

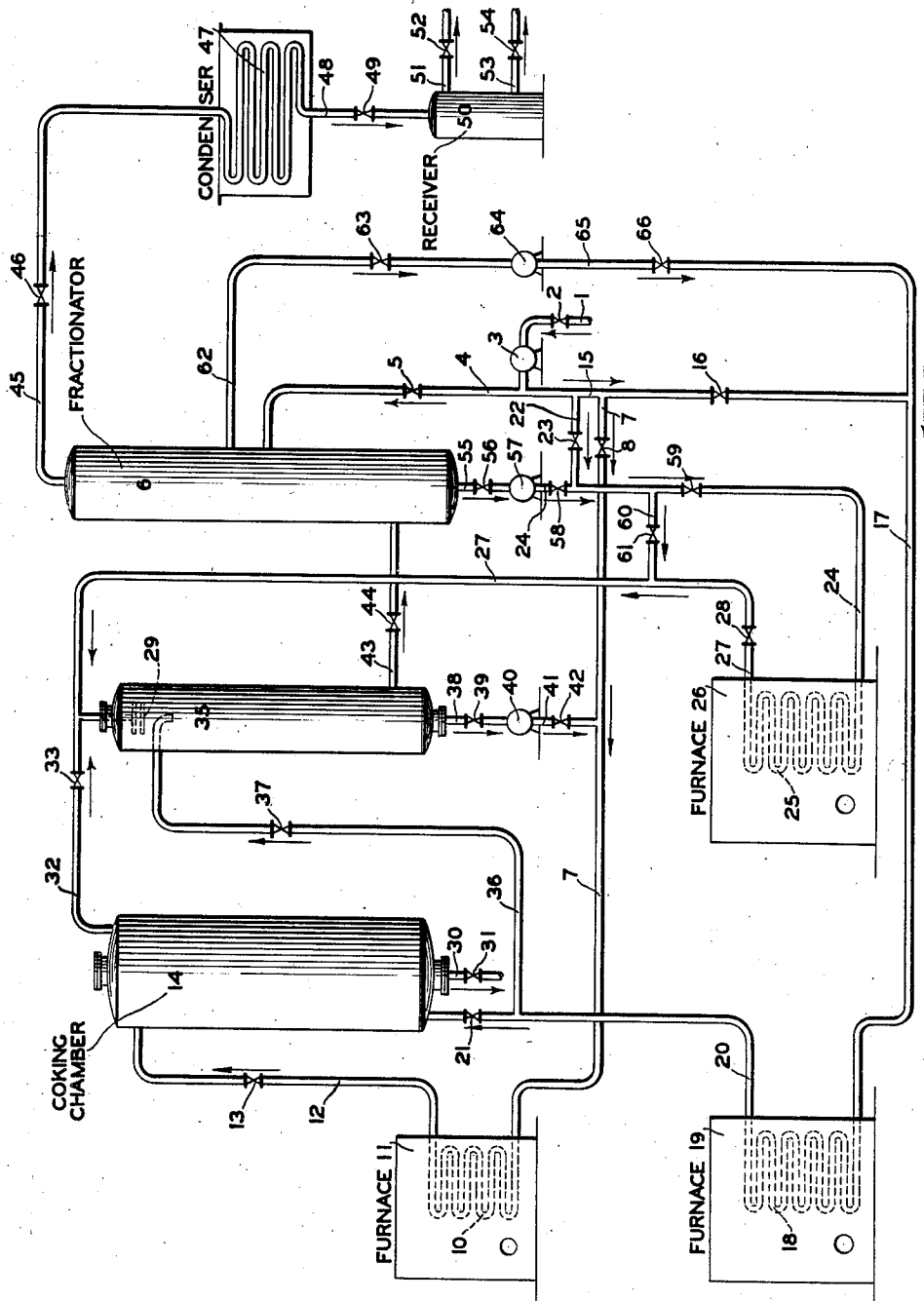
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CONVERSION OF HYDROCARBON OILS

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CONVERSION OF HYDROCARBON OILS

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This invention particularly refers to an improved process for the selective conversion of relatively low boiling and high boiling hydrocarbon oils under independently controlled conversion conditions of cracking temperature and superatmospheric pressure, reduction of the residual liquid conversion products of the process to coke in a relatively high pressure zone of the system, and continued conversion of the vaporous products from the coking operation in a high pressure reaction chamber together with other highly heated products of the process.

