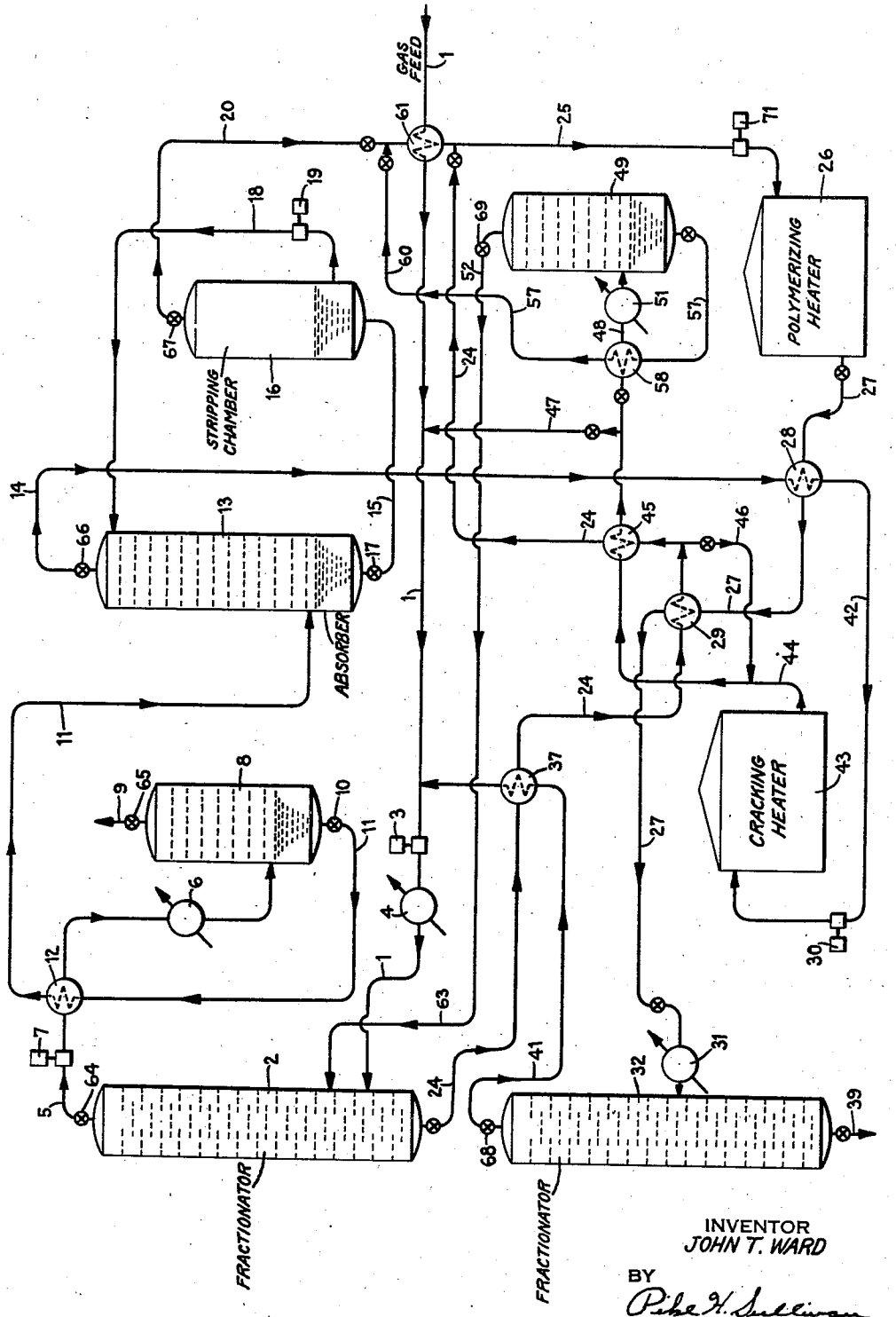
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PRODUCTION OF MOTOR FUELS

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PRODUCTION OF MOTOR FUELS

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1 Claim. (Cl. 196—10)

This invention relates to the production of normally liquid hydrocarbons, and more particularly, to the conversion of normally gaseous hydrocarbons to normally liquid hydrocarbons.

