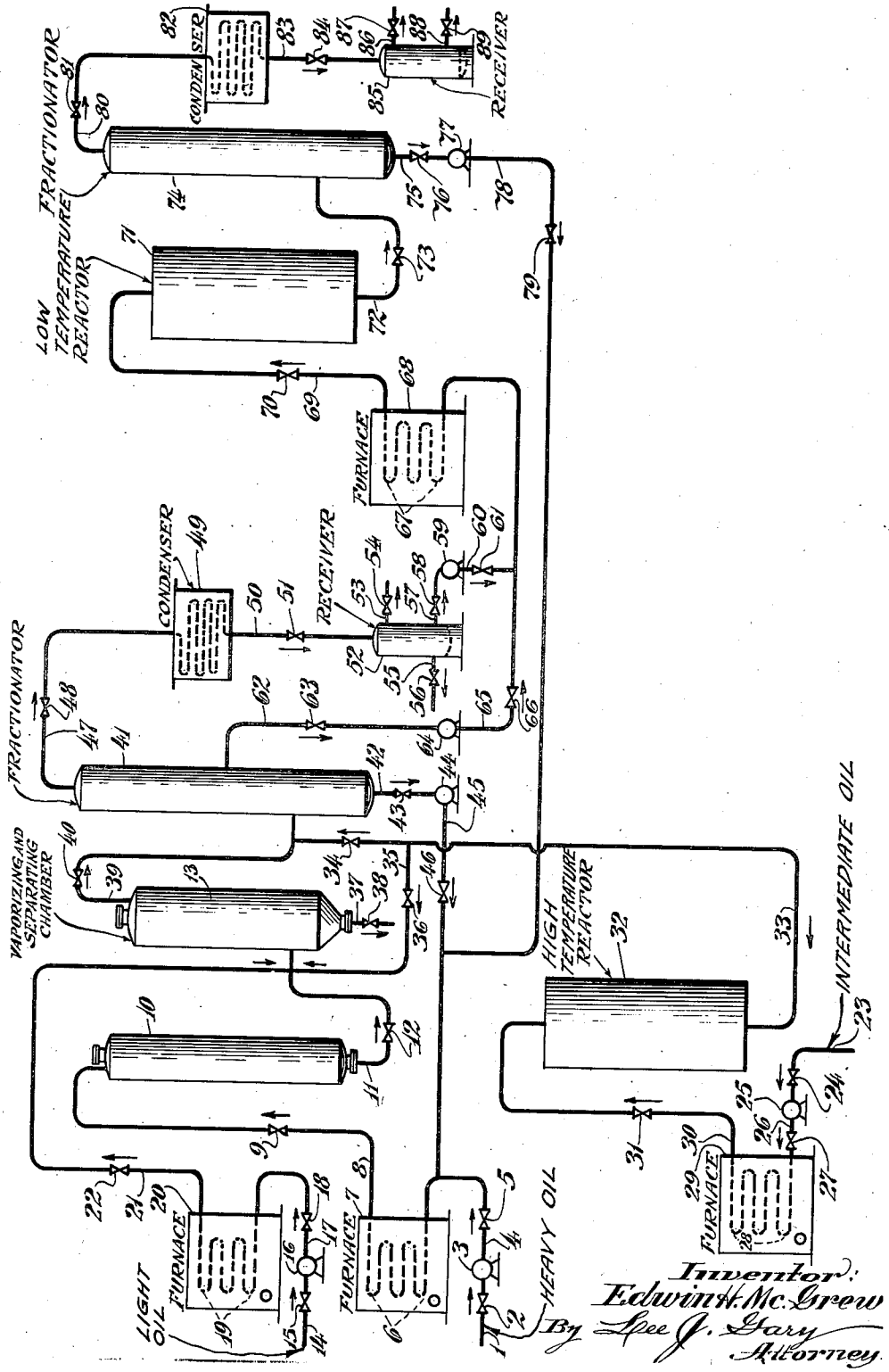
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HYDROCARBON CONVERSION

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HYDROCARBON CONVERSION

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5 Claims. (Cl. 196—49)

This invention relates to the production of a motor gasoline of relatively low olefin content, high octane rating, and relatively low potential gum content, which due to its relatively high degree of saturation is useful as aviation gasoline. Specifically, the invention is concerned with a process for converting hydrocarbon oils into the desired product by a novel combination of steps wherein said hydrocarbon oils are treated under optimum conditions for each specific fraction thereof.

