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CONVERSION OF HYDROCARBON OILS

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This invention relates to a process for the improved production of cracked gasoline and fuel oil from reduced crude petroleum and similar heavy oils in a more practical and economical manner.

Gasoline is by far the most important product of the petroleum industry. The first goal of this industry is, therefore, to produce the maximum quantity of gasoline of highest possible quality from a barrel of petroleum at the least possible cost. Perhaps the most important step forward towards this goal in recent years was the introduction of catalytic cracking. This process affords good yields of gasoline of considerably improved quality and is now in wide commercial use throughout the country. Although there are instances in the patent literature where it is indicated that the catalytic cracking process is applicable for the conversion of the most varied hydrocarbon oils, including heavy residual materials such as reduced crude petroleum, it is well established in practice that in order for catalytic cracking to be economically attractive it is necessary to process relatively clean oils of a non-refractory nature. Residual oils contain traces of ash constituents which quickly poison the cracking catalyst. Also, when it is attempted to crack residual oils such as reduced crude petroleum it is found that the oil is largely decomposed into a coke-like material which deposits on the catalyst and must be removed by burning. Even relatively clean oils vary greatly in their tendencies to produce coke in catalytic cracking and thus vary widely in their suitability as feed stocks for the process. One of the major problems of the petroleum industry, therefore, is to provide from a given quantity of petroleum the maximum amount of distillate stock suitable as a feed stock for the catalytic cracking process. The preferred feed stock is a straight-run distillate oil of the nature of gas oil obtained from petroleum by simple distillation. However, the amount of feed stock that can be so obtained is limited and the amount of residue fraction is large. Consequently, methods have been devised for cutting more deeply into the residue fraction in order to obtain greater quantities of catalytic cracking feed stock at the expense of the residue. In one commonly used method the residue is subjected to vacuum distillation to recover additional amounts of higher boiling distillate, so-called flashed distillate. In another method the residue fraction, with or without prior vacuum distillation, is subjected to a mild thermal treatment, sometimes loosely referred to as viscosity

breaking, after which vaporizable gas oil constituents formed by the thermal treatment are separated by distillation. The feed stocks produced by such methods are generally inferior to virgin straight-run gas oil as catalytic cracking feed stocks but are applicable in the catalytic cracking process.

There are two main problems encountered in the preparation of catalytic cracking feed stocks from residue fractions by these methods. The first is in producing a large quantity of feed stock without impairing the quality unduly. It may be stated as a general observation of past experience that the quality of the feed stock declines sharply as one cuts deeper into the residue fraction. The second deals with the quality of the residue left after removing the distillate intended as catalytic cracking feed stock. This residue is blended with other oil (so-called cutter stock) to specification viscosity and sold as fuel oil. It is desired to dispose of this residue in this manner but, on the other hand, it is also desired to maintain the production of fuel oil at a minimum since it has a relatively low value. As the amount of produced catalytic cracking feed stock is increased, the amount of residue decreases, which is desirable, but, on the other hand, the amount of cutter stock required to produce a suitable fuel oil increases so that the amount of fuel oil produced increases when the maximum production of distillate oil is approached. As the amount of distillate oil removed from the residue is increased by deeper distillation and/or viscosity breaking the quality of the remaining residue fraction and the resulting fuel oil declines. Thus, for example, it is possible in a typical case to remove 45% of a so-called long residue (reduced crude) as a virgin gas oil which is an excellent feed stock for catalytic cracking. If now through viscosity breaking or other conventional means 70% of the long residue is removed as distillate oil, it is found that the distillate oil is of much poorer quality as a catalytic cracking feed stock. If a still greater portion of the long residue is converted to distillate oil the distillate oil is of still worse quality as a catalytic cracking feed stock and it is impossible to utilize the residue in fuel oil. It is thus seen that as the amount of catalytic cracking feed stock produced from a given quantity of petroleum is increased by present methods the quality of the feed stock declines, the amount of fuel oil increases, the quality of the fuel oil decreases and, if carried beyond a certain point it becomes impossible to produce

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fuel oil at all. As a result of this condition and the complicated nature of the processes, no solution satisfactory in all respects has been developed so far and the refiner is required to strike a compromise which is not completely satisfactory with respect to maximum quantity of catalytic cracking feed stock, quality of catalytic cracking feed stock, minimum quantity of fuel oil, or quality of fuel oil.

