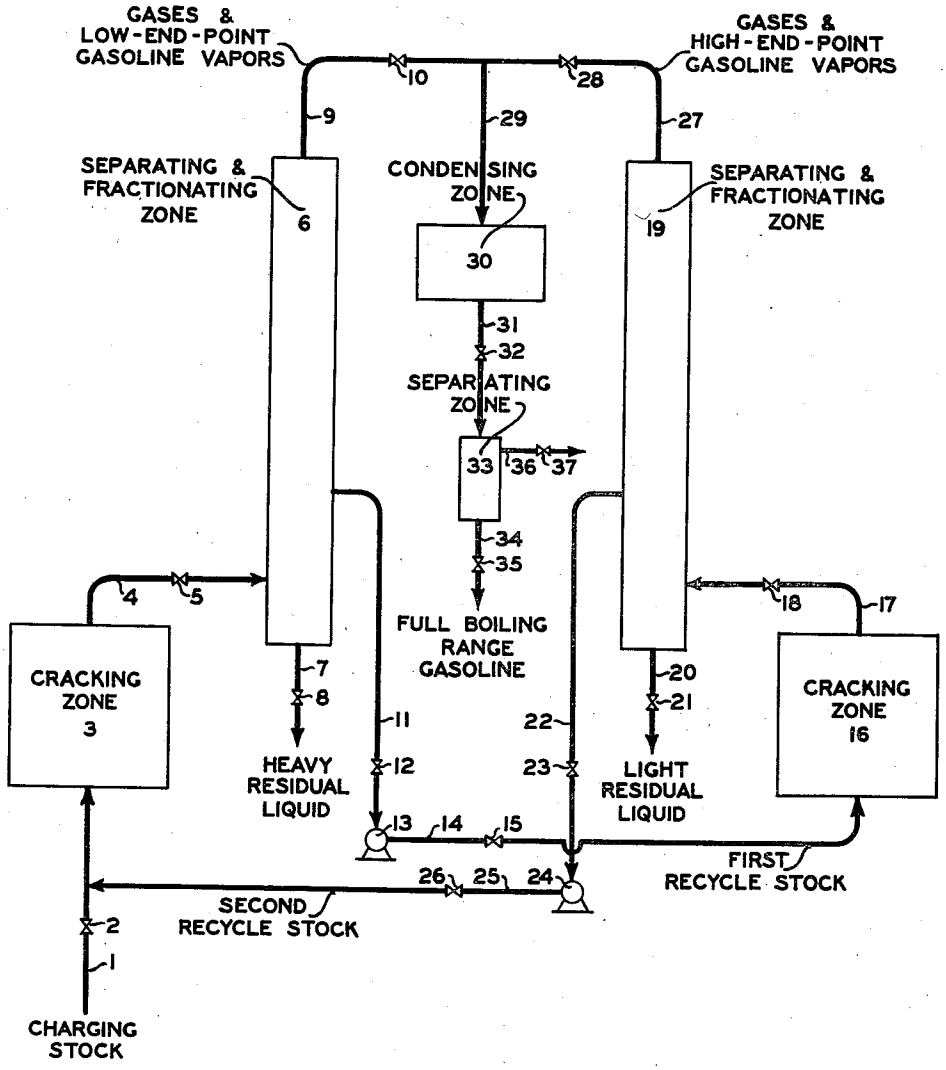
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CONVERSION OF HYDROCARBON OILS

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CONVERSION OF HYDROCARBON OILS

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The invention relates specifically to an improved process of cracking hydrocarbon oils to produce therefrom high yields of good antiknock gasoline and residual liquids of the desired characteristics.