The invention involves principally thermal cracking treatment of a combined feed, comprising essentially a relatively heavy hydrocarbon oil, such as, for example, reduced or topped crude and reflux condensate, thermal reforming treatment of a relatively light hydrocarbon oil, such as, for example, gasoline, naphtha, or kerosene, high temperature catalytic cracking treatment of an intermediate oil, such as, for example, kerosene or gas oil, common fractionation of the conversion products from the thermal cracking and reforming treatments, and the high temperature catalytic cracking treatment and low temperature catalytic conversion treatment of the distillate and light reflux condensate formed and separated therein.

The term "thermal cracking treatment" as used throughout the specification and claims refers to the conversion of heavy hydrocarbons into lighter hydrocarbons by heat and pressure, and in all instances involves the scission of carbon to carbon bonds. The term "thermal reforming treatment" on the other hand, refers to the treatment of relatively light hydrocarbons to improve their octane rating and may involve the scission of carbon to carbon bonds, the scission of carbon to hydrogen bonds, cyclization and many other reactions of lesser importance. The term "high temperature catalytic cracking treatment" refers to the treatment of hydrocarbon oils in the presence of catalytically active masses at temperatures ranging, for example, from 800 to 1200° F. and at pressures varying from substantially atmospheric to 200 pounds or more per square inch to effect substantial conversion to gasoline boiling range hydrocarbons, and ordinarily involves the scission of carbon to carbon bonds, although other reactions such as cyclization and the scission of carbon to hydrogen bonds may also take place. The term "low temperature catalytic conversion treatment" refers to the treatment of hydrocarbons at relatively low temperatures ranging, for example, from 500 to 900° F. and at pressures ranging from substantially atmospheric to 200 pounds or more per square inch in the presence of a catalyst of essentially the same composition as that employed in the high temperature catalytic cracking treatment and the reaction is essentially that of hydrogen transfer.

It has been found that when mixtures of olefin-containing gasolines produced by either non-catalytic or catalytic methods and a relatively heavy hydrocarbon oil, such as intermediate conversion products from a non-catalytic cracking treatment or from a once-through catalytic cracking treatment, are subjected to contact with a catalyst essentially the same composition as that employed in the catalytic cracking treatment but at lower space velocities and lower temperatures, a substantially saturated gasoline product is obtained. Whereas, in high temperature catalytic cracking treatments temperatures of the order of 800 to 1200° F. are employed with pressures of from substantially atmospheric to 200 pounds or more per square inch with space velocities of from 2 to 6 volumes of hydrocarbon material per volume of catalyst per hour, in the low temperature treatment temperatures of the order of 500 to 900° F. are employed with pressures of from substantially atmospheric to 200 pounds or more per square inch and with space velocities of from .5 to 2.

The hydrogen content of the intermediate conversion products from a non-catalytic cracking treatment is ordinarily high as compared to that of the intermediate conversion products from a catalytic cracking treatment when recycle operation is employed in both cases, and therefore the intermediate conversion products from the non-catalytic cracking treatment are preferred as the hydrogen donor. On the other hand, the hydrogen content of the intermediate conversion products formed in a once-through catalytic cracking treatment is also high, and this material may be employed as the hydrogen donor in the low temperature catalytic conversion treatment.

