

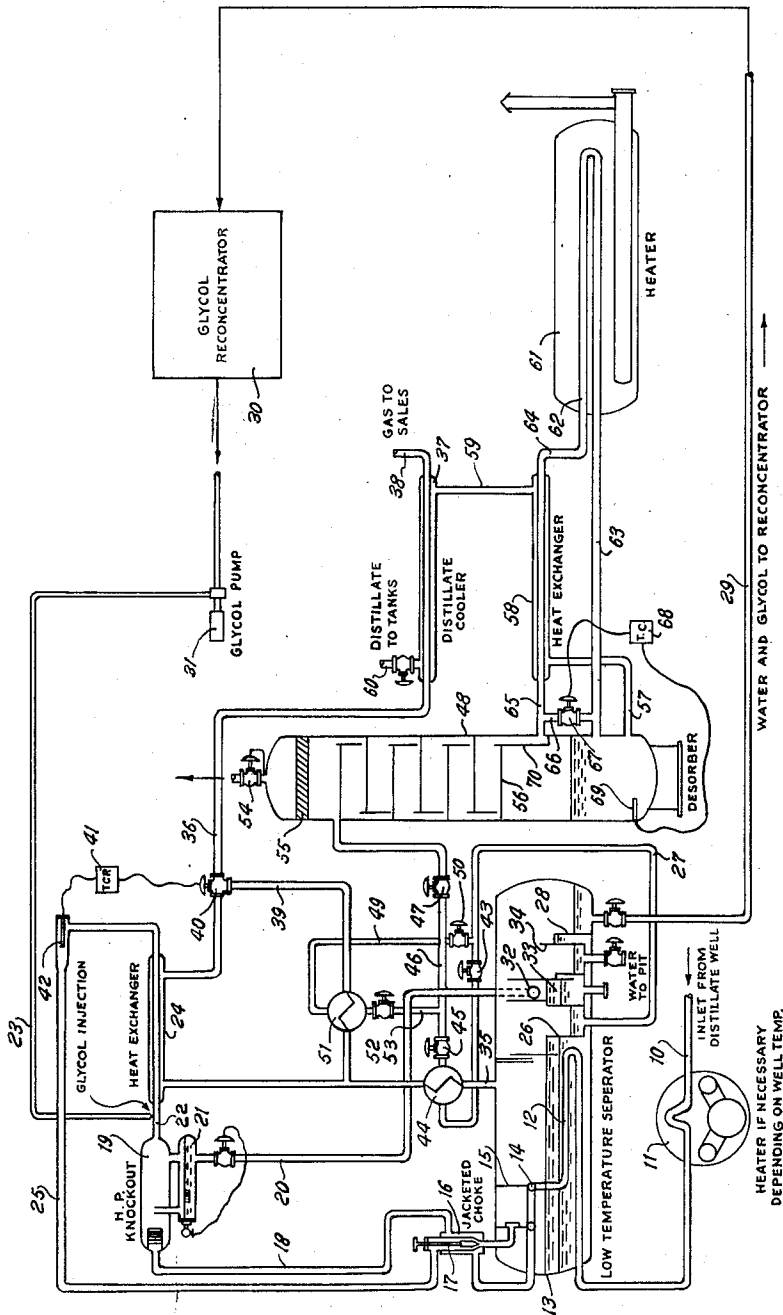
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LOW TEMPERATURE SEPARATION SYSTEMS

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LOW TEMPERATURE SEPARATION SYSTEMS

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2 Claims. (Cl. 183—2.7)

This invention relates to new and useful improvements in low temperature separation systems.

The invention is particularly concerned with low temperature separation systems as applied in the petroleum industry to the separation of distillate or light hydrocarbons from well streams of medium or high pressure and which are predominantly gaseous in nature. Well streams of this character not only include marketable quantities of gas, but consist predominantly of gas and dictate the conservation of all possible high pressure gas for economic operation. Further, such well streams require the use of equipment capable of handling large volumes of gas and which desirably includes provision for desorbing or stabilizing the distillate or liquid hydrocarbons separated and recovered from the well stream with maximum conservation of gas and of the gravity and volume of the recovered distillate.