The object of the present invention is to provide a process wherein this compromise may be shifted towards the desired goal thereby allowing a larger production of the desired catalytically cracked gasoline and a smaller quantity of fuel oil of satisfactory quality from a given quantity of petroleum. It is, furthermore, an object of the invention to provide a method for accomplishing the object in a practical manner while producing high quality gasoline with a low coke production.

These objects are accomplished by the process hereinafter described in which selective catalytic cracking is applied in combination with selective thermal cracking in a particular manner designed to decrease the normal loss of quality of the distillate and residue upon producing a greater quantity or catalytic cracking feed stock from residual oils. The term "selective" is used to indicate that the materials are segregated into fractions of different characters, each of which is subjected to conditions most suitable for a more or less specific conversion. The process also has the advantages of flexibility and good controlability which are of much importance in practical application.

The process is explained in more detail in the following description made with reference to the accompanying drawing which illustrates by means of unscaled semi-diagrammatic figures the main flows and apparatus in a plant designed to operate in accordance with the principles of the invention. Referring to the drawing, the initial material is introduced into the plant by line 1. This initial material is normally so-called reduced crude, which is to say the residue remaining from topping crude petroleum. If the topping is carried out only to remove the straight-run gasoline, and possibly some kerosene, the residue is referred to as a long residue. If the topping is carried out under more drastic conditions to remove straight-run gas oil, the residue is referred to as short residue. The residue in either case boils mainly above 315° C. and contains thermally unstable and undistillable materials. While the process is particularly directed to the application of reduced crude petroleum, it will be apparent that hydrocarbon oils of a similar nature derived from oil shale and other sources are also applicable.

The initial material, as described above, is first subjected to a light thermal cracking treatment which may be likened to conventional viscosity breaking but differs therefrom in two respects. Firstly, the thermal treatment is carried out in the presence of appreciable amounts of straight-run gas oil which is still retained in the initial material. Secondly, the thermal treatment is carried out in the presence of a heavy gas oil which is a mixture of catalytically cracked gas oil and gas oil formed by a mild selective catalytic cracking operation to be described. Thus, the initial material containing straight-run gas oil entering by line 1 is commingled with the heavy gas oil mixture from

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line 56 and the resulting mixture is passed through a cracking furnace 2 in which it is heated under a small superatmospheric pressure to a temperature affording a mild or light thermal cracking. The severity of the thermal cracking may be judged by the amount of gasoline produced. Under suitable conditions not more than about 5% gasoline (205° C. E. P.) is produced. In a typical case the mixture is heated to about 480° C. under two atmospheres pressure in the cracking coil with the production of about 1% gasoline. The mixture is then subjected to a flash distillation in column 3 at approximately atmospheric pressure. A small amount of dephlegmation may be provided column 3 in order to sharpen the separation but this is not essential and is not illustrated. Also, if desired, some additional heat may be supplied to the chamber 3 by heating and recirculating a portion of the overhead vapors. This variation, although advantageous, is not essential and, in the interest of simplicity, it is not included in the illustrated flow.

The vaporous overhead product from column 3 consists mainly of distillate oil comprising straight-run gas oil separated from the initial material as well as distillate oil produced by both thermal and catalytic cracking of higher boiling oils; it also contains a small amount of gasoline and some gas. This product is passed by line 4 to a dephlegmator 5. In dephlegmator 5 the material is separated into a light oil boiling up to about 480° C. which is withdrawn by line 12 and a fraction of gasoline plus gas which is passed through a cooler 6 to a separator 8. The gases are withdrawn by line 7 and combined with the gases from the catalytic cracking operation for further handling in the conventional manner. The gasoline is withdrawn by line 8, e. g., at a temperature of 38° C. and 1.7 atmospheric pressure. The temperature at the top of dephlegmator 5 may be controlled by the recirculation of reflux through lines 9 and 10 and pump 11. Any light components which are dissolved in the oil fraction separated out in the dephlegmator 5 do not interfere with the catalytic cracking of this fraction as these light products pass through the catalytic cracking reactor without being appreciably affected; they are finally recovered when the end products are worked up.

