

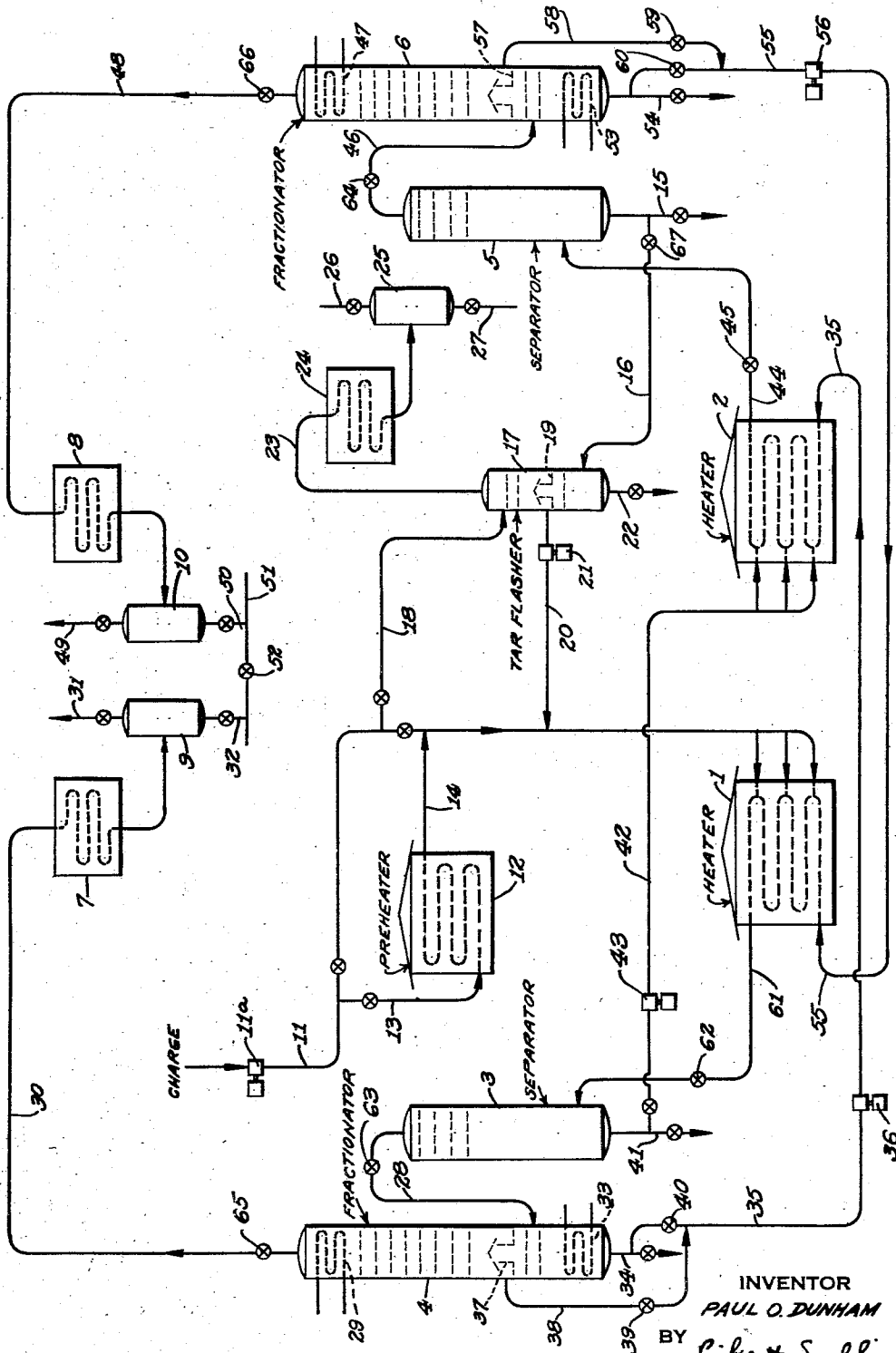
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TREATMENT OF HYDROCARBONS

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TREATMENT OF HYDROCARBONS

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This invention relates to the conversion of high-boiling hydrocarbons into lower-boiling hydrocarbons suitable for motor fuel and pertains more particularly to the processing of relatively heavy oils not amenable to the high-temperature drastic cracking treatment essential to produce maximum yields of high anti-knock gasoline, due to their tendency to form coke.