It has been the practice in low temperature systems to utilize the well stream with or without added heat content, as a means for heating the liquid accumulation portion of a low temperature separator, and other portions or elements of the system, to pass the well stream in regenerative heat exchange with cold exhaust gas for cooling, and then to expand the cooled gas through a choke into the low temperature separator. The pressure drop, and accompanying reduction in temperature, results in the separation of liquefiable hydrocarbon components of the well stream which separate and are stratified into the liquid accumulation portion of the low temperature separator while the cold separated gas is exhausted through the regenerative heat exchanger to a gas transmission pipe line or other point of use or disposal. The low temperature separator is operated at a pressure sufficiently above pipe line pressure as to permit the ready discharge of gas from the separator into the pipe line, and therefore, it is desirable that all possible gas be removed at this point.

It has further been the practice to draw off the separated liquids to a stabilizing column of tower, known as a desorber or stabilizer, wherein the liquid is passed downwardly over bubble trays or their equivalent, and with heat being supplied to the bottom of the tower to provide the stabilizing function well known in this art. The stabilized distillate or liquid hydrocarbons are withdrawn from the lower portion of the tower, and low pressure gas is taken off from the upper portion thereof.

It is desirable that a minimum quantity of gas be removed from the recovered liquids in the desorber since this gas is recovered at low pressure and may not be flowed directly into a transmission pipe line operating at a higher pressure. It is not economical to recompress this gas because of its fairly small volume, and yet, its loss represents a considerable economic disadvantage. Stated conversely, it is desirable that as much gas as reasonably possible be taken off in the low temperature separator which is operating at a higher pressure and from which gas may be conducted directly to a gas pipe line.

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Hence, it is preferable that the separated and accumulated liquids in the low temperature separator be maintained at a relatively high temperature in order to insure the evolution of substantially all of the dissolved gas from the separated liquids other than those portions of the more volatile hydrocarbons which may be retained in the separated liquids under normal storage conditions.

On the other hand, it is not desirable that the distillate feed to the desorber tower be at an elevated temperature since the tower is operating at a lower pressure than the low temperature separator and since the liquid is thus subjected to a pressure drop or "flashing" upon entry into the tower. This results in an appreciable loss or evolution of the light hydrocarbons from the liquid immediately upon entering the desorber and before the liquid can drop to the uppermost bubble plate in the desorber tower. On the contrary, it is desirable that the liquid feed to the desorber be relatively cold, preferably at a temperature lower than the temperature of the top tray in the desorber in order to eliminate the uncontrolled flashing of volatile hydrocarbons from the distillate feed to the desorber and therefore to bring the stabilizing of the distillate, or the removal of volatiles therefrom, under the controlled conditions maintained in the desorber.

It is, therefore, an important object of this invention to provide a low temperature separation system in which the liquid accumulation portion of the low temperature separator may be maintained at an elevated temperature, while the separated distillate fed from the low temperature separator to the desorber may be maintained at a low temperature to achieve the advantages of maximum gas removal in the low temperature separator and minimum hydrocarbon loss in the desorber due to instantaneous volatilization of portions of the distillate fed to the desorber.

A further object of the invention is to provide a system of the character described in which the cold exhaust gas flowing from the low temperature separator may be utilized for cooling of the distillate flowing from the low temperature separator to the desorber.

A further object of the invention is to provide a system of the character described in which the distillate fed from the low temperature separator to the desorber may be selectively cooled by heat exchange with the gas being exhausted from the low temperature separator, or with that portion of said gas which is by-passed around the regenerative heat exchanger employed for cooling the incoming well stream.

Other and more specific objects will be apparent from a reading of the following description and claims.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, wherein an example of the invention is shown, and wherein the figure is a schematic view illustrating a low temperature separation system adapted to carry out this invention and constructed in accordance therewith.

In the drawing, the numeral 10 designates a well stream inlet conductor through which a well stream under pressure flows to the low temperature separation system. This well stream is predominantly gaseous, may be under moderate or high pressure, will normally contain some water and/or water vapor, and may contain anywhere from a few barrels to several hundred barrels of recoverable liquefiable hydrocarbons per million cubic feet of gas.