One specific embodiment of the invention comprises cracking virgin hydrocarbon oil charging stock for the process, separating the resulting conversion products into vapors and heavy liquid residue, fractionating the vapors to recover therefrom gasoline of low end-boiling point and to condense their higher boiling components as reflux condensate, separately cracking said reflux condensate under independently controlled more severe cracking conditions than those to which said charging oil is subjected, separating the resulting products into vapors and a residual liquid substantially lighter than that separated from the first mentioned conversion products, fractionating the last named vapors separate from those aforementioned to recover therefrom gasoline of substantially higher end-boiling point than that recovered from the first named vapors and to condense their higher boiling components as reflux condensate, supplying the last named reflux condensate to the first mentioned cracking step for further cracking treatment therein in commingled state with the charging oil and commingling said low end-point and high end-point gasolines to form the final, full boiling range gasoline product of the process.

The process herein provided has several advantages over conventional selective cracking operations of the type in which virgin charging oil and reflux condensate or recycle stock recovered from vaporous products of the raw oil cracking operation are separately cracked under independently controlled conditions. The residual liquid fractions normally obtainable by the cracking of relatively heavy virgin oils, such as topped or reduced crude, fuel oil and the like, contain substantial quantities of relatively low-boiling fractions which are susceptible to further cracking to produce substantial additional yields of gasoline. In the present invention, the heavy residual liquid recovered from the products of the cracking operation to which the charging oil is supplied are substantially devoid of such desirable light fractions, the latter being stripped therefrom by flash distillation and included in the recycle stock supplied to the other cracking step of the system wherein they are converted into additional yields of gasoline. A lighter liquid residue is recovered from the products of the second mentioned cracking step. Since the products formed in this cracking operation are of a more highly aromatic nature than those formed by cracking of the charging oil, the relatively light components of this residual product would produce much smaller yields of gasoline and higher yields of coke and gas upon further cracking and are, therefore, not desirable as components of the recycle stock.

Due to the less aromatic nature of the products resulting from cracking of the charging oil, as compared with those resulting from cracking the recycle stock recovered from the products of the cracking operation to which the charging oil is supplied, the gasoline formed by cracking of the charging oil is of lower antiknock value than that formed by separate cracking of said recycle stock and, in the present invention, to improve the antiknock value of the final gasoline product, relatively heavy gasoline fractions of the products of the first mentioned cracking operation are included in the recycle stock recovered therefrom and supplied to the second mentioned cracking operation wherein they are further cracked or reformed to improve their antiknock value, fractionation of the vaporous products of the two cracking operations being accomplished in separate zones and regulated to produce fractionated vapors containing higher end-point gasoline from the vaporous products of the second mentioned cracking operation, as compared with the gasoline included in the fractionated vapors of the first mentioned cracking operation, and the two gasoline products are blended to form the final full boiling range gasoline product of the process.

Reflux condensate or recycle stock condensed from the vaporous products of the second mentioned cracking operation is of narrower boiling range than that condensed from the vaporous products of the first mentioned cracking step and by returning this material, as herein provided, to the initial cracking step, wherein it is further cracked in commingled state with the charging oil, a two-fold advantage is obtained. First, the material serves as a diluent for the heavier charging stock and permits the use of more severe cracking conditions in the initial cracking step than those to which the heavy charging stock alone could be advantageously subjected, whereby the gasoline resulting from this cracking operation is improved in antiknock value. Secondly, by this method of operation the conversion products of the initial cracking step will include a greater quantity of relatively

low-boiling vapors. This permits more extensive flash distillation of these products, whereby to form the desired relatively heavy residual product and include in the vapors subjected to fractionation and in the reflux condensate or recycle stock formed in this step relatively heavy fractions suitable for further cracking, which desirable heavy fractions could not be separated from the heavy residue by flash distillation if the heavy charging stock were cracked alone or in the absence of lighter fractions.

It will be apparent that the various features of the process, as above outlined, are mutually cooperative and interdependent. Although no novelty is claimed for any individual step of the process per se, invention is believed to reside in the novel and advantageous manner in which the various steps are herein cooperatively combined.

The accompanying drawing is essentially a flow diagram of the process provided by the invention and in conjunction with the following description will serve to further illustrate the method of operation contemplated by the invention.