The residue fraction from the bottom of the flash distillation chamber 3 contains the heavier portion of the unconverted initial feed as well as a considerable portion of two types of heavy distillate oils. These two types of heavy distillate oils, although contained in a single fraction, are distinct as one is produced by a very mild catalytic cracking of heavy oil and is relatively non-refractory, whereas the other consists of heavy oil produced from light oil in a severe catalytic cracking operation and is quite refractory. This residue is passed by line 12 to a second flash distillation, column 13, which is operated at a sub-atmospheric pressure, e. g., 20–40 mm. Hg. The conditions in column 13 are regulated to remove overhead as much material as possible while still retaining a residue which can be blended to produce fuel oil. This regulation may be through control of the pressure. Thus, the amount of residue decreases as the pressure is reduced. By suitably reducing the pressure, the desired amount of overhead product may be obtained without the necessity of supplying additional heat. In a typical case,

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the temperature in chamber 13 is 455° C. and the pressure is maintained at 30 millimeters of mercury. In the system described, the sensible heat of the residue of the first flash distillation is used for the evaporation in the second distillation. This is possible due to the high specific heat of heavy oils and their comparatively slight evaporation heat. If desired, the material passing by line 12 may be passed through a heater (not shown) to return the heat consumed in vaporization in chamber 3, thus reducing somewhat the vacuum required, or a small amount of additional heat may be added. If this stream is more drastically heated to effect any substantial cracking, however, the quality of the residue obtained from chamber 13 is impaired and it is found that a lesser amount of catalytic cracking feed stock can be prepared while still producing a residue which is suitable for the production of fuel oil by blending. The amount of residue obtained from the bottom of chamber 13 will depend upon the character of the initial feed stock and may vary widely. In some cases where very heavy asphaltic petroleum is involved, the minimum amount of residue that may be produced may be as much as 50% of the reduced crude, whereas with certain low gravity petroleums, the residue may be reduced to less than 10% of the reduced crude. In the case of reduced crude from Kuwait petroleum the best results are obtained when the quantity of residue removed is from 2 to 5% of the total distillate feeds to the catalytic cracking zones. In any case, this residue may be reduced to well below that possible by conventional viscosity breaking. This is due in part to the fact that in the process in question the combination of mild thermal treating and vacuum distillation is carried out in the presence of the described oils which tend to inhibit the normal degradation of the quality of the residue.

The residue fraction withdrawn from chamber 13 by line 14 is of the nature of pitch but is, nevertheless, readily blendable with catalytic gas oil or other cutter stock to produce stable fuel oil of suitable viscosity. Thus, catalytically cracked gas oil or other cutter stock introduced by line 16 is commingled with the hot residue in line 14 and the blend is then pumped through a cooler to fuel oil storage.

The overhead vaporous product from chamber 13 consists substantially entirely of heavy gas oil derived from thermal as well as catalytic operations. This oil is condensed in cooler 17 and then passed to a surge vessel 18 which is connected by line 19 to a steam ejector 20. Since no appreciable amounts of light products are present, the cost of maintaining a suitable vacuum in chamber 13 is unusually low in the described operation.

It will be noted that in the process as far as described, two distinct distillate fractions are produced. The first fraction withdrawn from column 5 is a relatively low boiling distillate fraction hereinafter referred to as light gas oil catalytic cracking feed. This oil is a mixture containing appreciable amounts of thermally cracked gas oil and gas oil produced by both very mild and relatively severe catalytic cracking. In spite of the inclusion of considerable amounts of these materials, it is an excellent catalytic cracking feed stock. It is slightly on the refractory side compared to straight-run gas oil but is not too refractory and its slight refractory nature is of advantage in this case as it

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allows the catalytic cracking to be carried out under relatively drastic conditions without over-cracking. It is under these conditions that the best quality gasoline is produced. The second fraction is that removed as overhead product from chamber 13. This high boiling oil, hereinafter referred to as heavy gas oil catalytic cracking feed, contains considerable amounts of oil produced by thermal cracking as well as some heavy refractory gas oil produced by severe catalytic cracking of the first mentioned lighter stock. It is consequently a heavy stock, e. g. specific gravity 0.90–0.97, and a poor catalytic cracking feed stock.

