

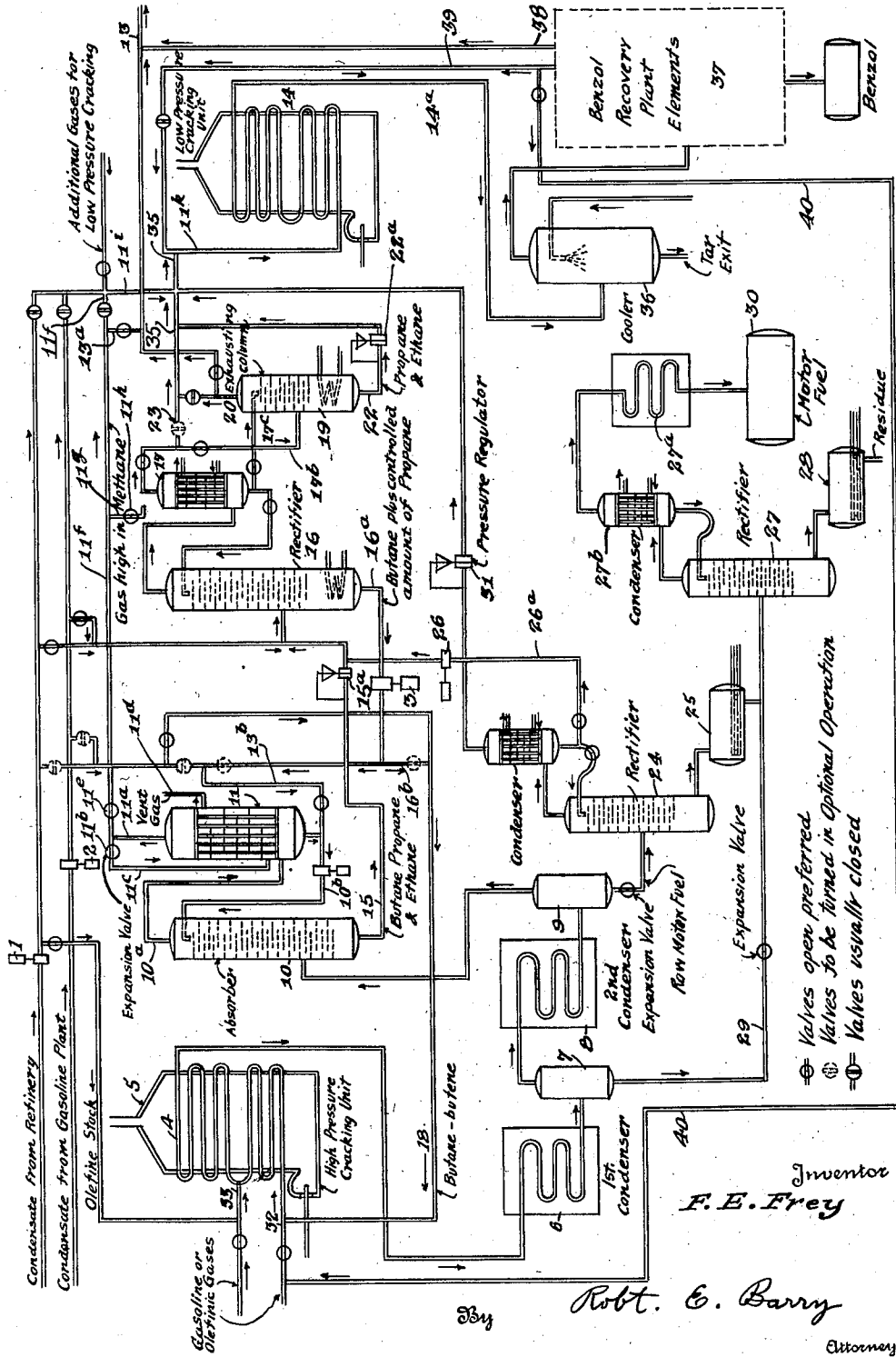
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F. E. FREY

