May 3, 1949. L. P. EVANS 2,469,332

METHOD FOR CONVERSION OF HYDROCARBONS

Filed June 12, 1946 2 Sheets-Sheet 1

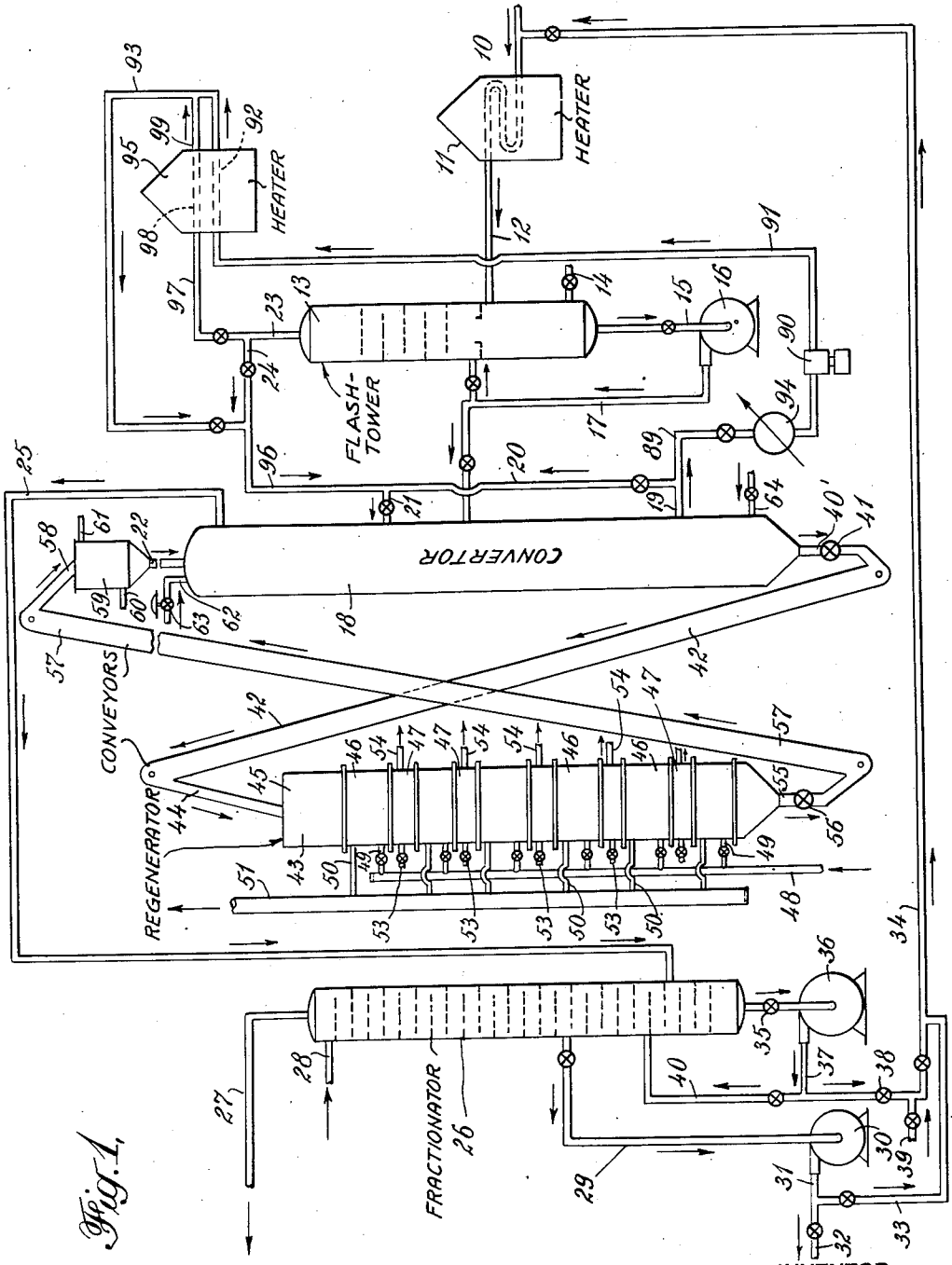


Fig. 1.

