

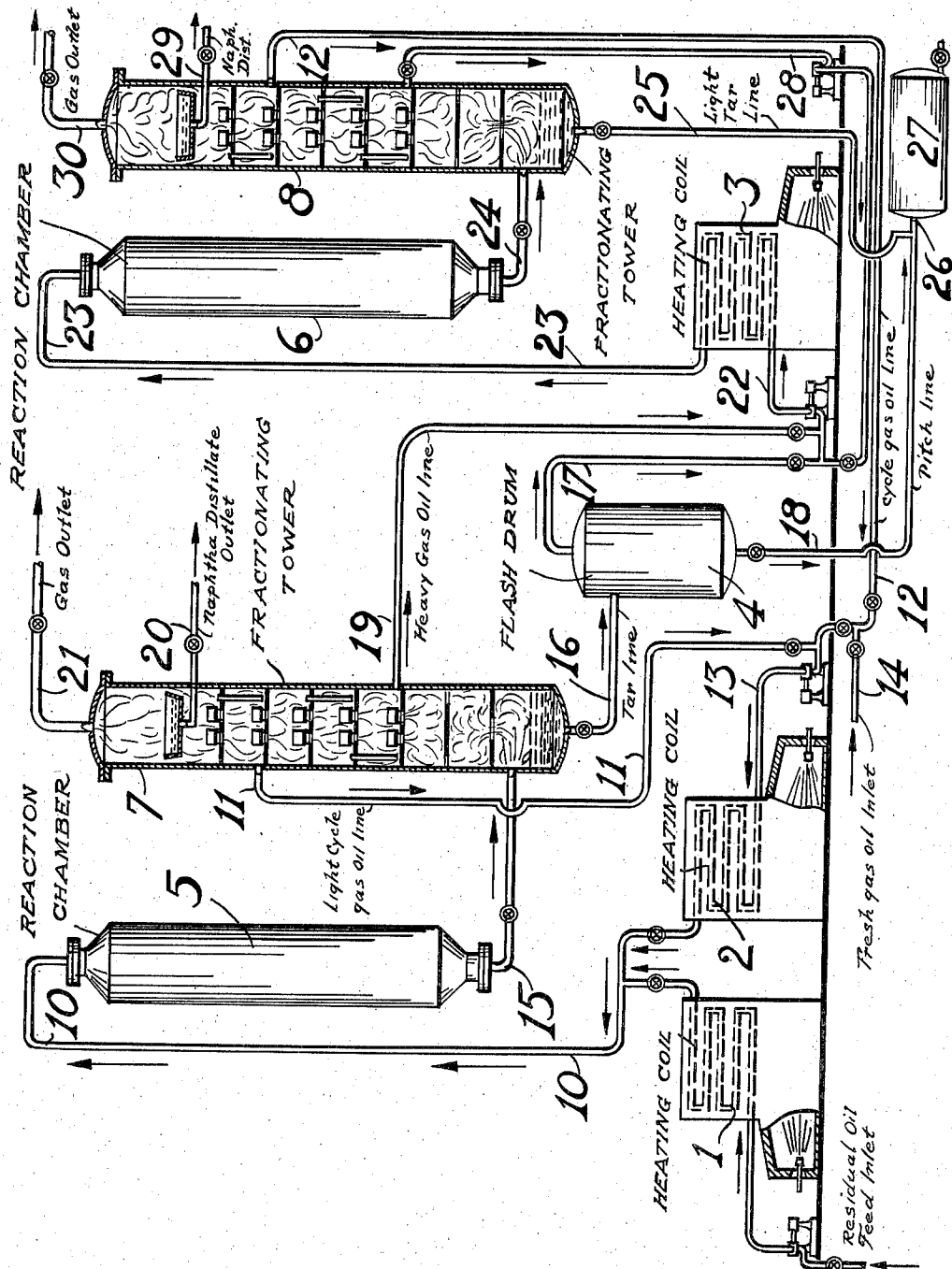
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CRACKING RESIDUAL OILS

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## CRACKING RESIDUAL OILS

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The present invention relates to cracking residual oils such as, for example, reduced crudes, and will be understood from the following description when read in conjunction with the drawing the sole figure of which is a diagrammatic representation partly in section of an apparatus appropriate for carrying out the invention.

One object of the present invention is to obtain a maximum yield of naphtha in the cracking of residual stocks. Another object is to eliminate or at least diminish the amount of coke formation which very often accompanies the cracking of such stocks. Still another object is to obtain a fuel oil of required fluidity in the cracking process.