In one embodiment, the invention comprises separating intermediate liquid conversion products of the process (reflux condensate formed by fractionation of the vaporous conversion products) into selected relatively low boiling and high boiling fractions, subjecting the high boiling fractions, either alone or together with hydrocarbon oil charging stock of a similar nature, to conversion conditions of cracking temperature and superatmospheric pressure in a heating coil, introducing the resulting heated products into an enlarged reaction chamber maintained at a substantial superatmospheric pressure wherein vaporous and residual liquid conversion products separate, withdrawing vaporous products from the reaction chamber, subjecting the same to fractionation for the formation of said reflux condensate, subjecting fractionated vapors of the desired end boiling point to condensation, recovering the resulting distillate, separately removing residual liquid conversion products from the reaction chamber, heating the same, either alone or together with hydrocarbon oil charging stock of high boiling characteristics, to a high conversion temperature under non-coking conditions in a separate heating coil, introducing the heated products into a coking chamber, preferably maintained at a slightly higher superatmospheric pressure than that employed in the reaction chamber, wherein their non-vaporous components are reduced to coke, supplying vaporous products from the coking chamber to further conversion in the reaction chamber, subjecting said selected low boiling fractions of the intermediate liquid conversion products (reflux condensate), either alone or together with hydrocarbon oil charging stock for the process of a similar nature, to independently controlled conversion conditions of cracking temperature and superatmospheric pressure in another separate heating coil, and introducing the heated products therefrom into either the reaction chamber or the coking chamber or, in part, to both.

As an alternative to the method of operation above outlined which, however, is not to be considered equivalent, the high boiling fractions of the intermediate liquid conversion products (reflux condensate), either alone or together with

hydrocarbon oil charging stock of a similar nature may, instead of being subjected to conversion in a heating coil, be supplied directly to the reaction chamber, in which case all or at least a substantial portion of the highly heated products from the relatively light oil heating coil of the system are also introduced directly into the reaction chamber to commingle with and effect conversion therein of said relatively high boiling oils.

The process offers a wide degree of flexibility with respect to the type of charging stock employed since it may, depending upon its characteristics, be subjected to conversion together with either the relatively low boiling or the relatively high boiling intermediate liquid conversion products or the residual liquid conversion products withdrawn from the reaction chamber or it may be separated, together with the intermediate liquid conversion products, into selected relatively low boiling and high boiling fractions which are separately subjected to conversion. On the other hand, two or more charging stocks of different characteristics may be employed, when desired, each being subjected to conversion in that stage of the system employing the most suitable conditions.

The features and advantages of the invention will be more apparent with reference to the accompanying diagrammatic drawing and the following description thereof. The drawing illustrates one specific form of apparatus embodying the features of the invention and permitting the alternative methods of operation above outlined.

Referring to the drawing, charging stock for the process, which may comprise any desired type of hydrocarbon oil, is supplied through line 1 and valve 2 to pump 3 by means of which it may be directed, all or in part, through line 4 and valve 5 into fractionator 6 wherein it commingles with the vaporous conversion products undergoing fractionation in this zone and is subjected therewith to fractionation. In this manner the charging stock may be separated, together with reflux condensate formed in the fractionator, into selected relatively low boiling and high boiling fractions which are subjected to separate conversion within the system, as will be later described. This method of operation is particularly desirable in case the charging stock comprises an oil of relatively wide boiling range but it may be employed, when desired, whenever the charging stock does not contain an appreciable quantity of undesirable low boiling fractions which will commingle with and contaminate the overhead vaporous product from the fractionator if supplied to this zone and when it does not contain an appreciable quantity of undesirable high boiling fractions which, if supplied to the fractionator, will contaminate the reflux condensate.