One factor limiting the cracking treatment of the heavy oils, such as crude, reduced crude, heavy gas oil, and other oil stocks containing constituents difficult to vaporize is the rapid formation of coke, which fouls the heating tubes and other parts of the cracking equipment. For each particular heavy oil cracked under conventional methods there is a more or less fixed relationship between the amount of coke formed and gasoline produced at various degrees of cracking. In view of this relationship, the cracking temperature and the length of time at which the oil is subjected to cracking treatment is limited to avoid the formation of troublesome coke deposition at the sacrifice of gasoline yield in this initial cracking stage in order to extend the length of operating runs.

In accordance with present practice these heavy oil stocks are subjected to a relatively mild cracking treatment, commonly known as viscosity breaking, regulated to produce an optimum yield of intermediate clean condensate. The cracked products are then separated into vapors and residue and the vapors fractionated to condense and separate the higher-boiling constituents as intermediate cycle stock from the gasoline produced from the process. The residue resulting from this viscosity-breaking treatment, with or without further treatment to free it of any lower-boiling constituents contained therein, is ordinarily rejected from the process as fuel oil or converted into solid coke by further treatment.

The intermediate cycle stock, formed by the initial mild cracking of the heavy oil, is then subjected to high-temperature drastic cracking treatment in a second stage to produce an optimum yield of gasoline of high anti-knock characteristics. The character of the intermediate cycle stock permits the production of a much larger yield of high anti-knock gasoline with a lesser amount of carbon deposition than do the original crude stocks or other stocks containing constituents difficult to vaporize.

Another factor, in addition to the formation of coke, limiting the extent of cracking in the second stage is the formation of gaseous constituents

boiling below the range of gasoline. While these gases do not interfere with the operation of the process, they do limit the yield of gasoline produced, and in many cases the extent of cracking of the intermediate gas oil in the second stage is limited to avoid excessive gas losses rather than to avoid coke difficulties.

An object of this invention is to improve the process of the general nature above outlined so as to produce a better yield of high anti-knock gasoline with a lesser amount of processing and equipment.

In accordance with the present invention a clean hydrocarbon oil suitable for high-temperature cracking treatment, such as a refractory recycle stock produced within the process, is subjected to elevated conditions of temperature and pressure to effect substantial conversion thereof. For example, it may be heated under elevated conditions of temperature and pressure during passage as a stream through an elongated heating zone of restricted cross section to effect cracking and conversion thereof to lighter products. A relatively heavy hydrocarbon oil which may be, for example, a reduced crude which constitutes the fresh feed to the system is then merged with the products of the above-mentioned cracking treatment, and the merged products are then subjected to a further cracking treatment. For example, the heavy oil may be introduced as a stream into the above-mentioned elongated heating zone intermediate the ends thereof and at a point or points removed a substantial distance from the inlet of the zone whereby before introduction of the heavy oil the light oil has passed through a substantial portion of the heating zone and has been raised to the desired maximum cracking temperature to effect substantial cracking thereof. The resulting mixture of light oil undergoing cracking and the heavier hydrocarbon oil, for example, reduced crude, cooled somewhat from the above maximum temperature by the admixture of the heavy oil, is passed through the remainder of the heating zone. The proportion of heavy oil added and the heat applied externally to the mixture is controlled to effect the desired cracking of the heavy hydrocarbon, which preferably may be a mild cracking with conversion thereof to lighter products including a substantial proportion of constituents boiling above the gasoline-boiling range. At the same time the portion of the heating zone through which the mixture passes may serve as a soaking section in the cracking of the light oil, and the conditions may be regulated

to effect further cracking of the light oil in this phase of its passage through the said elongated heating zone. At the same time the presence of constituents resulting from the cracking of the heavy hydrocarbon and constituents resulting from the cracking of light oil promotes reaction therebetween with resulting increase in production of hydrocarbons in and above the motor-fuel boiling range and consequent reduction in gas loss and coke deposition.