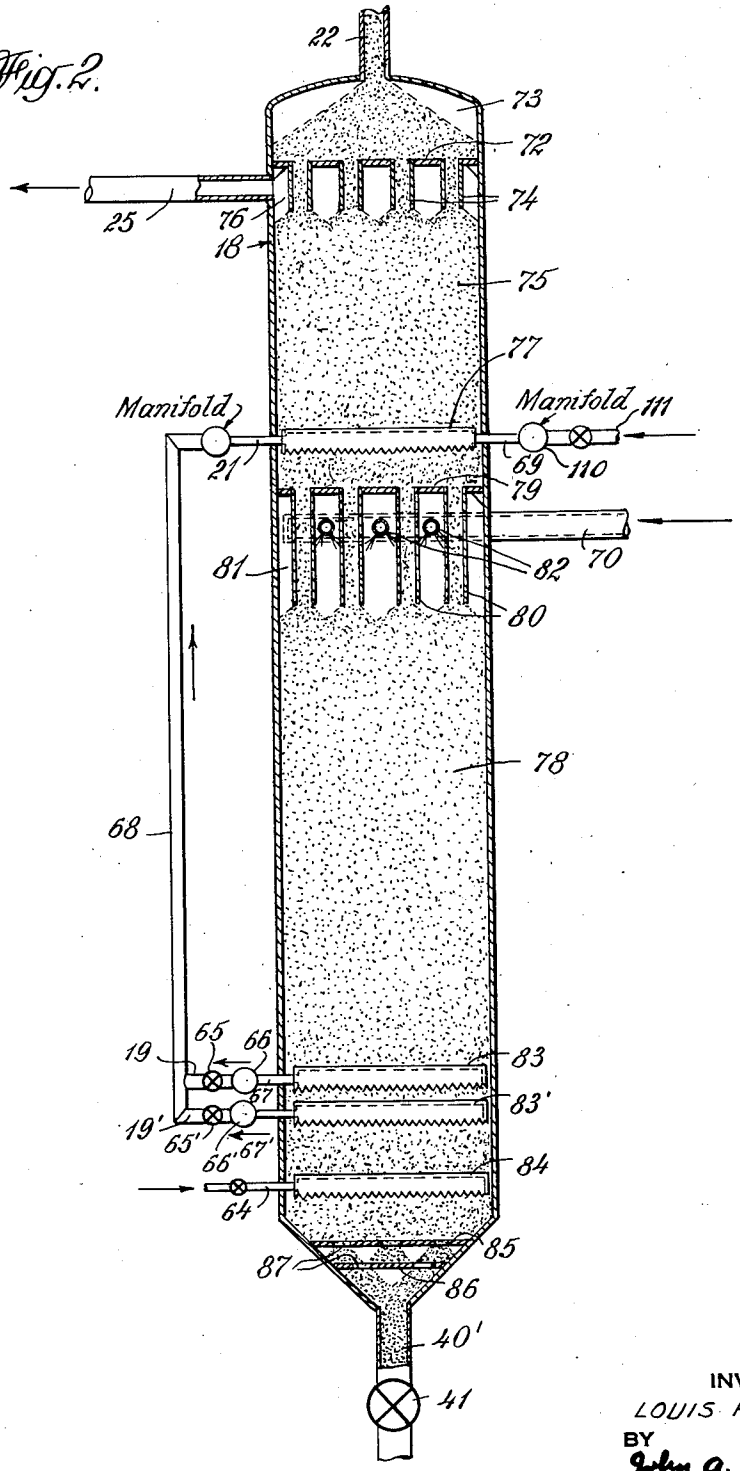
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Fig. 2.



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METHOD FOR CONVERSION OF HYDROCARBONS

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12 Claims. (Cl. 196—52)

1

This invention has to do with a method for conversion of hydrocarbons to lower boiling hydrocarbons preferably in the gasoline boiling range. The invention is specifically directed to a method for conversion of high boiling petroleum hydrocarbons in the presence of a moving contact mass material.

It is well known that when petroleum gas oils boiling within the range 450 to 750° F., for example, are contacted in the gaseous phase with particle form catalytic materials at temperatures above about 800° F. and usually at superatmospheric pressures, the gas oil may be converted to gasoline gas, and cycle oil. Typical of the catalytic materials employed in such processes are natural clays, bauxites, treated clays and synthetic associations of alumina, silica, or silica and alumina to which other constituents such as certain metallic oxides may be added. Such catalytic materials may vary in particle size from finely powdered material used in suspension flow type processes to granular particles ranging from 4 to 100 mesh size by Tyler screen analysis used in moving bed type processes.

Such hydrocarbon conversion processes have recently taken the form of one wherein the contact mass material is passed cyclically through a conversion zone wherein it is contacted with hydrocarbons to effect their conversion and resulting in deposition of a carbonaceous contaminant on the contact material and through a regeneration zone wherein it is contacted with a combustion supporting gas acting to burn the contaminant from the contact material.

The use of such catalytic processes for hydrocarbon conversion permits the use of lower temperatures and results in motor and aviation fuels of higher anti-knock properties and higher stability than the prior strictly pyrolytic conversion processes.