The reaction involved in low temperature catalytic conversion is essentially one of transferring hydrogen from the heavier hydrocarbons to the lighter olefinic hydrocarbons to convert the latter to paraffinic hydrocarbons, although cracking, cyclization, and isomerization reactions may also be involved. It is believed that in low temperature catalytic conversion treatment saturated hydrocarbons and particularly the naphthenic hydrocarbons of the recycle oil act as hydrogen donors for the olefinic hydrocarbons of

the gasoline, while the olefinic hydrocarbons become saturated to form paraffinic hydrocarbons and the naphthenic hydrocarbons are converted to aromatic hydrocarbons. Various other reactions, such as, for example, dehydrogenation and cyclization of an aliphatic hydrocarbon to form an aromatic hydrocarbon with the formation of two or three molecules of hydrogen which attach to the unsaturated olefinic hydrocarbons may also take place. However, since the invention is concerned primarily with a process in which the various reactions may be conducted, further discussion with regard to the chemical reactions which may possibly be involved is unnecessary for a full understanding of the invention which is to be described later in more detail.

In one specific embodiment the invention comprises subjecting combined feed comprising heavy reflux condensate, formed as hereinafter described, and a relatively heavy hydrocarbon oil to thermal cracking treatment in a heating coil and communicating reaction chamber, concurrently therewith subjecting a relatively light hydrocarbon oil to thermal reforming treatment, simultaneously in another step subjecting an intermediate oil to high-temperature catalytic cracking treatment in a heating coil and communicating high temperature catalytic reactor, commingling the conversion products from the three treatments and introducing the mixture to a vaporizing and separating chamber to separate a non-vaporous liquid residue from the vaporous conversion products, recovering the former, fractionating said vaporous conversion products to form light and heavy reflux condensate and to separate fractionated vapors boiling in the range of gasoline, subjecting the heavy reflux condensate to thermal cracking treatment, as previously described, cooling and condensing said fractionated vapors, separating the resulting distillate and gas and recovering the latter, commingling said distillate with the light reflux condensate, heating the mixture and subjecting the heated oil to contact with a cracking catalyst in the low temperature catalytic reactor, fractionating the conversion products from said low temperature catalytic reactor to form reflux condensate and to separate vapors boiling in the range of gasoline, subjecting said reflux condensate to thermal cracking treatment in commingled state with said heavy reflux condensate, formed as previously described, cooling and condensing said vapors and recovering the resulting distillate and gas as products of the process.

The accompanying diagrammatic drawing shows in conventional side elevation one specific form of the apparatus in which the object of the invention may be accomplished. It is to be understood, however, that the invention is not limited to the use of the specific form of apparatus herein shown and that various departures may be made therefrom without deviating from the spirit of the invention.

Referring now to the drawing, a relatively heavy hydrocarbon oil, such as, for example, a topped or reduced crude oil is introduced through line 1 and valve 2 to pump 3, which discharges through line 4 and valve 5, said heavy oil commingling with heavy reflux condensate, formed as hereinafter described, and the combined feed introduced to heating coil 6. The oil in passing through heating coil 6 is raised to the desired cracking temperature which may range, for example, from 850 to 1000° F. and is maintained at this temperature for a sufficient period of time to effect substantial thermal cracking thereof, heat being supplied from furnace 7. The hot conversion products leaving heating coil 6 at a superatmospheric pressure ranging, for example, from 200 to 600 pounds or more per square inch, are directed through line 8 and valve 9 into reaction chamber 10 wherein they are subjected to prolonged conversion at the cracking temperature. Reaction chamber 10 is preferably operated at a superatmospheric pressure substantially the same as that employed on the outlet of heating coil 6 and is preferable insulated to reduce radiation losses therefrom, although no insulation is shown in the drawing. The vaporous and liquid conversion products leaving chamber 10 are directed through line 11 and valve 12 into vaporizing and separating chamber 13 for treatment as hereinafter described.