When the charging stock is an oil of relatively low boiling characteristics comprising, for example, such materials as straight-run gasoline or other motor fuel or motor fuel fractions of inferior quality, kerosene, kerosene distillate, pressure distillate bottoms, light gas oil and the like it is preferably directed from pump 3 through line 15, valve 16 and line 17 to conversion in heating coil 18 together with the selected relatively low boiling fractions of the intermediate liquid conversion products of the process, which are supplied to heating coil 18 in the manner to be later described.

When the charging stock is an oil of exceptionally high boiling characteristics such as heavy crude petroleum, fuel oil, heavy topped crude or other oil of a heavy residual nature it is preferably diverted from line 15 through line 7 and valve 8 to conversion in heating coil 10 together with the residual liquid conversion products supplied to this zone from the reaction chamber, as will be later more fully described.

When the charging stock is an oil of intermediate boiling range characteristics such as, for example, gas oil, relatively light fuel oil or topped crude or the like it is preferably diverted from line 15 through line 22 and valve 23 into line 24 to commingle therein with the relatively high boiling fractions of the intermediate liquid conversion products of the process and be subjected therewith to conversion within the system, as will be later more fully described.

The relatively low boiling oils supplied to heating coil 18 are subjected in this zone to the desired relatively high conversion temperature, preferably at a substantial superatmospheric pressure, by means of heat supplied from a furnace 19 of suitable form and the heated products are discharged from the heating coil through line 20 wherefrom they may be directed, all or in part, through valve 21 in this line into coking chamber 14 or, all or in part, through line 36 and valve 37 into reaction chamber 35. When supplied, all or in part, to coking chamber 14, the highly heated products from heating coil 18 commingle in this zone with the nonvaporous conversion products undergoing coking therein and serve to assist their reduction to coke. When supplied, all or in part, to reaction chamber 35 the highly heated products from heating coil 18 commingle in this zone with the vaporous products from coking chamber 14, supplied thereto as will be later more fully described, and with the other oils supplied to this zone, as will be later more fully described, serving to supply heat to and assist conversion of the commingled materials in the reaction chamber.

Reaction chamber 35 is preferably maintained at a substantial superatmospheric pressure and, although not indicated in the drawing, this zone is preferably insulated in order to conserve heat so that the oils supplied to this zone, and more particularly their vaporous components, are subjected to appreciable continued conversion therein. In the particular case here illustrated, vaporous and residual liquid conversion products are separated in the lower portion of chamber 35 and separately withdrawn therefrom, the latter being directed through line 38 and valve 39 to pump 40 by means of which they are supplied through line 41, valve 42 and line 7 to conversion in heating coil 10, while the vaporous conversion products are directed from a somewhat higher point in the lower portion of the chamber

through line 43 and valve 44 to fractionation in fractionator 6.

The heavy residual oils supplied to heating coil 10 are preferably heated to a high conversion temperature in this zone, by means of heat supplied from a suitable furnace 11, without allowing the oil to remain within the heating coil for a sufficient length of time to permit any substantial formation and deposition of coke in this zone and in the communicating lines. The heated products are discharged from heating coil 10 through line 12 and valve 13 into coking chamber 14 wherein their non-vaporous components are reduced to substantially dry coke.

