Nov. 30 1943. F. H. PRAEGER 2,335,531

REFORMING SYSTEM

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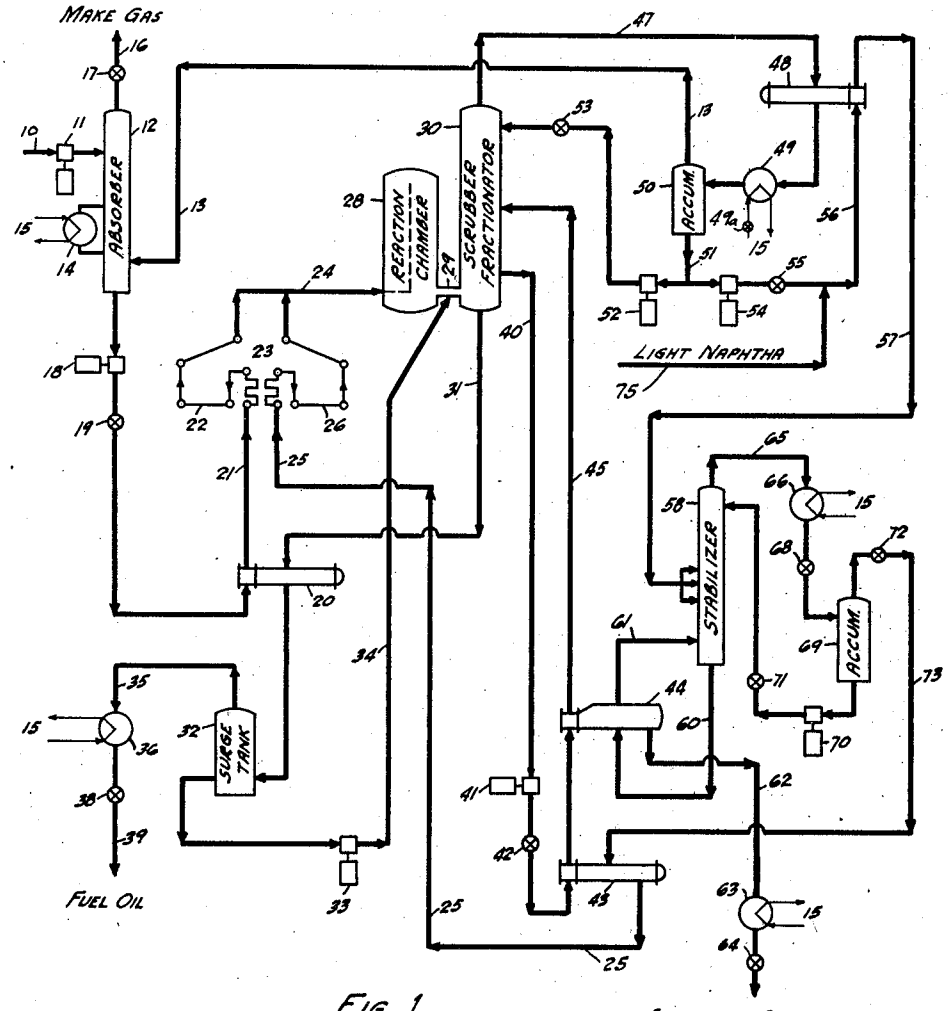

FIG. 1

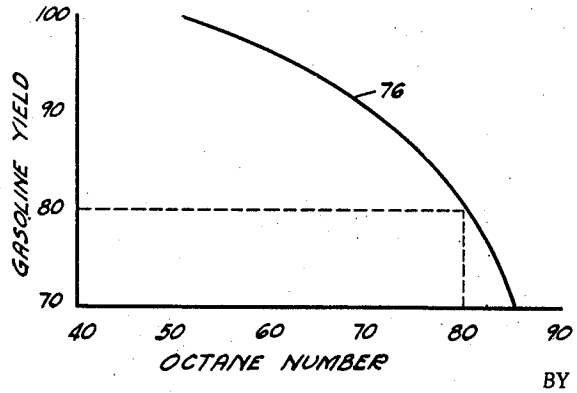

FIG. 2

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2,335,531

REFORMING SYSTEM

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19 Claims. (Cl. 196—9)

My invention relates to oil cracking and reforming systems, more particularly to systems for increasing the antiknock characteristics of naphtha or straight run gasoline and has for an object the provision of a cracking or reforming system of the true vapor phase type, in which the compressor has been entirely eliminated.

A further object of my invention is the provision of a system in which there is a substantial conversion of normally gaseous products into constituents suitable for inclusion in motor fuel. A further object of my invention is the provision of a simple, reliable, and inexpensive reforming system in which not only the compressor has been eliminated, but also in which the system as a whole, and in which the operation thereof, has been made simpler, easier, and more effective.

It has been characteristic of true vapor phase systems as previously proposed, such for example in Beardsley et al. Patent #1,842,318, Sachs Patents #2,016,297, #2,073,456, and Nash Patent #2,222,632 to derive from the system or elsewhere a hydrocarbon heat-carrier gas which after elevation to suitable pressure passes through a heating coil where it is elevated to a sufficiently high temperature to produce rapid cracking of a stream of vapors after mixture therewith. While systems of this character are now in operation and have proved commercially satisfactory, both the initial cost and the operating cost of the compressor used to produce the flow of gas through the system represent a substantial investment. Nevertheless, the compressor has heretofore been deemed an essential part of systems of the foregoing character because it was believed necessary to provide a large quantity of circulating gas per barrel of the hydrocarbon vapors to be mixed therewith.

