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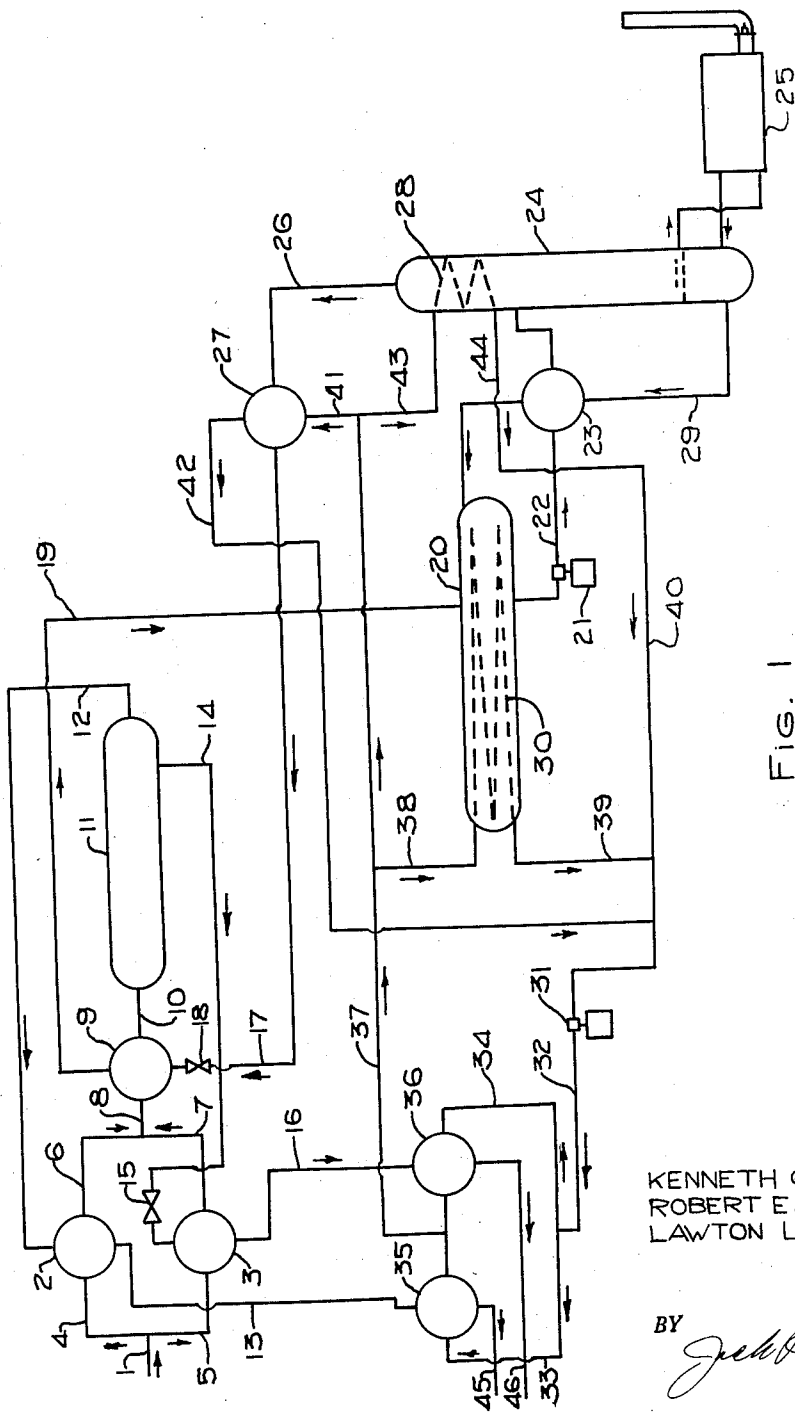
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2,909,905