Heretofore catalytic conversion of hydrocarbons in continuous moving catalyst processes has been chiefly limited to conversion of hydrocarbons in the gaseous phase. Consequently only those lighter charging stocks such as distillate gas oils which are vaporizable below the desired conversion temperature have been usable as catalytic conversion charging stocks. The required vaporization temperature of high boiling petroleum hydrocarbons such as residual crudes and heavy fuel oil cuts is so high that attempts to vaporize such stocks as catalytic conversion charge results in excessive pyrolytic cracking thereof principally to non-condensible gas and coke. Moreover, the contacting of such high

2

boiling hydrocarbons with catalysts sufficiently active and under sufficiently high temperature conditions to result in a reasonable severity in the cracking reaction results in the deposit of such large amounts of carbonaceous contaminant on the catalyst as to make the conversion process uneconomical and in many cases altogether commercially inoperable.

A major object of this invention is the provision of practical continuous process for the catalytic conversion of high boiling hydrocarbons to valuable lower boiling products such as motor and aviation gasolines. A specific object of this invention is the provision of a method for conversion of high boiling hydrocarbons in the presence of a moving contact mass material which process eliminates the necessity for vaporization of the hydrocarbons before the introduction thereof into the conversion zone.

A further object of this invention is the provision of a method for catalytic conversion of high boiling hydrocarbons such as residual crudes to high yields of lighter hydrocarbons boiling principally in the gasoline boiling range without deposition of an impractical amount of carbonaceous contaminant on the catalyst.

The method of this invention in general involves the contacting of heated liquid high boiling hydrocarbon charge with a moving stream of hot, partially spent contact mass material to effect conversion of the hydrocarbon liquid to lower boiling hydrocarbons existing in the gaseous phase under the conversion conditions. The lower boiling gaseous hydrocarbons are then contacted in the gaseous phase with a moving stream of freshly regenerated contact material to effect the final conversion of the hydrocarbons to the desired fractionatable products and causing the contact material to become partially spent by the deposit of a relatively small amount of carbonaceous contaminant thereon. The partially spent contact material is then passed to said first mentioned conversion step wherein it supports the initial partial hydrocarbon conversion or vis-breaking without causing the deposition thereon of impractically large amounts of additional carbonaceous contaminant.

The invention may be most readily understood by reference to the drawings attached hereto of which Figure 1 shows in an elevational view a flow arrangement of a continuous catalytic conversion process adapted for the method of this invention and Figure 2 is an elevational view, partially in section, of a preferred converter construction adapted for the method of this inven-

tion. Both of these drawings are highly diagrammatic in form.

Turning now to Figure 1, a typical example of the application of the method of this invention is the catalytic conversion of a topped crude containing both light gas oil such as has been heretofore alone suitable for catalytic charging stocks as well as high boiling hydrocarbons boiling well above the usual 750–800° F. end point of normal gas oil charging stocks. The wide boiling range charging stock is introduced from a suitable pump not shown through conduit 10 into the coils in heater 11 in which it is heated to a temperature sufficiently high to accomplish vaporization of the lower boiling portion of the charge but insufficient to cause any substantial amount of pyrolytic cracking, for example 800° F.

The heated stock passes through conduit 12 into flash tower 13 which may be of usual construction. Inert gas or steam may be admitted to tower 13 through conduit 14 to aid in the partial vaporization of the charging stock. The unvaporized portion which may for example contain a small quantity of hydrocarbons boiling in the range 800 to 900° F. but which for the most part boils substantially above 900° F. passes from the bottom of tower 13 through conduit 15 and pump 16 to conduit 17 through which it is introduced into converter 18 at an intermediate level along the length thereof such as at inlet 70. The high boiling liquid hydrocarbons so introduced contact hot partially spent contact material passing downwardly at a suitable conversion supporting temperature from the upper section of converter 18 so as to effect the conversion of said high boiling liquid hydrocarbons to lower boiling hydrocarbons existing in the gaseous phase under the conversion conditions. The lower boiling gaseous hydrocarbons are then withdrawn from the lower section of converter 18 through conduit 19 and then pass through conduits 20 and 21 into the upper section of converter 18 at a spaced vertical distance above the level of high boiling liquid introduction. The gaseous hydrocarbons then pass upwardly through the upper section of converter 18 counter-currently to contact material introduced as freshly regenerated particles at a suitable conversion supporting temperature through inlet leg 22. In connection with the term "gaseous" as used herein, for example, in the phrase "gaseous hydrocarbons," it should be understood that the term is used herein in describing and in claiming this invention in a sense sufficiently broad to include all materials of the type in question existing in the gaseous phase under the particular operation conditions involved regardless whether the normal phase of those materials at ordinary atmospheric conditions of temperature and pressure be gaseous or liquid. The vaporized portion of the original hydrocarbon charge is withdrawn from flash tower 13 through conduits 23 and then passed through conduits 24 and 21 into the upper section of converter 18 along with the partially converted gaseous hydrocarbons from the lower section thereof. Finally converted hydrocarbon products are withdrawn in the gaseous phase near the top of converter 18 through conduit 25 and are then passed to fractionating tower 26. Gasoline and noncondensible gas products are withdrawn from the upper end of tower 26 through conduit 27 and then passed to further fractionation and treating equipment (not shown). A condensed reflux liquid is returned to the top of the tower 26 through conduit 28. A

