

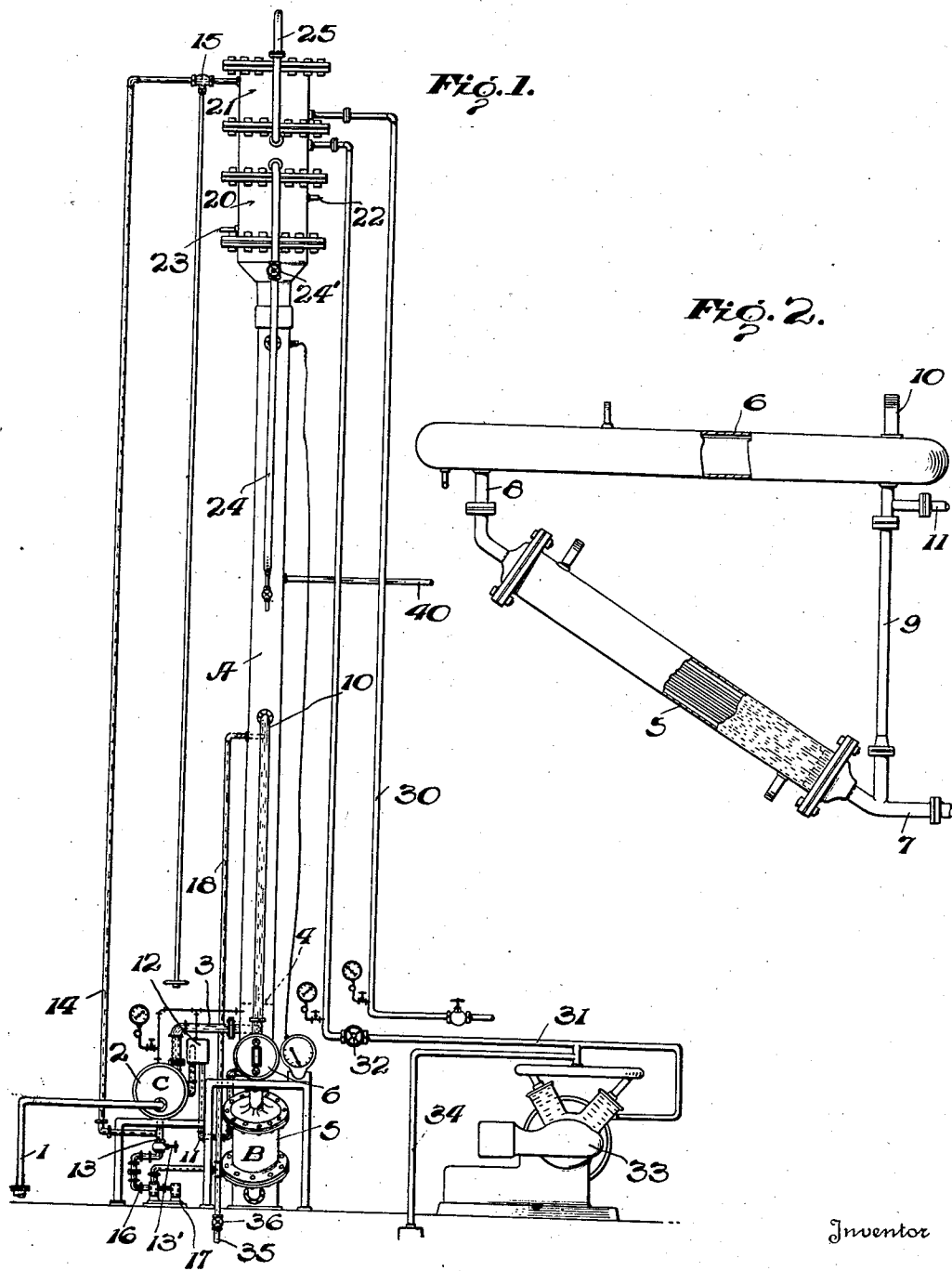
Sept. 8, 1942.