It is an object of the present invention to provide a method of treating a stream of normally gaseous hydrocarbons from an oil cracking operation or from any other suitable source, such as by the cracking of gaseous paraffins to gaseous olefins, which ordinarily consists of hydrogen, methane, and olefinic and paraffinic C_2, C_3, and C_4 hydrocarbons, to convert the stream to normally liquid hydrocarbons, fixed gases, e. g. hydrogen and methane, and gaseous hydrocarbons intermediate the liquid hydrocarbons and fixed gases.

The terms "normally gaseous" and "normally liquid" are used herein to describe hydrocarbons which are gaseous and liquid, respectively, at atmospheric conditions of temperature and pressure.

In the present invention a stream of gases of the type described is treated to separate therefrom fixed gases and a fraction containing substantially all the C_2 hydrocarbons (e. g. ethane and ethylene) of the stream. Ethylene is separated from the fraction, for example, by means of a preferential solvent by liquefaction and rectification or by an adsorbent, and returned to the stream at a point subsequent to the separation of fixed gases and C_2 hydrocarbons. The stream, thus enriched in olefins, is then subjected to a polymerizing treatment, either thermal or catalytic, to convert at least a portion thereof to normally liquid hydrocarbons.

The remainder of the fraction from which ethylene is separated, consisting essentially of the more refractory ethane is subjected to a pyrolytic cracking treatment to produce therein at least a portion of olefins. The cracked products may be added to the stream of gases for subjection to polymerization at a point preceding the separation of fixed gases and C_2 hydrocarbons, with or without the preliminary removal of fixed gases. Or the cracked products may have the fixed gases removed therefrom and be returned to the stream at a point subsequent to the removal of fixed gases and C_2 hydrocarbons and before the polymerizing treatment.

The products of the polymerizing treatment may have removed therefrom normally liquid hydrocarbons, formed by polymerization, and the remainder may be returned to the stream at a point preceding the separation of C_2 hydrocarbons, with or without the preliminary removal of fixed gases.

The accompanying drawing constitutes a diagrammatic plan of apparatus capable of operation embodying the invention but it is to be understood that it is illustrative only, the invention not being limited thereby.

Referring to the drawing for more detailed description, the feed, which consists ordinarily of normally gaseous hydrocarbons from an oil cracking operation or any other suitable source and contains hydrogen, methane, and olefinic and paraffinic C_2, C_3, and C_4 hydrocarbons, is introduced into the system through feed line 1. The stream is compressed by means of compressor 3 and cooler 4 to liquefy the C_3 and C_4 hydrocarbons prior to entering chamber 2, which may be a fractionator of suitable design. This is accomplished, for example, by maintaining a pressure of 300 pounds per square inch and a temperature of 30–60° F. in the top of chamber 2. Suitable cooling and reboiling means may be provided in the top and bottom, respectively, of chamber 2 to facilitate separation. The uncondensed gases, consisting of hydrogen, methane, and substantially all the ethylene and ethane of the stream, pass overhead through line 5 and are further cooled and compressed, by means of cooler 6 and compressor 7, to liquefy ethylene and ethane and permit the separation of fixed gases in separating chamber 8 which may be a suitable fractionator. A pressure of 500 pounds may be maintained with a temperature in the top of fractionator 8 of −10° to −20° F. The fixed gases, e. g. methane and hydrogen pass off through line 9. They may be further cooled by expansion, for example, by assisting in the work of compressing gases in line 5, and used to maintain proper temperature conditions in fractionator 8 by indirect heat exchange. Any other suitable cooling means may also be used for this purpose. Suitable reboiling means may be provided in the bottom of fractionator 8 to assist in separation. The C_2 hydrocarbons may be expanded somewhat by means of valve 10 through line 11 and cooler 12 to assist in cooling for liquefaction the gases passing through line 5. For example, the expansion may be from 500 pounds in chamber 8 to 300 pounds in line 11 and cooler 12.