In addition to the thermal cracking treatment of a heavy hydrocarbon oil, the invention also proposes to thermally reform a relatively light hydrocarbon oil, such as gasoline, naphtha, or kerosene, or any mixture thereof, and to catalytically crack an intermediate oil at relatively high temperatures to produce more valuable products than either of the two last mentioned charging stocks. The use of either of these operations is optional and may depend upon the amount of high octane substantially saturated motor fuel desired, which may vary for each specific case. In accordance with the objects of the invention, however, since both thermal reforming and high temperature catalytic cracking yield a gasoline product rich in olefinic hydrocarbons and since the objective in all cases is to treat each hydrocarbon oil under the optimum conditions for the production of motor fuel, such operations may be conveniently employed in combination with a thermal cracking treatment and the gasolines produced in all cases subjected to low temperature catalytic conversion treatment to produce a substantially saturated motor fuel.

Thermal reforming treatment, in the case here illustrated, may be accomplished by introducing a relatively light hydrocarbon oil, such as, for example, gasoline, naphtha, or kerosene, or any mixture thereof, through line 14 and valve 15 to pump 16, which discharges through line 17 and valve 18 into heating coil 19. The oil in passing through heating coil 19 is subjected to thermal reforming treatment at a temperature ranging, for example, from 950 to 1050° F. by means of heat supplied from furnace 20. The conversion products leaving heating coil 19 at a pressure ranging, for example, from 500 to 1200 pounds per square inch are directed through line 21 and valve 22 into line 11 where they commingle with the vaporous and liquid conversion products from reaction chamber 10.

The high temperature catalytic cracking treatment may be accomplished by introducing an intermediate oil, such as kerosene, or gas-oil, or any mixture thereof, through line 23 and valve 24 to pump 25, which discharges through line 26 and valve 27 into heating coil 28. The oil in passing through heating coil 28 is substantially completely vaporized and raised to the desired temperature, which may range, for example, from 800 to 1200° F. without substantial pyrolytic cracking thereof by means of heat supplied from furnace 29. The heated vapors leaving heating coil 28 at a pressure ranging, for example, from substantially atmospheric to 200 pounds or more per square inch are directed through line 30 and

valve 31 into reactor 32 wherein the vapors are subjected to contact with a cracking catalyst disposed therein while maintaining the hydrocarbon vapors at substantially the same temperature as that employed on the outlet of the heating coil by means of heat supplied from an external source.

The preferred cracking catalysts for use in the present process consists in general of a precipitated alumina hydrogel and/or zirconia hydrogel composited with silica hydrogel, the gel composite being washed, dried, formed into particles and calcined to produce a catalytic mass. It is not intended, however, that the process should be limited to these particular catalysts, for other catalysts, such as, for example, the hydrosilicates of alumina, acid treated clays, and the like, may be used within the broad scope of the invention.

In the following specification and claims the terms silica, alumina, silica-zirconia, and silica-alumina-zirconia masses are used in the broad sense to designate the synthetic composites referred to above. The preferred catalysts may be prepared by precipitating silica from a solution as a hydrogel within or upon which the alumina and/or zirconia are deposited also by precipitation as hydrogels. The silica hydrogel may conveniently be prepared by acidifying an aqueous solution of sodium silicate by the addition of a required amount of hydrochloric acid. After precipitating, the silica gel is preferably washed until substantially free from alkali metal salts. The washed silica hydrogel is then suspended in a solution of alumina and/or zirconium salts and an alkaline precipitant, such as ammonium hydroxide, ammonium carbonate or ammonium sulfide added to the solution to precipitate aluminum and/or zirconium hydrogels. The final precipitate, comprising essentially hydrated silica and hydrated alumina and/or zirconia, is washed to substantially completely remove water soluble materials and dried at about 300° F. to produce a rather crumbly and granular material which may be ground and pelleted or sized to produce particles of catalyst after which the catalyst particles are calcined at a temperature in the approximate range of 1000 to 1500° F. Various other procedures, such as, for example, co-precipitation of the hydrated gels may be employed, when desired, to produce the preferred catalyst.