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2,295,211

PROCESS OF SELECTIVELY RECOVERING DESIRABLE CONSTITUENTS OF NATURAL GAS

Filed Dec. 28, 1939



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UNITED STATES PATENT OFFICE

2,295,211

PROCESS OF SELECTIVELY RECOVERING
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Application December 28, 1939, Serial No. 311,415

13 Claims. (Cl. 196—7)

This invention relates to a process of selectively recovering desirable constituents of natural gas and wet natural gas. In a more particular sense the invention relates to an improved type of fractionation of naturally occurring mixtures of hydrocarbon gases and vapors to separate and recover the heavier constituents as liquids while retaining the more volatile constituents in a gaseous state.

In the past many methods have been proposed for effecting the separation of hydrocarbon liquids from natural and artificial hydrocarbon gas mixtures. Such a separation does not present any great difficulty at relatively low pressures, i. e. up to about 700 to 800 lbs. However, at more elevated pressures fractionation becomes very difficult. In order to obviate the difficulties inherent in such high pressure fractionation, it has been the practice to initially reduce the pressure and then to proceed with fractionation at such reduced pressure range.

Such a method of procedure is a distinct disadvantage in many types of operation as for example, in cyclic processes in which natural or casinghead gas is withdrawn from a well for extraction of certain constituents and the residue gas is returned to the producing horizon. In the past when the operating pressure on the well was high it was felt necessary to reduce the pressure in order to secure the desired fractionation. A natural concomitant of the drop in pressure was a marked expansion of the gas thus requiring greater volumetric capacities in the treating apparatus and a larger expenditure of power in recompressing the gas for repressuring the well.

It has been discovered that eminently satisfactory fractionation of these hydrocarbon mixtures may be effected under any pressure up to several thousand pounds per square inch and without any reduction in pressure of the gas other than that which is an incident of the static resistance of the treating system.

The striking advantages of such a method of operation will at once be apparent. With such a high pressure fractionation it becomes possible, in most instances, to directly return the residue gas back to the producing horizon with but little if any compression, thus effecting large savings in power cost. Such a system operating at substantially well pressure permits the use of compact apparatus of small volumetric capacity as compared to earlier systems.

The novel method of fractionation described herein, is to be distinguished as well from the

earlier methods which involved a preliminary reduction in pressure as from the more recent methods which utilize the so-called "retrograde condensation." In this latter method a decided pressure reduction is effected but under such circumstances that the concomitant expansion and drop in temperature is utilized to condense some of the heavier constituents. As will be seen, the method of the present invention involves a substantially isopiestic system in which separation of the different constituents is effected by thermal distillation and fractional condensation.

In order to enable a more ready comprehension of the principles of the invention a typical operation will be described in conjunction with the illustrative apparatus shown in the accompanying drawing. It will be understood, that this is given didactically to explain the new method and not as the exclusive manner of effectuating it. In the drawing Figure 1 is an elevation view of fractionating tower and associated units and Figure 2 is an enlarged detail of the reboiler unit of Figure 1.

As shown in the drawing, the essential elements of the apparatus unit include a fractionating tower A, a reboiler unit B, connected with the base of the tower and a preheater unit C. The fractionating tower A may be of any suitable size and in the illustrative embodiment comprises a tower about 53 ft. high and about 6 in. in diameter. This tower preferably is packed with iron Raschig rings and is adapted to be maintained under pressure and, in conjunction with the preheater and reboiler serves to fractionate the incoming gases under substantially the pressure obtaining in the well. The unit may be connected to a well through the line 1. As shown in the drawing this line enters the heat exchanger 2 and is connected at its discharge end to the gas line 3 which communicates with the tower A at a low point and below baffle 4. The gases passing through the line 1 are adapted to be preheated in the heat exchanger 2 by hot fluids circulated to and from the reboiler unit.