The second or heavy gas oil catalytic cracking feed obtained from separator 18 is fed through line 21 by means of pump 22 to a tubular reactor 24 in which it is mixed with hot freshly regenerated cracking catalyst which is fed by catalyst standpipe 25 from the catalyst regenerator 26. In general, it is desired to preheat the heavy gas oil mixture below cracking temperature and this may be accomplished by passing the material through tubes in the furnace 23 in which it is heated to, for example, 370° C. prior to passing it to tube 24. Tube 24 is connected with reactor 27 and extends up to the reactor to a point above the level of the bed of fluidized cracking catalyst 30 contained therein. Tube 24 is also of such a relatively small diameter that the mixture of oil vapors and powdered cracking catalyst exists therein in the form of a dilute phase, i. e., the mixture is at a velocity above that affording separation of a fluidized (pseudo liquid) phase. The purpose of this arrangement is to subject the heavy gas oil feed to a mild catalytic cracking treatment conducive to the conversion of this particular oil into light gas oil which is more suitable for further cracking to gasoline while, at the same time, avoiding as far as possible the adverse effect of this relatively poor cracking stock. Thus, the heavy gas oil feed is contacted with freshly regenerated catalyst under relatively high temperature conditions, e. g. 500–600° C., for a very short contact time under conditions of a high catalyst to oil ratio. This takes advantage of two known facts which are: (1) the coke formed on catalytically cracking any feed to any given depth of cracking decreases as the temperature of catalytic cracking is increased and (2) that the coke formed on catalytically cracking any feed to any given depth of cracking decreases as the applied catalyst to oil ratio is increased. Thus, although this heavy gas oil is a poor catalytic cracking feed for gasoline production, only a small amount of coke is produced by the mild high temperature cracking of this stock into the light gas oil range. It might also be mentioned that this heavy gas oil feed is difficult to preheat due to its great tendency to coke the heating tubes. Since in the described process this oil is heated to the high cracking temperature by contact with relatively large quantities of hot regenerated catalyst, it is not necessary to preheat the oil to relatively high temperatures where this coking problem is encountered.

The heavy gas oil feed is not only cracked at a high temperature and at a high catalyst oil ratio but, at the same time, the period of contact is so short that only partial conversion into lower boiling products is achieved. The period of contact can be governed on the one hand by the diameter chosen for the line 24 but, besides this, it can also be regulated by supplying

steam, e. g. 50–200 mole per cent via line 28. To help in adjusting the reaction conditions to the optimum in any given case the following relations may be used: the conversion increases by 2.7% by weight, based on the feed, for each 10° C. rise in the reaction temperature; doubling the rate of throughput lessens the conversion by 5–10% by weight; doubling the catalyst-to-oil weight ratio increases the conversion by 3–6% by weight.

The catalyst which comes through line 24 to the reactor 27 flows against a deflector cap 29 so that it is diverted in the direction of the catalyst bed 30 in the reactor while the vapors escape upwards. During the time that the catalyst moves in the direction of the bed 30, it comes into contact with the stream of vapors escaping from the catalyst bed 30 whereby heavy volatilizable components of the coke on the catalyst are largely stripped before the catalyst settles in the bed 30. The oil components which remain absorbed on the catalyst are subjected to cracking conditions in the bed 30 so that part of the absorbed oil component is removed and very little coke remains on the catalyst.

The catalyst introduced into the reactor 27 by tube 24 collects in the lower section of the reactor as the bed 30 which constitutes the main catalytic cracking zone. Thus, whereas the residence time of the catalyst in tube 24 is only a matter of seconds, the residence time of the catalyst in bed 30 is several minutes, e. g. 10–15 minutes. The temperature in the bed 30 is lower than that in tube 24 due to the endothermic heat in the cracking reaction. By way of example, the temperature in the bed 30 may be 480° C. when the temperature in the tube 24 is 515° C.

The above described light gas oil catalytic cracking feed, after being suitably preheated if desired in a coil in furnace 23, is introduced, e. g. at 425° C., into the catalyst bed 30 near the bottom. If desired, some hot regenerated catalyst may also be fed to the bed 30 together with the light oil fraction to increase the temperature in the reactor, but this is not usually necessary and is not illustrated. The catalyst in the bed 30, unlike the catalyst in tube 24, is retained in a fluidized condition (pseudo liquid state) by the vapors of the light gas oil feed. Under the relatively severe cracking conditions prevailing in the bed 30, the light gas oil feed is catalytically cracked with the production of a large yield of high quality gasoline. The conditions may vary from case to case but are typically as follows:

Light gas oil feed, 0.85–0.88. specific gravity.
Temperature _____ 450–550° C.
Throughput rate___ 0.2–1.0 kg./hr./kg. catalyst.
Catalyst/oil, weight 2–20. ratio.
Pressure _____ 1–5 atmospheres.

The level of the bed 30 may be adjusted to give a space velocity affording the desired conversion to gasoline and may be maintained substantially constant at the desired level by withdrawing catalyst through line 31 to a stripping vessel 32 wherein it is stripped of occluded and absorbed hydrocarbons by steam or any other suitable stripping gas introduced by line 33. The stripped catalyst is then picked up by a stream of air from line 61 and carried to the regenerator 26 wherein the remaining carbonaceous deposits are burned in the conventional manner. In order to avoid overheating of the

catalyst in the regeneration zone, a portion of the catalyst may be continuously withdrawn by standpipe 63 and recycled with air from line 62 through a cooler 64. Steam generated in the cooler 64 may be used as a stripping gas.

