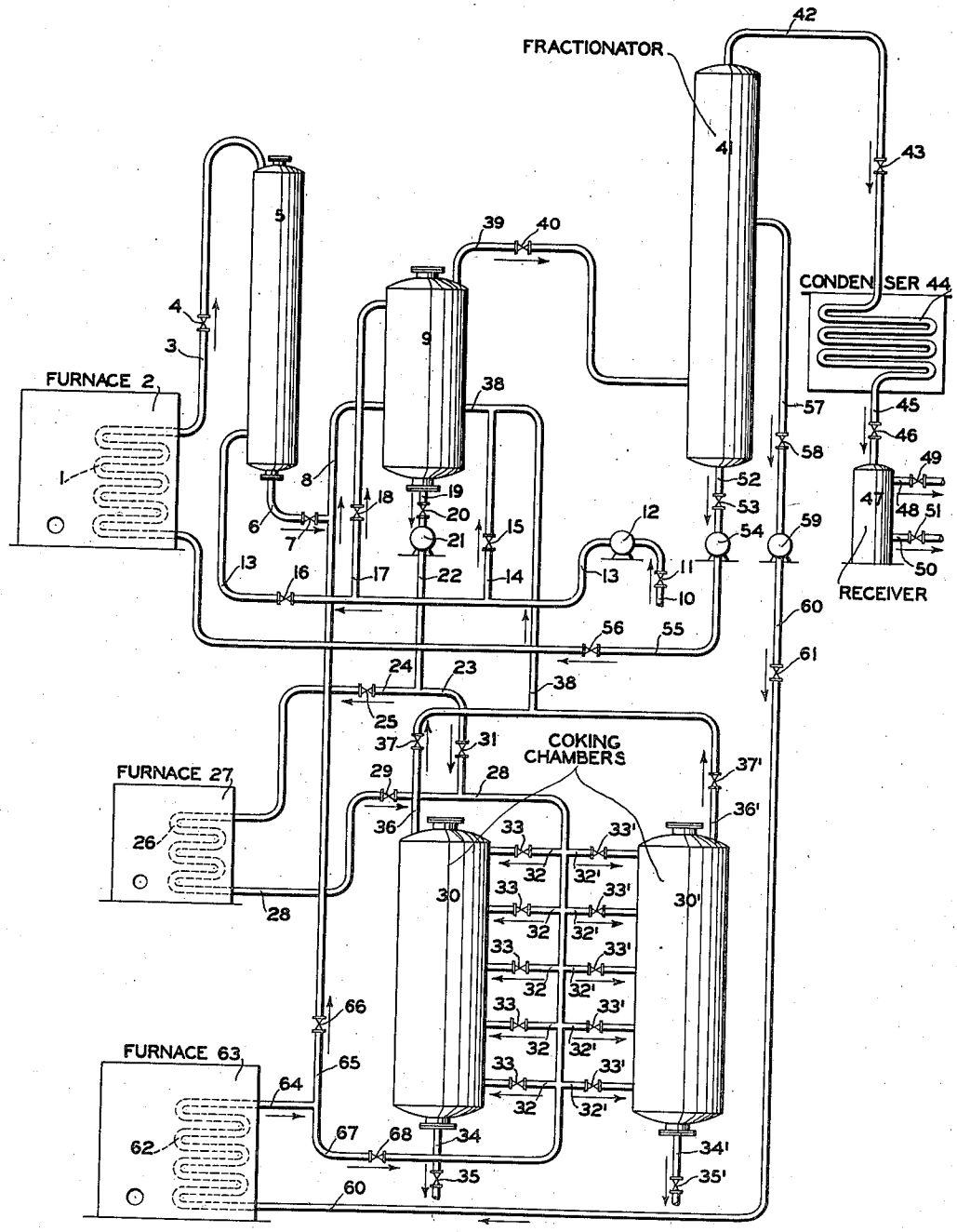
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CONVERSION OF HYDROCARBON OILS

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CONVERSION OF HYDROCARBON OILS

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This invention refers to an improved process for the fractional distillation of hydrocarbon oils of relatively wide boiling range accompanied by conversion of their low-boiling fractions, together with the intermediate conversion products of the process, and reduction of their high-boiling fractions to coke, together with residual liquids resulting from said conversion.