Positioned adjacent the base of the tower is a reboiler system including the inclined reboiler tank 5 and the upper communicating tank 6. Tank 5 preferably is of the shell and tube type and is provided internally with a bank of tubes to heat the condensate passing therethrough. The unit 5 is connected at its lower end through the line 7 to the bottom or kettle section of the tower A and at its upper end through line 8 to the tank 6. The reboiler tank 5 is also connected

to the tank 6 through the branch line 9. As will be seen more fully hereinafter, the reboiler units, including tanks 5 and 6 with their circuit connections 8 and 9, form a closed thermal circulation circuit through which the liquid product collecting in the base of the tower is heated and circulated. This unit comprises, in a sense, a fractional distillation zone. Lighter constituents which are evolved in the circuit, notably methane and ethane, pass overhead from tank 6 through the line 10 and are introduced into the tower A at an intermediate point, preferably about 20 ft. up from the base of the tower.

The reboiler system is interconnected with the heat exchanger 2. For this purpose line 11 is connected with the upper section of line 9 at one end and to the shell of heat exchanger 2 at the other. Preferably the leveling box 12 is interposed in the circuit. Hot fluids introduced into the heat exchanger 2 are withdrawn through the line 13 controlled by valve 13'. A portion of these fluids is passed through the line 14 and pressure control valve 15 into the upper cooling section of the tower. The remainder of the hot liquid products in the heat exchanger is passed through branch 16, pump 17 and line 18 into an intermediate section of the tower A to serve as a reflux liquid. It is particularly to be observed that the inlet for the reflux liquid is positioned below the inlet of gas line 10.

The upper section of the tower A comprises the serially arranged coolers 20 and 21. These are preferably of the internal tube type. Connected to the cooler 20 are the inlet and outlet lines 22 and 23 respectively, through which the cooling medium, such as water, is introduced and withdrawn. In operation, gases which pass upwardly through the tubes of the condenser 20, are cooled by indirect contact with the cooling medium and the gaseous products are then discharged into the communicating cooler 21. Condensate from the cooler may be fed back through line 24, controlled by valve 24' to the upper section of tower A as shown.

The gases and vapors which are preliminarily cooled in the cooler 20 pass outwardly of this cooler through line 25 and are introduced into the top of the cooler 21. In passing downwardly through the interior tubes of this cooler the gases are further cooled by indirect heat exchange with an expanded and cooled fraction from the preheater introduced through the expansion valve 15. Expansion of the liquid products passing through line 14 commensurately reduces the temperature to give a refrigeration cooling.

The condensate and vapors formed in the cooler 21 as a result of this expansion and cooling are withdrawn through line 30 and passed through a suitable stabilizer (not shown) to recover the valuable constituents, as for example a natural gasoline fraction.

The cooled gases, consisting largely of methane and ethane, are withdrawn from the lower end of the tubes in cooler 21 and discharged from the system through line 31. Pressure may be maintained on this line by valve 32.

In one method of operation, high pressure gases from line 31 may be discharged directly into a residue well. When it is desired to increase the pressure on these gases, prior to delivery to a well, line 31 may be connected to the intake side of compressor 33 and the gas at any desired higher pressure may be forced into a well through line 34. During the operation of the

system, the excess of the liquid fraction accumulating in the reboiler system may intermittently or continuously be removed through line 35 controlled by valve 35 and subjected to any desired type of treatment. It may for example be passed to a stabilization unit or to a unit for the production of polymer gasoline.

It will be appreciated that the described apparatus enables the operation of a novel and highly effective process. This process may be employed for treating natural gas for the recovery of heavier valuable constituents, e. g. propane or butane and the like, and repressuring a producing horizon; similarly the system may be employed for processing a wet gas to recover a casinghead gasoline fraction as well as other valuable heavy constituents of the raw gas and the residue reintroduced into the producing horizon. It will be understood that when the process is utilized for treating casinghead gases a separator is interposed between the well and tower to remove the heavy oil prior to fractionation of the gases.