METHOD FOR PROCESSING A NATURAL GAS STREAM

Filed June 5, 1957

2 Sheets-Sheet 1



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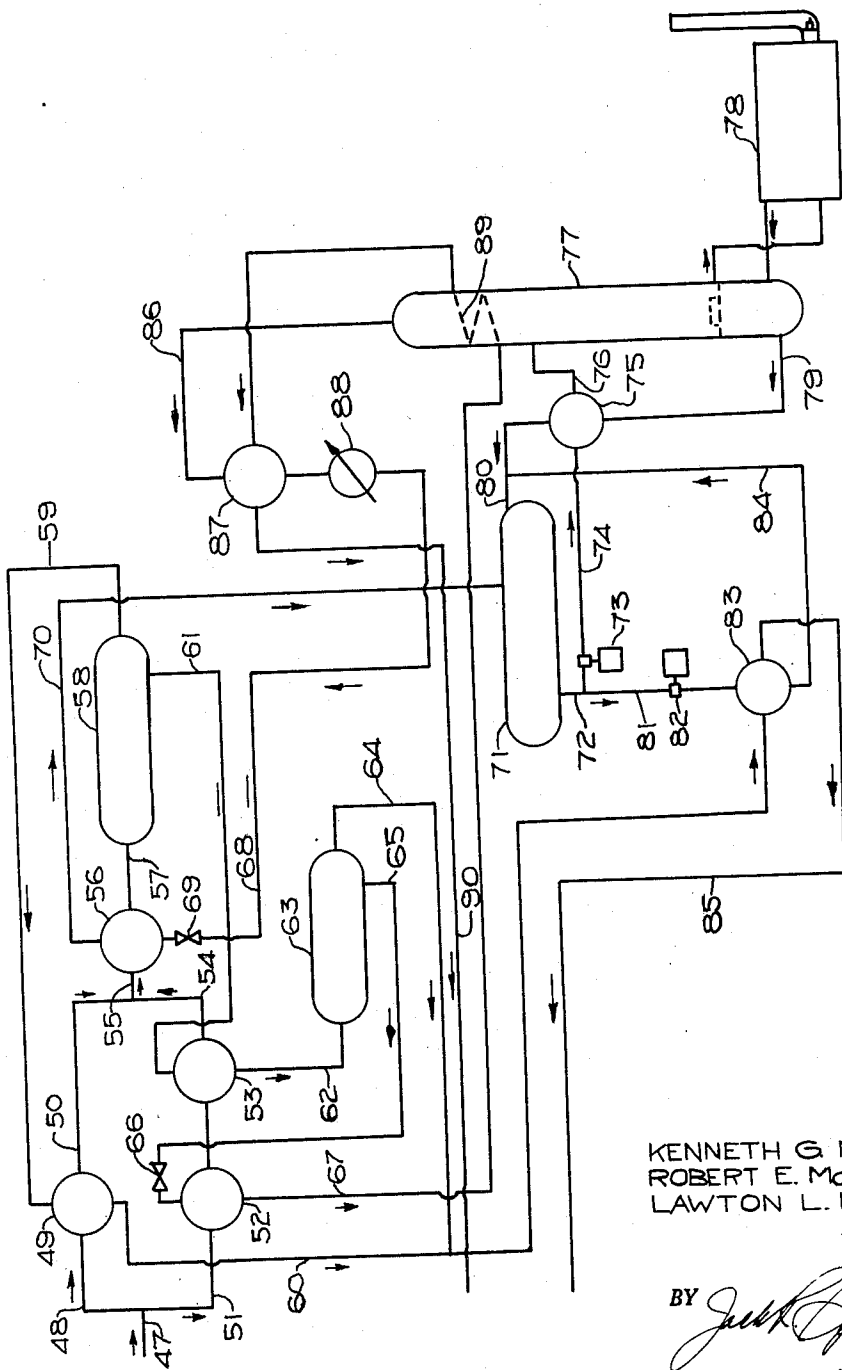
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2 Sheets-Sheet 2



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2,909,905

METHOD FOR PROCESSING A NATURAL GAS STREAM

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2 Claims. (Cl. 62—23)

The present invention relates generally to a method for processing a hydrocarbon fluid stream to recover the desirable liquefiable hydrocarbon components from the stream.

The processing of natural gas streams under pressure requires that the temperature of the stream be reduced to an extent whereby the maximum amount of desirable liquefiable components of the stream are recovered from the stream. Such processing requires substantial artificial cooling of the stream, especially when sufficient excess pressure is not available for expansion cooling. Therefore, the primary object of the present invention is to provide a method for processing such a fluid stream to obtain a maximum recovery of desirable liquefiable components of the fluid stream.

Another object of the present invention is to provide a method of processing a natural gas stream with artificial refrigeration in which the gas stream is used to absorb a substantial portion of the heat necessary for the artificial refrigeration. A still further object of the present invention is to provide a more efficient method of processing a natural gas stream with artificial refrigeration to recover the desirable liquefiable hydrocarbons. Still another object of the present invention is to provide an improved method of processing a natural gas stream with an absorption type refrigeration.