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PROCESS FOR CONVERTING HYDROCARBONS

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PROCESS FOR CONVERTING
HYDROCARBONS

Frederick E. Frey, Bartlesville, Okla., assignor
to Phillips Petroleum Company, Bartlesville,
Okla., a corporation of Delaware

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This invention relates to an improved process for converting volatile aliphatic hydrocarbons, especially natural gas and/or the gases produced by the cracking and distilling of petroleum, or by the destructive distillation of bituminous materials such as coal, into valuable normally liquid hydrocarbons by thermal treatment.

It has been proposed to convert such gases into aromatic oils by heating them to elevated temperatures, 1250–1750° F. for a sufficient time to effect a substantial conversion into aromatic oils. The conversion takes place at atmospheric or higher pressure with the formation of aromatic oils, and, owing to the drastic cracking conditions required, the gaseous hydrocarbons are for the most part destroyed with the exception of methane which is produced in the cracking, and which in itself can be converted into oils by cracking at excessively high temperatures only. Consequently, little material suitable for retreatment is obtained.

It has also been proposed to convert gaseous hydrocarbons into normally liquid hydrocarbons by heating to a reaction temperature under high pressure, above 500 pounds per square inch. In this way gaseous olefines have been shown to polymerize to liquid hydrocarbons in good yield. The conversion of the more refractory gaseous paraffins into normally liquid products has also been proposed. While gases produced by oil cracking processes contain both paraffins and olefines, natural gases contain only the paraffins. At a temperature of preferably 950–1100° F. and pressure of preferably 2000 to 3500 pounds per square inch, butane may be converted in a single cracking operation into normally liquid hydrocarbons mostly aliphatic and alicyclic in nature to the extent of 8–16 per cent. I have found that propane at such pressures requires a higher temperature, while ethane is inferior to propane. In fact, the presence of propane and ethane, I have found, is usually undesirable in admixture with butanes or gaseous olefines to be converted under such high pressures into liquid hydrocarbons, inasmuch as they detract from the efficiency of the conversion unit. In the treatment of the lower boiling paraffins under heat and heavy pressure to produce an optimum conversion into aliphatic and alicyclic hydrocarbons of higher boiling point, I have found that when the time of reaction is the minimum necessary to produce a virtually maximum yield of volatile oils, there survives a great part of the paraffins treated unaltered, and some of the unchanged paraffins may be advantageously separated from the products and returned to the cracking operation. The butanes and butenes formed, I have found, are particularly suitable for retreatment and may be isolated for this purpose by any suitable means, for example, fractional distillation. Methane,

ethane, ethylene, propane, and propylene, I have found to be formed in considerable amounts, in such high pressure thermal treatment, that is, in quantities comparable to the oils formed and exceeding 5 per cent of the hydrocarbon treated, and these lower paraffins are not as suitable for retreatment as the butanes. A part of the propane and ethane, however, may be returned with the butane chiefly for the sake of the yield of oils obtainable from the accompanying propylene or ethylene, but a considerable part of the hydrocarbons boiling below butane and butene must be continually discharged from the system. Consequently, in operating to obtain the best economy, a quantity of gas containing propane, ethane, propylene, ethylene, methane and hydrogen is obtained as a by-product.

The conversion of hydrocarbon gases into aromatic oils previously described may be accomplished at moderate pressures, say below 500 pounds per square inch, and is applicable to all simple paraffins and olefines, all of which give a substantial yield, of 7 per cent or more, of aromatic oils with the exception of methane which requires prohibitive conversion temperatures.

The present invention deals with a novel method and apparatus for combining the two methods of cracking above described, and the subjecting of the gaseous by-products of high pressure conversion to low pressure cracking and obtaining thereby an additional yield of oils.

An object of my invention is to treat hydrocarbon gases in a process which embodies both methods of conversion above described in such a manner that increase in yield of oils, flexibility of operation as regards relative proportions and qualities of liquid products, and economies in operation are obtained which are not realized in the use of either process alone.