The operation, in sharp contradistinction to prior methods, is carried out at well pressure (or if desired at higher than well pressure). In carrying out the process, the tower A is first charged with a mixture of butane, propane and pentane introduced through line 40. Raw gas from a primary source, such as a gas well, and, in a typical case, at a pressure of substantially 2700 lbs., and a temperature of approximately 80° F. is conveyed through line 1 and thence through the internal tubes in the heat exchanger 2. During passage through the heat exchanger the gas is preheated and is then discharged through line 3 at a temperature of substantially 140° F. into the lower portion of the tower below the baffle 4. In the tower the upwardly flowing gases are contacted with a countercurrent flow of scrubbing liquid which is continuously introduced into the tower through line 18. Due to such direct contact, the liquid refluxing medium largely condenses the heavier constituents of the gas and returns these to the base of the tower.

The heavier condensed hydrocarbons accumulating in the base of the tower flow by gravity into the reboiler tank 5 through line 7. In the reboiler the condensate is heated by indirect contact with the steam and the temperature of the condensate is raised to the order of 230° F. Due to the increase of temperature and to the expansion of occluded gases, thermal circulation is initiated and the heated liquid flows upwardly through line 8 into the denuder tank 6 and back to the reboiler through line 9. During this cycle a predetermined portion of the circulating stream is withdrawn through line 11 and passed to the preheater 2 in the manner described. The quantity which is introduced into the preheater 2 is equivalent to that withdrawn from lines 30 and 35.

It will be appreciated that this method of split or double fractionation is as unique as it is effective. It will be observed that the liquid products from the base of the tower pass through the restricted areas of the tubes of reboiler 5 and after receiving a considerable increment of heat are passed into the relatively large area in denuder tank 6. The velocity of the stream is therefore diminished in tank 6 and the lighter constituents of the mixture, principally methane and ethane, rapidly evolve and pass upwardly through line 10 into the tower A. This reboiler unit, therefore, comprises a special type of ther-

mal distillation unit in which condensate from the bottom of the tower is fractionally distilled under the prevailing pressure of the system to remove the lighter ends and these lighter ends are reintroduced into the tower at a point spaced from the primary fractional condensation zone. The reboiler unit also serves to add a considerable amount of heat to the condensate for the purpose of preheating the incoming raw gas.

In the operation thus far described, it will be seen that the lower section of the system comprises two concurrently operating fractionating systems. In the first, in the lower part of the tower itself the raw gas enters at well pressure and at a definite preheat. This stream of raw thermally expanded gas is refluxed for a predetermined portion of its travel during which constituents heavier than ethane are largely removed by fractional condensation. Thereupon the condensate is subjected to a segregated and special fractionation, namely a high pressure fractional distillation in which the more volatile components, largely methane and ethane, are removed and reintroduced into the tower above the primary or condensation zone and the condensate itself is heated for the purpose of preheating the raw gas.

In the intermediate and upper sections of the tower the gas from both fractionation zones passes upwardly and is cooled and densified by direct contact with a cooling liquid introduced into the upper end of the tower through line 14. In this intermediate section the temperature of the high pressure gases is reduced to the order of about 60° F. In further passage through the cooler 20 the temperature of the gas is again reduced with resulting knock-back of heavier entrained constituents.

In the final stage of cooling the gases passing downwardly through line 25 and the tubes in cooler 21 are subjected to refrigeration cooling. The cooled gas consisting essentially of methane is thus reduced to a temperature of approximately -5° F. and is discharged through line 31 for utilization as previously described. The condensate and vapors formed in cooler 21 as a result of the expansion and cooling of liquid from preheater 2, and at a temperature of substantially -5° F., are withdrawn through line 30 and treated as desired, for example by passage through a preheater and to a suitable stabilization unit whereby desirable products such as pentane, gasoline, propane, butane and the like are separated out.