The temperature of the well stream may vary depending upon the particular well or wells from which the

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stream is flowing, and also depending upon the flow rate or the age of the particular well or wells involved. Hence, it is often desirable to incorporate in the system a heater 11 through which the well stream is conducted via the pipe 10 in order that the stream may be brought to the desired temperature.

The stream is then taken through heating coils 12 located in the lower portion of a low temperature separator vessel 13, then through the heating coil 14 of a spinner drum 15 disposed within the vessel 13 and into the jacket 16 surrounding a pressure-reducing choke 17. At each of these points, the well stream, being at an elevated temperature of possibly 100° to 150° F., will impart some degree of heating, and will, in turn, itself be cooled. There may be some condensation of liquids due to this cooling, or there may already be present in the well stream water or hydrocarbons in the liquid phase. Hence, the well stream is taken from the jacket 16 through a conductor 18 to a high pressure separator or liquid knock-out 19 in which liquids are separated, and drawn off through a conductor 20 after accumulation in a vessel 21 disposed beneath the separator 19. Thus, the well stream leaving the separator 19 through the conductor 22 is predominantly if not entirely gaseous in nature.

It is important that no gas hydrates be allowed to form in the well stream prior to the introduction of the same into the low temperature separator 13, and yet, to obtain maximum liquid recoveries, it may be desirable to cool the well stream below the gas hydrate formation temperature prior to pressure reduction of the well stream in the choke 17. Therefore, if desirable or necessary, a hydrate inhibitor or desiccant, such as diethylene glycol, triethylene glycol, calcium chloride solution, and similar materials, may be injected into the well stream through a branch conductor 23 leading into the conductor 22 immediately downstream of the separator 19. The inhibitor functions to depress the hydrate formation temperature, and permits the cooling of the well stream to temperatures much below those possible when no inhibitor is used.

The well stream is then passed through a heat exchanger 24 in which it is cooled to the desired degree by indirect heat exchange with cold gas being exhausted from the low temperature separator 13. The cooled well stream then flows from the heat exchanger through a conductor 25 to the choke 17, wherein the pressure of the well stream is reduced considerably and marked chilling or cooling of the well stream occurs in such expansion due to the Joule-Thompson effect. The cold, reduced-pressure well stream is then admitted tangentially into the spinner drum 15 which is maintained at a relatively warm temperature by means of the coil 14.

The pressure reduction and cooling of the well stream results in the condensation of both hydrocarbon and aqueous liquids which settle to the lower portion of the separator 13 and into proximity with the heating coils 12. The hydrocarbon or distillate stratum, of course, float upon the water or aqueous stratum, and is skimmed off into a sump 26 for withdrawal through a distillate discharge conductor 27. The water stratum flows along the lower portion of the low temperature separator and is overflowed into a sump 28 from which it is withdrawn through a conductor 29 leading to an inhibitor reconcentrating unit 30 for the removal of water. The reconcentrated inhibitor is driven by a pump 31 into the conductor 23 for recirculation into the well stream passing through the conductor 22.

The well stream sometimes contains formation water having therein dissolved salts, or contains other materials or liquids which should not be commingled with the water and inhibitor mixture collected in the separator 13 around the heating coils 12. These liquids are removed in the high pressure separator 19 and flow through the conductor 20 to an auxiliary inlet 32 discharging into a sump 33 in the low temperature separator 13 and wherein the distillate and water present in such liquids may stratify.

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The distillate is skimmed from the sump 33 into the sump 26, while the aqueous stratum is overflowed from the sump 33 into a separate sump 34 from which such aqueous material may be withdrawn for discharge and disposal.

The low temperature separator may be operated at any suitable pressure, but normally is maintained at a pressure of 500 to 1500 pounds per square inch or more so that the gas from the well stream may be discharged directly into a gas transmission pipe line which may be operating at a pressure of from several hundred pounds per square inch to as much as 1200 pounds per square inch. The cold separated gas is withdrawn from the upper portion of the low temperature separator through a conductor 35 leading to the shell of the heat exchanger 24 wherein the cold gas is employed for cooling the incoming well stream. From the shell of the heat exchanger, the discharge gas is taken through a conductor 36 to a heat exchanger 37, described hereinafter, and then discharged at 38 to the pipe line or other point of use or sale. A by-pass conductor 39 is provided between the conductors 35 and 36, and is connected into the conductor 36 through a three-way valve 40 which is diaphragm-operated and controlled by a temperature controlling regulator 41 having its temperature sensing bulb 42 exposed to the well stream flowing through the conductor 25. Thus, the temperature controlling regulator 41, by operating the valve 40, controls the quantity or volume of cold gas flowing through the heat exchanger 24 to provide the desired degree of cooling for the well stream entering the heat exchanger from the conductor 22 and to maintain a constant or desired degree of cooling of said incoming well stream.