The cracked products from the above-mentioned heating zone consisting of the conversion products of the light oil and the heavier hydrocarbon oil are passed to a separator to effect separation of the vapors and liquid residue. The vapors are fractionated to produce therefrom a recycle stock and a naphtha distillate. The recycle stock is subjected separately to elevated conditions of temperature and pressure, for example, by passage as a stream through a separate elongated heating zone of restricted cross section whereby conversion thereof to lighter products including gasoline constituents is effected. At least a portion of the residue resulting from the separation of the cracked products from the first-mentioned heating zone is merged with the products for the last-mentioned cracking treatment and the merged products are then subjected to a further cracking treatment. For example, it may be introduced as a stream into the said separate heating zone intermediate the ends thereof at a point or points removed a substantial distance from the inlet of the zone whereby before introduction of the heavy oil said cycle stock has passed through a substantial portion of the said separate heating zone to effect substantial cracking thereof. The resulting mixture is passed through the remainder of the said separate cracking zone in the manner described in connection with the first-mentioned cracking zone whereby cracking of the residue to effect conversion thereof to lighter products including a substantial proportion of constituents boiling above the gasoline boiling range is effected and whereby, if desired, further cracking of the cycle stock is effected. The regulation of the proportions of the stocks introduced into the separate heating zone and the application of heat thereto may be regulated in the same manner as in the first-mentioned heating zone although the conditions maintained are not necessarily the same but may be varied depending upon the particular stocks under treatment and the products desired.

The conversion products from the last-mentioned cracking treatment are passed to a separate separator to effect separation thereof into vapors and liquid residue. The vapors are fractionated to separate therefrom a condensate and naphtha distillate. The said condensate contains a large proportion of constituents which has survived two cracking steps and is therefore rather refractory. All or a portion thereof may be utilized as the feed stock for the first-mentioned relatively drastic cracking treatment.

Various modifications may be employed in connection with the above-described process, as will be apparent from the following more detailed description with reference to the accompanying drawing.

The drawing is a diagrammatic view in elevation of apparatus suitable for carrying out the method of the invention. The invention will be further described with reference to the drawing, but it is to be understood that such description

and reference to the drawing are for purposes of illustrating an embodiment of the invention which is not limited thereby but is capable of other embodiments.

Referring to the drawing, heaters 1 and 2 are provided for the separate treatment of separate streams of relatively light hydrocarbon oil at relatively high temperature and pressure, for example, in the vapor phase. The function of heaters 1 and 2 may be performed by individual coils suitably located in a single furnace which may be also employed for heating other coils through which hydrocarbon liquids are passed. However, for purposes of simplification, heaters 1 and 2 are shown as separate entities, each provided with a coil. Separator 3 and fractionator 4 are provided to effect separation of the conversion products from heater 1 into vapors and liquid residue and fractionation of the vapors, respectively, and separator 5 and fractionator 6 are provided to afford similar treatment of the conversion products from heater 2. Condensers 7 and 8 are provided to receive naphtha distillate from fractionators 4 and 6, respectively, and effect condensation of the naphtha contained therein while distillate receivers 9 and 10 are provided to receive the condensate from condensers 7 and 8, respectively, to effect separation of incondensibles therefrom.

The fresh feed to the system, for example, reduced crude may be introduced through line 11 provided with pump 11a and is introduced into an intermediate point or points of the coil of heater 1, as indicated. The reduced crude or other heavy oil introduced as fresh feed to the system may be preheated by passage through preheater 12 which is indicated as separately housed but which may constitute a separate coil located, for example, in a cooler portion of the furnace structure which houses the coils of heaters 1 and 2. All or a portion of the fresh feed may be diverted from line 11 through line 13 for passage through preheater 12, and the preheated oil is returned to line 11 through line 14.