Referring to the drawing, the virgin hydrocarbon oil charging stock, which preferably comprises heavy crude oil, reduced or topped crude, fuel oil or the like, is supplied through line 1 and valve 2 to cracking zone 3 which may be any suitable form of cracking equipment, such as, for example, an externally heated cracking coil or a cracking coil and reaction chamber connected in series. The charging oil is cracked in zone 3 in commingled state with lighter hydrocarbon oil supplied to this zone from within the system, as will be later described, under conditions of temperature, pressure and time regulated to produce high yields of gasoline from the commingled oils. The resulting conversion products are directed through line 4 and valve 5 to separating and fractionating zone 6.

Substantial superatmospheric pressure is employed in cracking zone 3 and this pressure is substantially reduced in zone 6 to accomplish extensive further vaporization or flash distillation of the liquid components of the conversion products supplied thereto. The vaporous conversion products, including those evolved by said flash distillation, are separated from the remaining heavy non-vaporous residue in zone 6 and the residual liquid is removed from the system to cooling and storage or elsewhere, as desired, through line 7 and valve 8. The vapors are fractionated in zone 6 to separate normally gaseous components and gasoline fractions of relatively low end-boiling point from their higher boiling components, which latter are condensed as reflux condensate or recycle stock for further cracking.

The low end-point gasoline vapors and gases are directed from zone 6 through line 9 and valve 10 to condensing and separating equipment, as will be later described, and the reflux condensate or recycle stock formed in zone 6 is directed therefrom through line 11 and valve 12 to pump 13 by means of which it is supplied through line 14 and valve 15 to further cracking treatment in cracking zone 16.

The relatively wide boiling range recycle oil supplied to zone 16 is subjected therein to independently controlled cracking conditions, preferably more severe than those employed in zone 3. Zone 16 may comprise any suitable form of cracking equipment and the conversion products formed therein are directed through line 17 and valve 18 to separating and fractionating zone 19 which is preferably operated at a substantially reduced pressure relative to that employed in zone 16 to effect flash distillation and further vaporization of the liquid components of the conversion products. However, less extensive flash distillation is accomplished in zone 19, as compared with that accomplished in zone 6 and the non-vaporous liquid residue removed from zone 19 through line 20 and valve 21 to cooling and storage or elsewhere, as desired, is of a lighter nature than that removed from zone 6.

The vaporous components of the conversion products supplied to zone 19 and the vapors evolved by flash distillation therein are fractionated to separate therefrom normally gaseous fractions and gasoline vapors of higher end-boiling point than those removed from zone 6 and to condense their higher boiling fractions as reflux condensate or recycle stock. The latter is directed from zone 19 through line 22 and valve 23 to pump 24 by means of which it is supplied through line 25 and valve 26 to further cracking treatment in zone 3 in commingled state with the virgin charging stock.

The gases and high end-point gasoline fractions, resulting from the fractionation afforded the vapors in zone 19, are directed therefrom through line 27 and valve 28 and commingle in line 29 with the gases and lower end-point gasoline vapors from zone 6, the commingled materials being directed to condensing zone 30 wherein they are cooled sufficiently to condense substantially all of their normally liquid fractions. The resulting distillate and uncondensed gases are directed through line 31 and valve 32 to collection and separation in zone 33 wherefrom said distillate, which comprises the full boiling range gasoline product of the process, is directed through line 34 and valve 35 to storage or to any desired further treatment. The gases which remain uncondensed and undissolved in the distillate recovered from zone 33 are directed therefrom through line 36 and valve 37 to storage or elsewhere, as desired.