In carrying out my invention in one form thereof, I have found that by charging a naphtha to the reforming system as an absorbing menstruum, sufficient gas may be absorbed which, in addition to a stream of cycle gas withdrawn at high pressure from a stabilizing system, provides the requisite minimum quantity in the system. More particularly, by countercurrently contacting the normally gaseous constituents in the system with the charging stock, a considerable quantity thereof is absorbed. From the reformed naphtha there are removed in the stabilizer gases largely comprising C_3's and C_4's, or those having three to four carbon atoms per molecule and these gases form the supply of cycle gas. The stabilizer is maintained under relatively high pressure so that the derived gases may flow directly through a heating coil without need for a compressor since these gases, forming the heat-carrier, are used to produce the reforming of the charge. A part of these gases is converted into constituents suitable for inclusion in the final motor fuel product and an increase in the yield of desired product is thereby obtained.

While my invention is particularly adapted to reforming operations, it is also effective in reducing the size of the compressor in gas oil cracking units, or in units for cracking materials heavier than gas oil.

For a more complete understanding of my invention, reference should now be had to the drawing in which I have diagrammatically illustrated in Fig. 1 a system embodying a preferred form of my invention, single lines for the most part indicating the connecting pipe lines. Fig. 2 is a graph wherein I have plotted yield in volume per cent against octane numbers.

Referring to the drawing, I have shown my invention in one form as applied to a reforming system in which the charge, such for example, as heavy naphtha, enters the system through supply line 10, and by pump 11 is elevated to the pressure of the absorber 12, around 150# per square inch gage. The charge flows downwardly over a plurality of trays (not shown) of the bubble type, or other means included in the absorber 12 for providing intimate contact between the charge and gases introduced into the absorber by way of line 13. To increase the quantity of gas absorbed, an intercooler 14 is preferably provided about mid-way of the absorber with cooling water circulated therethrough as indicated at 15. Wherever cooling water is used, inlets with a control valve (not shown) and outlets are indicated by the reference numeral 15. Depending upon the size of the system, the temperatures of the charge and the cooling water, additional intercoolers may be provided and arranged at several places along the absorber. The lighter gases, not absorbed are withdrawn from the system by way of line 16 under control of a pressure regulating valve 17.

The rich oil comprising the naphtha charge and the absorbed gases are withdrawn from the bottom of the absorber, elevated in pressure by the pump 18 and under the control of the valve 19 pass through a heat exchanger 20 and by way of line 21 to a heating coil 22 of a heater 23, which is illustrated as of the double end fired type. As later explained, the rich oil is elevated in temperature during passage through the heat exchanger 20 and its temperature is further in-

creased by passage through the coil 22 of the heater 23. The absorbed gas assists in vaporizing the naphtha, the vaporization thereof being complete materially before exit from the coil 22. After complete vaporization of the charge, the vapors are further elevated in temperature until they reach a discharge temperature of approximately 1000 to 1080° F. The time of heating is relatively short, particularly after the vapors reach an elevated temperature and the design is such that the vapors enter the transfer line 24 with little, if any, thermal cracking or reformation thereof. Concurrently with the foregoing, cycle gas by way of line 25 passes through coil 26 of the heater 23, where it is elevated in temperature to between 1200 and 1300° F. and in the transfer line 24 it commingles with the vaporized charge.

The cycle gas serves as a heat-carrier and when commingled with the hot vapors substantially instantaneously elevates their temperature to a rapid cracking or reforming temperature.

The mixture of the heat-carrier gas and the vapors then enters a reaction chamber 28 so designed that sufficient time is provided, by the flow of the vapors and gas from the top of the reaction chamber to the outlet, to permit the substantial completion of the desired reforming reaction. The vapors and gas exit through a transfer line 29, connecting the reaction chamber to the lower part of a combined scrubber-fractionating column 30. In the transfer line 29, and preferably as the vapors and gas enter the scrubber-fractionator 30, they are thoroughly contacted, scrubbed and washed by the heavy residuum withdrawn from the bottom of the scrubber 30 by way of line 31. This residuum, after passing through the heat exchanger 20, enters a surge tank 32, and is withdrawn therefrom by a pump 33 and returned to the transfer line 29 by way of line 34.

The relatively hot residuum withdrawn from the scrubber is effective, during passage through the heat exchanger 20, in materially elevating the temperature of the rich oil flowing through the heat exchanger 20 in heat exchange therewith. Excess residuum produced in the system flows from the top of the surge tank 32 by way of line 35, is reduced in temperature by cooler 36, through which there is circulated cooling water, and is withdrawn to storage under the control of valve 38 by way of line 39.