The coke produced in chamber 14 is allowed to accumulate within this zone until the chamber is substantially filled or until its operation is completed for any other reason following which the coke may be removed in any well known manner (not shown) and the chamber prepared for further operation. When desired, a plurality of coking chambers may be employed, although only one is illustrated in the drawing, in which case the chambers preferably are alternately operated, cleaned and prepared for further operation in order that the coking stage, in common with the rest of the system, may be operated continuously. Chamber 14 is provided with a suitable drain-line 30, controlled by valve 31, and this line may also serve, when desired, as a means of introducing steam, water or other suitable cooling material into the chamber after its operation is completed and after it has been isolated from the rest of the system in order to hasten cooling and facilitate cleaning of the chamber. Chamber 14 is preferably operated at a slightly higher superatmospheric pressure than that employed in reaction chamber 35 by means of which the vaporous products withdrawn from the upper portion of the coking chamber may be directed through line 32 and valve 33 into reaction chamber 35 without the aid of a pump or compressor, although it is entirely within the scope of the invention, when desired, to operate chamber 14 at any desired pressure down to substantially atmospheric and to employ a pump or compressor (not shown) in line 32.

The vaporous products from the coking chamber supplied to reaction chamber 35, as described, commingle in this zone with the other oils supplied thereto and are subjected therewith to continued conversion in the reaction chamber. This method of operation also serves as a means of separating from the vaporous products of the coking operation any entrained heavy liquid particles, such as tars and pitch-like material or other undesirable heavy components of a high coke-forming nature, which commingle in chamber 35 with the residual liquid conversion products and are supplied therewith to further treatment, in the manner previously described, in heating coil 10.

The vaporous conversion products supplied, as described, to fractionator 6 are subjected to fractionation in this zone, either alone or together with any charging stock supplied thereto, as previously described, for the formation of reflux condensate comprising the components of the vaporous conversion products or the vaporous conversion products and commingled charging stock boiling above the range of the desired final light distillate product of the process.

Fractionated vapors of the desired end boiling point are withdrawn from the upper portion of the fractionator together, with uncondensable gas

produced by the operation, and directed through line 45 and valve 46 to condensation and cooling in condenser 47. The resulting distillate and uncondensed gases pass through line 48 and valve 49 to collection and separation in receiver 50. The gas may be released from the receiver through line 51 and valve 52. Distillate may be withdrawn from receiver 50 through line 53 and valve 54 to storage or to any desired further treatment. When desired, regulated quantities of the distillate collected in receiver 50 may be recirculated, by well known means (not shown) to the upper portion of fractionator 6 to serve as a refluxing and cooling medium in this zone for assisting fractionation of the vapors and to maintain the desired vapor outlet temperature therefrom.

The reflux condensate formed in fractionator 6 is separated by fractional distillation in this zone into selected relatively low boiling and high boiling fractions. The selected low boiling fractions are withdrawn, either alone or together with any corresponding charging stock or fraction thereof supplied to the fractionator, from one or a plurality of suitable intermediate points in this zone, provision being made, in the case here illustrated, for removing the relatively low boiling oil from the fractionator through line 62 by means of which it is directed through valve 63 to pump 64 and supplied therefrom through line 65, valve 66 and line 17 to conversion, in the manner previously described, in heating coil 18.

The relatively high boiling fractions of the reflux condensate are withdrawn from the lower portion of the fractionator, either alone or together with any high boiling charging stock or high boiling components thereof supplied to this zone, and directed through line 55 and valve 56 to pump 57 by means of which this relatively high boiling oil is fed through line 24 and valve 58 and may be directed through valve 59 in this line to conversion in heating coil 25 or may be diverted therefrom through line 60 and valve 61 into line 27 to be directed therefrom into reaction chamber 35 and subjected to conversion therein.

The oils supplied to heating coil 25 are subjected therein to the desired conversion temperature, preferably at a substantial superatmospheric pressure, by means of heat supplied from a furnace 26 of suitable form and the heated products are discharged through line 27 and valve 28 into reaction chamber 35, preferably being directed against the inner surface of the walls of this zone by means of a suitable spreader flange or spray arrangement such as indicated at 29, whereby the heavy liquid components of the heated oils contact the walls of the chamber and pass rapidly downward thereover to its lower portion while the vaporous components commingle with the other heated products supplied to this zone and are subjected therewith to appreciable continued conversion in the reaction chamber.