The preferred range of operating conditions which may be employed in conducting the process of the invention are approximately as follows: The maximum temperature to which the charging stock is heated will vary depending upon its characteristics and may range, for example, from 800 to 950° F., or thereabouts, preferably with a superatmospheric pressure in this cracking zone of the order of 100 to 500 pounds, or more, per square inch. The maximum temperature to which the first recycled stock is heated in cracking zone 16 may range, for example, from 850 to 1000° F., or thereabouts, and preferably a superatmospheric pressure of the order of 150 to 800 pounds, or more, per square inch is employed in this zone. Separation of the products from each cracking zone into vapors and non-vaporous residue is accomplished at a substantially reduced pressure relative to that employed in the corresponding cracking zone and the residual liquid resulting from cracking of the charging oil and second recycle stock is subjected to more extensive flash distillation than that resulting from cracking of the first recycle stock, either by employing lower pressure or higher temperature, or both, in the separating zone to which the products of cracking zone 3 are supplied. The pressure employed in the frac-

tionating, condensing and collecting portions of the system may be substantially the same or somewhat lower than that employed in the preceding flash distilling zone employing the lowest pressure or, when desired, fractionation of the vaporous products of the two cracking steps may be accomplished at different pressures, in which case a pressure corresponding to or less than that employed in the fractionating zone utilizing the lowest pressure is employed in the condensing and collecting equipment, when the overhead vaporous streams from the two fractionating zones are commingled. It is, however, within the scope of the invention to separately condense the overhead distillate product of each fractionating step and subsequently blend the low end-point and high end-point gasolines produced in any desired proportion.

As an example of one specific operation of the process, the charging oil, which is a 25° A. P. I. gravity Mid-Continent topped crude, is subjected in zone 3, together with the recycle stock formed in zone 19 to a cracking temperature of approximately 920° F. at a superatmospheric pressure of about 200 pounds per square inch. The resulting vaporous and liquid conversion products are supplied to the vaporizing or flash distilling section of zone 6 which is operated at a superatmospheric pressure of approximately 30 pounds per square inch. This pressure is substantially equalized in the succeeding fractionating, condensing and collecting equipment. The total reflux condensate formed in zone 6 is subjected in zone 16 to a cracking temperature of approximately 960° F. at a superatmospheric pressure of about 350 pounds per square inch and the products from this step are cooled to a temperature of approximately 750° F. by commingling the same with precooled regulated quantities of the reflux condensate formed in zone 19 and the commingled materials are introduced into the vaporizing or flash distilling section of the latter zone which is operated at a superatmospheric pressure of approximately 100 pounds per square inch. The fractionating section of zone 19 is operated at substantially the same pressure and the pressure of the overhead vaporous stream therefrom is reduced to approximately 30 pounds per square inch before being commingled with the overhead vaporous stream from zone 6.

The residual liquid recovered from the products resulting from cracking of the charging oil and second recycle stock has a gravity of approximately 3.7° A. P. I., a viscosity of approximately 800 S. F. S. at 122° F. and amounts to approximately 26% by volume of the charging oil. The residual liquid recovered from the products resulting from cracking of the first recycle stock has a gravity of approximately 5° A. P. I., a viscosity of approximately 30 S. F. S. at 122° F. and amounts to approximately 9% by volume of the charging oil. The end-boiling point of the gasoline recovered from the fractionating step of the initial cracking operation is approximately 250° F. and that recovered from the fractionated vapors of the cracking operation to which the first recycle stock is supplied has an end-boiling point of approximately 400° F. The blended gasoline product amounts to approximately 55% by volume of the charging oil and has an octane number of approximately 70–72 as determined by the motor method.

I claim as my invention:

1. The process of cracking hydrocarbon oils, which comprises cracking a virgin residual oil charging stock under sufficient superatmospheric pressure to maintain a substantial portion thereof in liquid phase, separating the resulting products at a substantially reduced pressure into vapors and heavy residual liquid and recovering the latter, fractionating the vapors to separate therefrom normally gaseous fractions and good antiknock gasoline of relatively low end-boiling point and to condense their higher boiling components as reflux condensate, separately cracking said reflux condensate under conditions regulated to improve the antiknock value of the relatively high-boiling gasoline fractions included therein and to convert its higher boiling components into substantial additional yields of good antiknock gasoline, separating the resulting vaporous and liquid products under a pressure substantially higher than said reduced pressure whereby to produce a substantially lighter residual liquid than that recovered from the products of the initial cracking step, fractionating the last named vapors to separate therefrom normally gaseous fractions and gasoline of substantially higher end-boiling point than that included in the fractionated vapors of the initial cracking step, subjecting the fractionated vapors of both cracking operations to condensation to form said low end-point and said high end-point gasolines, and blending the latter in regulated proportions to form the final full boiling range gasoline product of the process.