The fresh feed may be preheated by other means, if desired. For example, all or a portion of the fresh feed from line 11 may be diverted therefrom through line 18 and introduced into the upper portion of tar flasher 17, as indicated. Tar flasher 17 is provided in its upper portion with suitable gas and liquid contact means whereby the vapors passing upwardly are contacted with the fresh feed which descends to effect heating of the fresh feed with vaporization of light constituents therein and condensation, and absorption by the fresh feed, of liquid constituents of the vapors suitable for recovery and treatment therewith. A trap-out tray 19 is provided in tar flasher 17 to collect the fresh feed and absorbed constituents before admixture with the heavy residue resulting from the flashing of the tar. The thus preheated fresh feed is withdrawn from trap-out tray 19 through line 20 provided with pump 21 and reintroduced into line 11 for passage to heater 1.

The primary feed stock for heater 1 is introduced therein through line 55 and is ordinarily a relatively refractory cycle stock from the system. The feed stock introduced to the coil of heater 1 from line 55 is heated under relatively drastic conditions of temperature and pressure to effect substantial conversion thereof to lighter products including gasoline constituents. Heavy oil fresh feed from line 11, which may be a reduced crude, alone or mixed with heavy con-

densate, is introduced into the coil of heater 1 at one or more points intermediate the ends thereof, as described above. The point or points of introduction of the reduced crude and the arrangement and heating of the coil of heater 1 are controlled whereby the cycle stock introduced from line 55 passes through a substantial portion of the coil of heater 1 prior to the introduction of the said reduced crude through line 11 to effect substantial cracking of the said cycle stock prior to admixture with the reduced crude. The totally or partially cracked cycle stock is cooled by admixture with the reduced crude which may be preheated in the manner described. The reduced crude is heated by admixture with the cycle stock, and by further application of heat to the coil, to a temperature sufficient to effect a mild cracking of the reduced crude with conversion to lighter products including constituents boiling above the gasoline boiling range. At the same time the conditions of admixture of the reduced crude and cycle stock and the further application of heat to the mixture may be controlled to effect further cracking of the cycle stock in the presence of and concurrently with the primary cracking of the reduced crude. The temperature maintained in the portion of the coil containing the mixture is ordinarily preferably substantially lower than the temperature to which the cycle stock is heated prior to admixture with the reduced crude. Conveniently the coil of heater 1 may be arranged within the furnace in which it is housed whereby that portion of the coil through which the mixture of cycle stock and reduced crude is passed is located in a cooler portion of the furnace whereby it serves as a soaking section for the cracking of the cycle stock while effecting the desired cracking of the reduced crude.

The cracked products from heater 1 are withdrawn therefrom through line 61 with or without a reduction in pressure by means of valve 62 and introduced into separator 3 to effect separation of vapors and liquid residue.

The vapors separated in separator 3 pass overhead from separator 3 after having removed therefrom substantially all entrained heavier liquid by contact with suitable baffles, etc., located in the upper portion of separator 3. The vapors thus separated pass overhead through line 28 to the lower portion of fractionator 4. Fractionator 4 is provided with suitable fractionating elements such as bubble trays for effecting vapor and liquid contact, and the top temperature thereof is regulated by means of cooling coil 29 or by direct reflux to condense insufficiently cracked constituents. Vapors uncondensed in fractionator 4, consisting of gasoline constituents and lighter products, pass overhead through line 30 which connects with condenser 7 wherein the gasoline constituents condense as the desired distillate. The products from condenser 7 pass to distillate receiver 9 in which separation of liquids and gases is effected, the gases being withdrawn through line 31 and the liquids through line 32.

The liquids condensed in fractionator 4 collect in the bottom thereof which is provided with a heating coil 33 or other heating means to regulate the temperature therein and are withdrawn therefrom through line 34. All or a portion thereof may be diverted as cycle stock through line 35 provided with a pump 36 as fresh feed to heater 2. If desired, the character of the fresh feed for heater 2 may be varied by providing a trap-out tray 37 in fractionator 4 whereby a somewhat

lighter cut is collected than in the bottom of the fractionator 4. This lighter cut may be admixed with the heavier cycle stock passing through line 35 by means of line 38 connecting line 35 and trap-out tray 37, or the said lighter cut may constitute all of the fresh feed passing through line 35 by suitable manipulation of valves 39 and 40 in lines 38 and 35, respectively.