The present invention is particularly directed to the treatment of hydrocarbon oils of relatively wide boiling range such as crude petroleum, topped crude and the like which contain an appreciable quantity of high-boiling materials of a relatively high coke-forming nature unsuitable for conversion under the relatively severe conversion conditions best suited to the treatment of their lower boiling components.

In accordance with the invention the high-boiling fractions of the charging stock of a relatively high coke-forming nature are separated from its lower boiling components by commingling the charging stock with hot conversion products of the process in the stage of the system wherein separation of vaporous and residual liquid conversion products is accomplished, its low-boiling components being thereby vaporized and subjected to fractionation together with the vaporous conversion products of the process and to the further treatment afforded the intermediate conversion products (reflux condensate) resulting from said fractionation while said high-boiling components of the charging stock commingle with the residual liquid conversion products and are subjected therewith to coking.

Coking of the high-boiling fractions of the charging stock and the residual liquid conversion products may be accomplished, in accordance with the invention, by passing the commingled oils through a heating coil into one or a plurality of enlarged coking chambers; the oils being subjected in the heating coil to a temperature sufficient to effect reduction of the oil to substantially dry coke in the succeeding coking zone without allowing it to remain in the heating coil for a sufficient length of time to permit any substantial formation and deposition of coke in this zone. On the other hand the residual liquid conversion products and the high-boiling fractions of the charging stock may, when desired, be supplied to the coking zone without additional heating, in which case a suitable heat carrying medium is preferably introduced into the coking zone to assist the coking operation or, when desired, heating of the high-boiling oils may be employed in conjunction with the use of a heat carrying medium supplied to the coking zone.

In accordance with one method of operation, the intermediate conversion products of the process and the low-boiling fractions of the charging stock may be separated, by fractional condensation in the fractionator of the system to which they are supplied in vaporous state, into selected relatively low-boiling and high-boiling fractions, said low-boiling and high-boiling fractions being subjected to independently controlled conversion conditions in separate heating coils of the system. When this method of operation is employed a regulated portion or all of the highly heated relatively low-boiling products from the heating coil to which said low-boiling fractions are supplied may, when desired, be introduced into the coking zone as a heat carrying medium for assisting the coking operation.

Another feature of the invention comprises returning the vaporous products from the coking zone to the vaporizing chamber of the cracking system wherein said separation of vaporous and liquid conversion products and substantial vaporization of the charging stock is accomplished. By this method of operation the heat contained in the relatively hot vaporous products from the coking zone is utilized to assist vaporization of the low-boiling fractions of the charging stock and this heat exchange serves, on the other hand, to cool the vaporous products from the coking zone sufficiently to effect the removal therefrom of entrained heavy liquids and similar high-boiling materials of a high coke-forming nature and said high-boiling materials commingled in the vaporizing chamber with the residual liquid conversion products and the non-vaporous high-boiling fractions of the charging stock and are returned therewith to the coking zone.

In one embodiment, the invention comprises subjecting an oil recovered from within the system to conversion conditions of cracking temperature and superatmospheric pressure in a heating coil and communicating reaction chamber, withdrawing vaporous and liquid conversion products from the reaction chamber and introducing the same into a reduced pressure vaporizing chamber wherein separation of vaporous and residual liquid conversion products is accomplished, supplying hydrocarbon oil charging stock for the process to said vaporizing chamber whereby its low-boiling components are vaporized and separated from its non-vaporous high-boiling components, withdrawing residual liquid conversion products and said high-boiling fractions for the

charging stock from the vaporizing chamber and subjecting the same to coking in a coking chamber, returning vaporous products from the coking chamber to said vaporizing chamber, subjecting vaporous products from the vaporizing chamber, comprising said low-boiling fractions of the charging stock and the vaporous products from the cracking and coking operation, to fractionation whereby their insufficiently converted components are condensed as reflux condensate and separated into selected relatively low-boiling and high-boiling fractions, subjecting fractionated vapors of the desired end-boiling point to condensation, collecting and separating the resulting distillate and gas, supplying the high-boiling fractions of said reflux condensate to the first mentioned heating coil for said conversion, subjecting the selected low-boiling fractions of said reflux condensate to independently controlled conversion conditions of cracking temperature and superatmospheric pressure in a separate heating coil, introducing a regulated portion of the resulting highly heated products into the coking chamber and supplying the remainder to said vaporizing chamber.