2. The process of cracking hydrocarbon oils, which comprises cracking a virgin residual oil charging stock under sufficient superatmospheric pressure to maintain a substantial portion thereof in liquid phase, separating the resulting products at a substantially reduced pressure into vapors and heavy residual liquid and recovering the latter, fractionating the vapors to separate therefrom normally gaseous fractions and good antiknock gasoline of relatively low end-boiling point and to condense their higher boiling components as reflux condensate, separately cracking said reflux condensate under conditions regulated to improve the antiknock value of the relatively high-boiling gasoline fractions included therein and to convert its higher boiling components into substantial additional yields of good antiknock gasoline, separating the resulting vaporous and liquid products under a pressure substantially higher than said reduced pressure whereby to produce a substantially lighter residual liquid than that recovered from the products of the initial cracking step, fractionating the last named vapors to separate therefrom normally gaseous fractions and gasoline of substantially higher end-boiling point than that included in the fractionated vapors of the initial cracking step, and to condense their higher boiling fractions as reflux condensate, subjecting the fractionated vapors of both cracking operations to condensation to form said low end-point and said high end-point gasolines, blending the latter in regulated proportions to form the final full boiling range gasoline product of the process, and further cracking the last mentioned reflux condensate in the initial cracking step with said charging stock.

3. The process of cracking hydrocarbon oils, which comprises cracking a virgin residual oil charging stock under sufficient superatmospheric pressure to maintain a substantial portion thereof in liquid phase, separating the resulting products at a substantially reduced pressure into va-

pors and heavy residual liquid and recovering the latter, fractionating the vapors to separate therefrom normally gaseous fractions and good antiknock gasoline of relatively low end-boiling point and to condense their higher boiling components as reflux condensate, separately cracking said reflux condensate under conditions regulated to improve the antiknock value of the relatively high-boiling gasoline fractions included therein and to convert its higher boiling components into substantial additional yields of good antiknock gasoline, separating the resulting vaporous and liquid products under a pressure substantially higher than said reduced pressure whereby to produce a substantially lighter residual liquid than that recovered from the products of the initial cracking step, fractionating the last named vapors to separate therefrom normally gaseous fractions and gasoline of substantially higher end-boiling point than that included in the fractionated vapors of the initial cracking step and to condense their higher boiling fractions as reflux condensate, and subjecting the fractionated vapors of both cracking steps to condensation in commingled state to form the final full boiling range gasoline product of the process.

4. The process of cracking hydrocarbon oils, which comprises cracking a virgin residual oil charging stock under sufficient superatmospheric pressure to maintain a substantial portion thereof in liquid phase, separating the resulting products at a substantially reduced pressure into vapors and heavy residual liquid and recovering the latter, fractionating the vapors to separate therefrom normally gaseous fractions and good antiknock gasoline of relatively low end-boiling point and to condense their higher boiling components as reflux condensate, separately cracking said reflux condensate under conditions regulated to improve the antiknock value of the relatively high-boiling gasoline fractions included therein and to convert its higher boiling components into substantial additional yields of good antiknock gasoline, separating the resulting vaporous and liquid products under a pressure substantially higher than said reduced pressure whereby to produce a substantially lighter residual liquid than that recovered from the products of the initial cracking step, fractionating the last named vapors to separate therefrom normally gaseous fractions and gasoline of substantially higher end-boiling point than that included in the fractionated vapors of the initial cracking step and to condense their higher boiling fractions as reflux condensate, subjecting the fractionated vapors of both cracking steps to condensation in commingled state to form the final full boiling range gasoline product of the process and further cracking the last mentioned reflux condensate in the initial cracking step with said charging stock.

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