The preferred range of operating conditions which may be employed to accomplish the desired results in an apparatus such as illustrated and above described may be approximately as follows: The heating coil to which the relatively high boiling reflux condensate is supplied, when such a zone is utilized, may employ an outlet conversion temperature ranging, for example, from 825 to 950° F., preferably with a superatmospheric pressure at this point in the system of from 100 to 500 pounds, or thereabouts, per

square inch. The reaction chamber is preferably maintained at a substantial superatmospheric pressure of the order of 100 to 500 pounds, or thereabouts, per square inch, and a slightly higher pressure than that employed in the reaction chamber is preferred in the coking zone. The pressures employed in the fractionating, condensing and collecting portions of the system may be substantially the same or lower than the pressure employed in the reaction chamber. The heating coil to which the low boiling fractions of the reflux condensate are supplied preferably employs an outlet conversion temperature of from 900 to 1050° F. and a superatmospheric pressure substantially the same or higher than that employed in the reaction chamber is preferred at the outlet from this coil ranging, for example, from 200 to 800 pounds, or more, per square inch. The temperature employed at the outlet from the heating coil to which the heavy residual liquid from the reaction chamber is supplied may range, for example, from 800 to 1050° F., the preferred range being from 900 to 1000° F. The pressure employed at this point in the system preferably is substantially the same or somewhat higher than that employed in the coking zone.

As a specific example of the operation of the process as it may be accomplished in an apparatus such as illustrated and above described: The charging stock is an East Texas crude oil of about 39° A. P. I. gravity containing approximately 32% of straight-run gasoline boiling up to 400° F. The charging stock is supplied to the fractionator of the system from which materials having an end-boiling point of approximately 385° F. are recovered as the overhead motor fuel product while the higher boiling fractions of the commingled charging stock and vaporous conversion products are separated into materials boiling above and below approximately 550° F. The high boiling fractions of the charging stock and reflux condensate are subjected in a heating coil to an outlet conversion temperature of approximately 925° F. at a superatmospheric pressure of about 200 pounds per square inch. Substantially the same pressure is employed in the reaction chamber to which these heated products are supplied. The low boiling fractions of the commingled charging stock and reflux condensate are subjected in a separate heating coil to an outlet conversion temperature of approximately 950° F. at a superatmospheric pressure of approximately 400 pounds per square inch, approximately 20% by volume of the heated products being introduced into the coking chamber and the remainder supplied to the reaction chamber. Residual liquid from the reaction chamber is quickly heated in another separate heating coil to an outlet conversion temperature of approximately 950° F. and the resulting heated products are introduced into alternately operated coking chambers maintained at a superatmospheric pressure of approximately 210 pounds per square inch. Vaporous products from the coking zone are introduced into the reaction chamber. This operation will produce, per barrel of charging stock, approximately 70% of good anti-knock motor fuel (including the straight-run gasoline recovered from the charging stock) and approximately 55 pounds of low volatile coke of uniform quality and good structural strength, the remainder being chargeable, principally, to uncondensable gas.

I claim as my invention:

1. In a process for the conversion of hydrocarbon oils, wherein an oil of relatively high boiling characteristics is subjected to conversion conditions of cracking temperature and superatmospheric pressure in a heating coil, the heated products introduced into an enlarged reaction chamber, also maintained at a substantial superatmospheric pressure and at cracking temperature, wherein vaporous and residual liquid conversion products separate, the vapors subjected to fractionation for the formation of reflux condensate which is separated into selected relatively low boiling and high boiling fractions, the latter returned to said heating coil for further cracking, fractionated vapors of the desired end boiling point subjected to condensation and the resulting distillate recovered, the improvement which comprises separately removing residual liquid conversion products from the reaction chamber, heating the same to a high conversion temperature under non-coking conditions in a separate heating coil, introducing the resulting heated products into an enlarged coking chamber wherein their non-vaporous components are reduced to coke, withdrawing vaporous products from the coking chamber and supplying the same for further cracking to the reaction chamber, subjecting said selected low boiling fractions of the reflux condensate to independently controlled conversion conditions of cracking temperature and superatmospheric pressure in another separate heating coil, and introducing regulated quantities of the resulting heated products into the reaction chamber.