After the thorough washing and scrubbing of the vapors and gas by the heavy oil, they rise upwardly through the scrubber-fractionator 30. The lower part of the vessel 30 performs the functions heretofore performed by a separate vessel known as the scrubber. Thus the vapors and gases after intimate mixture with the scrubbing medium are introduced into a fairly large free space within the lower portion of the vessel 30. The vapors and gases rise upwardly and enter the fractionating section, while the scrubbing medium and condensate, the residuum, flows to the bottom of the tower or vessel 30 and exits therefrom by way of line 31. Preferably near the upper part of the scrubber section of the vessel or tower 30 there is provided a collecting deck (not shown) from which a heavy oil is withdrawn by way of line 40, pump 41, and under the control of valve 42 flows through a heat exchanger 43, a reboiler 44 and by way of line 45 is returned to the tower 30 several trays above the aforesaid collecting deck. The withdrawal of this side stream serves the desirable function of removing heat from the rising gases and vapors, and the side stream also comprises the reboiler oil or heating medium for the reboiler 44 associated with the stabilizer later to be described. The upper part or section of the vessel 30 performs all of the functions normally provided by the usual form of fractionating column or bubble tower. By suitable means, for example by a plurality of trays and bubble caps (not shown) disposed in the upper portion of the vessel, the rising vapors and gases are countercurrently fractionated by reflux pumped into the top of the column.

The overhead stream from the tower 30 comprising the gases and materials suitable for inclusion in motor fuel is withdrawn through line 47 and successively passes through a heat exchanger 48 and the main condenser or cooler 49 and thence into an accumulator 50. The normally incondensible gases of the system, those which remain uncondensed in the accumulator 50, are withdrawn from the accumulator by way of line 13 and flow directly to the absorber 12 where they are contacted with the heavy naphtha or charging stock. Condensate is withdrawn from the accumulator by way of line 51, a part by pump 52 being returned under the control of valve 53 to the upper part of the tower 30 as reflux therefor. The remaining part, by pump 54 under the control of valve 55, passes by way of line 56 through exchanger 48 where it is elevated in temperature by heat exchange with the overhead products flowing therethrough. After its elevation in temperature in exchanger 48, the condensate flows by way of line 57 into the stabilizer 58. This condensate, or stabilizer-feed includes not only materials suitable for motor fuel but a substantial proportion of lighter materials such as hydrocarbons having two, three, and four carbon atoms per molecule. In the stabilizer 58 the charge is counter-currently contacted with reflux by suitable means, for example by a plurality of bubble trays (not shown). A stream from the bottom of the stabilizer is withdrawn by way of line 60 and introduced into the reboiler 44. It is elevated in temperature by exchange with the reboiler oil so that the lighter constituents separate therefrom and return by way of line 61 to the stabilizer 58. The remaining condensate, denuded of its lighter constituents, is withdrawn by way of line 62, cooled in cooler 63 and under control of valve 64 may be sent to storage as stabilized gasoline, the principal end-product of the system.

The lighter fraction of the stabilizer feed is withdrawn as overhead from the stabilizer 58, passes by way of line 65, condenser 66 and under the control of valve 68 flows into an accumulator 69. Condensate in the accumulator is withdrawn by way of pump 70 and under the control of valve 71 is returned to the upper part of the stabilizer 58 as reflux therefor. Gases and uncondensed hydrocarbons are withdrawn from the top of the accumulator 69 and under the control of valve 72 flow by way of line 73 through the exchanger 43 and thence by way of line 25 to the coil 26 of the heater 23. The overhead from the accumulator 69 thus comprises the source of cycle gas or heat-carrying medium.

I have found it desirable to elevate the temperature of the cycle gas by heat exchange with the reboiler stream and for this purpose there has been provided the heat exchanger 43. There is an advantage in reducing the temperature of the reboiler medium 40 before its introduction

into the reboiler 44. In other words, the liquid withdrawn from the stabilizer and introduced into the reboiler 44 while suitably elevated in temperature, is not subjected to a high mean temperature difference but one which is high enough to supply the heat for the necessary reboiling of the liquids withdrawn from the stabilizer.

While it is to be understood my invention is not to be strictly limited to the exact operating conditions (temperatures and pressures) set forth below, it is believed the unexpected results which have been achieved as a result of my invention may be more fully appreciated by the following description of a typical embodiment of my invention as applied to different charging stocks.

For example, a relatively heavy naphtha, one having a gravity of 53.2° A. P. I., an initial boiling point of 211° F., a 50% point of 289° F., a 90% point of 377° F., and an end point of 418° F. was charged to the absorber by the pump 11, the pump having a discharge pressure adequate to insure induction of the naphtha into the absorber, operating at from 150 to 160 lbs. per square inch gauge. This pressure is maintained by the valve 17 as before explained. At the same time, lighter gases from accumulator 50 flow into the absorber 12 by way of line 13 due to the fact the tower 30 and the accumulator 50 operate at higher pressures. For example, the pressure on the accumulator 50 is maintained at from 155 to 170 lbs. per square inch gauge. These gases consist largely of hydrocarbons having from one to three carbon atoms per molecule, although a small percentage of C_4 and heavier compounds may be present. In the described operation, there were present not more than about 7 to 10% by weight of C_4's and C_5's and higher.