A further object of my invention is to convert volatile normally liquid hydrocarbons having a tendency to detonate, when used as fuel in an internal combustion engine, into other normally liquid hydrocarbons having a less tendency to detonate.

Further advantages of the embodiment to be described are:

(1) The cost of gas compression is minimized by the use of separating and purifying operations which deliver charging stock in liquid form to the high pressure conversion operation.

(2) The low pressure gas cracking operation is applied (a) to uncondensed gases and vapors available at low pressure; (b) propane and other constituents which should be discarded from the high pressure gas conversion system.

(3) Liquefied hydrocarbon gases suitable in themselves for conversion into normally liquid hydrocarbons are used as an absorbing medium for extracting gases at high pressure.

(4) Absorption of lower gaseous hydrocarbons are improved by chilling the absorbing medium through the expansion of light hydrocarbon gases formed in the process under high pressure.

- 5 (5) Economies are achieved through the use of existing equipment and facilities of a refinery or natural gasoline plant in connection with the process.

10 With the foregoing objects outlined and with other objects in view, the invention consists in the novel features hereinafter described in detail in connection with the accompanying drawing, which shows an elevation of my improved apparatus.

15 A charging stock consisting predominantly of butane but which may contain gaseous olefines and limited amounts of lower paraffins is delivered by pumps 1, 2 and 3 continuously under a pressure between 500 pounds and 5000 pounds per square inch through a heating tube 4 positioned within a furnace housing 5 wherein the hydrocarbons are maintained at a cracking temperature in a range between 750° F. and 1200° F., but preferably between 850° and 1100° F., for a time sufficient to effect the conversion of a substantial portion of the charging stock into normally liquid hydrocarbons, together with quantities of paraffins and olefines lower than butane and butene. The thermally treated hydrocarbons are discharged into a primary condenser 6 maintained under substantially the same pressure as the coil 4, where the temperature is reduced by direct or indirect cooling means to effect condensation of some gasoline and heavier liquid hydrocarbons. The liquid is separated in separator 7 from vapors, and the vapors are discharged into a secondary cooler condenser 8 and a separator 9. A further extraction of heat takes place in condenser 8 and the greater part of the unconverted butane, together with the remainder of the normally liquid hydrocarbons are condensed. Vapors discharged from 9 enter an absorber or rectifier 10, still under such high pressure, and therein undergo further condensation and come into contact with an absorption liquid which, under the conditions existing in the absorber, absorbs ethane, ethylene, and higher hydrocarbons, leaving in the unabsorbed gas the greater part of the methane and any gases of lower boiling point, which gases are discharged from the absorber through a pipe 10a that leads to the lower portion of a heat exchanger 11 of the plate and tube type. After passing through the tubes of the heat exchanger, these gases are discharged through a pipe 11a and some of the same may be expanded through an expansion valve 11b and a conduit 11c back into the heat exchanger 11. Due to the expansion of this portion of the gases, a very low temperature will be maintained in the heat exchanger and this will result in the condensation of a portion of the gases entering the heat exchanger from the pipe 10a. Such condensate is returned to the top of the absorber or rectifier through a pipe 10b. Gas which has been expanded through the heat exchanger may be vented from the system through the pipe 11d.

If desired, some of this high pressure gas may be also utilized as a cooling agent for other purposes. For example, some of the gas from pipe 11a may be fed through a manually controlled valve 11e, pipes 11f and 11g and an expansion valve 11h to any suitable point in the system where a refrigerating effect is desired.

75 Should it be desired to crack this gas which is

high in methane, some of it may be fed from the pipe 11f through pipes 11i and 11k into a low pressure cracking unit 14.

If preferred, some of the gas which is high in methane may be vented from the system through the line 13 by passing the same through a valved pipe 13a which connects pipes 11f and 13.