light cycle oil boiling above the gasoline range is withdrawn from tower 26 through conduit 29 and may then be pumped by pump 30 either to storage via conduits 31 and 32 or back to charge heater 11 as recycle stock via conduits 31, 33 and 34. A heavier cycle or fuel oil boiling, for example, above about 700° F. is withdrawn from the bottom of fractionator 26 through conduit 35. The heavier cycle oil may then be pumped by pump 36 to storage via conduits 37, 38 and 39 or to heater 11 as recycle via conduits 37, 38 and 34. A portion of the heavy cycle oil may also be returned to an intermediate section of tower 26 via conduit 40.

The contact mass material flows, as has been shown, serially through the upper and lower conversion zones within converter 18, wherein it may flow as a substantially compact column of downwardly moving particles. Carbonaceous material accumulates on the contact material during its passage through both conversion zones so that the contact material finally withdrawn through conduit 40 and flow control valve 41 requires regeneration to restore its catalytic activity. The spent contact material is conveyed by a conveyor 42 which may be of any suitable type adapted to convey high temperature solid materials, for example, a continuous bucket elevator, to the top of a regeneration vessel 43 to which it charges through conduit 44. The regenerator may be of a number of types adapted to permit burning of the carbonaceous contaminant from the contact material at controlled elevated temperatures generally in the range 800–1200° F. The regenerator shown is of multi-stage construction having an uppermost surge section 45 and a plurality of alternating burning sections 46 and cooling sections 47. Combustion supporting gas, such as air, is supplied from manifold 48 to the several burning stages through separate inlets 49. Spent regeneration gas passes from the several regeneration stages through separate outlets 50 to outlet manifold 51. A heat transfer medium such as high pressure steam, water, low melting metal alloys or fused inorganic salts, may be introduced into each cooling zone through inlets 53, which connect with heat transfer tubes within the cooling zones. Heat transfer medium leaves the cooling zones through outlets 54 from which it may pass to a cooling system (not shown). The number of burning stages provided may vary from about 6 to 20 depending upon the amount of contaminant to be burned from the contact material. Hot regenerated contact material passes from the bottom of regenerator 43 through conduit 55 and flow control valve 56 to conveyor 57 by which it is delivered through conduit 58 into surge hopper 59 located above the converter.

The temperature of the regenerated contact material may be adjusted to a suitable conversion supporting level at any convenient location between the final burning stage and the converter. For example, a heat exchange fluid may be admitted through inlet 60 to heat transfer coils within surge hopper 59 and withdrawn therefrom through outlet 61. The contact material then passes through the gravity feed leg 22 to converter 18. Other suitable means such as a system of feed locks may be substituted for the feed leg 22. The escape of hydrocarbons from the upper end of converter 18 is prevented by the introduction thereinto through conduit 62 and pressure control valve 63 thereon of an inert seal gas such as steam or flue gas. The spent contact

material leaving the lower conversion zone is purged substantially free of gaseous hydrocarbons by an inert purge gas introduced through inlet 64 near the lower end of converter 18.