The structure thus far described is disclosed in the co-pending application of Jay P. Walker et al., Serial No. 316,632, filed October 24, 1952 as a continuation-in-part of application Serial No. 185,608, filed September 19, 1950, now abandoned, in the co-pending application of Clarence O. Glasgow et al., Serial No. 389,536, filed November 2, 1953, as a continuation-in-part of application Serial No. 249,148, filed October 1, 1951, now abandoned, and of the co-pending application of Joseph L. Maher, Serial No. 382,392, filed September 25, 1953, now Patent No. 2,728,406, issued December 27, 1955. Reference is made to the aforesaid applications.

While the present invention is applicable to medium to high pressure gaseous well streams of any nature, it finds most beneficial use in conjunction with relatively rich well streams containing fifty to one hundred barrels or more of recoverable, liquefiable hydrocarbons per million cubic feet of gas. This is true because the low temperature separator is operated at appreciable pressure and the liquids separated therein will contain quantities of gas in proportion to such pressure. Obviously, this gas is carried from the low temperature separator in the liquids when they are discharged therefrom, and the quantity of gas lost in this manner will be in proportion to the quantity or volume of liquids separated and removed. A very lean well stream which produces only small amounts of distillate will suffer a proportionately small loss of gas in solution in such distillate. On the other hand, a rich well stream from which large quantities of distillate and liquids are separated will undergo a proportionately larger loss of gas because of the larger volume of gas-carrying liquid withdrawn from the low temperature separator.

To overcome this loss of valuable gas which is readily saleable so long as it is maintained at the pressure of the low temperature separator, it is prudent to remove as much gas as possible from the liquids accumulating in the low temperature separator, and this is accomplished by maintaining said liquids at a relatively elevated temperature. Hence, it may be desirable to maintain the distillate overlying the heating coils 12 at a temperature of 60° to 90° F., or even higher, in order that all possible gas be driven from the distillate, and so long as excessive

vaporization of liquefiable hydrocarbons does not occur to an extent at which such vapors would be lost out the gas discharge conductor 35. In many cases, a distillate temperature of at least 60° F. has been found important to drive off the gas with adequate thoroughness.

Normally, the heater 11, if employed, is thermostatically controlled so as to heat to any desired temperature the well stream passing through the conductor 10 to the heating coils 12. Thus, any desired quantity of heat may be imparted to the coils 12, and the distillate present within the low temperature separator may be maintained at the proper or desired temperature level. In this manner, the distillate is substantially denuded of gas at the operating pressure of the low temperature separator 13, and this gas is driven from the distillate into the vapor or gas space of the low temperature separator for discharge at pipe line pressure through the conductor 35. The gas lost by retention in the distillate is thereby minimized.

The relatively gas free distillate is withdrawn from the low temperature separator through the conductor 27 and through a valve 43 to a heat exchanger 44 connected into the cold gas discharge conductor 35. From the heat exchanger, the distillate passes through a valve 45, a conductor 46 and through a valve 47 into the upper end of a desorber column or tower 48. There is also provided a branch or by-pass conductor 49 leading from the conductor 27 upstream of the valve 43 and through a valve 50 into a heat exchange 51 connected into the cold gas by-pass conductor 39. This alternate flow path for the distillate leads from the heat exchanger 51 through a valve 52 and through a conductor 53 connected into the conductor 46 between the valves 45 and 47.

The desorber is provided with a gas outlet conductor 54 at its upper end with a mist extractor 55 being disposed in the desorber between the distillate inlet and said gas outlet. Below the distillate inlet, the tower carries a plurality of bubble trays 56, or equivalent structures, and a stabilized distillate outlet conductor 57 is provided at the lower end of the desorber leading to a heat exchanger 58, and from the heat exchanger 58 through a conductor 59 to the heat exchanger 37. The cooled and stabilized distillate is discharged from the heat exchanger 37 through an outlet conductor 60 to storage tanks or other points of use or disposal.