The cycle stock introduced to the coil of heater 2 from line 35 is subjected to elevated conditions of temperature and pressure to effect substantial cracking thereof. All or a portion of the liquid residue separated in separator 3 and withdrawn therefrom through line 41 may be diverted through line 42 connecting with line 41 and provided with a pump 43 and introduced into the coil of heater 2 intermediate the ends thereof as indicated. The heating of cycle stock in the coil of heater 2 is controlled to effect substantial cracking thereof prior to the introduction and admixture therewith of the liquid residue from line 42 as described above. To this end the connections between line 42 and the coil of heater 2 are arranged to permit passage of the cycle stock which constitutes the primary fresh feed to the heater 2 through a substantial portion of the coil prior to the introduction of the liquid residue which constitutes the secondary feed to the heater 2.

The regulation of the cracking conditions, location of the coil and relative proportion of heavy liquid added through line 42 may be controlled along the same principles described in connection with the operation of heater 1 although the exact conditions selected do not necessarily follow those of heater 1 but are selected to effect the production of the desired product from feed stocks which differ in character from those introduced into heater 1.

The cracked products from heater 2 are withdrawn therefrom through line 44 with or without reduction in pressure by means of valve 45 and introduced into separator 5 to effect separation thereof into vapors and liquid residue. The liquid residue may be withdrawn therefrom through line 15 for further treatment elsewhere, for example, by flashing in tar flasher 17, as described above. Suitable baffles, etc., may be provided in the upper portion of separator 5 whereby the ascending vapors are freed of entrained liquids. Thereafter the vapors pass overhead from separator 5 through line 46 and are introduced into the lower portion of fractionator 6 wherein conditions of temperature and pressure are maintained to effect condensation and separation of liquids boiling above the gasoline boiling range. A cooling coil 47 or other cooling means, such as reflux means, may be provided in the top of the fractionator 6 to effect condensation from the vapors of undesirably heavy constituents. The vapors consisting of gasoline constituents and lighter products pass overhead through line 48 to condenser 8 wherein constituents within the gasoline boiling range condense as a desired distillate. The resulting condensate is introduced into distillate receiver 10 wherein separation of liquid and gases is effected. The gases are withdrawn through line 49 and the liquids through line 50.

Line 32 and line 50 connect with line 51 which is provided with a valve 52 located between the points of connection. By this means the gasoline withdrawn from receivers 9 and 10 through lines 32 and 50, respectively, may be separately withdrawn through opposite ends of line 51, or by

means of suitable manipulation of valve 52 any desired blending of the products may be effected.

The liquids separated as condensate in fractionator 6 collect in the bottom thereof which is provided with heating means such as heating coil 53 to effect the desired temperature control at that point. The condensate may be withdrawn through line 54, and all or a portion thereof may be diverted through line 55 provided with a pump 56 for passage to heater 1 as the primary fresh feed therefor. Instead of using the condensate from the bottom of fractionator 6 as the cycle stock for heater 1 an intermediate cut may be taken by means of trap-out tray 57 whereby a cycle stock somewhat lighter than that collected in the bottom of fractionator 6 may be provided. The cycle stock from trap-out tray 57 may be admixed with that passing through line 55 by means of line 58 which connects trap-out tray 57 and line 55 in any desired proportion, or the lighter cut from trap-out tray 57 may constitute all of the cycle stock passed through line 55 to heater 1 by suitable manipulation of valves 59 and 60 located in lines 58 and 55, respectively.

The cycle stock introduced into the coil of heater 2 from line 35 ordinarily contains substantial proportions of gas-oil constituents from the vis-breaking of the reduced crude and will therefore be less refractory than the cycle stock introduced to heater 1 from line 55 which consists primarily of the more refractory uncracked constituents from the cracking of the cycle stock introduced to heater 2 through line 35. The cracking conditions applied in heater 2 may therefore be less drastic than those applied in heater 1.