A striking feature of the present process of fractionation at high pressures is the exceedingly large capacity of a plant of the present as compared with that of earlier methods. Thus a unit of the type described is capable of processing two million cu. ft. of gas per day. This great capacity is established by the unique fractionation. As explained, in the present method the entire system is held at substantially well pressure. On entering the raw gas is immediately preheated and consequently expanded and then refluxed in a primary condensation zone with a continuously circulating stream of reflux liquid from which liquid the lighter constituents, especially methane, are largely removed before recirculating. In these circumstances the recirculating stream of reflux liquid not only serves as a condensing medium but also in a sense, as a methane denuding or scavenging medium.

Another salient advantage of the present method resides in the physical character of the efflu-

ent gas. Since a high partial pressure of methane obtains in the upper portion of the tower and since the system is carried at a very elevated absolute pressure the gas discharged from the system is of high density. When this gas is fed directly to a well, or through a compressor and thence to a well, this high density greatly facilitates the gas flow down into the well.

The improved process, as noted, involves the fractionation of hydrocarbon gas mixtures at high pressures. While a typical operation at 2700 lbs. per sq. in. has been described, it will be understood that the process is available for employment at a wide range of pressures, i. e. from the order of 700 lbs. per sq. in. up to several thousand pounds.

It will be appreciated that within the broad concept of the invention many permissive variations in mechanical arrangements of the apparatus and in operative technique are possible. All such modifications which invoke the broader principles of the invention are comprehended in the appended claims.

I claim:

1. The process of recovering liquefiable constituents from natural gas which is at a high pressure of the order of 700 lbs. per square inch and above which comprises, passing the gas to a fractionating zone, preheating the gas prior to admission to said zone, and contacting the preheated gas in the said zone with a scrubbing liquid comprised of heavier condensable components of the gas and maintaining the zone under substantially the well pressure of the gas.

2. The process of recovering liquefiable constituents from natural gas which is at a high pressure of the order of above 700 lbs. per square inch which comprises, passing a stream of the gas to a fractionating zone maintained at substantially the same pressure as the gas being treated, heating the gas in passage to said zone, contacting the preheated gas stream in a lower section of the zone with a reflux liquid comprised of heavier condensable components of the gas contacting the gas, scrubbed in the lower section of the zone, with a reflux liquid comprised of lighter condensable components of the gas in an upper section of the zone, and separately withdrawing from the zone a condensate of heavier components and a fractionated gas.

3. The process of treating natural gas to recover liquefiable constituents thereof which comprises, passing the gas to a fractionating zone maintained under substantially well pressure, heating the gas and contacting it in a lower portion of said zone with a reflux liquid comprised of heavier constituents of the gas, withdrawing a condensate of heavier constituents from one section of the zone and a fractionated gas from another section of the zone.

4. The process of treating natural gas to recover liquefiable constituents thereof which comprises passing the gas to a fractionating zone without substantially reducing the pressure of the gas, heating the gas in transit to the zone, contacting the gas in the lower portion of the zone with a recirculating stream of reflux liquid consisting of liquefiable components of the gas, continuously heating the resulting condensate, abstracting lighter gases from the heated condensate and returning the condensate to the zone.

5. The process of treating natural gas to recover liquefiable constituents thereof which comprises passing the gas to a fractionating zone

without substantially reducing the pressure of the gas, heating the gas in transit to the zone, contacting the gas in the lower portion of the zone with a recirculating stream of reflux liquid consisting of liquefiable components of the gas, withdrawing the condensate from the zone, heating such condensate, abstracting lighter gases from the condensate and introducing such gases to an upper portion of the zone, passing the heated condensate in indirect heat exchange relationship to the incoming raw gas and then returning the condensate to the said zone to scrub the preheated raw gas.

6. The process of treating natural gas to recover liquefiable constituents thereof which comprises passing the gas to a fractionating tower in which the gas is maintained under substantially well pressure, heating the gas prior to introduction to the tower, scrubbing the preheated gas in the lower section of the tower with a recirculating stream of reflux liquid to condense heavier constituents of the raw gas, withdrawing liquid products from the bottom of the tower, heating such products and separating lighter gaseous constituents, introducing such gaseous constituents into the tower at a point above the point of introduction of the stream of reflux liquid, utilizing the said heated condensate to preheat incoming raw gas and then passing said condensate into the tower to scrub incoming preheated gases.