During its countercurrent contact with the charging stock, about 40% to 50% of the total number of cubic feet of gas entering the absorber 12 was absorbed. This corresponds with an absorption of the gases by between 52% to 59%, by weight. With this degree of absorption and without excessive cooling of the charging stock, the rich naphtha, now about 130 vol. per cent of the lean naphtha, was charged to coil 22. The vapors and gases in the heating coil were elevated in temperature to between 1050 and 1135° F. and discharged into the transfer line 24. The stabilizer 58 and the accumulator 69 operate at pressures from 250 to 275 lbs. Thus the gases rich in C_3's and C_4's readily flow from the accumulator 69 through the exchanger 43 and by way of line 25 to the coil 26 of heater 23. The heat carrier or cycle gas consists of C_3's and C_4's to the extent of about 60–70%, the remainder thereof being made up of both heavier and lighter hydrocarbon gases. After elevation of the cycle gas to about 1200° F., it commingles with the heated vapors and gases from coil 22 quickly to elevate their temperature and to initiate reforming thereof. A reaction time for the mixture of hydrocarbons of the order of one to two minutes was provided by the reaction chamber 28.

The scrubbing oil, in quantity from one to two times that of the charging stock, consisted of a heavy residuum of approximately 7 to 10° A. P. I.

After separation of the gases in the accumulator 50, the condensate therefrom is charged to the stabilizer 58 by the pump 54. Heretofore it has been necessary to utilize a compressor to elevate the gases from the accumulator 50 to a sufficiently high pressure for introduction into the flash gas coil 22, or into a flash drum. In accord with my invention, the gas flows from accumulator 50 to the absorber 12 and after the absorption of the gases by the charging stock the enriched naphtha is readily introduced into the coil 22 at a pressure adequate to insure the maintenance on the scrubber-fractionator and accumulator 50 of a pressure to insure the return flow of the gases to the absorber 12 by way of line 13. In other words, by absorbing the gases in the liquid charge, the enriched naphtha may be elevated as a liquid to any desired pressure and there is avoided the need for a compressor separately to elevate the pressure of the gases for introduction into the coil 22.

As indicated on the drawing, there may be introduced into the line 56 by way of line 75 a light naphtha, itself not suitable as motor fuel, but which can be blended with the reformed heavy naphtha to produce a greater yield of stabilized gasoline. In the embodiment of my invention now being described, this light naphtha, having an end point of about 200° F., represented about 30% by volume of the lean or heavy naphtha introduced through line 10. About 34% of this light naphtha consisted of compounds having five carbon atoms per molecule and less.

In accord with the foregoing embodiment of my invention, there was produced a yield of 83.7% by volume of stabilized gasoline having an octane number '39 research method, of 77.2. By the addition of only 1 cc. of tetraethyl lead this octane number was increased to 85.1, and by the addition of 2 cc. and 3 cc. the octane was increased to 88.2, and 89.7, '39 research method.

The great flexibility of a reforming system as heretofore described, is made apparent by reference to Fig. 2, wherein I have plotted yield in volume per cent as ordinates, and octane numbers, '39 research method, as abscissae. It will be observed that the curve 76 at 100% yield shows an octane number of 50.9, the octane number of the original charging stock which includes the light naphtha introduced into the line 75. The system may be operated to produce any desired octane number from 50.9 up to 86, after which the yield decreases so rapidly it becomes inexpedient to run for higher octane numbers. The yield of 80% of 80 octane stabilized gasoline of motor fuel, 10# Reid vapor pressure, as indicated by the broken lines, however, is considerably above that ordinarily achieved by any reforming system of which I am informed.

In accord with my invention, normally gaseous hydrocarbon compounds over and above those usually converted in the same system when using a compressor are converted into constituents suitable for inclusion in the stabilized gasoline, to a degree which not only accounts for a yield as much as 1% to 2% greater, but also for octane numbers of from one to three numbers higher than would be the case without any conversion of gaseous compounds.

As the yield of gasoline decreases with increased octane number by approximately 1% per octane number, '39 research method, it is at once apparent that increasing the octane number of the product by two numbers, due to the converted gaseous constituents, results in an increase of 4% in yield for a corresponding octane number without such conversion.

In this connection, and in a modified form of my invention, I have introduced hydrocarbons having four carbon atoms per molecule, mostly butane, directly into the stabilizer in place of the lighter naphtha. The introduction of the

butane likewise increased the yield and octane number materially over operation without the added C_4 compounds, and by as much as 5% in yield and 1 to 3 octane numbers. State differently, there was a conversion of the C_4 compounds to as much as 65% to 70% of the amount thereof by weight charged to the system. When it is considered that these embodiments of my invention are all characterized by a relatively low-pressure operation, below 200 lbs. in the reaction chamber, the conversion of these gaseous compounds into constituents suitable for inclusion in the motor fuel is contrary to generally accepted theory but nevertheless represents new results which have been achieved and which characterize my invention.