Reactor 32 is preferably of the type which employs a plurality of relatively small diameter reactor tubes containing the desired catalyst, the tubes being confined within an enclosed zone to which heat from an external source may be supplied for the purpose of maintaining the reactants at the desired temperature during the conversion reaction. In addition, since relatively short periods of operation are employed in catalytic cracking because of the rather rapid deposition of carbon upon the surface and within the pores of the catalyst particles which necessitates frequent reactivation, it is preferred that a plurality of reactors be employed, although only one is shown in the drawing, in order that one or more may be segregated and the catalysts disposed therein subjected to reactivation while conversion of the hydrocarbon vapors is being accomplished in the other or others. Suitable means, not shown, may be employed for reactivating the catalyst disposed within the various reactors during the period those particular reactors are segregated from the balance for the purpose of reactivation.

Although the reactor described above constitutes the preferred type of reactor, it is not intended that the invention should be limited in this respect, for various other types of reactors, known to those in the art, may be substituted therefor without departing from the broad scope of the invention.

The conversion products leave reactor 32 by way of line 33 and a portion or all are directed through valve 34 and commingled with the vaporous conversion products from vaporizing and separating chamber 13 in line 39. Preferably, however, the conversion products in line 33 are directed through line 35 and valve 36 and commingled with the vaporous and liquid conversion products from reaction chamber 10 and the conversion products from heating coil 19 in line 11 for treatment as hereinafter described.

Vaporizing and separating chamber 13 is preferably operated at a reduced pressure relative to that employed in either of the three conversion treatments or at substantially the same pressure as that employed in the high temperature catalytic cracking treatment in reactor 32 when low pressures are employed therein, and it may range, for example, from 25 to 250 pounds or more per square inch. The liquid conversion products introduced in commingled state with the vaporous conversion products in chamber 13 are subjected to substantial further vaporization therein to form a non-vaporous liquid residue which is withdrawn from chamber 13 by way of line 37 and valve 38, cooled and subjected to any desired further treatment.

The vaporous conversion products separated in chamber 13, together with the vapors evolved therein, are directed through line 39 and valve 40 into fractionator 41, which is preferably maintained at a superatmospheric pressure of the same order as that employed in chamber 13. The vapors introduced to fractionator 41 are subjected to fractionation therein to form light and heavy reflux condensate and to separate fractionated vapors which may comprise gasoline boiling range hydrocarbons or may, when desired, include hydrocarbons boiling above the range of gasoline. The heavy reflux condensate is directed through line 42 and valve 43 to pump 44, which discharges through line 45 and valve 46 into line 4 where said heavy reflux condensate commingles with the heavy oil to form combined feed and said combined feed thereafter subjected to thermal cracking treatment, as previously described.

Fractionated vapors separated in fractionator 41 are directed from the upper portion thereof through line 47 and valve 48 to cooling and condensation in condenser 49. The distillate in condenser 49, together with undissolved and uncondensed gases, is directed through line 50 and valve 51 into receiver 52 wherein said distillate is separated from the undissolved and uncondensed gases, the latter being withdrawn from receiver 52 by way of line 53 and valve 54 and recovered or subjected to any desired further treatment. A portion of the distillate collected and separate in receiver 52 may be returned to the upper portion of fractionator 41 by well known means, not shown, as a refluxing and cooling medium. A portion or all of the remaining distillate in receiver 52 may be withdrawn therefrom by way of line 55 and valve 56 and recovered as a product of the process. Preferably, however, the remaining

distillate in receiver 52 is directed through line 57 and valve 58 to pump 59, which discharges through line 60 and valve 61 into line 65 for treatment as hereinafter described.

Light reflux condensate from fractionator 41 is directed through line 62 and valve 63 to pump 64, which discharges through line 65 and valve 66 and said light reflux condensate commingled with the distillate removed from receiver 52, as previously described, the mixture thereafter being supplied to heating coil 67.

