Jan. 21, 1936. P. D. BARTON 2,028,432

COMBINED RECTIFICATION AND REFRIGERATION PROCESS

Filed March 19, 1934

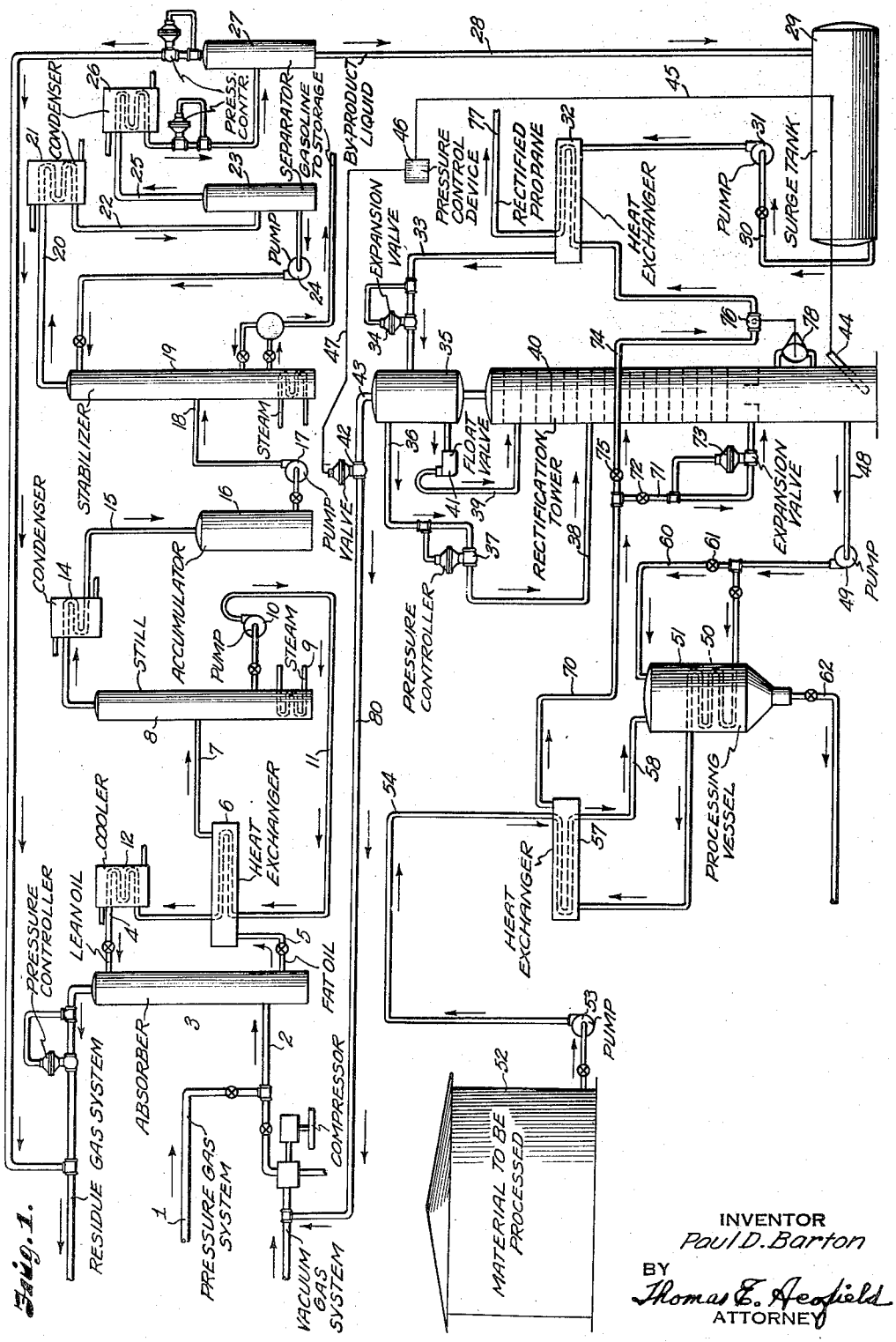


Fig. 1.