2. In a process for the conversion of hydrocarbon oils wherein an oil of relatively low boiling characteristics is subjected to conversion conditions of cracking temperature and superatmospheric pressure in a heating coil, the resulting heated products introduced, at least in part, into a reaction chamber also maintained at substantial superatmospheric pressure and at cracking temperature, wherein vaporous and residual liquid conversion products are separated, the vapors withdrawn from the reaction chamber and subjected to fractionation for the formation of reflux condensate which is separated into selected relatively low boiling and high boiling fractions, said relatively low boiling fractions of the reflux condensate returned to the heating coil for further cracking, fractionated vapors of the desired end boiling point subjected to condensation and the resulting distillate recovered, the improvement which comprises separately removing residual liquid conversion products from the reaction chamber, subjecting the same to a high conversion temperature under non-coking conditions in a separate heating coil, introducing the resulting heated products into an enlarged coking chamber wherein their non-vaporous components are reduced to coke, withdrawing vaporous products from the coking chamber and introducing the same into the reaction chamber wherein they are subjected to continued cracking, subjecting said high boiling fractions of the reflux condensate to independently controlled conversion conditions of cracking temperature and superatmospheric pressure in another separate heating coil, and introducing the resulting heated products into the reaction chamber.

3. A hydrocarbon oil conversion process which

comprises fractionating cracked vapors to form relatively heavy and light reflux condensates, passing resultant lighter reflux condensate through a heating coil and heating the same therein to cracking temperature under pressure, discharging at least a portion of the heated products from said coil into a reaction zone maintained under cracking conditions of temperature and pressure, subjecting heavier reflux condensate formed by said fractionation to independently controlled cracking conditions of temperature and pressure in a second heating coil and introducing it to the reaction zone and subjecting the same to conversion therein, heating liquid conversion products from the reaction zone to coking temperature and distilling the same to coke in a coking zone, introducing vapors evolved in the coking zone into the reaction zone and subjecting the same to conversion therein, removing vaporous conversion products from the reaction zone and supplying the same to the fractionating step as said cracked vapors, and finally condensing the fractionated vapors.

4. A hydrocarbon oil conversion process which comprises fractionating cracked vapors to form relatively heavy and light reflux condensates, heating such heavy and light reflux condensates to cracking temperature under pressure in separate heating coils, the lighter reflux condensate being heated to higher temperature than the heavier reflux condensate, discharging the heated heavier reflux condensate into a reaction zone maintained under cracking conditions of temperature and pressure, heating liquid conversion products from the reaction zone to coking temperature and distilling the same to coke in a coking zone, introducing at least a portion of the heated lighter reflux condensate into the coking zone to assist the coking of said liquid products therein, discharging another portion of the heated lighter reflux condensate into the reaction zone, introducing vapors evolved in the coking zone into the reaction zone and subjecting the same to conversion therein, removing vaporous conversion products from the reaction zone and supplying the same to the fractionating step as said cracked vapors, and finally condensing the fractionated vapors.

5. A hydrocarbon oil conversion process which comprises fractionating cracked vapors to form relatively heavy and light reflux condensates, heating such heavy and light reflux condensates to cracking temperature under pressure in separate heating coils, the lighter reflux condensate being heated to higher temperature than the heavier reflux condensate, discharging the heated heavier reflux condensate into a reaction zone maintained under cracking conditions of temperature and pressure, heating liquid conversion products from the reaction zone to coking temperature and distilling the same to coke in a coking zone, introducing at least a portion of the heated lighter reflux condensate and vapors evolved in the coking zone into the reaction zone and subjecting the last-named vapors to conversion therein, removing vaporous conversion products from the reaction zone and supplying the same to the fractionating step as said cracked vapors, and finally condensing the fractionated vapors.

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