compensate for the gas leaving the system in liquid and gaseous phase.

Preferably after the gas has expanded and done work, and the gas in the liquid phase has been separated out and discharged from the system, the resulting dry gas will pass through a plurality of compression stages, some of the dry compressed gas, usually at less than the final compression pressure, will be discharged from an intermediate compression stage at a pressure suitable for use as a fuel, to provide all or part of the power to operate the compression stages and other equipment or for other purposes. The remaining dry gas will pass through all the compression stages to be recycled at substantially the same pressure as the raw gas supplied for make up and circulation than the system with the recycled gas.

The raw gas may or may not be previously cleaned and purified, but in any event it will usually contain some nitrogen, other gases and inerts not condensible at the temperatures and pressures of liquefaction of the methane. When the methane is liquefied, while it may contain some of the above impurities in solution, the quantity will be less than that in the gas, therefore, after separation of the liquid from the dry gas, the remaining dry gas will be relatively richer in such impurities than is the raw gas.

This condition, if allowed to continue, would ultimately result in recycling an unsatisfactory and uneconomical gas too rich in such impurities.

The proportions of such impurities may vary with the gas supplied to the system. The relative proportions of the impurities left in the dry gas after separation out of the liquid and in solution the liquid may vary. Therefore, the amount of gas in gaseous phase discharged from the system must be controlled so that it will take out with it substantially the same quantity of the impurities as came into the system with the raw gas. The dry gas discharged from the system will be richer in these impurities than the raw gas, and it is only necessary to control the discharge of such smaller quantity of richer gas to maintain substantial equality between the impurities entering the system and those leaving it.

A liquefaction system to which my invention is especially well adapted is disclosed in my copending application Serial Number 259,253 filed in the United States Patent Office November 30, 1951, now Patent No. 2,705,406.

In the claims and elsewhere, I have for convenience used the term "nitrogen" as a generic term to include not only nitrogen itself, but any other substances which are inert or do not condense at the condensation or liquefaction temperature of the gas being liquefied.

For purposes of illustration but not of limitation, reference will be made to a possible set of conditions representative of the practice of this invention. It may be assumed, for this purpose, that the natural gas issuing from the well 10 is cleaned to remove some higher hydrocarbons, carbon dioxide and moisture and contains about 1.5 mol percent (about 2.6 percent by weight) nitrogen and that about 21 percent of the gas fed to the expansion means 12 is condensed and removed from the system as a condensate consisting mostly of liquid methane. At minus 260° F. at atmospheric pressure, the condensate will contain about .2 mol percent of nitrogen dissolved therein and such amounts of nitrogen will be removed with the condensate from the system. If the feed to the expansion turbine is calculated to contain about 3.8–4.0 mol percent nitrogen, the concentration of nitrogen remaining in the dry gas separated from the wet exhaust will contain about 5 mol percent of nitrogen.

To take out enough nitrogen from the dry gas to compensate for the amount introduced into the system by the fresh gas from the well, containing only about 1.5 mol percent of nitrogen, less the amount extracted from the system with the condensate, containing about .2 mol percent nitrogen, bleeding off as little as 9 percent by weight of the dry gas from the recycle system will be sufficient.

It will be understood that the amount of dry gas bled from the system will vary inversely in proportion to the concentration of nitrogen permissible in the feed to the expansion turbine and directly with the concentration of nitrogen in the gas from the well. An economical balance can be readily established depending upon the conditions existing at the liquefaction plant and the demand for gaseous material for use as a fuel or the like in operation of the equipment or for other purposes.

The amount of nitrogen contained in the dry gas bled from the system for nitrogen control will be insufficient to interfere with the burning characteristics thereof for such use as a fuel.

I claim:

1. The method of controlling and limiting the nitrogen concentration in a recycling system, which liquefies a combustible gas, which may contain nitrogen, by causing the gas to expand and do external work with resultant liquefaction of part of the gas, separating the liquid from the unliquefied dry gas and discharging the liquid from the system, compressing the dry gas to a pressure above that at which separation from the liquid took place and dis-

charging some of it from the system, compressing the remaining dry gas and recycling it through the system, together with fresh gas added in such quantity as to compensate for the liquefied and dry gas discharged from the system.

2. The method of controlling and limiting the nitrogen concentration in a recycling system, which liquefies a combustible gas, which may contain nitrogen, by causing the gas to expand and do external work with resultant liquefaction of part of the gas, separating the liquid from the unliquefied dry gas and discharging the liquid from the system, compressing the dry gas discharging part of the compressed dry gas from the system and recycling the remainder of the dry gas through the system with fresh gas added in such quantity as to compensate for the liquefied and dry gas discharged from the system.

3. The method of controlling and limiting the nitrogen concentration in a recycling system, which liquefies a combustible gas, which may contain nitrogen, by causing the gas to expand and do external work with resultant liquefaction of part of the gas, separating the liquid from the unliquefied dry gas and discharging the liquid from the system, compressing the dry gas to a pressure above that at which separation from the liquid took place and discharging some of it from the system using such discharged dry gas as a fuel to provide at least some of the power to operate the system, compressing the remaining dry gas and recycling it through the system, together with fresh gas added in such quantity as to compensate for the liquefied and dry gas discharged from the system.

4. The method of controlling and limiting the nitrogen concentration in a recycling system, which liquefies a combustible gas, which may contain nitrogen, by causing the gas to expand and do external work with resultant liquefaction of part of the gas, separating the liquid from the unliquefied dry gas and discharging the liquid from the system, compressing the dry gas, discharging part of the compressed dry gas from the system, using such discharged dry gas as a fuel to provide at least some of the power to operate the system and recycling the remainder of the dry gas through the system with fresh gas added in such quantity as to compensate for the liquefied and dry gas discharged from the system.

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