Though in one of the foregoing embodiments of my invention light naphtha was introduced into the stabilizer, and in the other, gaseous C_4 compounds were introduced, my invention is not limited to operations of that character. More particularly, in accord with a further embodiment of my invention, a full range straight run gasoline, 340° F. end point with an initial of as low as 89° F. (95% recovery) and an octane number of 59.6, '39 research method, was directly charged to the absorber 12. There was produced a yield of 81.5% of 80.0 octane number, '39 research method, 10# Reid vapor pressure, stabilized gasoline. Thus this charging stock was increased from its original octane number of 59.6 to an octane of 80.0. In another operation on the foregoing full range charging stock with an increased cracking temperature, there was produced a yield of approximately 70% by volume of stabilized gasoline having an octane number of 86. By the addition of 1 cc. of T. E. L. this octane number was increased to 91.5; by 2 cc., to 93.5; and by 3 cc. to 94.7, measured by the '39 research method.

My invention is not limited to naphtha reforming but may be usefully employed for cracking heavier charging stocks such as gas oil. In most cases it is desirable to recycle a portion of the heavier material, which portion may be derived from the bubble tower and in vapor phase introduced into the superheater coil 22. The raw charging stock at a relatively low, or air temperature, is used as the absorbing menstruum for the absorber 12. The recycle stock because of its higher bubble tower temperature is not desirable as an absorbing menstruum and is usually additionally heated by heat exchange. In consequence, the total amount of material to be cracked includes the recycle stock which may equal or exceed the raw feed. Where the gas requirements cannot be satisfied by absorption alone, it may sometimes be desirable to provide a compressor (not shown) for the purpose of elevating in pressure an additional quantity of gas which may be added to the superheater and/or the cycle gas coils.

A study of the foregoing illustrations shows that the separation of the normally gaseous hydrocarbons into rich and lean fractions and the presence in the reaction chamber of the gases absorbed from the lean fraction in mixture with the low octane gasoline results in the conversion of a part of the absorbed gases as well as a part of the rich cycle gas into products suitable for inclusion in the high octane gasoline or motor fuel.

In contrast with prior true vapor phase cracking and reforming systems characterized by compressor-circulation of gases, the results achieved by my present invention are equal and even superior to said prior systems when operated with all make-gas passing to a catalytic polymerizing unit. This great superiority is the direct result of causing the reforming or cracking reactions to occur under conditions which are substantively different from systems prior to my invention. In the prior true vapor phase reforming system the flash gas had a specific gravity of approximately .865 and the cycle gas a specific gravity of approximately .920, whereas in accord with my invention the absorbed gases have a specific gravity of about 1.41 and the cycle gas a specific gravity of about 1.42. In the old compressor type of system a much larger percentage of gases was withdrawn from the system and they included a larger percentage of hydrocarbons having 3, 4, and 5 carbon atoms per molecule. The higher specific gravities of the recycled gases in accord with my invention is partly the result of the absorption in the absorber of a large proportion of gases richer or heavier than ethane and a relatively small absorption of the ethane and lighter gases. In this way there is in the reaction zone a higher percentage of less refractory gases which, by reason of their temperature and the particular conditions under which the reaction takes place, in part at least accounts for the surprising conversion of these gaseous products into constituents suitable for inclusion in the final product of motor fuel, or high octane gasoline.

The particular conditions under which the reaction takes place substantively differ from the old compressor type of system by reason of the fact that the reaction occurs in the presence of all of the gases made in the system except the small percentage of the light gases withdrawn from the top of the absorber. The results are superior to those which would be expected on the consideration alone of the mass action effect of gases. There occurs a conversion or reversion or combination of a material portion of the gases to the end that the total result of the complex reactions is the production of a surprisingly small amount of make gas. The internal gas cycle is built up to a point where the cycle gas and the absorbed gases bear a weight per cent of between 30% and 60% of the fresh feed and there is produced only that small proportion of ethane and lighter gases which are withdrawn from the top of the absorber.

My invention further differs from the compressor type of system in other important aspects. First, as above explained, the charge together with the gases absorbed by it is in liquid phase elevated to the desired pressure. The mixture then flows through the heating tubes where it is vaporized and thence through the remainder of the reforming system without need for a compressor anywhere in the system. Second, the overhead stream from the scrubber-fractionator is cooled to a greater extent than in the former compressor system so that a larger percentage of the normal gaseous constituents are condensed and withdrawn as a liquid from the accumulator 50. In fact the condensation is adequate to provide for the supply of the cycle gas as well as for the desired vapor pressure of the final product. In liquid form this condensate is charged to the relatively high pressure stabilizer, around 300# gauge, and as a result of the larger proportion of condensed normally gaseous hydrocarbons there becomes available a larger quantity of those normally gaseous hydrocarbons as an overhead gaseous stream from the stabilizer, which gaseous stream forms the supply of the cycle gas. By the

very convenient and satisfactory expedient of varying cooling temperature as by controlling the rate of flow of the cooling water through the main condenser **49** by means of valve **49***a*, the quantity of cycle gas made available in this manner may be controlled as desired and within relatively wide limits, and preferably so that the combined cycle gas and absorbed gas will always bear the aforesaid weight per cent of from 30% to 60% of the other hydrocarbons present in the reaction zone. As a result of these factors, ease of control of the system as a whole is made possible and any abnormalities incident to operation are readily and quickly corrected. Of equal practical importance is the fact the system as a whole is simpler in character and less costly.