The vaporous mixture of stripping gas, catalytically cracked gasoline, catalytically cracked gas oil, gas oil produced by the mild catalytic cracking in tube 24, and some unconverted oil, is withdrawn from the catalytic cracking reactor by line 39 and passed to a fractionating column 40. In fractionating column 40 gases and gasoline vapors are removed at the top and fed through line 41 via cooler 42 to a separator 43 in which a nonstabilized gasoline with a final boiling point of, for example, 205° C. is separated off at, for example, 38° C. and a pressure of, for example, 1.35 atmospheres. The uncondensed gases are discharged through line 44. The temperature at the top of the fractionating column may be regulated in the conventional manner by recirculating reflux by means of pump 45 through line 46 and cooler 47.

A gas oil fraction is removed from the fractionating column 40 through line 48 and freed of lighter components in side stripper 49. The lighter components are fed back to the fractionating column through line 50 while the gas oil fraction boiling between, for example, 205° C. and 370° C. is removed through line 51 via pump 52 and cooler 53.

An oil fraction which boils, for example, between 315° C. and 540° C. is removed via line 54 and pump 55. This fraction, which consists to a large extent of light oil produced by the mild catalytic cracking in the tubular reactor 24, is passed to line 37 wherein it commingles with the above-described light gas oil catalytic cracking feed and is cracked therewith under the relatively severe conditions maintained in the fluidized catalyst bed 30.

The temperature in the lowest part of the fractionating column 40 may be regulated by circulating part of the bottom product via line 56, pump 57, cooler 58 and line 59. The remaining part of the bottom product discharged through line 56 is fed by means of pump 60 to the supply line 1 where it commingles with the fresh feed as described above and is then further subjected to the described thermal cracking treatment in the presence of the initial feed. The heavy oil supplied from line 56 and combined with the initial feed may comprise, for example, approximately 25% of the total fresh feed. The particular manner of utilizing the heavy bottom product of fractionating column 40 as well as the distillate gas oil fraction withdrawn by line 54 are essential parts of the present method.

It will be noted that in the described process the initial material to be cracked is divided into a lower and a higher boiling distillate fraction. The higher boiling fraction is cracked at a higher temperature and during a shorter period in the presence of the catalyst than the lower boiling fraction, and in such a particular way as to obtain a product containing, besides gas oil, higher boiling components which are partly conducted in a cycle to the lower boiling fraction to be cracked, whilst still higher boiling components are combined with the fresh initial material and subjected together with this to a thermal cracking treatment in order to increase the content of products which can suitably be used as feed for the catalytic cracking, whilst the products obtained by catalytic cracking of the

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lower boiling fraction are worked up, together with the products obtained from the higher boiling fraction, on the said end and cycle products. Thus, the lower and higher boiling fractions treated are not straight run fractions but composites of thermal and catalytic fractions which are particularly chosen for handling in the specific described manner.

Example.—5000 tons of a reduced crude boiling above 315° C. (obtained by topping crude petroleum) are fed daily through line 1 of a plant such as illustrated in the attached drawing and, together with 1000 tons per day of heavy oil, the origin of which will be subsequently explained, are subjected to a mild thermal cracking treatment under a pressure of two atmospheres and to a temperature of 482° C. (measured in the outlet of the cracking furnace). The product from the cracking furnace is conducted to a flash column 3 whence vapors obtained are conducted to a dephlegmator 5 from which a fraction boiling between 260° C. and 482° C. amounting to 2400 tons and composed of 350 tons of thermally cracked oil, 650 tons of fresh feed and 400 tons of products from the heavy cycled oil is fed daily to the preheater 23 together with 1200 tons per day of cycled oil boiling between 315° C. and 540° C. which is withdrawn from the fractionating column 40.

The residue obtained in the flash distillation in column 3 is subjected to a second flash distillation at a pressure of 30 millimeters of mercury and a temperature of 455° C.