From line 11 the C_2 hydrocarbons are introduced into absorber chamber 13 wherein the ethylene of the mixture is selectively absorbed by a suitable selective solvent such as acetone, acetaldehyde, or liquid acetylene. The remain-

ing part of the fraction, consisting essentially of ethane, passes off overhead through line 14.

The mixture of solvent and ethylene is withdrawn from absorber 13 by means of line 15 and expanded into stripping chamber 16 by means of valve 17. In chamber 16 the pressure is adjusted to permit the dissipation of ethylene from the solvent which is then returned through line 18 and pump 19 to chamber 13 for re-use. The evolved ethylene passes off overhead through line 20 and may be further treated for recovery of any entrained absorbent in suitable apparatus not shown.

From chamber 2 the liquefied C_3 and C_4 hydrocarbons are withdrawn to pass through line 24 and various heat exchangers to the junction of lines 20 and 24 where they are combined with previously separated ethylene and passed through line 25 by compressor 71 to polymerizing heater 26 wherein they are heated to a temperature of 750°–1200° F. at a pressure of 400 to 3000 pounds per square inch. After being heated under polymerizing conditions to effect conversion into liquids the products are passed through line 27 to cooler 28 wherein they are sharply cooled to prevent over-polymerization by heat exchange with the cool ethane, etc., gases passing from chamber 13 through line 14 or by quenching with suitable hydrocarbons. The polymerized products continue through line 27 and are further cooled in cooler 29 by heat exchange with the C_3 and C_4 gases passing from chamber 2 in line 24. The cooled products of polymerization may be further cooled, if necessary, by means of cooler 31 and are passed to fractionator 32 wherein they are subjected to conditions of temperature and pressure to cause condensation of normally liquid hydrocarbons and fractionation of the stream into a gaseous fraction consisting essentially of normally gaseous hydrocarbons and a liquid fraction consisting essentially of normally liquid hydrocarbons. This may be accomplished by concurrent stripping, scrubbing, and absorption operations for which suitable refluxing and reboiling means may be provided. Fractionation may be maintained at a pressure of about 50 pounds per square inch and with a temperature of 80°–100° F. in the top.

By means of fractionator 32 the normally liquid hydrocarbons formed by polymerization are separated from lower boiling hydrocarbons and are withdrawn through line 39. The normally liquid hydrocarbons thus obtained may be fractionated to separate a satisfactory motor fuel of good quality, leaving a heavier fraction which may be suitably utilized, for example, as charging material in an oil cracking operation or for quenching the polymerized products.

The normally gaseous hydrocarbons separated in fractionator 32 pass through line 41 and are added to the stream passing to chamber 2 through line 1. These gases may be preliminarily cooled by heat exchange, in cooler 37, with materials passing through line 24 or cooled or liquefied gases from other parts of the system.

The ethane fraction passing from chamber 13 through line 14 is preliminarily heated by heat exchange with the products of polymerization in cooler, or heat exchanger, 28. The fraction then proceeds through compressor 30 and line 42 to cracking heater 43 wherein it is subjected to a cracking treatment at a temperature of 1250° F.–1750° F. and at a pressure of 0–500 pounds per square inch to convert at least a portion thereof to olefins.

The products of the cracking operation pass from heater 43 through line 44 and are cooled quickly, for example, by heat exchange, in heat exchanger 45, with the C_3 and C_4 hydrocarbons passing through line 24 from chamber 2. If desired, a portion of the C_3 and C_4 hydrocarbons may be added to the products of cracking through line 46 to quench the hot gases and prevent over-cracking. Contact with the hot gases also will serve to polymerize at least a portion of the C_3 and C_4 hydrocarbons used for quenching, which polymerization will be checked by the subsequent cooling of the combined gases in cooler 45, to prevent over-polymerization.

