

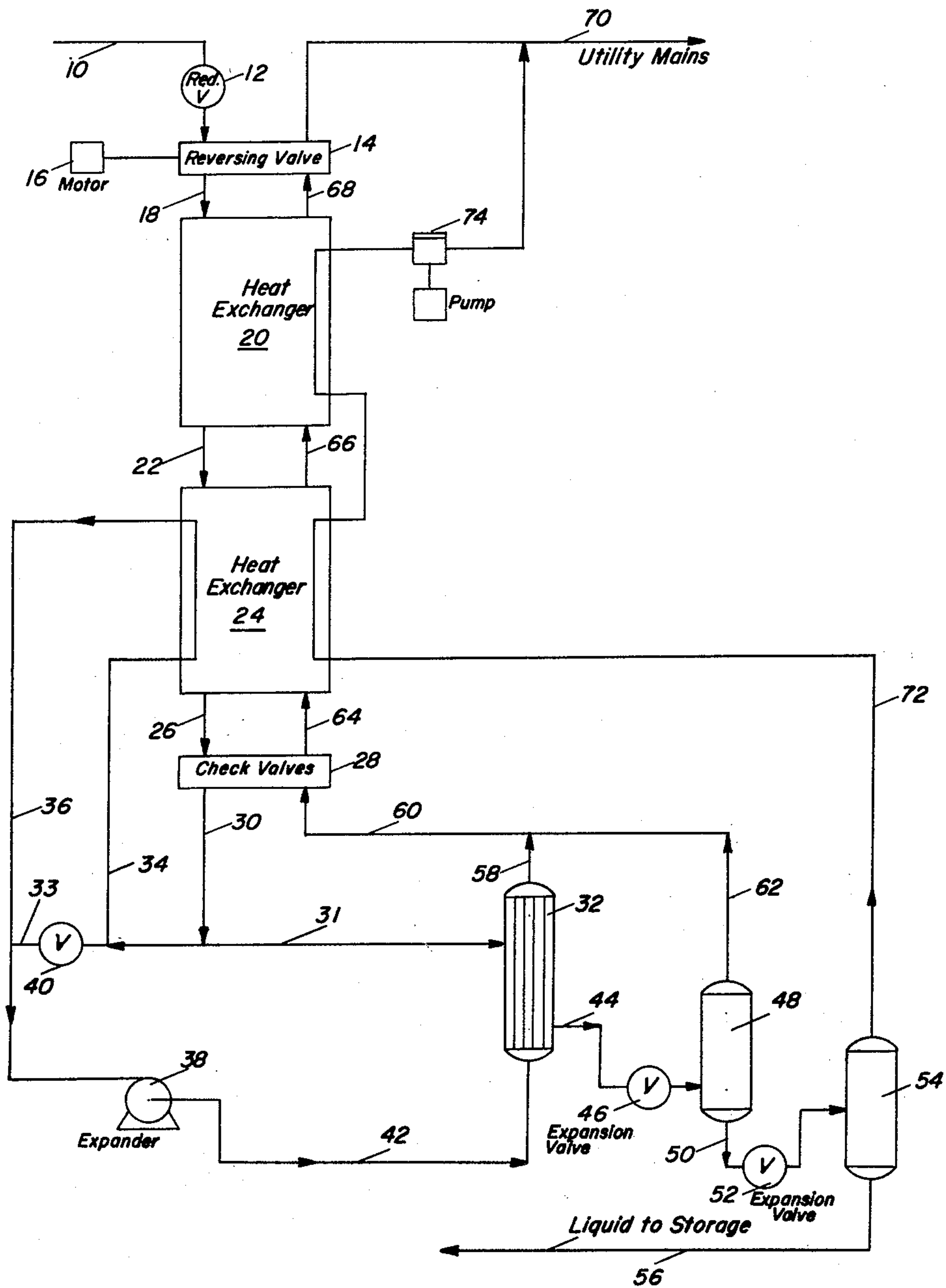
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NATURAL GAS LIQUEFACTION AND SEPARATION

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3,182,461 NATURAL GAS LIQUEFACTION AND SEPARATION

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5 Claims. (Cl. 62-13)

This invention relates to the distribution of natural gas and more particularly to the recovery of a portion of the gas as liquid by the appropriate conversion of the inherent energy of the gas in the pipeline.