It will be further observed that the charge, enriched by the absorbed gases, is progressively heated and flows directly to the reaction zone or chamber and there is eliminated in the case of a totally vaporizable charge, a flash zone or chamber in which new conditions of equilibrium obtain. The intimate mixture of absorbed gas throughout the charging stock is believed to contribute to the complex reactions which appear to take place under conditions which inhibit formation of normally gaseous compounds which cannot be usefully utilized in motor fuel.

While I have described particular embodiments of my invention, it is to be understood I do not limit myself thereto since many modifications may be made and I therefore contemplate by the appended claims to cover any such modifications as fall within the spirit and scope of my invention.

What I claim is:

1. In a conversion system for hydrocarbons in which a heat carrier heated to a high temperature is utilized to supply heat to hydrocarbons undergoing conversion, the method which comprises cooling and fractionating the reaction products resulting from the conversion of said hydrocarbons, withdrawing a condensate therefrom which includes said heat carrier and products suitable for motor fuel, in an absorption zone utilizing a vaporizable liquid hydrocarbon for absorbing from the gases which were not condensed in said cooling and fractionating operations substantially all of the hydrocarbons heavier than ethane, applying heat to vaporize said liquid hydrocarbons and said absorbed gases and to elevate their temperature to within the range of their conversion temperature during a time interval insufficient for material conversion thereof, separating said heat carrier from said condensate, applying heat to said heat carrier to raise its temperature substantially to within the range of its conversion temperature, during a time interval insufficient for material conversion thereof, commingling all of said heated hydrocarbons, and retaining the commingled hydrocarbons in a reaction zone for the conversion thereof under the aforesaid conditions, whereby only a relatively small amount of products unsuitable for use in motor fuel is produced.

2. In a conversion system for hydrocarbons in which a heat carrier heated to a high temperature is utilized to supply heat to hydrocarbons undergoing conversion, the method which comprises separating from the reaction products resulting from the conversion of said hydrocarbons a vapor stream containing all products suitable for motor fuel and lighter hydrocarbons to be used as said heat carrier, cooling said vapor stream to produce a condensate which includes said heat carrier and said products, in an absorption zone utilizing a vaporizable liquid hydrocarbon for absorbing substantially all of the hydrocarbons heavier than ethane from the gases not condensed by said cooling of said vapor stream, applying heat to vaporize said liquid hydrocarbons and said absorbed gases and rapidly to elevate their temperature, separating said lighter hydrocarbons from said condensate for use as said heat carrier, applying heat to said heat carrier to raise its temperature for the supply of heat to the hydrocarbons to be converted, commingling all of said heated hydrocarbons, and retaining the commingled hydrocarbons in a reaction zone for the conversion thereof under conditions which produce a relatively small amount of products unsuitable for use in motor fuel.

3. The method as set forth in claim 2 in which the quantity of said lighter hydrocarbons utilized as said heat carrier is controlled directly by varying the extent of cooling of said vapor stream.

4. The method as set forth in claim 2 in which the gases absorbed by said liquid hydrocarbon have a specific gravity of about 1.4 and the lighter hydrocarbons forming said heat carrier having a specific gravity of about 1.4.

5. The method set forth in claim 2 in which ethane and lighter gases are withdrawn from said absorption zone, to produce conversion of said commingled hydrocarbons in the substantial absence of said ethane and lighter gases.

6. The method of reforming gasoline of low octane number into gasoline of high octane number in the substantial absence of all gaseous products lighter than propane, which comprises separating from said reformed products a vapor stream containing said high octane gasoline and lighter hydrocarbons, cooling said vapor stream to produce a condensate which includes said high octane gasoline and normally gaseous hydrocarbons to be used as a heat carrier, in an absorbing zone utilizing said low octane gasoline for absorption of uncondensed gases of hydrocarbons heavier than ethane, applying heat to the mixture resulting from the absorption to vaporize it and to elevate its temperature to within the range of its reforming temperature, separating said lighter hydrocarbons from said high octane gasoline by application of heat and fractionation, applying heat to said lighter hydrocarbons to elevate their temperature above the temperature of said mixture and to form said heat carrier therefor, commingling said heat carrier and said mixture to produce conversion in vapor phase of normally gaseous and liquid constituents to said high octane products suitable for inclusion in motor fuel, and withdrawing ethane and lighter gases as substantially the only gases withdrawn from the reforming operation.

7. A method of converting hydrocarbons in vapor phase in the substantial absence of all gaseous products lighter than propane resulting from the conversion reactions, and characterized by the use of a gaseous heat carrier, which comprises separating from the reaction products a vaporous and gaseous stream containing all products suitable for use as motor fuel and lighter products, cooling said stream to produce a condensate which includes said products suitable for motor fuel and normally gaseous hydrocarbons in quantity adequate for use as said heat carrier, in an absorbing zone utilizing vaporizable liquid hydrocarbons to absorb from the gases not condensed by said cooling operation substantially all of the hydrocarbons heavier than ethane,

applying heat to the mixture of said liquid hydrocarbons and their absorbed gases to vaporize the same and to elevate the temperature thereof to within an approximate conversion temperature during a time interval insufficient for material conversion to occur, concurrently separating said heat carrier from said condensate, applying heat to said heat carrier to raise its temperature materially above said temperature of said mixture, and commingling said heat carrier with said mixture to produce simultaneous conversion of all of said commingled hydrocarbons.