A preferred form of the converter construction is shown in Figure 2 wherein is shown the single elongated vessel 18 closed on either end and provided at its upper end with inlet leg 22 and at its lower end with solid outlet conduit 40 having flow control valve 41 thereon. A partition 72 extends across the upper section of vessel 18 so as to provide an uppermost seal zone 73. Uniformly distributed conduits 74 depend from partition 72 for flow of contact material from the solid zone 73 to the upper conversion zone 75. The conduits 74 also provide a gas-solid disengaging space 76 from which final conversion products may be withdrawn through outlet 25. A row of gas distributor throughs of which one, trough 77, may be seen, is provided across the lower section of zone 75 for distribution of gaseous reactants thereinto. These troughs are supplied on one end by gaseous hydrocarbons from the lower conversion zone 78 through inlet conduits 21 and on their opposite ends by vaporizable constituents of the original charge through conduits 69, manifold 110 and inlet 111. A partition 79, separates the upper conversion zone 75 from the lower conversion zone 78, and conduits 80 depend from partition 79 for flow of contact material from the upper to the lower conversion zone. The conduits 80 substantially restrict the cross-sectional area of the solid material column between the two conversion zones and thereby provides a solid material seal between the two zones which effectively limits gaseous flow therebetween. Liquid hydrocarbons are introduced into the gaseous space 81 provided by conduits 89 in the upper end of zone 78 through inlet manifold 70 extending along the side of the vessel, which manifold is provided with suitable spray headers 82 extending into the vessel and arranged to uniformly spray the liquid hydrocarbons on to the surface of the contact material within zone 78. Two rows of spaced horizontally extending collecting troughs 83 and 83' are provided within the lower section of zone 78 for separation of gaseous hydrocarbons from the solid contact material. The separated gaseous hydrocarbons are withdrawn from the collector troughs through pipes 67 and 67' to manifolds 66 and 66', respectively. The gaseous hydrocarbons flow from manifolds 66 and 66' through outlet conduits 19 and 19', respectively into manifold 68 by which they are conducted to inlet 21 to zone 75. Flow control valves 65 and 65' are provided on conduits 19 and 19', respectively to permit adjustment of the rate of gaseous hydrocarbon withdrawal from each row of collecting troughs. Another row of gas distributing troughs 84 supplied with inlets 64 is provided near the bottom of vessel 18 for introduction of purge gas. Two partitions 85 and 86 having properly positioned orifices 87 therein are provided within the tapered drain section 87 for uniform withdrawal of solid material from all sections of the conversion zone thereabove. It should be understood that Figure 2 is highly diagrammatic in form and the invention is not intended to be limited to the exact construction shown therein. Modified structural means of providing the two superposed conversion zones and for introduction of reactants thereinto and for withdrawal of products therefrom will become readily apparent to those skilled in the art. The proper length of each conversion zone varies from one application of the invention to another depending upon such factors as catalyst rate of flow and activity, the nature of the reactants and the space velocity thereof. In general, the length of each conversion zone for a commercial application wherein the catalyst flows as a substantially compact column may be between about 3 to 30 feet; the catalyst rate of flow between about 0.5 to 10 feet per minute; the volumetric ratio of catalyst (measured as a compact mass of particles) to liquid hydrocarbons charged to the lower conversion zone (measured as liquid at 60° F.) between about 2 to 20 volumes of catalyst per volume of oil charged. The catalyst to oil ratio in the upper conversion zone is generally somewhat lower than that in the lower conversion zone.

The proper temperature of the freshly regenerated contact material charged to the uppermost conversion zone varies considerably depending upon the desired conversion temperatures for the particular operational application involved, the catalyst to oil ratio and the materials involved. In general, the catalyst temperature should be sufficient to support the desired conversion. In many operations this means that the catalyst charged to the upper zone should be at a temperature sufficient to supply heat required for the gaseous hydrocarbon conversion in the upper zone plus the heat required to convert liquid hydrocarbon charge to gaseous hydrocarbons of lower boiling point in the lower zone all without the catalyst temperature falling below a suitable conversion temperature in said lower zone. Generally catalyst temperatures below about 800° F. are undesirable in the lower conversion zone. It has been found that for various applications the desirable inlet temperature of the freshly regenerated catalyst to the upper zone will fall within the range about 900–1200° F.

In some operations it is desirable to supply all or part of the heat required for the conversion in the upper zone by super-heating of the gaseous hydrocarbon charge thereto. Thus, turning again to Figure 1, gaseous hydrocarbons withdrawn from the lower conversion zone through outlet 19 may be conducted through conduit 89 and condenser 94 to pump 90 by which it is pumped through conduit 91 and through coil 92 in heater 95. Heated gaseous hydrocarbons at a temperature substantially above the desired conversion temperature then pass through conduits 93, 96 and 21 into the upper conversion zone. Similarly, the vaporizable portion of the original hydrocarbon charge may be passed from the top of flash tower 13 through conduits 23 and 97 and coil 98 in heater 95; and then through conduits 93, 93, 96 and 21 into the upper conversion zone. By this latter method of operation it is also possible in some operations to supply a portion of the heat required for the conversion in the lower conversion zone as well as that for the upper conversion zone, thereby permitting lower overall catalyst temperatures, more desirable for some hydrocarbon stocks, in the upper conversion zone.

The method of this invention is obviously also adapted for conversion alone of hydrocarbon charge stocks containing substantially no lower boiling hydrocarbons capable of being vaporized in the flash tower 13, for example, reduced crude cuts having initial boiling points of 900° F. and higher. In a typical operation a heavy coastal vacuum distillate having an A. P. I. gravity of 19.4; and a mid-boiling point of 1030° F. was charged as a liquid at about 827° F. into a first conversion zone in contact with partially spent