According to the present invention, the residual stock is heated to a cracking temperature or at least a temperature such that a further temperature increase will induce a substantial cracking of the stock. The heated residue is then admixed with a cycle gas oil or its equivalent which has been heated to a still higher temperature and which tolerates such higher temperatures due to the absence of tarry matter. The mixture of residual and cycle gas oil is then passed through a digesting zone, preferably of the type known as a soaking drum, for the purpose of obtaining an appreciable amount of cracking. Such a process of obtaining additional cracking of a residual stock by admixture with a clean cycle gas oil heated to a higher temperature than the residual stock has the disadvantage that the clean circuit synthesizes a tar which possesses a certain although low volatility. The more volatile part of it which will be designated as light tar, has a volatility which is identical with a large part of the heavy gas oil synthesized from the residue by cracking. However, this heavy gas oil is a premium cracking stock whereas the light tar is a stock which while it will stand quite a high temperature, when it does reach its cracking temperature it goes to inordinate quantities of gas and coke. If recycled in an ordinary unit this dirty light tar goes either to the residual stream of coil No. 1 or to the clean circuit of coil No. 2. In either case it is bad.

The heavy gas oil obtained in my process from the residual stock cannot be separated from the light tar by rectification because they have approximately the same volatility. Use of selective solvents or similar methods is impractical. However, they can be separated by sending the two to a third circuit in which the cracking conditions are adequate to crack the heavy gas oil but

inadequate to coke the light tar. This separation, which represents an important feature of the present invention, depends therefore on taking advantage of one property in which the components differ significantly; that is the susceptibility to cracking. The cracking conditions can be varied by either temperature and/or pressure and time, but are preferably predominantly varied by the temperature. The temperature in the third circuit should be lower than in the second and higher than in the first. Thus, for example, for a specific crude for which the coil outlet temperature on the residuum in the first coil should be 800–850° F. or lower, and on the light gas oil in the second coil should be 975–1000° F. or higher, on the third coil through which the mixture of heavy gas oil and light tar is sent, it should be between 850–975° F., and preferably between 900–950° F. These temperatures are illustrative only since residua may be successfully cracked at higher temperatures. It is advantageous in many cases to maintain the outlet temperature of the heating coil for the cycle gas oil at least 100° F. higher than the outlet temperature of the heating coil for the residuum.

Practically any oil which can be distilled out of a practically once cracked residuum is a good cracking stock. Hence, the tar from the residuum stream should be flashed in a flash vaporizer to the heaviest practical pitch. Such pitch will be too heavy for a fuel oil. However, the light tar from the third circuit is of low molecular weight and thin, although readily cokable because of its low hydrogen-carbon ratio. This light tar is therefore used in the preferred form of my process for fluxing the pitch to a suitable blended fuel.

The cycle stock fed to coil 2 is capable of producing a tar of higher A. P. I. gravity number than that of the tar produced from the cycle stock fed to coil 3. Under the conditions of operation maintained in coil 2 and in the reaction chamber 5, however, the tar produced from the cycle stock will be negligible so that, for all intents and purposes, the tar drawn off from fractionating tower 11 may be considered the tar produced from the residual feed oil fed into coil 1. Thus, in order to operate the unit to produce a tar of specified gravity from a given feed stock, the separating or fractionating tower operating on the products resulting from the passage of the fresh feed stock through the heating coil and reaction chamber is so controlled as to yield a tar of the lowest possible A. P. I. gravity number without coking and this tar is brought up to the

desired gravity number by being blended with a tar of higher gravity number produced by cracking a gas oil recovered from said separator. By this procedure, the constituents suitable for cracking in the initial material are utilized to the fullest extent and at the same time a fuel oil of the desired gravity number is obtainable.

The function of coil No. 1 is primarily to crack residual oil into heavy gas oil and some light gas oil. The function of coil No. 2 is primarily to crack light cycle gas oil to naphtha. The function of coil No. 3 is primarily to make it possible to separate heavy gas oil synthesized in coil No. 1 and the soaker following it from the light tar of the same volatility synthesized in coil No. 2 by cracking the former preferably predominantly to light gas oil. The function of the flash vaporizer is to strip out of the cracked residuum all except the completely non-volatile fractions. All volatile fractions are, or may be returned to the system at suitable points for cracking with the exception of the light tar which is used for blending with the pitch.