In accomplishing these and other objects of the present invention, we have provided an improved process which may readily be understood by reference to the accompanying drawings wherein:

Fig. 1 is a flow diagram of a form of apparatus for practicing the preferred method of the present invention.

Fig. 2 is a flow diagram of a modified form of the present invention.

Referring more in detail to the drawings:

A hydrocarbon fluid stream such as a natural gas well stream under pressure is conducted to the system illustrated in Fig. 1 through influent duct 1. In order to better illustrate the advantages of the present invention, temperatures and pressures of a fluid stream will be assumed, it being understood that these assumptions are for the purpose of illustration rather than any definite limitation. For example, a fluid stream having a pressure of eight hundred (800) pounds per square inch and an influent temperature of 70° F. would benefit from the method of the present invention as disclosed in Fig. 1.

The influent stream flowing through duct 1 is split whereby one portion of the stream is conducted to heat exchanger 2 and the other portion to heat exchanger 3 through ducts 4 and 5 respectively. The well stream fluids are cooled in both heat exchangers 2 and 3 and are discharged therefrom through ducts 6 and 7. These two portions of the fluid stream are combined and conducted through duct 8, heat exchanger 9, duct 10 into separator 11. The fluid stream is further cooled in heat exchanger 9 by artificial refrigeration as hereinafter more fully explained. Thus, it can be seen that without the

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advantage of having sufficient excess pressure to allow for expansion cooling of the fluid stream that the temperature of the fluid stream flowing through duct 8 can approach 20° F. or lower and the temperature of the fluid stream flowing through duct 10 in separator 11 may be 0° F. or lower, the pressure remaining substantially constant (800 pounds per square inch) throughout the entire system previously described.

Gas outlet duct 12 conducts gas separated from the fluid stream within separator 11 to heat exchanger 2 at a temperature of approximately 0° F. After providing this cooling of a portion of the influent fluid stream, the separated gas being discharged from heat exchanger 2 through duct 13 will have a temperature of approximately 60° F. and still a pressure of approximately 800 pounds per square inch.

The liquids separated from the fluid stream are discharged through liquid outlet duct 14 which connects into heat exchanger 3. Pressure reducing valve 15 is positioned in liquid outlet duct 14 near heat exchanger 3 to reduce the pressure of the separated liquids from 800 pounds down to approximately 100 pounds per square inch. The liquids, after cooling the portion of the influent fluid stream flowing through heat exchanger 3, are discharged through duct 16 having a temperature of 60° F. It should be noted that the volume of flow through heat exchanger 2 and heat exchanger 3 should be controlled to allow the greatest efficiency of cooling of the fluid stream.

Liquid ammonia at approximately 200 pounds per square inch pressure is supplied to heat exchanger 9 through duct 17 and pressure reducing valve 18. The ammonia vapors, after cooling the fluid stream within heat exchanger 9, are discharged through vapor duct 19 into absorber 20. The ammonia vapors delivered to absorber 20 are absorbed by weak solutions of ammonia in water and are discharged through pump 21 and duct 22 as a liquid having a greater concentration of ammonia in the solution. Warming of the solution flowing through duct 22 takes place in heat exchanger 23 prior to the discharge of the solution into generator 24. Heater 25 heats the solution gathering in the lower portion of generator 24 in order to drive off the ammonia vapors. These vapors rise through generator 24, are discharged out through duct 26 and are condensed in condenser 27. The condensed liquid flows into duct 17 thereby completing the refrigeration cycle. The vapors rising in generator 24 are cooled by cooling coils 28 in the upper portion of generator 24. This cooling provides sufficient cooling to reflux generator 24. If desired, coils 28 may be eliminated and a portion of the liquids condensed in condenser 27 may be delivered to the upper portion of generator 24 to provide refluxing. Weak solutions are drawn from the lower portion of generator 24 and conducted through ducts 29 and heat exchanger 23 wherein the solution to be dumped into generator 24 is warmed and the weak solution is discharged into absorber 20 preferably in the form of a spray in order to absorb the ammonia vapors being discharged therein through duct 19. Since the ammonia vapors may be driven out of solution by heat, it has often been found necessary to cool absorber 20 with cooling coils 30.