A portion of the liquid residue separated in separator 5 and withdrawn through line 15 may be diverted therefrom through line 16 and flashed in tar flasher 17 to release therefrom as hot vapors the lighter constituents contained therein. The heavy residue resulting from the flashing of the tar collects in the bottom of tar flasher 17 and is withdrawn therefrom through line 22 for suitable use elsewhere. Any vapors undesired for condensation and incorporation in the fresh feed, for example, vapors consisting essentially of gasoline constituents pass overhead from tar flasher 17 through line 23 which is provided with a condenser 24. In condenser 24 gasoline constituents are liquefied, and the condensate is then introduced into receiver 25 wherein separation of incompressibles therefrom is effected, the gases being withdrawn through line 26 and the gasoline through line 27 for any suitable use or for further treatment.

According to the preferred method of operation of the invention a gas oil which may be a cycle stock having an end point of 650° to 750° F. is passed through line 55 for introduction into the coil of heater 1. The cycle stock is preferably passed through a portion of the coil located in a relatively hot portion of the furnace housing the coil, and is there heated, at a pressure of 200 to 1000 pounds per square inch, to a temperature of 900° to 1100° F. for a time sufficient to effect substantial cracking and conversion of 20 to 40% to gasoline constituents. Fresh feed stock, which may be a reduced crude having a gravity of 20° to 26° A. P. I., is introduced to the system through line 11 and into the coil of heater 1 at one or more intermediate points thereof after being preheated if desired. The introduction of the reduced crude at an intermediate

point or points of the coil of heater 1 is arranged to permit the previous substantial cracking of the cycle stock before such introduction.

The temperature and quantity of reduced crude introduced into the coil of heater 1 and the degree of heating applied to that portion of the coil through which the merged products pass is controlled whereby the merged products are heated to a temperature of 800° to 925° F., preferably 850° to 875° F., at a pressure equal to or lower than that under which the cycle stock is preliminarily cracked. The rate of passage of the merged products through the furnace is controlled to effect a mild cracking of the reduced crude whereby there is effected a 15 to 30% conversion thereof into constituents boiling below the boiling range of the original reduced crude, of which conversion products approximately half are in the gasoline boiling range.

The conversion products from heater 1 are withdrawn therefrom through line 61 and introduced into separator 3 preferably with a reduction in pressure by means of valve 62. Separator 3 is operated to effect passage overhead as vapors of all constituents suitable or desired as cycle stock. For example, all constituents boiling below 650° to 750° F. may be passed overhead as vapors. For example, the separator 3 may be operated at a pressure of 25 to 100 pounds per square inch.

The vapors separated in separator 3 pass overhead therefrom through line 28 and are introduced into the lower portion of fractionator 4 with or without a reduction in pressure by means of valve 63 in line 28, if desired.

Fractionator 4 is maintained under conditions of temperature and pressure to effect the passage overhead as vapors of all constituents suitable for use as gasoline. Or a light naphtha distillate may be separated overhead, and the heavier portion of the naphtha fraction may be recovered as cycle stock. For example, the fractionator 4 may be operated at a pressure of from atmospheric to 100 pounds per square inch with a top temperature of 400° to 450° F.

The cycle stock recovered as condensate in fractionator 4 may be withdrawn therefrom and passed to heater 2 as primary fresh charge therefor through line 35. The cycle stock withdrawn from tower 4 may consist of material collected in trap-out tray 37 or in the bottom of tower 4, or both, in any desired proportion. In heater 2 the cycle stock is passed through a portion of the coil located in a relatively hot portion of the furnace for a time sufficient to effect substantial cracking of the cycle stock. For example, it may be heated at a pressure of 200 to 600 pounds per square inch to a temperature of 900° to 1050° F. to effect a conversion of 20 to 40% thereof to gasoline constituents. Liquid residue withdrawn from the lower portion of separator 3 through lines 41 and 42 may then be introduced into the coil of heater 2 at a point or points subsequent to the carrying out of the above-mentioned cracking of the cycle stock. The liquid residue may be preheated or precooled as desired but its temperature, the proportion thereof introduced, and the degree of heating of that portion of the coil through which the merged products pass are controlled to effect cracking of the liquid residue to lighter products with or without further cracking of the cycle stock. For example, the merged products may be maintained at a temperature of 825° to 925° F., preferably 900° to 925° F., at or below the pressure obtaining during the prelim-

inary separate cracking of the cycle stock. The rate of passage of the merged products through the coil is controlled to effect 15 to 30% conversion of the liquid residue into constituents boiling below the boiling range of the said liquid residue of which approximately half may be gasoline constituents.