For supplying a kettle or source of heat for the lower portion of the desorber, a heater 61 is provided and contains a heating coil 62 connected to the lower end of the desorber by a conductor 63 and also connected by a conductor 64 to the heat exchanger 58, and from the heat exchanger 58 through a conductor 65 to the desorber at a point elevated from the lower portion thereof. A by-pass conductor 66 is connected between the conductors 63 and 65 through a diaphragm-operated valve 67 operated by a temperature control 68 having a temperature-sensing probe or element 69 disposed in the bottom of the desorber tower 48. Liquids flow from the downcomer 70 of the lowermost tray 56 of the desorber column 48 by gravity through the conductor 65 to the heat exchanger 58 and by the conductor 65 to the heating coil 62. The heated liquids return by gravity from the coil 62 through the conductor 63 into the bottom of the desorber. Obviously, the temperature controller 68 operates by opening the valve 65 and permitting the by-passing of these liquids through the conductor 66 rather than the passage of such liquids through the heating coil 62. The liquids discharged from the desorber through the conductor 57 will be relatively hot and will be cooled by passage through the heat exchanger 58 while functioning to preheat the liquids flowing to the coil 62. These discharged hydrocarbons will be further cooled by passage through the heat exchanger 37 wherein the liquids pass in indirect heat exchange relationship with the cool gas passing to the gas outlet conductor 38, and hence, the stabilized hydrocarbons will be released to storage through

the discharge conductor 60 at moderate, or substantially ambient, temperature.

The temperature of the various trays in the desorber 48 will depend upon the type of distillate or liquid hydrocarbons which it is desired to produce. Light hydrocarbons of this type are normally classified on the Reid vapor pressure scale, and assuming that material having a Reid vapor pressure of 18 pounds per square inch is being produced, the temperature of the top tray of the desorber tower may well be in the neighborhood of 50° F. On the other hand, if material of Reid vapor pressure of 30 or 40 pounds per square inch is being produced, the temperature of the top tray of the desorber may be somewhat lower than this figure. It is true, however, that with a constant distillate composition, and at a constant operating pressure for the desorbing tower 48, the lower the temperature of the distillate feed to the top of the tower through the conductor 46, the lower will be the flash loss by instantaneous vaporization of portions of the distillate feed as said distillate enters the top of the tower. It is not the loss of methane or ethane from the distillate feed that is of importance, but rather, the loss of pentanes and heavier homologs carried from the distillate by the lighter hydrocarbons and lost through the gas outlet 54. If the distillate feed to the desorber tower is quite warm, there will be appreciable gas losses as well as heavier hydrocarbon losses. Thus, if the distillate were discharged directly from the low temperature separator into the desorber 48 at the temperature at which the distillate is maintained in the low temperature separator, inordinate losses of dissolved and heavier hydrocarbons would occur in the upper portion of the desorber 48 before the liquid could flow onto the uppermost plate or tray of the desorber and come fully within the controlled stabilizing conditions being maintained in the desorber. Assuming a top tray temperature of 50° F., and a distillate feed to the upper end of the desorber at a temperature of 80° F., it is obvious that the distillate, in undergoing a pressure drop of the several hundred pounds per square inch or more pressure differential that exists between the low temperature separator and the desorber, will be subjected to flash vaporization in which excessive quantities of gas may be lost, as well as heavier and more valuable hydrocarbons. Even assuming flow of the distillate directly onto the uppermost plate of the desorber tower, there will be a time interval required for cooling of this distillate feed to the top tray temperature, and during this time, this objectionable vaporization would take place.