All or a portion of the gases cooled in cooler 45 may be combined, through line 47, with the gas feed to the system passing through line 1, or all or a portion thereof may be passed through line 48 to separator 49 which may be a fractionator. The gases are suitably cooled, for example, to a temperature of −10° to −20° F. by cooler 51 to liquefy C_2 to C_4 hydrocarbons in separator 49 and permit removal overhead of fixed gases through line 52. A pressure of about 500 pounds per square inch is maintained in fractionator 49 by suitable means. The condensed C_2, C_3 and C_4 hydrocarbons collect in the bottom of separator 49 and are withdrawn through line 57. Suitable cooling and reboiling means may be provided in the top and bottom, respectively, of chamber 49 to facilitate separation. The hydrocarbons condensed in separator 49 are passed through line 57 and cooler 58 to effect a preliminary cooling of the incoming gases in line 48.

From line 57 gases pass through line 60 and are combined with the ethylene passing through line 20. The low temperature of the combined gases may be utilized, for example, by passing them in heat exchange in heat exchanger 61, with the incoming gas feed in line 1. By this means the gas feed is cooled prior to compression and the mixed gases in line 20 are warmed as a preliminary to polymerization.

The fixed gases passing from fractionator 49 through line 52 may be separately recovered and utilized, or they may be introduced into chamber 2, e. g., by line 63, to recover any entrained higher boiling hydrocarbons. By this means all the fixed gases pass from the system through line 9 from chamber 8.

The high pressure of the fixed gases may be utilized to assist in compression and pumping by expanding them from 500 pounds per square inch pressure to 300 pounds per square inch pressure. As a result they are further cooled and assist in maintaining proper temperature conditions in fractionator 2.

Suitable valves 64, 65, 66, 67, 68 and 69 are provided in the overhead lines from chambers 2, 8, 13, 16, 32, and 49, respectively, to maintain the proper pressures in the respective chambers.

Fractionators 2, 8, 32, and 49 are provided with suitable trays or plates whereby they are capable of promoting a combined fractionation, absorption, condensation, and stripping action by the liquids and gases therein. Absorber 13 may be similarly provided to facilitate contact of the gases and absorbent.

The temperature and pressure required in absorber chamber 13 and expansion chamber 16 will depend upon the solvent employed. If it is desired to use an adsorbent instead of a solvent it is necessary to provide parallel contact towers,

to permit alternate saturation and revivification of the adsorbent, e. g., cuprous chloride. Other methods of separating ethane and ethylene, such as fractional distillation, may be used.

In the detailed description the polymerization step is described as pyrolytic but it is to be understood that the advantages of the invention may be realized equally well in connection with any suitable method of polymerization.

Similarly the treatment of ethane to produce ethylene and higher hydrocarbons is described as a cracking operation. However, the invention is not limited thereby, and any method of treatment to produce the same results, such as catalytic dehydrogenation by means of a chromic oxide gel as the catalyst, may be used.

The invention provides a complete, efficient method of converting a large proportion of the normally gaseous hydrocarbons, resulting from an oil cracking operation, to normally liquid hydrocarbons. The removal of C_2 hydrocarbons from the gaseous stream and the separation and return of ethylene to the stream provides a stream of gases rich in olefins and especially subject to efficient polymerization by reason of the absence of ethane therefrom. The concurrent cracking of the ethane fraction provides an efficient method of disposal of this gas to produce a cracked gas containing a large proportion of ethylene and higher hydrocarbons, readily subject to polymerization.

It is to be understood that the embodiment of the invention described herewith is to be taken as a preferred example and that many changes and modifications may be made without departing from the scope of the invention.

I claim:

The method of treating a hydrocarbon gas comprising ethane, ethylene and normally gaseous olefinic and paraffinic hydrocarbons higher boiling than ethane to produce normally liquid hydrocarbons therefrom which comprises separating from said gas ethylene and normally gaseous hydrocarbons higher boiling than ethane, subjecting said separated ethylene and higher boiling hydrocarbons in admixture separately from remaining constitutents of said hydrocarbon gas to elevated conditions of temperature and pressure to effect thermal conversion thereof to normally liquid hydrocarbons, separating ethane from said first-mentioned hydrocarbon gas, heating said separated ethane in a zone separate from the zone of said first-mentioned conversion operation to effect substantial cracking thereof, and combining products of said cracking operation with said first-mentioned hydrocarbon gas for fractionation and processing therewith.

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