INVENTOR
Paul D. Barton
BY
Thomas E. Penfield
ATTORNEY

Patented Jan. 21, 1936 2,028,432

UNITED STATES PATENT OFFICE

2,028,432

COMBINED RECTIFICATION AND REFRIGERATION PROCESS

Paul D. Barton, Scarsdale, N. Y., assignor to Alco Products Incorporated, New York, N. Y., a corporation of Delaware

Application March 19, 1934, Serial No. 716,281

5 Claims. (Cl. 62—175.5)

My invention relates to a combined rectification and refrigeration process and more particularly to a process for utilizing by-product liquid ethane-propane hydrocarbon mixtures from recovery and stabilization plants for refrigeration and particularly the chilling of hydrocarbon oils undergoing treatment at sub-atmospheric temperatures while submitting the fluid hydrocarbons to rectification.

The by-product liquid which is obtained from recovery and stabilization plants consists largely of a mixture of ethane and propane together with other hydrocarbons. This by-product liquid material is of little commercial use unless the highly volatile ethane is separated by rectification from the less volatile propane. The propane is usually recovered from the rectification system and transferred to steel containers for shipping. Commonly this rectification is carried out at a relatively high pressure in order that the normally gaseous ethane may be condensed with water as the cooling medium. The condensation of ethane is necessary in order to obtain reflux liquid for the rectification. The factors which control the condensation of hydrocarbon vapors are temperature and pressure. If the rectification operation is carried on at a lower temperature, the pressure will be shifted downwardly.

In general, my invention contemplates rectifying at low temperatures and at comparatively low pressure in such a manner that the heat of reboiling necessary for rectification is supplied from material to be refrigerated and is dissipated as latent heat of the overhead or exit fluids from the rectifying system.

It happens that the latent heat of ethane compares very favorably with that of both propane and ammonia at the temperature range which would be employed for obtaining refrigeration temperatures below 0° F. As an illustration, at —40° F. and assuming that for purposes of comparison, the evolved refrigerant vapor must be recompressed and condensed at 75° F. the following table will represent the B. t. u. per mol, divided by the number of compressions through the compression range.

Ammonia	741
Ethane	954
Propane	977

Due to the fact that the proportion of ethane in the volatile refinery by-product liquid is to be rectified, and can be controlled, the rectification temperature is under the control of the operator. The possibility of controlling the proportion of ethane in the by-product liquid is due to the fact that the exit vapor from a stabilization unit, which is the source of the by-product liquid, is relatively rich in ethane. As the stabilization pressure is increased, the by-product liquid obtained therefrom becomes richer in ethane.

When a material such as the by-product liquid just described is allowed to boil freely at reduced pressure, (for example when a sample of the liquid is drawn into an open Dewar flask) the temperature rapidly falls to the average boiling temperature of the mixture at that pressure. I have observed that the same composition liquid when expanded across a throttle valve to the same reduced pressure produces a temperature far lower than the average boiling temperature of the mixture and approaches the boiling point of the lighter component. For example, a mixture consisting mainly of ethane, propane, and butane, the proportion of propane being large, was observed to produce temperatures as follows:

a. Temperature of a freely boiling body of liquid at atmospheric pressure	—16° F.
b. Temperature in outlet of stream from throttle valve at atmospheric pressure	—50° F.

I consider the discovery of this effect an important feature of this invention and the process as described is designed to take advantage of this effect. This effect will be hereafter referred to as "preferential vaporization."

The accompanying drawing illustrates an apparatus capable of carrying out my process.