By reason of the high pressure existing in a portion of the system, liquefied hydrocarbon gas, preferably butane, may be used as an absorption or reflux medium in 10. This medium extracts the valuable hydrocarbons more effectively at a reduced temperature. Accordingly, butane from a pipe 13b is mixed with the cold condensate from the heat exchanger 11 before said condensate enters the absorber or rectifier.

The liquid separated in 10 contains the absorption medium, the butane and butene not previously condensed, and the greater part of the propane, propylene, ethane and ethylene formed by the high pressure conversion operation. This liquid is discharged by pipe 15 through a pressure regulator 15a into a rectifier and condenser 16 and 17 in which the butane and butene mixed with a controlled limited proportion of propane and lighter hydrocarbons are separated under a pressure of about 500 pounds per square inch, and returned by pump 3 through pipe 18 to be retreated in the high pressure conversion coil 4. Hydrocarbons lighter than butane, in gaseous and liquid condition, pass respectively from condenser 17, through pipes 17b and 17c to an exhausting or rectifying column 19 in which lighter hydrocarbons, chiefly methane may be separated under a pressure of about 500 pounds per square inch and discharged through pipe 20, leaving the system at 13. The liquefied hydrocarbons discharged at 22 are chiefly ethane and ethylene, propane and propylene, and are led through a pressure reducing valve 22a to the low pressure cracking unit 14 for conversion into aromatic oils under a pressure between atmospheric and 500 pounds per square inch, but preferably about 150 pounds per square inch. If the quantity of methane is not large, it need not be separated and discarded, and by opening valve 23, all the vapors from 16 may pass directly to the cracking unit 14.

The normally liquid hydrocarbons formed in the high pressure conversion coil 4 which condense, together with the butane, in 8 and 9, are fractionated in a rectifier 24 having a still 25; the butane and lighter hydrocarbons being delivered by pump 26 through pipes 26a and 15 into the rectifier 16 wherein butane and butene are separated and passed through 16a, 3 and 16b, ultimately into pipe 18 to return to the high pressure conversion coil, while lighter vapors may be allowed to pass through a pressure regulator 31 and into the cracking unit 14. The normally liquid hydrocarbons are fractionated in the rectifier 27 together with the condensate from 7, which enters through pipe 29, and the vapors from the rectifier 27 are condensed in a condenser 27a and such condensate becomes the motor fuel distillate which is collected in a receiver 30. A less volatile residue is discharged from the still 28.

A conventional reflux condenser 27b is positioned between the rectifier 27 and condenser 27a.

Normally liquid hydrocarbons, as for example, the higher boiling fractions of natural gasoline, of low anti-knock value, may be introduced, preferably mixed with other charging stock, to the high pressure conversion coil 4 at 32 to undergo

conversion into liquid hydrocarbons of higher anti-knock value, which are recovered at 30. Or such material, as well as gases of high olefine content, may be charged into an intermediate point of the high pressure conversion zone at a point 33 nearer the exit to avoid excessive re-
 5 action in case a refractory charging stock requiring a high temperature, such as butane, is at the same time undergoing treatment and entering from pipe 18.

The gaseous hydrocarbons lighter than butane, produced by the pressure conversion operation and separated as described, are passed into a common conduit 35 into which also may be led
 15 other hydrocarbon gases of limited methane content, which may be available at a moderate pressure. These gases pass into the low pressure cracking unit 14 in which they are heated to a temperature of 1250-1750° F., for a time sufficient to produce a substantial yield of aromatic
 20 oils. The reaction products are discharged from 14 through a conduit 14a into a primary cooler 36 in which by either direct or indirect cooling means, the temperature is reduced and tar separated; thence into an extraction plant 37 in
 25 which the remainder of the oils, which are largely aromatic, are separated and a small amount of lighter olefinic hydrocarbons may be isolated and returned to either conversion zone through valved
 30 pipes 39 or 40. The dry gas is then discharged from the system through pipes 38 and 13. The gases discharged from the system, owing to their high hydrogen-carbon ratio, are particularly suitable for the production of hydrogen.