Referring now to the drawing, the numerals 1, 2 and 3 designate heating and cracking coils for the residual oil, light cycle gas oil and heavy gas oil respectively. The heating coils are arranged in gas or oil-fired furnaces. Three separate furnaces are shown on the drawing, although the three heating coils may also be arranged in the various sections of a single furnace. The numeral 4 designates a flash drum, numerals 5 and 6 reaction chambers and 7 and 8 fractionating towers. The bottoms of the fractionating towers function as tar separators. It will be understood that independent tar separators may also be provided for, in which case they are arranged between the soaking drums and the bubble towers. The towers 7 and 8 are provided with fractionating means, such as bellcap plates in their upper part and discs and doughnuts in their lower part. Heat exchange coils at the top of the fractionating towers 7 and 8 and lines for returning reflux to the upper plates of the towers are provided for, as well known in the art, but are not shown in the drawing. These principal parts are operatively connected by various lines and a preferred method of operating the unit is as follows:

The feed stock of residual oil is pumped from a storage tank (not shown) through heating coil 1 and transfer line 10 into the soaking drum 5. The stock may be preheated prior to its passage through the heating coil in liquid or vapor heat exchangers (not shown) in various appropriate parts of the unit. The cycle gas oil obtained as reflux in towers 7 and 8 is pumped through lines 11, 12 and 13 respectively to the heating coil, after which it is united with the heated residual oil and passed through transfer line 10 to the soaking drum 5. Fresh gas oil obtained in distillation of crudes, or in another cracking operation, may be added through line 14, if desired. The cracking initiated in coils 1 or 2 or in coil 3 only is continued and carried to the desired extent in the soaking drum 5. The hot cracked effluent from this drum is then transferred through line 15 into the tower 7, from the bottom of which the separated heavy tar is removed through line 16 into the flash drum 4. From this flash drum all the vaporizable products consisting of heavy gas oil, mostly obtained from the cracking of the residual feed stock, and light tar mostly synthesized during the cracking of the light cycle gas oil together with some lighter products, are removed through the over-

head vapor line 17, while the pitch is discarded through bottom line 18. A further amount of heavy gas oil is obtained as side stream in tower 7 and is removed through line 19. The light cycle gas oil is collected in tower 7 at a higher level and is returned to coil 2 through line 11 as previously described. Still at a further level in tower 7, the naphtha distillate is obtained as side stream and removed through line 23 into a distillate storage tank (not shown). Finally the gas is passed through the overhead line 21 into a gas storage tank (not shown). The contents of vapor line 17 and the side stream line 19 consisting of heavy gas oil and light tar are then pumped through line 22, heating coil 3 and transfer line 23 into the soaking drum 6. The cracking conditions in coil 3 and soaking drum 6 are maintained strenuous enough to crack the heavy gas oil but not sufficient to crack the refinery light tar to a considerable extent. This is the more readily achievable by choosing cracking conditions adequate to crack heavy gas oil to light gas oil, but not attempting to choose cracking conditions sufficiently drastic to crack heavy gas oil to any large extent all the way to naphtha. Of course the lighter conditions which produce predominantly light gas oil as the cracked product will also produce some naphtha and gas but in smaller amounts. The hot cracked effluent is passed through line 24 into the lower part of tower 8 at the bottom of which a tar collects, consisting mostly of the light tar. This is removed through line 25, fluxed with a pitch from line 18 and then passed through line 26 through a heat exchanger or cooler (not shown) into the fuel oil storage tank 27. A heavy gas oil which collects in tower 8 as lowest side stream is returned through lines 28 and 22 to the cracking coil 3. A light gas oil is obtained as middle side stream and is returned to cracking coil 2 through lines 12 and 13. A naphtha distillate is collected as upper side stream and removed through line 29 into the distillate storage tank (not shown). Finally the gas is passed through line 30 into the gas storage tank (not shown).

My process may be modified in various ways. Thus, for example, soaking drums 5 and 6 may be omitted altogether and replaced by corresponding soaking sections, i. e. moderately heated tubes in furnaces 1 and 3 respectively in which the cracking is completed to the desired extent. Other changes and modifications will be apparent to those skilled in the art and, therefore, my process is not to be limited by the example given for illustration but only by the following claims in which it is my intention to claim all novelty inherent in the invention.