The accompanying diagrammatic drawing illustrates one specific form of apparatus in which the process of the present invention as outlined in the foregoing specific embodiment may be accomplished. The apparatus illustrated also provides for various alternative methods of operation, some of which have been previously mentioned and all of which are entirely within the scope of the present invention. It will be understood, of course, that the various alternative methods of operation illustrated and described are not equivalent but may be selected to suit requirements and serve to give the process greater flexibility.

Referring to the drawing, heating coil 1 is located within a furnace 2 of any suitable form and the oil supplied thereto, as will be later more fully described, is heated to the desired conversion temperature, preferably at a substantial superatmospheric pressure, and the heated products are discharged through line 3 and valve 4 into reaction chamber 5.

Chamber 5 is also preferably maintained at a substantial superatmospheric pressure and, although not illustrated in the drawing, this zone is preferably insulated in order to prevent the excessive loss of heat therefrom by radiation so that conversion of the heated oil supplied thereto, and particularly its vaporous components, may continue in the reaction chamber. In the case here illustrated, both vaporous and liquid conversion products are withdrawn in commingled state from the lower portion of chamber 5 through line 6 and valve 7 and are introduced through line 8 into vaporizing chamber 9.

Simultaneous with the operation above described, hydrocarbon oil charging stock for the process is supplied through line 10 and valve 11 to pump 12 by means of which it is fed through line 13 and may be introduced through line 14, valve 15 and line 38 into vaporizing chamber 9 to commingle therein with the hot conversion products of the process supplied to this zone. The charging stock is subjected to vaporization in chamber 9 by means of heat recovered from the hot conversion products with which it is commingled in this zone whereby its high-boiling components, comprising materials of a high coke-forming nature which remain unvaporized, are separated from its lower boiling vaporous components. In order to assist vaporization of the charging stock and further vaporization of the liquid conversion products supplied to chamber 9 from the reaction chamber the vaporizing chamber is preferably operated at a substantially reduced pressure relative to that employed in the reaction chamber.

It is also within the scope of the invention, instead of supplying all of the charging stock direct to vaporizing chamber 9, to introduce a regulated portion or all of the charging stock through valve 16 in line 13 into the lower portion of reaction chamber 5 to commingle with and cool the conversion products withdrawn from this zone to chamber 9 in the manner previously described, or when desired, a portion or all of the charging stock may be commingled in line 6 or in line 8 with the stream of conversion products passing from chamber 5 to chamber 9, although means for accomplishing this are not illustrated in the drawing. The present invention also contemplates the introduction of a regulated portion or all of the charging stock, when desired, through line 17 and valve 18 into the upper portion of vaporizing chamber 9, wherein suitable baffles or other fractionating means, not illustrated, may be employed, the charging stock thereby serving as a washing or refluxing medium to assist the removal of any undesirable high-boiling materials from the vaporous products in the vaporizing chamber prior to their fractionation for the formation of reflux condensate.

The residual liquids remaining unvaporized in chamber 9, comprising residual liquid conversion products of the process and high-boiling fractions of the charging stock, are withdrawn from the lower portion of this zone through line 19 and valve 20 to pump 21 by means of which they are fed through line 22 and may be directed through line 23, valve 31 and line 28 into coking chambers 30 and 30', being supplied thereto at any desired point or plurality of points by means of a plurality of lines 32 and 32' controlled by the respective valves 33 and 33', or the high-boiling oils from chamber 9 may be directed from line 22 through line 24, valve 25, heating coil 26, line 28 and valve 29 into coking chambers 30 and 30' through one or a plurality of the respective lines 32 and 32' controlled by the respective valves 33 and 33'.

Heating coil 26 is located within a suitable furnace 27 and, although indicated in a conventional manner in the drawing, the form of furnace 27 and heating coil 26 is preferably such that relatively high rates of heating are obtained in this zone so that the heavy oils supplied thereto are quickly heated to a temperature sufficient to effect their subsequent reduction to coke in coking chambers 30 and 30' without allowing them to remain in the heating coil for a sufficient length of time to permit any substantial formation and deposition of coke in the heating coil and the lines communicating with the coking chambers.