The mixture of oil introduced to heating coil 67 is raised to a temperature in the range of 500 to 900° F. without substantial pyrolytic cracking thereof by means of heat supplied from furnace 68. The heated oil leaving heating coil 67 at a pressure ranging, for example, from substantially atmospheric to 200 pounds or more per square inch is directed through line 69 and valve 70 into reactor 71 where it is subjected to contact with a cracking catalyst while maintaining the oil at substantially the same temperature as that employed on the outlet of heating coil 67. The catalyst employed in reactor 71 may be of the same composition as that employed and described in connection with reactor 32. The low and high temperature catalytic conversion reactions differ essentially with respect to temperature and contact times employed, the reaction in reactor 32 being carried out at a relatively high temperature and short contact time, whereas the reaction in reactor 71 is carried out at a lower temperature and at a longer contact time. Reactors 32 and 71 may be essentially of the same design, however, as was previously mentioned, various other types of reactors may be employed to accomplish the desired results.

The conversion products leaving reactor 71 are directed through line 72 and valve 73 into fractionator 74 which is maintained at substantially the same or at a reduced pressure relative to that employed on the outlet of reactor 71. The conversion products introduced to fractionator 74 are subjected to fractionation therein to form reflux condensate and to separate the gasoline boiling range hydrocarbons. Reflux condensate formed in fractionator 74, which in this stage of the process contains relatively large amounts of aromatic hydrocarbons, is preferably subjected to thermal cracking treatment and this may be accomplished by directing the same through line 75 and valve 76 to pump 77, which discharges through line 78 and valve 79 into line 45 where said reflux condensate commingles with the heavy reflux condensate from fractionator 41, the mixture thereafter being subjected to the same treatment as that performed on the heavy reflux condensate, as previously described.

Fractionated vapors from fractionator 74 are directed through line 80 and valve 81 to cooling and condensation in condenser 82. Distillate, together with undissolved and uncondensed gases in condenser 82, is directed through line 83 and valve 84 to collection and separation in receiver 85. Normally gaseous hydrocarbons collected and separated in receiver 85 are directed from the upper portion thereof through line 86 and valve 87 to storage or to any desired further treatment. A portion of the distillate collected in the lower portion of receiver 85 may be returned to the upper portion of fractionator 74 by well known means, not shown, as a refluxing and cooling medium therein. The balance of the distillate collected in receiver 85 is removed therefrom by way of line 88 and valve 89 and recovered as a product of the process.

In carrying out one specific operation of the process illustrated and above described, the conditions employed and results obtained were approximately as follows:

A 25° A. P. I. gravity mid-continent reduced crude oil was commingled with heavy reflux condensate, formed as hereinafter described, and the mixture subjected to thermal cracking treatment in the heating coil and communicating reaction chamber at a temperature of 930° F. and under a superatmospheric pressure of 300 pounds per square inch.

In another step of the process a 53° A. P. I. gravity straight-run gasoline fraction was subjected to thermal reforming treatment in a heating coil at a temperature of 1010° F. and under a superatmospheric pressure of 750 pounds per square inch.

In another step of the process a 35° A. P. I. gravity straight-run gas-oil fraction was vaporized and heated to a temperature of 950° F. and the resulting vapors subjected to contact with a silica-alumina-zirconia catalyst under a superatmospheric pressure of approximately 60 pounds per square inch while maintaining the vapors in the catalytic zone at a cracking temperature.

The conversion products from the thermal cracking and reforming treatments and the catalytic cracking treatment were commingled and the mixture introduced to a vaporizing and separating chamber maintained under a superatmospheric pressure of 50 pounds per square inch. The liquid conversion products introduced to the vaporizing and separating chamber were subjected to substantial further vaporization to form a non-vaporous liquid residue and the latter, corresponding to approximately 25.3% of the total charge, recovered as a product of the process.

The vapors from the vaporizing and separating chamber were fractionated to form light and heavy reflux condensates and to separate vapors boiling below 400° F. The heavy reflux condensate was subjected to conversion, as previously described. The fractionated vapors were subjected to cooling and condensation and the resulting distillate and gas collected and separated.