The conversion products from heater 2 are withdrawn therefrom through line 44 and introduced into separator 5 preferably after a reduction in pressure by means of valve 45. In separator 5 the passage overhead as vapors of substantially all constituents desired or suitable for use as a cycle stock is effected. For example, vaporization may be controlled to effect separation into vapors of constituents boiling at 650° to 750° F. and below. The uncondensed vapors are passed overhead from separator 5 through line 46 and introduced into the lower portion of fractionator 6 with any reduction in pressure being effected by means of valve 64 in line 46.

The fractionator 6 is operated under conditions of temperature and pressure to effect the separation overhead as vapors of constituents desired for use as gasoline. Alternatively, if desired, the heavier portion of the naphtha fraction may be retained as condensate to form part of the cycle stock collected in fractionator 6. This cycle stock may consist of material collected in trap-out tray 57 or condensate collected in the bottom of fractionator 6 or both in any desired proportion. The cycle stock thus recovered is passed through line 55 for processing in heater 1 in the manner described above.

Vapors uncondensed in fractionators 4 and 6 are passed overhead through lines 30 and 48, respectively, with any desired reduction in pressure being accomplished by means of valves 65 and 66 in lines 30 and 48, respectively. The vapors then pass through condensers 7 and 8, respectively, wherein gasoline constituents are liquefied. The resulting mixtures are passed respectively to distillate receivers 9 and 10 wherein separation of gases and liquid is effected. The liquids constituting the gasoline product of the process are withdrawn from receivers 9 and 10 through lines 32 and 50, respectively, and may be suitably blended in line 51 or separately collected as desired. The gases separated in receivers 9 and 10 are withdrawn therefrom and from the system through lines 31 and 49, respectively.

The fresh feed to the system consisting preferably of reduced crude or a similar product introduced through line 11 may be preheated in any desired manner prior to introduction into intermediate point or points of the coil of heater 1. For example, all or a portion thereof may be diverted from line 11 through line 13 and passed through preheater 12 whereby the reduced crude is preheated to the desired degree, for example, to 500° F.

Or if desired all or a portion of the reduced crude may be diverted from line 11 through line 18 for direct contact with hot vapors flashed from the liquid residue collected in the bottom of separator 5. This liquid residue is withdrawn from separator 5 through line 15. All or a portion thereof may be diverted from line 15 through line 16 with a suitable reduction in pressure being effected by means of valve 67 located in line 16. The flashed residue is introduced into the bottom of tar flasher 17 to effect separation of vapors and residue. The residue collects in the bottom of tar flasher 17 and is withdrawn therefrom through line 22. The vapors pass upwardly

through tar flasher 17 past the trap-out tray 19 and into intimate contact with the descending reduced crude introduced through line 18 whereby the reduced crude is preheated with the condensation and absorption by the reduced crude of any desired portion of the constituents of the vapors desired for further treatment. The uncondensed vapors pass overhead through line 23 and into condenser 24 wherein condensation of normally liquid constituents is effected. The mixture then passes to collector 25 wherein separation of liquids into gases is effected, the gases being withdrawn therefrom through line 26 and the liquids through line 27.

The preheated reduced crude is withdrawn from trap-out tray 19 through line 20 for reintroduction to line 11 and passage to heater 1.

Both methods of preheating the fresh charge may be employed simultaneously, or one or the other may be employed, or any other desired method such as heat exchange by indirect contact with hot products from any part of the system may be used.

The invention thus provides a method for the efficient production of gasoline of high anti-knock value from a charging stock of relatively great coke-forming tendency with the minimum production of gas and coke and with the minimum amount of processing and equipment necessary.