8. In a system in which vaporizable liquid hydrocarbons undesirable as motor fuel are in vapor phase in a reaction zone thermally converted into products valuable for motor fuel, the method which comprises separating from the products from the reaction zone a vapor stream containing all of said valuable products and all lighter products, by controlled condensation of said vapor stream producing a condensate containing said valuable products and a desired amount of lighter hydrocarbons to be used as a heat carrier, utilizing the charge of said undesirable liquid hydrocarbons for absorption of uncondensed gases of substantially all hydrocarbons heavier than ethane, withdrawing from the system said ethane and lighter hydrocarbons, heating and fractionating said condensate to separate said heat carrier therefrom, separately and concurrently applying heat to said heat carrier and to said gas-enriched charge respectively to elevate them to within the ranges of their conversion temperatures, during time intervals insufficient for material conversion to occur, in said reaction zone commingling said heat carrier and said gas-enriched charge for their conversion in the substantial absence of ethane and lighter gases into said valuable products.

9. The method as set forth in claim 8, in which the quantity of heat carrier is controlled directly by varying the extent of cooling of said vapor stream, and in which the weight per cent of said heat carrier and of said absorbed gases is maintained between 30% and 60% of the remaining hydrocarbons in said reaction zone.

10. The method as set forth in claim 8, in which specific gravities of said heat carrier and of said absorbed gases are approximately equal to 1.4 and in which they form a weight per cent of between 30% and 60% of the other hydrocarbons in said reaction zone.

11. In a vapor phase cracking system in which a heat carrier consisting of gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with charging stock uncondensed gases made during said cracking for absorption of a substantial quantity of said gases, heating said enriched charging stock to convert the same into said stream of heated vapors, commingling therewith said heat carrier at a temperature which induces rapid cracking of said vapors, fractionating and cooling said reaction products to produce a condensate and said uncondensed gases, returning said gases for said contact with said charging stock, in a separating zone removing from said condensate lighter constituents, heating said lighter constituents to a high temperature to form the source of supply of said heat carrier, said cooling of said cracked products being sufficient to condense said lighter constituents in quantity adequate for the supply of said heat carrier, and removing from said separating zone a stabilized product suitable for use as motor fuel.

12. In a vapor phase cracking system in which a heat carrier consisting of gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with charging stock uncondensed gases made during said cracking for absorption of from 30% to 50% of said gases, heating said enriched charging stock to convert the same into said stream of vapors, commingling therewith said heat carrier gas at a temperature and in quantity sufficient further to elevate the temperature of said stream of vapors to produce rapid cracking thereof, fractionating and cooling the reaction products to produce a condensate consisting of motor fuel and lighter hydrocarbons having from 3 to 4 carbon atoms per molecule, returning the uncondensed gases for said contact with said charging stock, elevating said condensate to a superatmospheric pressure of the order of 250 to 300 lbs. per square inch, in a zone maintained under said high pressure removing from said condensate the larger part of said lighter hydrocarbons, heating said lighter hydrocarbons to said high temperature to form the source of supply of said heat carrier gas, and removing from said high pressure zone a stabilized product suitable for use as motor fuel.

13. In a vapor phase cracking system in which a heat carrier consisting of normally gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with a heavy naphtha charging stock, the lighter gases made during said cracking for absorption of a substantial quantity of said gases, heating said enriched charging stock and producing therefrom said stream of vapors, commingling therewith said heat carrier at a temperature quickly to further elevate their temperature and to induce rapid cracking thereof, fractionating and cooling said reaction products to produce a condensate consisting of motor fuel and normally gaseous hydrocarbons, returning the lighter uncondensed gases for said contact with said heavy naphtha charging stock, elevating said condensate to a high pressure, in a zone maintained under said high pressure removing from said condensate said normally gaseous hydrocarbons, concurrently introducing into said zone of high pressure a stream of light naphtha, removing from said light naphtha lighter constituents thereof, withdrawing from said high pressure zone said gaseous hydrocarbons and said lighter constituents, under the applied pressure from said high pressure zone heating them to a high temperature to form the source of supply of said heat carrier, and removing from said high pressure zone a stabilized liquid product suitable for use as motor fuel.

14. In a vapor phase cracking system in which a heat carrier consisting of normally gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with a heavy naphtha charging stock, uncondensed gases made during said cracking for absorption of a substantial quantity of said gases, heating said enriched charging stock and producing therefrom said stream of vapors, commingling therewith said heat carrier at a temperature quickly to further elevate their

temperature and to induce rapid cracking thereof, fractionating and cooling said reaction products to produce a condensate consisting of motor fuel and normally gaseous hydrocarbons, returning the uncondensed gases for said contact with said naphtha charging stock, elevating said condensate to a high pressure, in a zone maintained under said high pressure removing from said condensate said normally gaseous hydrocarbons, concurrently introducing into said zone of high pressure a stream including light hydrocarbons having about four carbon atoms per molecule, withdrawing from said high pressure zone said light and said gaseous hydrocarbons, under the applied pressure from said high pressure zone heating them to a high temperature to form the source of supply of said heat carrier, and removing from said high pressure zone a stabilized liquid product suitable for use as motor fuel.