The 400 end point distillate recovered was commingled with the light reflux condensate, the mixture heated to a temperature of 750° F. and thereafter subjected to contact with a silica-alumina-zirconia catalyst at a pressure of approximately 100 pounds per square inch while maintaining the temperature of the materials undergoing conversion at substantially that at which they were discharged from the heating coil. The conversion products from the low temperature catalytic treatment were fractionated to form reflux condensate, which was supplied to the thermal cracking treatment, and to separate fractionated vapors boiling below 300° F. which were cooled, condensed, and recovered as a product of the process.

The above described operation, based on a total feed, distributed approximately as follows:

44% reduced crude, 22% straight-run gasoline, and 34% gas-oil resulted in a yield of approximately 63.5% of 300 end point gasoline having an octane number of 74 and a bromine number of 9. With the addition of 6 cc. of tetraethyl lead the octane rating was raised to 96. In addition, normally gaseous hydrocarbons were obtained, corresponding to approximately 100% minus the yield of gasoline and liquid residue, which con-

tained a high percentage of polymerizable olefins.

I claim as my invention:

1. The process of converting hydrocarbons, which comprises subjecting combined feed comprising a relatively heavy hydrocarbon oil and reflux condensates, formed as hereinafter described, to thermal cracking treatment, concurrently therewith subjecting a relatively light hydrocarbon oil to thermal reforming treatment and an intermediate oil to high temperature catalytic cracking treatment, commingling the conversion products from said thermal cracking and reforming treatments and from said high temperature catalytic cracking treatment, supplying the mixture to a vaporizing and separating zone to separate non-vaporous liquid residue which is recovered as a product of the process from the vaporous conversion products, fractionating said vaporous conversion products to form light and heavy reflux condensate and to separate vapors boiling in the range of gasoline, supplying said heavy reflux condensate to treatment as aforesaid, cooling and condensing said vapors and recovering the resulting distillate and gas, commingling said distillate with the light reflux condensate and subjecting the mixture to low temperature catalytic treatment, fractionating the conversion products from said low temperature catalytic treatment to form reflux condensate and to separate fractionated vapors, supplying said reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said fractionated vapors and recovering the resulting distillate and gas as products of the process.

2. The process of converting hydrocarbons, which comprises subjecting combined feed comprising a relatively heavy hydrocarbon oil and reflux condensates, formed as hereinafter described, to thermal cracking treatment, concurrently therewith subjecting a relatively light hydrocarbon oil to thermal reforming treatment and an intermediate oil to high temperature catalytic cracking treatment, commingling the conversion products from said thermal cracking treatment and said thermal reforming treatments and supplying the mixture to a vaporizing and separating chamber to separate a non-vaporous liquid residue which is recovered as a product of the process from the vaporous conversion products, commingling said vaporous conversion products with the conversion products from said high temperature catalytic cracking treatment, fractionating the mixture to form light and heavy reflux condensates and to separate vapors boiling in the range of gasoline, supplying said heavy reflux condensate to thermal cracking treatment as aforesaid, cooling and condensing said vapors and recovering the resulting distillate and gas, commingling said distillate with the light reflux condensate and subjecting the mixture to low temperature catalytic treatment, fractionating the conversion products from said low temperature catalytic treatment to form reflux and to separate fractionated vapors, supplying said reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said fractionated vapors and recovering the resulting distillate and gas as products of the process.

3. The process of converting hydrocarbons, which comprises subjecting combined feed comprising a relatively heavy hydrocarbon oil and reflux condensates, formed as hereinafter described, to thermal cracking treatment, concurrently therewith subjecting a relatively light hydrocarbon oil to thermal reforming treatment and an intermediate oil to high temperature catalytic cracking treatment in the presence of a silica-alumina catalyst, commingling the conversion products from said thermal cracking and reforming treatments and from said high temperature catalytic cracking treatment, supplying the mixture to a vaporizing and separating zone to separate non-vaporous liquid residue which is recovered as a product of the process from the vaporous conversion products, fractionating said vaporous conversion products to form light and heavy reflux condensate and to separate vapors boiling in the range of gasoline, supplying said heavy reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said vapors and recovering the resulting distillate and gas, commingling said distillate with the light reflux condensate and subjecting the mixture to low temperature catalytic treatment in the presence of a catalyst of essentially the same composition as hereinbefore set forth, fractionating the conversion products from said low temperature catalytic treatment to form reflux condensate and to separate fractionated vapors, supplying said reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said fractionated vapors and recovering the resulting distillate and gas as products of the process.