What I claim is:

1. A method of processing hydrocarbon oil to convert higher-boiling hydrocarbons into lower-boiling hydrocarbons suitable for motor fuel which comprises subjecting fresh charging oil to cracking conditions of time and temperature until the desired degree of conversion has been attained, thereafter passing the cracked products to a separating zone and separating the same into vapors and residue, fractionating the vapors so separated into a distillate fraction of the desired motor fuel boiling range, a light condensate fraction substantially free of tarry constituents and a heavy condensate fraction containing tarry constituents, subjecting said light condensate fraction to cracking in a separate cracking zone under more drastic temperature conditions than that to which said fresh oil is

subjected, combining the cracked products from said last-named cracking zone with said first-named cracked products prior to passing the same to said separating zone, subjecting said heavy condensate fraction to cracking conditions more mild than that to which said light condensate fraction is subjected in a separate cracking zone until the desired conversion has been effected, passing the cracked products from said last-named cracking zone into a separating zone independent from said first-named separating zone and separating the products therein into vapors and residue, fractionating the resulting vapors to form a desired distillate fraction within the motor fuel boiling range, a light condensate fraction relatively free of tarry constituents and a heavy condensate fraction containing tarry constituents, combining said last-named light condensate fraction with said first-named light condensate fraction prior to its passage to the cracking zone, combining said last-named heavy condensate fraction with said first-named heavy condensate fraction prior to its passage to the last-named cracking zone.

2. A method of processing hydrocarbon oil to produce motor fuel and a residue suitable for fuel oil, which comprises subjecting fresh charging stock containing crude constituents to cracking in a cracking zone until the desired conversion has been attained, passing the cracked products into a separating zone, separating the cracked products into a vapor fraction and a liquid residue fraction having a viscosity greater than that desired for said fuel oil, fractionating the vapor so separated to separate the same to a desired distillate fraction, a light condensate fraction boiling above the motor fuel boiling range and a heavy condensate fraction, subjecting the light condensate fraction to cracking in a cracking zone separate from said first named cracking zone to convert said condensate fraction into lower boiling constituents within the motor fuel boiling range, combining cracked products from the said last named cracking zone with the cracked products from the said first named cracking zone, subjecting the liquid residue from the initial separation after the initial cracking step to additional distillation to vaporize additional constituents therefrom and produce a liquid residue having a viscosity greater than that desired for fuel oil, subjecting the heavy condensate fraction produced from the initial cracking operation and said additional constituents from the liquid residue of the initial cracking operation to cracking in a cracking zone separate from said initial cracking zone to convert the mixture into lower boiling constituents within the motor fuel boiling range, thereafter passing the cracked products from the last named cracking zone into a separating zone separate from the said first named separating zone, separating the cracked products in said separating zone into a vapor fraction and a liquid residue fraction having a viscosity less than that desired for said fuel oil, combining the residue from the additional distillation of the initial residue from the said first named separating zone with the residue from the second named separating zone to produce a fuel oil of desired gravity and fractionating the vapors from the last named separating zone to separate a desired distillate fraction and condensate fractions, and returning said condensate fractions to the cracking zones for the original condensate fractions.

3. A method of processing hydrocarbon oil to convert higher boiling hydrocarbons into lower

boiling hydrocarbons suitable for motor fuel and a residue suitable for fuel oil, which comprises subjecting fresh charging oil to cracking conditions of time and temperature until the desired degree of conversion has been attained, thereafter passing the cracked products to a separating zone and separating the same into vapors and residue, fractionating the vapors so separated into a distillate fraction of the desired motor fuel boiling range, a light condensate fraction substantially free of tarry constituents and a heavy condensate fraction, subjecting said light condensate fraction to cracking in a separate cracking zone under more drastic temperature conditions than that to which said fresh oil is subjected, combining the cracked products from said last named cracking zone with said first named cracked products, subjecting said heavy condensate fraction to cracking conditions more mild than that to which said light condensate is subjected in a separate cracking zone until the desired conversion has been effected, passing the cracked products from said last named cracking zone into a separating zone independent from said first named separating zone and separating the products therein into vapors and residue, fractionating the resulting vapors to form a desired distillate fraction within the motor fuel boiling range, a light condensate fraction relatively free of tarry constituents and a heavy condensate fraction, combining said last named light condensate fraction with said first named light condensate fraction prior to the passage to the second named cracking zone, combining said last named heavy condensate fraction with said first named heavy condensate fraction prior to its passage to the last named cracking zone and combining the residue from the first named separating zone with the residue from the second named separating zone to produce a fuel oil of desired gravity.