In the present invention, the advantages of relatively high temperatures in the liquid section of the low temperature separator are retained, and the disadvantages of high temperature feed to the desorber 48 are eliminated by conducting the distillate from the discharge conductor 27 selectively through the heat exchangers 44 or 51 in order that the distillate may be cooled and reduced in temperature by indirect heat exchange with the relatively cold gas flowing through the conductors 35 and 39. The valve 47 is desirably a diaphragm-operated valve controlled by a float (not shown) disposed within the sump 26 and thus operating to discharge distillate to the desorber tower 48 in accordance with the rate of accumulation of the distillate within the sump 26. By closing the valves 50 and 52, the distillate may be passed through the heat exchanger 44, while, by closing the valves 43 and 45, and opening the valves 50 and 52, the distillate may be passed through the heat exchanger 51.

The alternate flow paths for cooling or chilling of the distillate are provided to meet operating conditions and to insure an adequate supply of cold gas to the heat exchanger 24. The volume of distillate flowing to the desorber is relatively small in comparison to the volume of the incoming well stream, and no very large volume of cold gas is required for adequate cooling of this distillate. In the event the heat exchanger 24 is operating at or near capacity, it may not be desirable to warm the

cold gas flowing through the conductor 35 to any appreciable extent, and hence, it may not be desirable to use the heat exchanger 44. Normally, however, there will always be some gas flowing through the conductor 39 and by-passing the heat exchanger 24, and thus, the heat exchanger 51 may be employed for cooling of the distillate without in any way impairing the cooling capacity of the heat exchanger 24.

It is desirable that the distillate being fed to the desorber through the conductor 46 and the valve 47 be reduced in temperature to a level near, or preferably below, the temperature of the uppermost tray of the desorber tower. Hence, flash or uncontrolled vaporization from the incoming distillate is eliminated, and the removal of gas and very light hydrocarbons from the distillate is brought within the controlled operating conditions of the desorber tower. Usually, the distillate discharged from the low temperature separator 13 is not in proper condition for storage without further removal of dissolved gas and very light hydrocarbons, but at the same time, it is not desirable to remove all of the very light hydrocarbons from this liquid. A considerable quantity of these lighter materials may be retained in the distillate in storage by solution therein, and this retention of the lighter hydrocarbons increases the gravity and volume of the distillate, as well as the value thereof. Stabilization of the recovered distillate, as contrasted to simple flash or low pressure gas separation thereof, is therefore advantageous when the composition and the volume of the recovered distillate warrants the installation and operation of the desorber 48. With the present invention, the full advantages of the desorber tower are realized by bringing the separation and removal of very light hydrocarbons from the distillate completely and entirely within the control of the stabilizer and by utilizing the stabilizer at fullest efficiency upon the complete distillate stream being fed thereto.

Of course, it is not essential that the high pressure separator 19, the heat exchanger 24, or the inhibitor injection through the conductor 23 be employed. Media other than the well stream may be employed for heating the separated hydrocarbons, and the well stream may be cooled by means other than the expansion through the choke 17. Further, the cold distillate feed to the de-

sorber is advantageous and need not always be accompanied by enhanced heating of the distillate.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

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

1. A low temperature separation system for recovering liquefiable hydrocarbons from gaseous well streams under pressure, including, a low temperature hydrocarbon and gas separator, a well stream inlet conductor leading to the separator means in the inlet conductor for cooling the well stream; the low temperature separator enclosing a cold gas zone and a liquid hydrocarbon accumulation zone, a cold gas outlet conductor leading from the separator, a desorber vessel for stabilizing the separated liquid hydrocarbons, a liquid hydrocarbon outlet conductor leading from the separator to the desorber vessel, a first heat exchanger having one flow path connected into the well stream inlet conductor and another flow path connected into the cold gas outlet, a cold gas by-pass conductor connected into the cold gas outlet conductor on both sides of the first heat exchanger for by-passing cold gas around the first heat exchanger, a second heat exchanger having one flow path connected into the cold gas outlet conductor and another flow path connected into the liquid hydrocarbon outlet conductor, a liquid hydrocarbon by-pass conductor connected into the liquid hydrocarbon outlet conductor on both sides of the second heat exchanger by by-passing liquid hydrocarbons around the second heat exchanger, a third heat exchanger having one flow path connected into the cold gas by-pass conductor and another flow path connected into the liquid hydrocarbon by-pass conductor, and valves for controlling flow through the two-by-pass conductors.

2. A low temperature separation system as set forth in claim 1, and heating means in the low temperature separator in the liquid hydrocarbon accumulation zone.

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