4. The process of converting hydrocarbons, which comprises subjecting combined feed comprising a relatively heavy hydrocarbon oil and reflux condensates, formed as hereinafter described, to thermal cracking treatment at a temperature of from 850 to 1000° F. and under a superatmospheric pressure of from 200 to 600 pounds per square inch, concurrently therewith subjecting a relatively light hydrocarbon oil to thermal reforming treatment at a temperature of from 950 to 1050° F. and at a pressure of from 50 to 200 pounds per square inch, and an intermediate oil to high temperature catalytic cracking treatment in the presence of a silica-zirconia catalyst at a temperature of from 800 to 1200° F. and under a pressure of from substantially atmospheric to 200 pounds per square inch, commingling the conversion products from said thermal cracking and reforming treatments and from said high temperature catalytic cracking treatment, supplying the mixture to a vaporizing and separating zone to separate non-vaporous liquid residue which is recovered as a product of the process from the vaporous conversion products, fractionating said vaporous conversion products to form light and heavy reflux condensate and to separate vapors boiling in the range of gasoline, supplying said heavy reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said vapors and recovering the resulting distillate and gas, commingling said distillate with the light reflux condensate and subjecting the mixture to low temperature catalytic treatment in the presence of a catalyst of essentially the same composition as that hereinbefore set forth at a temperature of from 500 to 900° F. and at a pressure of from substantially atmospheric to 200 pounds per square inch, fractionating the conversion products from said low temperature catalytic treatment to form reflux condensate and to separate fractionated vapors, supplying said reflux condensate to said thermal

cracking treatment for treatment as aforesaid, cooling and condensing said fractionated vapors and recovering the resulting distillate and gas as products of the process.

5. The process of converting hydrocarbons, which comprises subjecting combined feed comprising a relatively heavy hydrocarbon oil and reflux condensates, formed as hereinafter described, to thermal cracking treatment at a temperature of from 850 to 1000° F. and under a superatmospheric pressure of from 200 to 600 pounds per square inch, concurrently therewith subjecting a relatively light hydrocarbon oil to thermal reforming treatment at a temperature of from 950 to 1050° F. and at a pressure of from 50 to 200 pounds per square inch, and an intermediate oil to high temperature catalytic cracking treatment in the presence of a catalyst consisting essentially of silica composited with alumina and zirconia, at a temperature of from 800 to 1200° F. and at a pressure of from substantially atmospheric to 200 pounds per square inch, commingling the conversion products from said thermal cracking and reforming treatments and from said high temperature catalytic cracking treatment, supplying the mixture to a vaporizing and separating zone to separate non-vaporous liquid residue which is recovered as a product of the process from the vaporous conversion products, fractionating said vaporous conversion products to form light and heavy reflux condensate and to separate vapors boiling in the range of gasoline, supplying said heavy reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said vapors and recovering the resulting distillate and gas, commingling said distillate with the light reflux condensate and subjecting the mixture to low temperature catalytic treatment in the presence of a catalyst of essentially the same composition as that hereinbefore set forth at a temperature of from 500 to 900° F. and at a pressure of from substantially atmospheric to 200 pounds per square inch, fractionating the conversion products from said low temperature catalytic treatment, to form reflux condensate and to separate fractionated vapors, supplying said reflux condensate to said thermal cracking treatment for treatment as aforesaid, cooling and condensing said fractionated vapors and recovering the resulting distillate and gas as products of the process.

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