Referring now to the drawing, refinery gases from any suitable source are collected and enter the pressure gas line 1 and pass through line 2 to the absorber 3. Low pressure gases enter through the vacuum gas system. In the absorber, a menstruum enters through line 4 and passes in contact with the refinery gases. The fat oil is withdrawn through line 5 and passes through heat exchanger 6, through line 7, into the still 8 in which heat supplied through coil 9 denudes the menstruum, which is pumped by pump 10 through line 11, through exchanger 6, through cooler 12, through line 4 for recycling. The vapors from still 8 are condensed in condenser 14 and pass through line 15 to the accumulator 16 from whence they are pumped by pump 17 through line 18 to the stabilizer 19. The vapors from the stabilizer 19 pass through line 20, through condenser 21, through line 22, into separator 23. Separator 23 serves as an accumulator for reflux liquid which is returned to the tower by pump 24.

The gases and lighter hydrocarbons pass overhead through line 25, through condenser 26 into separator 27. It is to be understood that the stabilization system is under a relatively high pressure which may be between 200 and 300 pounds gauge under normal conditions. It is to be understood further that any suitable pressure may be supplied to the by-product liquid collected from the stabilizer system. This liquid consists of a mixture of hydrocarbons which are normally gaseous and chiefly of ethane and propane. The by-product liquid from separator 27 passes through line 28 into surge tank or accumulator 29. From the surge tank 29, the by-product liquid, which is still under high pressure as above indicated, passes through line 30, through pump 31, through heat exchanger 32, through line 33, through expansion valve 34, into the shell of reflux condenser 35. The reduction of pressure on this liquid will produce a great refrigerating effect through "preferential vaporization". The system is so operated that the temperature existing within shell 35 is about —60° F. The reduction of pressure on the liquid by-products is to within a few pounds of the tower pressure, only enough pressure being maintained to insure flow into the tower. The vaporized and unvaporized liquids will automatically separate in the condenser shell. The vaporous fluids will leave the condenser shell through line 36 and pass through pressure controller 37, through line 38, into the rectification tower 40. The liquid component of the by-product fluid will pass from condenser shell 35 through line 39 in which control valve 41 is interposed. The liquid may be introduced into the rectification tower at a point above the introduction of the vaporous component so that the vapors will rise countercurrent to the liquid in the rectification tower, thus taking the fullest advantage of the partial pressure effect of the lighter fraction on the boiling point of the heavier. The pressure in the tower is held at a lower point than that of the condenser shell and will be determined by temperature desired at the bottom of the tower. The pressure can be easily controlled by means of pressure control valve 42, which is interposed in line 43 leading from the rectification tower. At the bottom of the tower 40, I provide a thermocouple 44 which is connected by conductors 45 to a pressure control device 46 which, through line 47, controls valve 42. It is to be understood that the possible refrigeration temperature obtainable by my system is controlled by two factors. Since, in any rectifying system, material on any plate is actually at its boiling point, the temperature on any plate is controlled by the pressure of the system. Assuming, then, that the rectifying column 40 is run at atmospheric pressure and that the material at the bottom of the tower is pure propane, the temperature at that point will be —44° F. If the temperature become higher, the thermocouple 44 would react to operate control device 46, to open valve 42, thus reducing the pressure in the tower. With a drop in pressure, the temperature will drop. Should the temperature become lower than —44° F. the operation of pressure control device will tend to close valve 42 which will increase the pressure within the tower, which will tend to raise the temperature existing therein.

The rectified propane collecting in the bottom of tower 40 is withdrawn through line 48 and pumped by pump 49 through coil 50 in tank 51. If it is desired, for example, to refrigerate a hydrocarbon oil to undergo treatment at subatmospheric temperatures, the oil in tank 52 will be pumped by pump 53 through line 54, through heat exchanger 57, through line 58, into tank 51. A bleeder line 60, controlled by valve 61, admits propane to tank 51 to act as a diluent. The chilled, diluted oil is withdrawn from tank 51 through valve controlled line 62. The heat exchanger imparts heat to the propane which was withdrawn from the rectification tower. The heated propane leaves heat exchanger 57 and passes through line 70. A portion of the propane passes through line 71 which is controlled by valve 72, through expansion valve 73 into the tower in order to supply the heat of reboiling. The remaining rectified propane passes through line 74, which is controlled by valve 75, and valve 76, through heat exchanger 32, through line 77, from which it is stored in steel cylinders for shipping. Valve 76 is controlled by the liquid level device 78.