These and other advantages are evident from the foregoing description in which the invention is illustrated by reference to certain specific embodiments. It is to be understood, however, that the invention is not limited by such reference but is capable of other embodiments.

I claim:

1. A method of treating hydrocarbon oil to form low boiling hydrocarbons suitable for motor fuel which comprises passing a stream of relatively light clean hydrocarbon oil formed as hereinafter specified through an elongated heating zone of restricted cross section and applying heat thereto under cracking conditions of temperature and pressure to effect cracking and conversion into lighter products, introducing a stream of residual hydrocarbon oil into said heating zone intermediate the ends thereof and into intimate mixture with said light oil passing there-through after said light oil has passed through a substantial portion of said heating zone and substantial cracking thereof has been effected whereby said residual hydrocarbon oil is maintained under cracking conditions to effect conversion into lighter products in the presence of said light oil during the passage of the merged products through the remainder of said heating zone, passing the resultant cracked products into a separating zone wherein separation of vapors from liquid residue takes place, passing the separated vapors into a fractionating zone wherein the vapors are fractionated to form a condensate and a desired distillate, passing said condensate in a stream through a separate elongated heating zone of restricted cross section and applying heat thereto under cracking conditions of temperature and pressure to effect cracking and conversion into lighter products, introducing resultant liquid residue into said separate heating zone intermediate the ends thereof and into intimate mixture with said condensate passing therethrough after said condensate has passed through a substantial portion of said heating zone and substantial cracking thereof has been effected whereby the liquid residue is maintained under cracking conditions to effect conversion

thereof to lighter products in the presence of said condensate during the passage of the merged products through the remainder of said separate heating zone, passing the resultant cracked products into a second separating zone wherein separation of vapors from residue takes place, introducing the separated vapors into a second fractionating zone wherein the vapors are fractionated to form a heavy reflux condensate, a lighter reflux condensate and a desired distillate and directing said lighter reflux condensate to the first-mentioned heating zone as said relatively light clean hydrocarbon oil.

2. A method of treating hydrocarbon oil to form low boiling hydrocarbons suitable for motor fuel which comprises passing a stream of relatively light clean hydrocarbon oil formed as hereinafter specified through an elongated heating zone of restricted cross section and applying heat thereto under cracking conditions of temperature and pressure to effect cracking and conversion into lighter products, introducing a stream of residual hydrocarbon oil into said heating zone intermediate the ends thereof and into intimate mixture with said light oil passing therethrough after said light oil has passed through a substantial portion of said heating zone and substantial cracking thereof has been effected whereby said residual hydrocarbon oil is maintained under cracking conditions to effect conversion into lighter products in the presence of said light oil during the passage of the merged products through the remainder of said heating zone, passing the resultant cracked products into a separating zone wherein separation of vapors from liquid residue takes place, passing the separated vapors into a fractionating zone wherein the vapors are fractionated to form a conden-

sate and a desired distillate, passing said condensate in a stream through a separate elongated heating zone of restricted cross section and applying heat thereto under cracking conditions of temperature and pressure to effect cracking and conversion into lighter products, introducing resultant liquid residue into said separate heating zone intermediate the ends thereof and into intimate mixture with said condensate passing therethrough after said condensate has passed through a substantial portion of said heating zone and substantial cracking thereof has been effected whereby the liquid residue is maintained under cracking conditions to effect conversion thereof to lighter products in the presence of said condensate during the passage of the merged products through the remainder of said separate heating zone, passing the resultant cracked products into a second separating zone maintained under superatmospheric pressure wherein separation of vapors from liquid residue takes place, introducing the separated vapors into a fractionating zone wherein the vapors are fractionated to form a heavy reflux condensate, a lighter reflux condensate and a desired distillate, directing said lighter reflux condensate into the first-mentioned heating zone as said relatively light clean hydrocarbon oil, directing liquid residue from the second separating zone into a flashing zone wherein the pressure is reduced and separation of vapors from residue takes place and directing a stream of residual hydrocarbon oil into contact with said hot vapors to preheat the residual oil and introducing the resultant preheated residual oil into the first-mentioned heating zone as said residual hydrocarbon oil.

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