A quantity of pitch-like residue amounting to 1050 tons/day, 850 tons of which comes from the fresh feed and 200 tons of which comes from the heavy cycled oil, is removed from the low pressure flash chamber and blended with cutter stock to specification fuel oil viscosity. In addition, there is obtained from the low pressure flash chamber 2400 tons of distillate, 400 tons of which are obtained from the heavy cycled oil. This material is passed to the preheater 23 in which it is preheated to a temperature of 370° C. The material is then brought into contact with freshly regenerated catalyst having a temperature of 590° C. and passed to a tubular reactor 24. The temperature in the reaction zone 24 is about 515° C.

The light catalytic cracking feed consisting of the light gas oil recovered in the first flash distillation and gas oil removed from the product fractionating column 40 is preheated in preheater 23 to 426° C. and then passed to the reactor 27 where the temperature is maintained at 482° C.

The total vaporous product from the reactor 27 is passed to a fractionating column 40 from which a gasoline fraction (2060 tons) is removed at 205° C. and 1.35 atmospheres. At an intermediate point in the fractionating column where the temperature is 260° C., a light fraction of catalytically cracked gas oil is removed. At a still lower point in the fractionating column where a temperature of 315° C. prevails, a fraction of cycle oil is removed in the quantity of 1200 tons daily. Heavy gas oil is discharged at the bottom of the fractionating column at 370° C. and is conducted in a quantity of 1000 tons per day by line 1 and mixed with incoming fresh initial material.

Thus, out of 1000 tons of heavy oil which are cycled per day through the thermal cracking apparatus in a mixture with the fresh feed, 400 tons are converted into light catalytic cracking

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feed, 400 tons are rerouted to be converted into light catalytic cracking feed by the mild catalytic cracking treatment, and 200 tons are removed as a pitch-like residue of such quality that it may be blended with cutter stock to produce stable fuel oil of suitable viscosity. The total quantity of gas, including the C4 components, amounts to 650 tons per day, 50 tons of which are formed in the thermal cracking operation. The quantity of coke deposited on the catalyst and subsequently burned in the regeneration step amounts to 240 tons per day, or only 4.8% by weight of the feed. Of the 2060 tons of gasoline produced only 100 tons is thermal gasoline; thus the ratio of catalytic to thermal gasoline produced is 19.6.

Although the invention is particularly suitable for use with a fluidized catalyst and has been described in that particular connection, the invention is not limited to this fluidized catalyst technique; the principles described can also be applied to advantage in other forms of catalytic cracking.

I claim as my invention:

1. A process for the conversion of hydrocarbon oils in which a higher boiling and a lower boiling distillate fraction are prepared from an initial material of the nature of reduced crude petroleum and separately catalytically cracked, characterized in that the initial material is subjected to a mild thermal cracking treatment in the presence of added recycle heavy oil produced as hereinafter specified and then subjected to a flash distillation under substantially atmospheric pressure to separate said lower boiling distillate fraction from a first residue fraction, said first residue fraction is subjected to a flash distillation at sub-atmospheric pressure to separate said higher boiling fraction and a second residue, said second residue is blended with cutter stock to produce fuel oil, said higher boiling fraction is subjected to a mild catalytic cracking treatment at a relatively high temperature with freshly regenerated cracking catalyst, said lower boiling distillate fraction is mixed with a light oil, produced as hereinafter described, and subjected to a relatively severe catalytic cracking treatment under conditions to produce a maximum amount of gasoline with catalyst partially spent in treating said higher boiling fraction, the products of said two cracking treatments being passed to a common fractionation zone wherein there are separated and removed as separate streams a gasoline plus gas fraction, a light gas oil fraction which is said light oil and is admixed with the said lower boiling fraction and subjected to relatively severe catalytic cracking as aforesaid, and a higher boiling residue fraction which is said recycle heavier oil and is subjected to the aforesaid mild thermal treatment with said initial material as aforesaid.

2. Process according to claim 1, further characterized in that the catalytic cracking of said higher boiling fraction is carried out by passing said fraction with powdered cracking catalyst through a tubular cracking zone at a high velocity, and the mixture of hydrocarbon products and powdered catalyst issuing from said zone is discharged into a space above a bed of fluidized cracking catalyst which constitutes the catalytic cracking zone in which the said light oil is catalytically cracked, whereby the powdered catalyst used in said tubular cracking zone accumulates in said bed and the mixed vaporous hydro-

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carbon products of both cracking zones are withdrawn from said space as a common stream.

3. Process according to claim 1, further characterized in that the said mild thermal cracking treatment is controlled to produce no more than 5 per cent gasoline, and the said lower boiling distillate oil separated from the said residue fraction in the first flash distillation boils between about 260° C. and 540° C.

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