clay-type catalyst entering said zone at a temperature of about 860° F. and leaving said zone at a temperature therebelow and above 800° F. The catalyst to oil ratio was 6.7 volumes of catalyst per volume of oil charge and the oil space velocity in volumes of oil (measured at 60° F.) per hour per volume of catalyst in the conversion zone was about 0.38. Gaseous conversion products from said first zone were then passed through a second conversion zone into which freshly regenerated catalyst was introduced at about 1050° F. Also passed through said second zone along with said products from said first zone was a stream of gas oil from the coastal stock having a gravity of about 24.3° A. P. I. and a boiling range by A. S. T. M. distillation between 512–925° F. The catalyst from said second zone was passed to the first zone and the gaseous products from said second zone were withdrawn and subjected to fractionation. The gaseous hydrocarbons from said second zone were found to contain about 41.4% volume of stabilized 400° F. E. P. 10# R. V. P. gasoline, about 10.9% vol. of C_4's not required for the gasoline, about 5.9% by wt. C_3's and lighter, about 41.0% volume of gas oil boiling above the gasoline, and having an end point by A. S. T. M. distillation of about 600° F., and about 5.9% volume of a heavier fuel oil. The amount of carbonaceous deposit upon the spent catalyst withdrawn from the first conversion zone (i. e., the lower zone) was about 3.1% by weight of the catalyst or 4.7% by weight of the original liquid hydrocarbon charge.

It should be understood that it is not intended that this invention be limited to the specific examples of operation conditions, applications, and apparatus construction set forth hereinabove, or that the invention be otherwise limited except as set forth in the following claims.

I claim:

1. A method for conversion of high boiling petroleum hydrocarbon charge to low boiling hydrocarbons within the gasoline boiling range which method comprises: heating said hydrocarbon charge to effect partial vaporization thereof, flashing said heated charge in a suitable confined flash zone to effect separation of the vaporized hydrocarbons from the liquid and passing the liquid hydrocarbons through a confined conversion zone in contact with concurrently flowing, partially spent particle-form contact material charged to said zone at an elevated conversion supporting temperature to effect conversion of said liquid hydrocarbons to lower boiling hydrocarbons, withdrawing lower boiling conversion products from said zone in the gaseous phase and passing said lower boiling products through a second zone in contact with freshly regenerated contact material charged to said zone at a suitable conversion temperature, passing said separated vaporized hydrocarbon charge through said second zone along with said lower boiling products from said first zone to effect conversion thereof, withdrawing gaseous conversion products from said second zone and passing the hot partially spent contact material from said second zone to said first zone as the contact material charge thereto.

2. A method for conversion of high boiling petroleum hydrocarbon charge to low boiling hydrocarbons within the gasoline boiling range which method comprises: heating said hydrocarbon charge to effect partial vaporization thereof, flashing said heated charge in a suitable confined flash zone to effect separation of the vaporized hydrocarbons from the liquid and passing the liquid hydrocarbons through a confined conversion zone concurrently with a substantially compact column of downwardly flowing particle-form contact mass material charged to said zone at an elevated conversion supporting temperature to effect conversion of said liquid hydrocarbons to lower boiling hydrocarbons, withdrawing lower boiling conversion products from said zone in the gaseous phase and passing said lower boiling products through a second zone in contact with a substantially compact column of freshly regenerated contact material charged to said zone at a suitable conversion temperature, passing said vaporized hydrocarbons separated from said liquid hydrocarbons in the original hydrocarbon charge through a heating zone to heat it to a temperature at least sufficient to supply its heat of conversion and passing said heated vaporized hydrocarbons through said second zone along with said lower boiling products from said first zone to effect conversion thereof, withdrawing gaseous conversion products from said second zone and passing the hot partially spent contact material from said second zone to said first zone as the contact material charge thereto.

3. A method for conversion of high boiling petroleum hydrocarbon charge to low boiling hydrocarbons within the gasoline boiling range which method comprises: heating said hydrocarbon charge to effect partial vaporization thereof, introducing the heated hydrocarbons to a flash chamber to effect separation of gaseous and high boiling liquid hydrocarbons, withdrawing the high boling liquid hydrocarbons from said flash chamber and introducing said liquid hydrocarbons into a confined conversion zone to pass along said zone in contact with and concurrently with the flow of particle-form contact mass material, moving through said zone as a substantially compact column and introduced into said zone at an elevated temperature suitable for supporting the conversion of said liquid hydrocarbons to lower boiling hydrocarbons existing in the gaseous phase under the conversion temperature conditions within said zone, withdrawing said lower boiling gaseous hydrocarbons from said zone and heating said gaseous hydrocarbons to a temperature sufficient to at least supply the heat required for further conversion thereof, withdrawing gaseous hydrocarbon charge from said flash chamber and further heating said gaseous hydrocarbons to a temperature sufficient at least to supply the heat required for conversion thereof, passing said last named heated gaseous hydrocarbons along with said heated gaseous hydrocarbons from said conversion zone through a second conversion zone in contact with a substantially compact column of particle-form contact material moving through said second zone and introduced thereinto at an elevated conversion supporting temperature, withdrawing final gaseous conversion products from said second zone, withdrawing partially spent hot contact material from said second zone and passing it to said first named zone as the contact material charge thereto.