It is well known that the transmission systems for natural gas customarily used in the transcontinental pipeline deliver the gas at the industrial terminals at pressures from as little as 200 p.s.i.g. to pressures in excess of 400 p.s.i.g. It is usually necessary, however, for domestic and industrial purposes to reduce the pressure to a distribution grid to a maximum pressure of about 50 p.s.i.g. Heretofore, this has been accomplished by expansion without any useful work or effect and thus with a definite loss of the energy potential. While this energy level is below that which can be economically recovered by the work of an expansion engine, nevertheless, there is a substantial value available if it can be utilized.

In accordance with my invention, I propose to recover a small percentage of the gas in liquid form by the use of this potential energy and to store such liquid for supplementary energy during periods of excessive gas requirements.

More particularly, by use of suitable heat exchangers, expansion engines and process flows, without the addition of more than nominal amounts of power, I find that it is possible to obtain a net condensate from typical pipeline natural gas which equals in heating value, molecular weight, and combustion characteristics the original pipeline gas, so that the liquefaction of a fraction of the gas can be carried out without degradation of the unit value of the original pipeline gas and the net condensate can be used without modification when there is a subsequent requirement for increased quantities of pipeline gas.

Although it is recognized that the percentage of gas that can be liquefied by this system is small, it is recognized that the energy is available all of the time and the recovery of amounts in the order of 4 to 8% over a year represent a very large added source of energy that can be used during the severe peak loads.

Further objects and advantages of my invention will appear from the following description of a preferred form of embodiment thereof taken in connection with the attached drawing which is a schematic flow diagram of a gas liquefaction cycle in accordance with my invention.

As pointed out, the natural gas from a transcontinental pipeline which enters the system in the line 10 is normally at a pressure of the order of 200 to 400 p.s.i.g. and generally at ambient temperature, as for example, 100° F. For my purposes this gas is passed through a reducing valve 12 to provide a control and to reduce the gas to about 200 p.s.i.g. as it enters the reversing valve 14. This valve is operated through the motor 16 in a suitable cycle.

The gas in line 18 is thus at about 95° F. as it enters heat exchanger 20. The gas then passes in contact with a cool surface hereinafter described so that the gas discharging from the heat exchanger through line 22 is at about -40° F. This gas then passes through the second heat exchanger 24 and is again in contact with a cold surface so that the gas is further reduced in temperature and discharges at 26 at about -178° F. The gas then passes through check valve 28 and the gas discharging in line 30 passes in part through line 31 to the methane liquefier 32, and in part through valve 40 and line 33 to expander

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38. A part of this gas passes through line 34 and heat exchanger 24 and thence through line 36 to the expander 38. This by-pass line 34 serves to control the temperature in the heat exchanger 24 and serves as the unbalance stream characteristic of reversing exchangers for control of temperature differences for the reversible condensation and revaporization of less volatile constituents.

The position of the reversing valves 16 is alternated periodically, as for example every three to sixty minutes, so that the pipeline gas passes alternately through one side and then the other side of heat exchangers 20 and 24. By this means water, butane, and propane are condensed from the feed gas on one side of heat exchanger 20 in the first part of the cycle, and revaporized into lower pressure gas from exchanger 24 in the second part of the cycle, while additional water, butane and propane are condensed from pipeline gas on the second side of exchanger. Similarly, carbon dioxide and ethane are condensed and revaporized in heat exchanger 24, using low pressure gas from line 60 (which see below) to receive the vaporized material. The design and attitude of heat exchangers 20 and 24 are such that condensed liquid cannot migrate longitudinally and disturb the temperature difference pattern essential to the complete revaporization of material. By this means, a gas essentially containing methane is available at line 30 to be used in expander 38 or methane liquefier 32.

The amount of gas which passes through the expander 38 is usually in excess of 90% of the total flow from heat exchanger 24 and as the pressure drops from about 200 p.s.i.g. to 50 p.s.i.g., the temperature of the gas will drop from -148° F. to about -220° F. The expanded gas in line 42 then passes through the methane liquefier 32 in countercurrent contact with the gas entering from the line 31 under such circumstances that the minor portion of the gas in line 31 is sub-cooled and partially liquefied. The cooled gas and liquid discharge from methane liquefier 32 through line 44 and the gas is further expanded in valve 46 into the flash separator 48. The liquid removed from the bottom of flash separator 48 through line 50 is again expanded in valve 52 into the low pressure flash separator 54. From 5 to 10% of the total gas may be removed through line 56 as liquid and passed to storage from which it is available for use in peak seasons. The low pressure gas in line 72 may then serve as an unbalance or heating stream for heat exchangers 24 and 20.