Coking chambers 30 and 30' are similar zones wherein reduction of the relatively heavy oils from chamber 9 to substantially dry coke is accomplished. It will be understood that although two coking chambers are shown in the drawing one or any desired number of a plurality of such zones may be employed when desired and, when a plurality is employed, the chambers may be simultaneously operated or, preferably, are alternately operated, cleaned and prepared for further operation in order that the coking stage

of the process, in common with the rest of the system, may be operated continuously. The coke produced may be allowed to accumulate within the coking chamber to be removed therefrom in any suitable well known manner, not illustrated, after the operation of the chamber is completed. Chambers 30 and 30' are provided with suitable drain lines 34 and 34' respectively controlled by the respective valves 35 and 35'. The drain lines may also serve, when desired, as a means of introducing steam, water or any other suitable cooling medium into the chambers, after their operation has been completed and after they have been isolated from the rest of the system, in order to hasten cooling and facilitate the removal of coke. Vaporous products are withdrawn from chambers 30 and 30' through the respective lines 36 and 36' controlled by the respective valves 37 and 37' and are directed through line 38 into vaporizing chamber 9, entering this zone at any desired point. In the case here illustrated the vaporous products from the coking zone commingle in line 38 with hydrocarbon oil charging stock for the process which is supplied to the vaporizing chamber, although they may, of course, be otherwise supplied to the vaporizing chamber in any desired manner.

The vaporous products from chamber 9, including the components of the charging stock vaporized in this zone as well as the vaporous conversion products from the reaction chamber and from the coking chambers which remain uncondensed in this zone, are directed through line 39 and valve 40 to fractionation in fractionator 41, wherein their components boiling above the range of the desired final light distillate product of the process are condensed as reflux condensate. Fractionated vapors of the desired end-boiling point are withdrawn, together with uncondensable gas produced by the process, from the upper portion of fractionator 41 through line 42 and valve 43 and are subjected to condensation in condenser 44. The resulting distillate and gas passes through line 45 and valve 46 to collection and separation in receiver 47. Uncondensable gas may be released from the receiver through line 48 and valve 49. Distillate is withdrawn from receiver 47 through line 50 and valve 51 to storage or to any desired treatment. When desired, a regulated portion of the distillate collected in receiver 47 may be recirculated by well known means, not shown in the drawing, to the upper portion of fractionator 41 to serve as a cooling and refluxing medium for assisting fractionation of the vapors and to maintain the desired vapor outlet temperatures from the frictionator.

The reflux condensate formed in fractionator 41 may collect within the lower portion of this zone to be withdrawn therefrom through line 52 and valve 53 to pump 54 by means of which it is supplied through line 55 and valve 56 to conversion, as heretofore described, in heating coil 1. It is, however, also within the scope of the invention to separate the reflux condensate formed in fractionator 41 into selected relatively low-boiling and high-boiling fractions in which case only the high-boiling fractions are supplied, as described, to heating coil 1; the low-boiling fractions being removed from the fractionator at any suitable intermediate point or plurality of points in this zone and, in the case here illustrated, the low-boiling reflux condensate is directed through line 57 and valve 58 to pump 59 by means of which it is supplied through line 60 and valve 61 to separate conversion in heating coil 62.

A furnace 63 of any suitable form supplies the required heat to the oil passing through heating coil 62 to subject the same to the desired conversion temperature, preferably at a substantial superatmospheric pressure, and the heated products are discharged from the heating coil through line 64 wherefrom they may be directed, all or in part, through line 65, valve 66 and line 8 into vaporizing chamber 9 or, when desired, the heated products from heating coil 62, instead of commingling in line 8 with the conversion products from chamber 5, may be separately supplied to the vaporizing chamber at any desired point or plurality of points in this zone, by well known means not shown in the drawing. Provision is also made for supplying a regulated portion or all of the hot conversion products from heating coil 62 into coking chambers 30 and 30' to serve as a heat-carrying medium for assisting reduction of the residual materials in the coking chambers to substantially dry coke. This may be accomplished by means of line 67, valve 68 and one or more the various branch lines 32 and 32' controlled by the respective valves 33 and 33'. It is particularly desirable, in case heating coil 26 is not employed, to employ heating coil 62 for separate conversion of the relatively low-boiling oils from fractionator 41 and to supply regulated quantities of the highly heated products from heating coil 62 to the coking zone to furnish additional heat thereto for assisting the coking operation. It is also entirely within the scope of the present invention to accomplish reduction of the high-boiling oils from chamber 9 to coke by further heating of the same in heating coil 26 in conjunction with the use of a heat-carrying medium in the coking chambers. The invention is, however, not limited to either of the methods of coking illustrated and described but may employ any suitable well known method and means such as externally heated coking chambers or suitable coking ovens or retorts, either alone or in conjunction with either or both of the specific methods illustrated.