4. A method for converting high boiling hydrocarbons to lower boiling products which comprises: maintaining a substantially upright confined, compact continuous column of downwardly flowing particle form contact mass material, replenishing said column at its upper end with freshly regenerated contact material at an

elevated conversion supporting temperature, withdrawing spent contact material from the lower end of said column at a controlled rate, introducing heated high boiling liquid hydrocarbons into said column at an intermediate level along its length, said liquid hydrocarbons boiling substantially all within a temperature range above the temperature of the column below said intermediate level, passing said high boiling hydrocarbons downwardly along with the contact material flow to effect conversion of said high boiling hydrocarbons to lower boiling hydrocarbons, withdrawing said lower boiling hydrocarbons in the gaseous phase from said column near the lower end thereof heating said lower boiling hydrocarbons in a separate heating zone, reintroducing said heated lower boiling hydrocarbons without substantial cooling into said column at a second intermediate level a spaced distance above said level of liquid introduction, passing said gaseous hydrocarbons upwardly through said column from the level of introduction to effect further conversion thereof and to add to the contact material a substantial portion of the heat required for the hydrocarbon conversion occurring in said column below said first named level of introduction, withdrawing low boiling gasiform hydrocarbon products from the upper section of said column and restricting the cross-sectional area of said column between said intermediate levels of liquid and gaseous hydrocarbon introduction so as to substantially limit interflow of gaseous material between the upper and lower section of said column, wherein the lower boiling hydrocarbons are heated in said separate heating zone to add thereto as sensible heat above the temperature level of the hydrocarbon conversion substantially more heat than that required for the hydrocarbon conversion occurring in the portion of said column above the second named level of introduction.

5. A method for catalytic cracking conversion of high boiling petroleum hydrocarbon fractions which method comprises: maintaining a substantially compact, vertical, confined column of downwardly moving particle-form contact mass material, delivering freshly regenerated contact material to the upper end of said column at an elevated temperature sufficiently high to supply heat required for the hydrocarbon conversion without the contact material falling below an active conversion temperature at any level along said column, withdrawing contact material from the lower end of said column, restricting the cross-sectional area of a vertical intermediate section of said column so as to divide said column into upper and lower zones having a length of seal column therebetween of substantially less cross-sectional area than said zones, heating a petroleum hydrocarbon fraction boiling above gasoline boiling range to accomplish partial vaporization thereof, separating the vaporized and non-vaporized fractions and introducing said non-vaporized fraction into the lower zone in said column near the upper end of said lower zone, said non-vaporized fraction having a boiling range substantially above the temperature of said column at the level of introduction of said non-vaporized fraction, passing said non-vaporized fraction downwardly with said contact material until it is substantially all converted to lower boiling hydrocarbons which exist in the gaseous phase under the temperature conditions in said lower zone, thereby causing a carbonaceous contaminant to be deposited on said contact material, withdrawing said lower boiling gaseous hydrocarbons from said lower zone and introducing them into said upper zone near its lower end, introducing said vaporized portion of the original petroleum fraction at a suitable conversion temperature into said upper zone along with said lower boiling gaseous hydrocarbons from said lower zone, and withdrawing low boiling gaseous conversion products from said upper end thereof.

6. A method for catalytic cracking conversion of high boiling petroleum hydrocarbon fractions which method comprises: maintaining a substantially compact, vertical, confined column of downwardly moving particle form contact mass material, delivering freshly regenerated contact material to the upper end of said column at an elevated temperature sufficiently high to supply heat required for the hydrocarbon conversion without the contact material falling below an active conversion temperature at any level along said column, withdrawing contact material from the lower end of said column, heating a petroleum hydrocarbon fraction boiling above gasoline boiling range to accomplish partial vaporization thereof, separating the vaporized and non-vaporized fractions and introducing said non-vaporized fraction into said column at an intermediate level along the length thereof and passing it downwardly through a first vertical section within the lower portion of said column to effect its conversion to gaseous lower boiling hydrocarbons, withdrawing said gaseous hydrocarbons from said column near its lower end, mixing said gaseous hydrocarbons with the vaporized portion of the original petroleum fraction and passing the mixed hydrocarbon stream in the gaseous phase through a second vertical section of said column within the upper portion thereof while substantially preventing gaseous flow between said first and second vertical sections within said column and withdrawing gaseous conversion products from said second vertical section.

7. A method according to claim 5 with the additional steps of passing said contact material from the lower end of said column through a regeneration zone in contact with a combustion supporting gas to burn said carbonaceous deposit from said contact material and returning regenerated contact material to the upper end of said column.

8. In a method according to claim 1 the additional steps of passing said low boiling hydrocarbon products from said second zone through a fractionating system to obtain therefrom a gasoline product and recycle fraction boiling above the gasoline boiling range, heating said recycle fraction and returning it to said confined flash zone.