7. A process of recovering liquefiable constituents from natural gas which comprises, passing gas directly from a well to a fractionating zone which is maintained under substantially well pressure, heating the gas in transit to the zone, contacting the gas in a lower section of said zone with a reflux liquid consisting of liquefied heavier constituents of the gas substantially free from methane, withdrawing a liquid fraction consisting of the heavier liquefiable constituents from the lower section of said zone and withdrawing uncondensable gases from another section of said zone.

8. In the treatment of natural gas to separately recover the liquefiable constituents and incondensable gases that improvement which comprises, passing the gases at well pressure to a fractionating zone and while maintaining substantially the initial pressure on the gas in said zone heating the raw gas to effect expansion thereof and immediately contacting the whole of the heated gas with a counter current stream of a reflux condensate comprised of the heavier liquefiable constituents of the gas.

9. A process of recovering liquefiable constituents from natural gas which is at a well pressure above 700 lbs. per sq. in. which comprises, continuously heating a stream of the gas, passing the preheated gas to a fractionating zone which is maintained at substantially well pressure and contacting the high pressure gas in said zone with a heated reflux liquid to condense the liquefiable components of the raw gas and continuously withdrawing a liquefied fraction from one section of the zone and a gas fraction consisting essentially of methane from another section of the zone.

10. A process of treating natural gas to recover valuable fractions therefrom which comprises, passing gas from a high pressure well to a frac-

tionating zone maintained under substantially well pressure, heating the gas in transit to said zone, contacting the heated gas, in the lower section of the zone with a reflux liquid consisting of the heavier constituents of the gas and thereby condensing the heavier constituents of the incoming gas, passing condensate collecting in the lower section of the zone to a separate heating zone to raise the temperature of the condensate and to largely evolve the contained methane, introducing the evolved methane into an upper section of the zone, cooling the gases in the upper section of the zone by indirect heat exchange with expanded and cooled reflux liquid and separately withdrawing from the zone a hot condensate and a cold gas.

11. A process of treating natural gas to recover valuable fractions therefrom which comprises passing gas from a high pressure well to a fractionating zone maintained under substantially well pressure, heating the gas in transit to said zone, contacting the heated gas, in the lower section of the zone, with a reflux liquid consisting of the heavier constituents of the gas and thereby condensing the heavier constituents of the incoming gas, passing condensate collecting in the lower section of the zone to a separate heating zone to raise the temperature of the condensate and to largely evolve the contained methane, utilizing the heated condensate to preheat the incoming gas and then as a refluxing liquid, introducing the evolved methane into an upper section of the zone and above the point of introduction of reflux condensate, cooling the gases in the upper section of the zone at least in part by indirect contact with expanded and cooled reflux liquid, and separately withdrawing from the fractionating zone a hot liquid condensate and a cold gas fraction.

12. The process of treating natural gas to recover liquefiable constituents thereof which comprises passing the gas to a fractionating zone without substantially reducing the pressure of the gas, heating the gas in transit to the zone, contacting the gas in the lower portion of the zone with a recirculating stream of reflux liquid consisting of liquefiable components of the gas, withdrawing the condensate from the zone, heating such condensate, abstracting lighter gases from the heated condensate and introducing such gases to an upper section of the zone and returning the condensate to the zone to scrub the preheated raw gas.

13. The process of treating natural gas to recover liquefiable constituents thereof which comprises passing the gas to fractionating tower in which the gas is maintained under substantially well pressure, heating the gas prior to introduction to the tower, scrubbing the preheated gas in the lower section of the tower with a recirculating stream of reflux liquid to condense heavier constituents of the raw gas, withdrawing liquid products from the bottom of the tower, heating such products and separating lighter gaseous constituents therefrom, introducing such separated gaseous constituents into the tower at a point above the point of introduction of the stream of reflux liquid and passing condensate, denuded of such lighter constituents, into the tower to scrub incoming gases.

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