4. A method of processing hydrocarbon oil to convert higher boiling hydrocarbons to lower boiling hydrocarbons suitable for motor fuel and a residue suitable for fuel oil, which comprises passing the fresh charging oil in a stream thru an elongated reactor of restricted cross sectional area under cracking conditions of time and temperature until the desired degree of conversion has been attained, thereafter passing the cracked products to a separating zone and separating the same into vapors and residue, fractionating the vapors so separated into a distillate fraction of the desired motor fuel boiling range, a light condensate fraction substantially free of tarry constituents, and a heavy condensate fraction, subjecting said light condensate fraction to cracking in a separate cracking zone under more drastic temperature conditions than that to which said fresh oil is subjected, combining the cracked products from said last named cracking zone with said first named cracked products, subjecting the liquid residue from the first named cracking zone to additional distillation to vaporize additional constituents therefrom and produce a liquid residue having a viscosity greater than that desired for motor fuel, subjecting the heavy condensate fraction and said additional vaporized constituents from the said first named liquid residue to cracking under conditions more mild than that to which said light condensate fraction is subjected in a cracking zone separate from previously mentioned cracking zones to convert the mixture to lower boiling constituents within the motor fuel boiling range, passing the cracked products from said last named cracking zone into a separating

zone independent from said first named separating zone and separating the products therein to vapors and residue, fractionating the resulting vapors to form a desired distillate fraction within the motor fuel range, a light condensate fraction relatively free of tarry constituents and a heavy condensate fraction, passing said last named light condensate fraction together with said first named light condensate fraction to the second mentioned cracking zone, and passing said last named heavy condensate fraction with said first named heavy condensate fraction to the last named cracking zone.

5. A method of processing hydrocarbon oil to produce motor fuel and a residue suitable for fuel oil which comprises subjecting fresh charging stock containing crude constituents to cracking in a cracking zone until the desired conversion has been attained, passing the cracked products into a separating zone, separating the cracked products into a vapor fraction and a liquid residue fraction, fractionating the vapor so separated to separate the same into a desired distillate fraction, a light condensate fraction boiling above the motor fuel boiling range and a heavy condensate fraction, subjecting the liquid residue so separated to additional distillation to vaporize additional constituents therefrom and produce a liquid residue having a viscosity greater than that desired for motor fuel, subjecting the light condensate fraction to cracking in a cracking zone separate from said first named cracking zone to convert said condensate fraction into lower boiling constituents within the motor fuel boiling range, combining cracked products from said last named cracking zone with the cracked products from said first named cracking zone, subjecting the heavy condensate fraction to cracking in a cracking zone independent of said first and said second named cracking zones until the desired conversion has been attained, thereafter passing the cracked products from the last named cracking zone into a separating zone separate from said first named separating zone, separating the cracked products in said separating zone into a vapor fraction and a liquid residue fraction having a viscosity less than that desired for said fuel oil, combining said last named residue with said second named residue to produce a fuel oil of desired gravity and fractionating the vapors from the last named separating zone to separate a desired distillate fraction and a condensate fraction, and returning said condensate fraction to the cracking zones for the original condensate fractions.

6. A method of processing hydrocarbon oil to produce motor fuel and a residue suitable for fuel oil, which comprises subjecting fresh charging stock containing crude constituents to cracking in a cracking zone until the desired conversion has been attained, passing the cracked products into a separating zone, separating the cracked products into a vapor fraction and a liquid residue fraction, fractionating the vapors so separated to separate the same to a desired distillate fraction, a light condensate fraction boiling above the motor fuel boiling range and a heavy condensate fraction, subjecting said light condensate fraction to cracking in a separate cracking zone under more drastic temperature conditions than that to which said fresh charging stock is subjected, combining the cracked products from said last named cracking zone with said first named cracked products prior to passing the said first named cracked products to said separating zone, subjecting the liquid residue from said separating zone to an additional distillation to vaporize additional constituents therefrom and produce a liquid residue having a viscosity greater than that desired for fuel oil, subjecting the heavy condensate fraction and said additional constituents vaporized from said first named liquid residue to cracking under conditions more mild than that to which said light condensate fraction is subjected in a cracking zone separate from said previously named cracking zones to convert the mixture into lower boiling constituents within the motor fuel boiling range, thereafter passing the cracked products from the last named cracking zone to a separating zone separate from said first named separating zone, separating the cracked products in said separating zone into a vapor fraction and a liquid residue fraction having a viscosity less than that desired for said fuel oil, combining said last named residue with the residue obtained from the additional distillation of the initial residue to produce a fuel oil of desired gravity, fractionating the vapors from the last named separating zone to separate a desired distillate fraction within the motor fuel boiling range, a light condensate fraction relatively free of tarry constituents and a heavy condensate fraction, combining said last named light condensate fraction with said first named light condensate fraction prior to its passage to the cracking zone and combining said last named heavy condensate fraction with said first named heavy condensate fraction prior to its passage to the last named cracking zone.

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