Since methane is the only gaseous hydrocarbon unsuitable for conversion into aromatic oils, all available hydrocarbon gases except those containing excessive amounts of methane may be treated in the low pressure cracking unit 14 to
 40 produce aromatic oils, including gases predominating in butane and butene, which, while suitable for conversion in higher yields into oils by high pressure conversion, may be available in excessive quantities or under pressures so low as
 45 to unfit them for conversion in the high pressure unit 4. For the high pressure conversion operation, hydrocarbons higher than propane are most suitable, but when propylene or ethylene are present in substantial concentrations in lighter
 50 gases, they are suitable for conversion in the high pressure unit, whether or not a high concentration of butane accompanies them. The operating conditions giving best results depends on the composition of charging stock. The conversion of butanes containing olefines in small
 55 amounts may be conducted at 1000-5000 pounds per square inch pressure, and 950-1200° F., the higher temperatures within the range being the more effective if ethane and propane are present in substantial amount. Lower temperatures are
 60 preferable when a high olefine content accompanies the paraffins, temperatures as low as 750° and pressures as low as 500 pounds per square inch giving good results when olefines predominate in the charging stock. A particularly suitable
 65 charging stock is the more easily liquefied gases produced in cracking petroleum, which gases predominate in butanes and butenes. Such gases may be converted to the extent of 50% and
 70 even more, into normally liquid hydrocarbons, while butanes give a somewhat lower yield, even with the greater extent of recycling which they require.

Gases from various sources, subject to the above limitations, may be treated in the high

pressure and the low pressure conversion operations while retaining the advantages of the novel combination of this invention. By the use of extraction by means of oil absorption, followed by distillation, concentrates of suitable gases
 5 may obviously be obtained in liquid form and under high pressure without the use of costly direct compression, and in some cases direct compression with or without the use of a liquid pump for further increasing the pressure may
 10 be profitably employed.

In conjunction with a natural gasoline extraction plant or a refinery, additional economies can be effected. The products of the high pressure conversion operation conducted in coil
 15 4, can be cooled in heat exchange relation with oils and gases of lower temperature, thereby effecting heat economies, and the products of the low pressure cracking step, formed at a higher temperature, may be used to effect cracking as
 20 well, both in contact and out of contact with oil to be cracked. Condensing and distilling units may likewise be used to perform a dual role in effecting separations of hydrocarbon constituents in connection with both the process for
 25 gas conversion and refinery gasoline plant operations, and many other obvious advantages can be gained from such combination.

Both the high pressure and low pressure conversion operations yield a substantial amount of
 30 normally liquid hydrocarbons when, in accordance with the foregoing disclosure, the appropriate hydrocarbons are heated to the proper temperature for a time sufficient to effect the desired conversion. Heat may be introduced continuously throughout the reaction periods or introduced chiefly during the first part of either re-
 35 action step without affecting the composition of the products from either conversion operation to such a degree that the combination process is inapplicable. The low pressure conversion is preferably conducted in accordance with U. S. Patent 1,847,238, March 1, 1932, and the high pressure conversion may be conducted in either
 40 one or two stages.

As an example of the process, a mixture of the butanes containing 70% n-butane and 30% isobutane was converted at 975° F. and 3100 pounds' pressure for a period of approximately 10 minutes, then maintained for a shorter time at a
 50 somewhat lower temperature to further synthetic reactions. Carbon formation was slight. 40% of the butane was discharged unconverted accompanied by 4% by weight of heavy oils, and 15% of normally liquid hydrocarbons boiling between 30 and 225° C. having a specific gravity of .725 at 20° C. The remainder consisted of gaseous products. The analysis of the gases in volume percent was as follows:

Hydrogen	1.0	60
Methane	40.5	
Ethane	16.6	
Ethylene	.2	
Propane	11.1	
Propylene	1.3	65
Butanes	27.7	
Butylenes	1.6	
Total	100.0	70