Pump 31 provides circulation of a heat exchange medium such as water through the cooling system for the absorption refrigeration system hereinbefore described. This heat exchange medium is pumped by pump 31 through duct 32 and divided into two streams flowing through ducts 33 and 34 into heat exchangers 35 and 36. The cooled heat exchange medium flows out of heat exchangers 35 and 36 and is conducted through header 37 and duct 38 to cooling coils 30 within absorber

20. The heat exchange medium being discharged from cooling coils 30 is conducted through duct 39 to return header 40 which connects into pump 31. Duct 41 connects into header 37 and delivers heat exchange medium to condenser 27 to cool and condense the ammonia vapors passing through condenser 27. The heat exchange medium leaving condenser 27 is conducted through duct 42 back to return header 40. Duct 43 connects into header 37 and conducts cooling medium to cooling coils 28 within generator 24. Duct 44 conducts the discharge of heat exchange medium from cooling coils 28 to return header 40.

When properly operated and all heat exchangers being properly sized, it may be assumed that the heat exchange medium temperature prior to any heat exchange will be 65° F. and that its temperature subsequent to heat exchange will be approximately 105° F. Under these circumstances the heat exchange within heat exchangers 35 and 36 between the heat exchange medium and the two phases, gas at 800 pounds per square inch and 60° F. and liquid at 100 pounds per square inch and 60° F., will provide sufficient cooling to reduce the temperature of the heat exchange medium from 105° F. down to the assumed initial temperature of 65° F. The gas flowing from heat exchanger 35 through duct 45 will then be at approximately 100° F. and 800 pounds per square inch. The liquid which is discharged through duct 46 from heat exchanger 36 will be at a temperature of approximately 100° F. and 100 pounds per square inch.

Referring to the flow diagram illustrated in Fig. 2, the influent stream is conducted into the system through duct 47 and to heat exchangers 49 and 52 through ducts 48 and 51. As in the system shown in Fig. 1, the stream is split, with one portion flowing through the gas cooler 49 and being discharged therefrom through pipe 50 and into duct 55. The other portion of the stream flows through duct 51, heat exchangers 52 and 53 and is conducted through duct 54 to combine with the stream flowing through duct 50 into duct 55. The total stream flows through artificial cooler 56 and duct 57 into separator 58. The gas from separator 58 is conducted through duct 59 to heat exchanger 49 wherein the cold gas is utilized to cool a portion of the influent fluid stream. The gas leaving heat exchanger 49 is conducted through duct 60 to the refrigeration equipment as hereinafter more fully described. The liquid is discharged from separator 58 through duct 61 to heat exchanger 53 wherein it cools the portion of the fluid stream flowing through heat exchanger 53. Duct 62 conducts the liquids from heat exchanger 53 into second stage separator 63. Separator 63 separates the gases which are vaporized from the liquid due to the heating of the liquids within heat exchanger 53. These gases are discharged through duct 64 and are combined with the gas stream flowing through duct 60. The liquids are discharged from separator 63 through duct 65, pressure reducing valve 66 and into heat exchanger 52. These liquids, after cooling the portion of the well stream flowing through heat exchanger 52 are discharged therefrom through duct 67 and are delivered to the refrigeration system as hereinafter more fully described.

Liquid refrigerant is delivered to heat exchanger 56 through duct 68 and pressure reducing valve 69. The vapors of the refrigerant which are discharged from heat exchanger 56 are conducted through duct 70 into absorber 71 wherein these vapors are absorbed into a water solution. The water solution is discharged from absorber 71 through duct 72, pump 73, duct 74, heat exchanger 75, duct 76 and into generator 77.

Heater 78 provides the necessary heating of the liquids collecting within the lower portion of generator 77. Liquids are discharged through duct 79 and are passed in heat exchange relation with the liquid flowing through heat exchanger 75 from absorber 71. The liquids from generator 77, being cooled and having warmed the liquid

solution which is to be dumped into generator 77, are conducted through duct 80 and sprayed into absorber 71 in such a manner as will best enable the liquids to pick up the vapors flowing into absorber 71 through duct 70. Duct 81 connects into the liquid discharge duct 72 and conducts a portion of the liquids from absorber 71 through pump 82, heat exchanger 83, duct 84 and into duct 80 which discharges the liquid from the lower portion of generator 77 and from heat exchanger 75 into absorber 71.