As was pointed out above, the proportion of ethane is controllable. It is believed that this fact enables the process to be conducted with great flexibility. In operation, practically all the ethane, together with a considerable proportion of propane, leaves the rectification tower at substantially atmospheric pressure and —60° F. In order to vaporize these products, heat must be supplied for reboiling. If the heat were supplied in the usual method by means of steam, a loss of propane to fuel would be occasioned, along with rejected ethane. As the proportion of ethane is increased, there is a corresponding drop in the top temperature of the column. This results in the knocking down of an increased amount of reflux and the proportion of propane in the exit vapors decreases. It will be observed that, combining this process with a stabilization process, the ethane leaving through line 43 and passing through line 80, is recycled to the absorption system. In this way, we have an added factor giving flexibility of control. It will be observed, therefore, that the two factors which control refrigeration temperature, namely, the pressure of the system and the condensation of the material, are both under the control of the operator. It will be observed that the sensible heat picked up by the cold circulating fluid in the refrigeration exchangers will not tend to increase the temperature of the liquid at the bottom of the tower when it is returned thereto. This is true because the liquid was at its boiling point at the lower temperature and, as soon as the pressure on the circulating liquid is released, there is immediate evaporation or flashing of a portion of the returning circulated liquid. This results in a drop in the temperature of the unvaporized portion, bringing it back to the temperature before it left the tower.

It will be seen that I have accomplished the objects of my invention. I am enabled to rectify the by-product fluid from refinery operations at a low pressure in a relatively inexpensive unit. I save the heat load which would be normally required for reboiling and supply this heat load by refrigerating material undergoing low temperature treatment. I am thus enabled to obtain a refrigerating effect at the desired temperature with a negligible expenditure of energy.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of my claims. It is further

obvious that various changes may be made in details within the scope of my claims without departing from the spirit of my invention. It is, therefore, to be understood that my invention is not to be limited to the specific details shown and described.

Having thus described my invention, what I claim is:

1. A process for rectifying normally gaseous hydrocarbons obtained from refinery operations including the steps of expanding compressed hydrocarbon fluids in a reflux condensing zone, introducing the fluid from said expansion step into a rectification zone, withdrawing a selected fraction from said rectification zone, supplying heat to the withdrawn fraction from a material being refrigerated and reintroducing a portion of the thus heated hydrocarbon fraction into the rectification zone.

2. A combined process of rectifying normally gaseous hydrocarbon mixtures and chilling a material being refrigerated which includes the steps of rectifying a mixture of hydrocarbon gases at reduced temperatures, withdrawing a selected fraction from the rectification zone, transferring heat from the material to be refrigerated to the fraction so withdrawn and reintroducing a portion of the fraction so heated into the rectification zone to supply the heat of reboiling.

3. In a rectification process in which hydrocarbon fluids are rectified by fractional condensation and reflux condensate is supplied by condensing exit vapors of the rectification zone, the steps comprising expanding hydrocarbon fluids in heat exchange with the exit vapors, introducing the fluids after said expansion step into the rectification zone, passing condensed fluids countercurrent to uncondensed fluids in the rectification zone while controlling the pressure within said zone in response to the temperature existing in said zone.

4. A process as in claim 3 in which fluids of said expansion step comprise liquid and gaseous components, including the additional steps of introducing the liquid component into the rectification zone at a point above that at which the gaseous components are introduced, and separately introducing the gaseous components.

5. In a process for rectifying normally gaseous hydrocarbons, the steps of establishing predetermined conditions for selective condensation of desired products comprising expanding compressed normally gaseous hydrocarbons to extract heat from eduction fluids of a rectification zone to form a reflux condensate, withdrawing a selected fraction from said zone and supplying heat thereto from a material being refrigerated, returning at least a part of said fraction so heated to the rectification zone to supply the heat of reboiling and supplying heat to the remainder of said fraction from said compressed hydrocarbons to be expanded.

PAUL D. BARTON.