The partially heated gas at about 50 p.s.i.g. from the methane liquefier 32 passes upwardly through the line 58 and line 60 to the check valve 28 with its temperature raised to about -190° F. In a similar manner, the gas from the high pressure separator 48 is removed through the line 62 and joins with the gas line 60. This gas at 45-50 p.s.i.g. is used to revaporize condensed water, butane, propane, ethane and carbon dioxide in the reversing cycle of heat exchangers 20 and 24 as described above.

The combined high pressure gas then passes upwardly through the line 64 through heat exchanger 24 and through line 66 into heat exchanger 20 and thence through line 68 and reversing valve 14 to the utility gas main line 70, which in the present case, is assumed to be at 40 p.s.i.g.

The low pressure gas from the low pressure separator 54 passes upward from the line 72 and through heat exchangers 24 and 20 and is then compressed at 74 before joining the utility main line 70.

To some extent, depending upon the efficiency of the heat exchangers, it is found that, by the cycle disclosed, pipeline gas at 200 p.s.i.g., can be converted to utility main gas at 50 p.s.i.g. with approximately 6% of the gas flow liquefied. If the initial gas is at 400 p.s.i.g. approximately 8% of the gas can be liquefied without external energy.

Reference has been made to the condensation and revaporization of the higher hydrocarbons and if it is un-

desirable to retain them in the system they can be removed as usually the ethane, propane and butane command pre-minimum prices relative to natural gas.

With the foregoing cycle there is no degradation of the gas being processed and the amount of liquid which is removed is ultimately used without any utility or any other loss. As mentioned, the unit is self-sustaining and it is merely a question of recovering more or less of the liquid depending upon pressure and heat exchanger efficiency.

While I have shown a preferred form of embodiment of my invention, I am aware that modifications thereof can be made within the scope and spirit of the specification herein and of the claims appended hereinafter and I, therefore, desire a broad interpretation of such specification and claims.

I claim:

1. A method of operating a plant for converting a high pressure natural gas predominantly methane supplied by a transmission line to a substantially lower pressure heating gas and for distributing said heating gas to consumers with a minimum of interruption, which comprises: (1) withdrawing said natural gas under transmission line pressure from the transmission line by which said gas is supplied to said plant; (2) cooling said gas in a reversing heat exchanger while under substantially transmission line pressure to form a gaseous fraction; (3) removing a part of the cooled gaseous fraction and returning it as an unexpanded unbalance stream to the exchanger; (4) expanding said part of said gaseous fraction to a pressure substantially corresponding to the distribution line pressure maintained by said gas plant; (5) passing said cold expanded gaseous fraction in heat exchange relationship with the balance of said natural gas to liquefy a part thereof at the high pressure; (6) substantially continuously, at least during periods of ample supply of said natural gas, conducting said liquid fraction in the liquid state to at least one storage vessel; and (7) passing the expanded gaseous fraction after the heat exchange of step 5 in heat exchange relation to the first mentioned gas to accomplish the cooling of step (2).

2. The method of operating a plant as claimed in claim 1 wherein the liquid removed is of substantially the same thermal value as the distribution line gas and is adapted to be reintroduced as vapor into said distribution line gas.

3. The method of claim 1 wherein the pipeline natural

gas contains impurities of the class of water, butane, propane, ethane and CO₂ and a portion of the high pressure low temperature liquid is flashed in part and the vapor is conducted through at least one of the heat exchange steps to unbalance the temperature therein and revaporize impurities formed on the heat exchange surfaces.

4. The method of claim 1 wherein the pipeline natural gas contains impurities of the class of water, butane, propane, ethane and CO₂ and the heat exchange step is carried out in reversing exchangers and a portion of the gas discharged therefrom is separately returned through one of the heat exchangers for unbalance and to condition the gas for entry into the expansion step and a portion of the high pressure low temperature liquid is flashed in part and the vapor is conducted through at least another part of the heat exchangers to unbalance the temperature therein and revaporize impurities formed on the heat exchange surfaces.

5. The method of operating a plant as claimed in claim 1 wherein the cooling of the gas is to a temperature in the order of below -200° F. at the high pressure, the expansion of step (4) is accomplished in doing work, and the part of the gas liquefied is in the order of about 4 to 8%.

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