9. The method for conversion of high boiling liquid hydrocarbon charge to lower boiling gasoline containing products which comprises: passing a regenerated finely divided solid contact material at an elevated conversion temperature through a first confined conversion zone while contacting it with gasiform hydrocarbons passed through said zone to effect conversion of said hydrocarbons to gasoline containing gasiform products and resulting in a preliminary deposition of carbonaceous contaminant on said contact material, passing the used contact material from said first conversion zone as a confined stream to said second zone while substantially preventing flow of hydrocarbon reactants from said conversion zones through said stream, passing said used contact material through said second conversion zone, passing high boiling liquid hydrocarbon charge into contact with said contact material in said

second conversion zone to convert said liquid hydrocarbons into lower boiling partially converted gasiform hydrocarbons, passing said gasiform hydrocarbons from said second conversion zone into contact with said contact material in said first conversion zone to effect conversion of said gasiform hydrocarbons to gasoline containing gasiform products as aforesaid, introducing a heated gasiform hydrocarbon charge from a source other than said second conversion zone into said first conversion zone to contact said contact material and undergo conversion in said first zone along with said partially converted hydrocarbons from said second zone, withdrawing mixed gasiform hydrocarbon products from said first conversion zone, passing the used contact material from said second zone through a confined regeneration zone while contacting it therein with a combustion supporting gas to burn off carbonaceous contaminant and passing the hot regenerated contact material to said first conversion zone.

10. The method for conversion of high boiling hydrocarbons to lower boiling hydrocarbon products in the presence of a moving finely divided contact material which comprises: passing a high boiling liquid hydrocarbon charge through a confined conversion zone in contact with a hot partially used finely divided contact material moving through said zone to effect a partial conversion of said liquid hydrocarbons at a suitable elevated conversion temperature to lower boiling gasiform hydrocarbons, effecting a separation of said gasiform hydrocarbons from said contact material and passing said partially converted gasiform hydrocarbons through a second conversion zone in contact with a freshly regenerated finely divided contact material charged to said second zone at a suitable conversion temperature to effect further conversion of said hydrocarbons to gasiform hydrocarbon products, passing a heated gasiform hydrocarbon from a source other than said first conversion zone through said second zone to contact said contact material therein along with said partially converted hydrocarbons from said first zone, effecting separation of the gasiform hydrocarbon products from said second zone from said separated contact material and passing the contact material from said second zone to said first zone as the partially used contact material charge thereto.

11. The method for conversion of high boiling hydrocarbons to lower boiling hydrocarbon products in the presence of a moving finely divided contact material which comprises: passing a high boiling liquid hydrocarbon charge through a confined conversion zone in contact with a hot partially used finely divided contact material moving through said zone to effect a partial conversion of said liquid hydrocarbons at a suitable elevated conversion temperature to lower boiling gasiform hydrocarbons, effecting a separation of said gasiform hydrocarbons from said contact material and passing said partially converted gasiform hydrocarbons through a second conversion zone in contact with a freshly regenerated finely divided contact material charged to said second zone at a suitable conversion temperature to effect further conversion of said hydrocarbons to gasiform hydrocarbon products, effecting separation of the gasiform hydrocarbon products from said second zone from said contact material, passing the contact material from said second zone to said first zone as the partially used contact material charge thereto, recovering a cycle stock boiling above gasoline from said gasiform products from said second zone, heating said cycle stock and passing it in the gaseous phase into said second zone to contact said contact material therein along with said partially converted products from said first conversion zone.

12. A method for converting high boiling hydrocarbons to lower boiling products which comprises: maintaining a substantially upright confined, compact column of downwardly flowing particle form contact mass material, replenishing said column at its upper end with freshly regenerated contact material at an elevated conversion supporting temperature, withdrawing spent contact material from the lower end of said column at a controlled rate, introducing heated high boiling liquid hydrocarbons into said column at an intermediate level along its length, said liquid hydrocarbons boiling substantially all within a temperature range above the temperature of the column below said intermediate level, passing said high boiling hydrocarbons downwardly along with the contact material flow to effect conversion of said high boiling hydrocarbons to lower boiling hydrocarbons, withdrawing said lower boiling hydrocarbons in the gaseous phase from said column near the lower end thereof, heating said lower boiling hydrocarbons to supply at least all the heat required for further conversion thereof and introducing said heated lower boiling hydrocarbons into said column at a second intermediate level a spaced distance above said level of liquid introduction, passing said gaseous hydrocarbons upwardly through said column from the level of introduction to effect further conversion thereof without any substantial drop in temperature of the contact material, withdrawing low boiling gasiphase hydrocarbon products from the upper section of said column and restricting the cross-sectional area of said column between said intermediate levels of liquid and gaseous hydrocarbon introduction so as to substantially limit interflow of gaseous material between the upper and lower section of said column.

LOUIS P. EVANS.

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