The gas being discharged from the system is conducted through duct 60 into heat exchanger 83 wherein the gas absorbs a portion of the heat contained in the liquids within absorber 71. The gas passes from heat exchanger 83 and is delivered through duct 85 to any suitable pipeline or gas transmission system. It is believed that the cooling of the liquids from absorber 71 will be sufficient so that internal cooling coils will not be needed. If sufficient heat is not absorbed by the gas stream in heat exchanger 83, then additional cooling may be used without departing from the spirit of the present invention. This may be in the form of flowing a cooling medium through heat exchange coils within absorber 71 and allowing the cooling medium to be air cooled.

The vapors boiled out of the liquid in generator 77 are conducted out through duct 86 into condenser 87 and are delivered through cooler 88 to duct 68 and pressure reducing valve 69 wherein the liquid condensed in condenser 87 is again used to provide cooling for the fluid stream heat exchange in heat exchanger 56. The liquids which are discharged from heat exchanger 52 through duct 67 are connected to cooling coil 89 within generator 77 and to condenser 87. This cools the upper portion of generator 77 to provide a reflux of condensed vapors. Reflux liquid could be provided from condenser 87, thus eliminating the necessity of cooling coil 89 in generator 77. The liquids are then discharged through duct 90 to suitable liquid storage facilities or to processing facilities for stabilization or fractionation. The liquid provides sufficient cooling of the refrigerant vapors in cooling coils 89 and condenser 87 and eliminates the necessity for a substantial amount of additional cooling in the refrigeration system. The extent to which the liquids can be used for cooling must be thoroughly understood and the amount of heat absorbed by these liquids should be definitely limited so as to comply with the temperature and pressure requirements for storage or the required pressure and temperatures of the liquid for any processing equipment to which the liquids are to be delivered.

Therefore, from the foregoing description it can be seen that we have provided a novel system for processing a fluid stream whereby the components of such stream are cooled, separated, used for initially precooling the fluid stream and subsequently for absorbing heat from the artificial refrigeration system which also is used to cool the influent stream. We have provided a system which takes advantage of the heat which may be absorbed by the separated components of the fluid stream. For example, it is often a tremendous heat saving to be able to heat the gas stream going to a pipeline to a temperature of approximately 100° F. This is advantageous if the stream is to be transported through a pipeline since it warms the gas to a temperature substantially above its dew point, thus further protecting the pipeline against condensation. Utilizing these streams to absorb heat will result in a large saving both in original equipment needed (such as water cooling towers) and in reduced operating costs.

What we claim and desire to secure by Letters Patent is:

1. The method of processing a hydrocarbon fluid stream comprising, dividing said fluid stream into a first stream and a second stream, precooling said first stream and said second stream, recombining said first and said second streams, cooling said recombined stream,

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separating the condensed liquids from said recombined stream, flowing said separated liquids into heat exchange relation with said second stream to precool said second stream, flowing the liquid-free fluid stream into heat exchange relation with said first stream to precool said first stream, flowing said separated liquids into heat exchange relation with refrigerant vapor to condense said refrigerant vapor, expanding said condensed refrigerant, flowing said expanded refrigerant into heat exchange relation with said fluid stream to provide said cooling of said fluid stream, absorbing said expanded refrigerant with an absorbent liquid, heating said absorbent liquid to vaporize said absorbed refrigerant, flowing said refrigerant vapors into heat exchange relation with said separated liquids to condense said refrigerant vapors, flowing said liquid-free fluid stream into heat exchange relation with said absorbent liquid to cool said liquid.

2. The method of processing a hydrocarbon fluid stream comprising, dividing said fluid stream into a first stream and a second stream, precooling said first stream and said second stream, recombining said first and said second streams, cooling said recombined stream, separating the condensed liquids from said recombined stream, flowing said separated liquids into heat exchange relation with said second stream to precool said second stream, flowing the liquid-free fluid stream into heat exchange relation with said first stream to precool said first stream,

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separating the gases released from said separated liquids by the heat exchange with said second stream, combining said separated gases into said liquid-free fluid stream, flowing said gas-free liquid stream into heat exchange with refrigerant vapor to condense said refrigerant vapor, expanding said condensed refrigerant, flowing said expanded refrigerant into heat exchange relation with said fluid stream to provide said cooling of said fluid stream, absorbing said expanded refrigerant with an absorbent liquid, heating said absorbent liquid to vaporize said absorbed refrigerant, flowing said refrigerant vapors into heat exchange relation with said gas-free liquid stream to condense said refrigerant vapors, flowing said liquid-free fluid stream into heat exchange relation with said absorbent liquid to cool said liquid.

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