Owing to the low olefine content, the gases lighter than butane and butene would decrease the throughput of the plant when added to the butane, which is recycled. The gaseous products of the above composition, exclusive of butane

and butene, may be cracked at 1475° F. with an exposure time of 0.2 minutes to produce 0.7 gallons of benzol per thousand cubic feet or, when the methane is separated and ethane, ethylene, propane, and propylene are cracked, 1.6 gallons per thousand cubic feet. In the complete conversion of this butane mixture by the combination process in which all unconverted butane and butene formed are returned to the pressure conversion, a yield of about 30 percent by weight of gasoline is obtained, together with 7 percent by weight of benzene. Heavy oil and tar amounting to about 7 and 4 percent respectively, are formed. About 52 percent of the original hydrocarbon survives the conversion steps as a gas suitable for fuel, containing chiefly, methane, but the gas produced by high temperature cracking contains about 16 percent of ethylene and 4 percent propylene and butylene by volume, which may be extracted under favorable conditions for treatment in either conversion step. The yields of normally liquid hydrocarbons will be augmented when gases containing olefines are available for treatment.

It will be noted that the combination is flexible in that the relative proportions of products from the high pressure and low pressure process can be varied within certain limits, and thereby render the combination process capable of operation under the most advantageous conditions. In other words, the yield of benzol from the low pressure cracking unit 14 could be increased at the expense of a decrease in yield of liquid products from the high pressure conversion zone 4. This mode of operation could be followed when the market price of benzol was considerably higher than the market price of high octane motor fuel.

While I have disclosed preferred ways of practicing the process, it will be understood by those skilled in the art that changes in procedure may be resorted to without departing from the spirit of the invention, as set forth in the claims.

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

1. A process for the conversion of normally gaseous hydrocarbons, composed chiefly of hydrocarbon mixtures consisting largely of butanes, into normally liquid hydrocarbons, which comprises continuously passing the hydrocarbons under a pressure ranging between 500 and 5000 pounds per square inch through a heating zone to effect thermal treatment at temperatures between 950 to 1100° F. and converting a substantial part of said hydrocarbons into normally liquid hydrocarbons essentially aliphatic in character, separating from the thermally treated hydrocarbons said normally liquid hydrocarbons, also separating from said thermally treated hydrocarbons higher gaseous hydrocarbons predominating in butane and gaseous hydrocarbons lighter than said butane returning the higher gaseous hydrocarbons to said heating zone, then passing said lighter gaseous thermally treated hydrocarbons, while under a pressure between atmospheric and 500 pounds per square inch, through a second heating zone and heating them therein to a temperature between 1250° F. and 1750° F. for a sufficient period of time to produce a substantial yield of aromatic oils, and thereafter separating the aromatic oils so produced from the mixture resulting from the last mentioned thermal treatment.

2. A process for converting hydrocarbons consisting largely of butanes into higher boiling hydrocarbons

predominantly of the boiling range of gasoline, which comprises continuously passing the aforesaid lower boiling hydrocarbons through a heating zone under a pressure of from 500 to 5000 pounds per square inch to effect conversion thereof, separating the resulting fluid into a fraction consisting mainly of motor fuel and heavier hydrocarbons, a second fraction consisting principally of hydrocarbon gases lighter than butane, and a third fraction of approximately the boiling range of the original charging stock, returning the last mentioned fraction to the inlet of the aforesaid heating zone for reprocessing, while subjecting the aforesaid second fraction to pyrolysis at temperatures between 1250° F. and 1750° F. and pressures above atmospheric and below 500 pounds per square inch for a sufficient period of time to produce a substantial yield of aromatic oils, and separating the aromatic oils so produced from the products of the last mentioned pyrolysis.