15. In a vapor phase cracking system in which a heat carrier consisting of normally gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with a heavy naphtha charging stock, uncondensed gases made during said cracking for absorption of a substantial quantity of said gases, heating said enriched charging stock to produce therefrom said stream of vapors, commingling therewith said heat carrier at a temperature quickly to further elevate their temperature and to induce rapid cracking thereof, fractionating and cooling said reaction products to produce a condensate consisting of motor fuel and normally gaseous hydrocarbons, returning the uncondensed gases for said contact with said naphtha charging stock, elevating said condensate to a high pressure, in a zone maintained under high pressure removing from said condensate said gaseous hydrocarbons, concurrently introducing into said zone of high pressure a stream of light hydrocarbons having about four carbon atoms per molecule, withdrawing from said high pressure zone said light and said gaseous hydrocarbons, under the applied pressure from said high pressure zone, heating them to a temperature high enough to induce said rapid cracking, said light and gaseous hydrocarbons forming the source of supply of said heat carrier, and removing from said high pressure zone a stabilized liquid product of high octane number and suitable for use as motor fuel.

16. In a vapor phase cracking system the method of operating the system without a compressor which comprises fractionating and cooling the reaction products to produce a condensate within the gasoline range and which includes a substantial proportion of lighter hydrocarbons having three to four carbon atoms per molecule, removing the uncondensed gases, elevating the pressure upon said condensate and transferring it to a high pressure zone, stripping from said condensate said lighter hydrocarbons and by said pressure flowing them through a heating zone, in said heating zone transferring heat to said lighter hydrocarbons to raise their temperature to above 1175° F., countercurrently contacting with charging stock said uncondensed gases for the absorption by it of a considerable quantity of said gases, applying heat to said enriched charging stock to raise it to a vaporization temperature, the presence of said absorbed gas reducing the partial pressure for complete vaporization thereof, applying heat to raise to a temperature above about 850° F. a stream of vapors at least in part derived from said charging stock, and commingling said heated hydrocarbons and said heated vapors to produce cracking thereof, and subjecting the reaction products to said fractionating and cooling operations as aforesaid.

17. In a vapor phase cracking system characterized by a maximum operating pressure of less than 300 lbs. per square inch, the method of operating the system without a compressor and with circulation of relatively large quantities of gas therethrough which comprises fractionating and cooling the reaction products to produce a condensate within the gasoline range and which includes a substantial portion of lighter hydrocarbons having 3 to 4 carbon atoms per molecule, separating the uncondensed gases from said condensate, elevating the pressure of said condensate and transferring it to a high pressure zone, in said zone stripping from said condensate said lighter hydrocarbons, utilizing said high pressure to produce flow of said lighter hydrocarbons through a heating zone, in said heating zone transferring heat to said lighter hydrocarbons to raise their temperature to above 1175° F., countercurrently contacting with charging stock said uncondensed gases for the absorption by it of a large quantity of said gases, applying heat to said enriched charging stock to raise it to a vaporizing temperature, the presence of said absorbed gas reducing the partial pressure of said charging stock, further elevating the temperature of said vaporized charging stock and gases to above about 850° F., commingling said heated hydrocarbons and said heated vapors and gases to produce cracking thereof and conversion of both charging stock and gases and gaseous hydrocarbons into products suitable for inclusion into motor fuel, and subjecting said reaction products to said fractionating and cooling operations as aforesaid.

18. In a vapor phase cracking system in which a heat carrier consisting of gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with a charging stock uncondensed gases made during said cracking for absorption of substantially all of the hydrocarbons heavier than ethane, heating said charging stock together with gases absorbed therein to convert the same into said stream of heated vapors, commingling therewith said heat carrier at a temperature which induces rapid cracking of said vapors, fractionating and cooling the reaction products to produce a condensate and said uncondensed gases, returning said gases for said contact with said charging stock, in a separating zone removing lighter constituents from said condensate, heating them to a high temperature to form the source of supply of said heat carrier, and a predetermined time after mixture of said heat carrier with said stream of heated vapors terminating the cracking reactions by rapid cooling of the reaction products.

19. In a vapor phase cracking system in which a heat carrier consisting of gaseous hydrocarbons is commingled with a stream of heated hydrocarbon vapors to produce cracking thereof, the method which comprises countercurrently contacting with charging stock uncondensed gases made during said cracking for absorption of substantially all of the hydrocarbons heavier than ethane, withdrawing from said absorption zone and from the cracking system the unabsorbed gases, heating said charging stock together with gases absorbed therein to convert the same into

said stream of heated vapors, commingling therewith said heat carrier at a temperature which induces rapid cracking of said vapors, fractionat- and cooling the reaction products to produce a condensate and said uncondensed gases, returning said gases for said contact with said charging stock, in a separating zone removing lighter constituents from said condensate, heating them to a high temperature to form the source of supply of said heat carrier, and a predetermined time after mixture of said heat carrier with said stream of heated vapors terminating the cracking reactions by rapid cooling of the reaction products, the withdrawal of unabsorbed gases from said absorption zone producing conversion of said commingled hydrocarbons in the substantial absence of ethane and lighter gases.

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