3. A process for converting hydrocarbons consisting largely of butanes into higher boiling hydrocarbons, which comprises subjecting the first mentioned hydrocarbons to conversion in a heating zone at temperatures of 750 to 1200° F. and pressures of 500 to 5000 pounds per square inch, separating the effluents from the said heating zone into a gasoline and heavier fraction, a recycle fraction of approximately the boiling range of the original charging stock, a lower boiling fraction predominantly methane, and a fraction containing principally hydrocarbons intermediate in boiling point between methane and the recycle fraction, returning the recycle fraction to the inlet of the aforesaid heating zone for reprocessing, discarding the high methane fraction, and cracking the aforesaid intermediate fraction at temperatures between 1250° F. and 1750° F. and under pressure between atmospheric and 500 pounds per square inch for a sufficient period of time to produce a substantial yield of aromatic oils.

4. A process for the conversion of normally gaseous hydrocarbons composed of hydrocarbons higher than methane and principally of hydrocarbons of three and four carbon atoms per molecule into normally liquid hydrocarbons, which comprises continuously passing the hydrocarbons while maintained under superatmospheric pressure between 500 and 5000 pounds per square inch through a heating zone and heating the hydrocarbons to a temperature between 750° F. and 1200° F. to effect conversion of a substantial part thereof into normally liquid hydrocarbons comprising motor fuel, separating normally liquid hydrocarbons from normally gaseous hydrocarbons and separating the normally gaseous hydrocarbons into a fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock and another fraction consisting principally of hydrocarbon gases of substantially the same boiling range as the charging stock, returning the last-mentioned fraction to the heating zone for further treatment, passing the fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock through another heating zone and heating it during its passage therethrough to a temperature of from about 1250° F. to 1750° F. for a sufficient period of time and while being maintained under a pressure between atmospheric and about 500 pounds per square inch to produce a substantial

yield of aromatic oils, and recovering said aromatic oils.

5. A process for converting hydrocarbons consisting largely of hydrocarbons having four carbon atoms per molecule into high boiling hydrocarbons predominantly of the motor fuel boiling range which comprises continuously passing said hydrocarbons while being maintained under a superatmospheric pressure between 500 and 5000 pounds per square inch through a heating zone and heating the hydrocarbons to a high temperature between 750° F. and 1200° F. to effect polymerization of a substantial part thereof into normally liquid hydrocarbons comprising motor fuel, separating under said pressure, normally liquid hydrocarbons from normally gaseous hydrocarbons and separating the normally gaseous hydrocarbons into a fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock and another fraction consisting principally of hydrocarbon gases of substantially the same boiling range as the charging stock, returning the last-mentioned fraction to the heating zone for further treatment, passing the fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock in a confined stream through another heating zone and heating it during its passage therethrough to a temperature of from about 1250° F. to 1750° F. for a sufficient period of time and while being maintained under a pressure between atmospheric and about 500 pounds per square inch to produce a substantial yield of aromatic oils, and recovering said aromatic oils.

6. A process for converting hydrocarbons consisting largely of hydrocarbons having four carbon atoms per molecule into high boiling hydrocarbons predominantly of the motor fuel boiling range which comprises continuously passing said hydrocarbons while being maintained under a superatmospheric pressure between 500 and 5000 pounds per square inch through a heating zone and heating the hydrocarbons to a high temperature between 750° F. and 1200° F. to effect polymerization of a substantial part thereof into normally liquid hydrocarbons comprising motor fuel, separating normally liquid hydrocarbons from normally gaseous hydrocarbons and separating the normally gaseous hydrocarbons into a fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock and another fraction consisting principally of hydrocarbon gases of substantially the same boiling range as the charging stock, returning the last-mentioned fraction to the heating zone for further treatment, separating methane from the fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock and discharging it from the process, and subsequently passing the remaining portion of the last-mentioned lighter fraction through another heating zone and heating it during its passage therethrough to a temperature of from about 1250° F. to 1750° F. for a sufficient period of time and while being maintained under a pressure between atmospheric and about 500 pounds per square inch to produce a substantial yield of aromatic oils, and recovering said aromatic oils.

7. A process for the conversion of normally gaseous hydrocarbons composed of hydrocarbons higher than methane and principally of hydrocarbons of three and four carbon atoms per molecule into normally liquid hydrocarbons, which

comprises continuously passing the hydrocarbons while maintained under pressure between 500 and 5000 pounds per square inch through a heating zone and heating the hydrocarbons to a temperature between 750° F. and 1200° F. to effect conversion of a substantial part thereof into normally liquid hydrocarbons comprising motor fuel, separating normally liquid hydrocarbons from normally gaseous hydrocarbons, separating the normally gaseous hydrocarbons into a fraction consisting principally of hydrocarbons lighter than the principal constituent of the charging stock and another fraction consisting principally of hydrocarbon gases of substantially the same boiling range as the charging stock, subjecting the last-mentioned fraction while under a pressure between 500 and 5000 pounds per square inch to a temperature between 750° F. and 1200° F. to effect further conversion thereof, passing the fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock through another heating zone and heating it during its passage therethrough to a temperature of from about 1250° F. to 1750° F. for a sufficient period of time and while being maintained under a pressure between atmospheric and about 500 pounds per square inch to produce a substantial yield of aromatic oils, and recovering said aromatic oils.

8. A process for the conversion of normally gaseous hydrocarbons composed of hydrocarbons higher than methane and principally of hydrocarbons of three and four carbon atoms per molecule into normally liquid hydrocarbons, which comprises continuously passing the hydrocarbons while maintained under pressure between 500 and 5000 pounds per square inch through a heating zone and heating the hydrocarbons to a temperature between 750° F. and 1200° F. to effect conversion of a substantial part thereof into normally liquid hydrocarbons comprising motor fuel, separating normally liquid hydrocarbons from normally gaseous hydrocarbons, separating the normally gaseous hydrocarbons into a fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock and another fraction consisting of hydrocarbon gases of substantially the same boiling range as the charging stock, subjecting the last-mentioned fraction while under pressure between 500 and 5000 pounds per square inch to a temperature between 750° F. and 1200° F. to effect further conversion thereof, passing the fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock through a second heating zone and heating it during its passage therethrough to a temperature from about 1250° F. to 1750° F. for a sufficient period of time and while being maintained under a pressure between atmospheric and about 500 pounds per square inch to produce a substantial yield of aromatic oils, separating normally gaseous hydrocarbons from said aromatic oils and returning at least a part of the last-mentioned gaseous hydrocarbons to the first-mentioned heating zone for further treatment.

9. A process for the conversion of normally gaseous hydrocarbons composed of hydrocarbons higher than methane and principally of hydrocarbons of three and four carbon atoms per molecule into normally liquid hydrocarbons, which comprises continuously passing the hydrocarbons while maintained under pressure between 500 and 5000 pounds per square inch through a heating zone and heating the hydrocarbons to a

- temperature between 750° F. and 1200° F. to effect conversion of a substantial part thereof into normally liquid hydrocarbons comprising motor fuel, separating normally liquid hydrocarbons from normally gaseous hydrocarbons, separating the normally gaseous hydrocarbons into a fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock and another fraction consisting of hydrocarbon gases of substantially the same boiling range as the charging stock, subjecting the last-mentioned fraction while under pressure between 500 and 5000 pounds per square inch to a temperature between 750° F. and 1200° F. to effect further conversion thereof, passing the fraction consisting principally of hydrocarbon gases lighter than the principal constituent of the charging stock through a second heating zone and heating it during its passage therethrough to a temperature from about 1250° F. to 1750° F. for a sufficient period of time and while being maintained under a pressure between atmospheric and about 500 pounds per square inch to produce a substantial yield of aromatic oils, separating normally gaseous hydrocarbons from said aromatic oils and returning at least a part of the last-mentioned gaseous hydrocarbons to the second heating zone for further treatment.
- FREDERICK E. FREY.**