In an apparatus such as illustrated and above described, the preferred range of operating conditions for accomplishing the objects of the invention may be approximately as follows: The heating coil to which the total reflux condensate, or only high-boiling fractions of the reflux condensate, are supplied may utilize a conversion temperature, measured at the outlet therefrom, ranging, for example, from 850 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 pressure employed in the reaction chamber may be substantially equalized or somewhat reduced relative to the pressure employed in the preceding heating coil. The vaporizing chamber is preferably operated at a substantially reduced pressure relative to that employed in the reaction chamber which may range, for example, from 100 pounds, or thereabouts, per square inch, down to substantially atmospheric pressure. The fractionating, condensing and collecting portions of the system may employ pressures substantially the same or somewhat lower than that employed in the vaporizing chamber. When a heating coil is employed for heating of the high-boiling oils from the vaporizing chamber, prior to their introduction into the coking chamber, the temperature employed at the outlet from this zone is preferably of the order of 900 to 1000° F., or thereabouts, with a pressure at this point in the system which may range, for ex-

ample, from a slight super-atmospheric pressure of 30 pounds or less per square inch up to a superatmospheric pressure of 200 pounds, or more, per square inch. The pressure employed in the coking chambers is preferably somewhat higher than that employed in the vaporizing chamber in order to permit the return of vapors from the coking chamber to the vaporizing chamber without the use of a pump or compressor and may range upward from 30 pounds, or less, per square inch to 200 pounds, or more, per square inch superatmospheric pressure. When a separate heating coil is employed for conversion of the low-boiling fractions of the reflux condensate the conversion temperature employed at the outlet from this zone may range, for example, from 900 to 1050° F., or thereabouts, and preferably a superatmospheric pressure of the order of 200 to 800 pounds, or more, per square inch, is employed at this point in the system, although lower pressures down to substantially the same as that employed in the coking chamber may be utilized, when desired.

As a specific example of one of the many possible operations of the process of the present invention as it may be accomplished in an apparatus such as illustrated and above described, the charging stock comprises a California crude of about 20.5° A. P. I. gravity containing approximately 12 percent of material boiling up to 400° F. and it is supplied to the vaporizing chamber of the cracking system. The reflux condensate is separated into fractions boiling above and below approximately 500° F. The high-boiling fractions are subjected in a heating coil to an outlet conversion temperature of approximately 950° F. at a superatmospheric pressure of about 300 pounds per square inch and are introduced into a reaction chamber operated at substantially the same pressure. Both vaporous and liquid products from the reaction chamber are introduced into the vaporizing chamber which is maintained at a superatmospheric pressure of approximately 45 pounds per square inch and from which residual liquid is withdrawn and subjected in a separate heating coil to a temperature of approximately 985° F. at a superatmospheric pressure of about 60 pounds per square inch and then introduced into alternately operated coking chambers maintained at substantially the same pressure. Vaporous products from the coking chambers are returned to the vaporizing chamber and the vaporous products from this zone are subjected to fractionation for the formation of said reflux condensate. The low-boiling fraction of the reflux condensate, which boil within the range of substantially 350 to 500° F., are subjected in another separate heating coil to an outlet conversion temperature of approximately 975° F. at a superatmospheric pressure of about 600 pounds per square inch. A portion of the highly heated products from the last mentioned heating coil is introduced into the body of residual materials undergoing coking in the coking chambers and the remainder supplied to the vaporizing chamber. This operation will produce, per barrel of charging stock, approximately 55 percent of motor fuel having an octane number of approximately 70 by the motor method and approximately 110 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 intermediate conversion products of the process are subjected to conversion conditions of cracking temperature and superatmospheric pressure in a heating coil and communicating reaction chamber, both vaporous and liquid conversion products withdrawn from the reaction chamber and introduced into a reduced pressure vaporizing chamber wherein separation of vaporous and liquid conversion products is accomplished, the improvement which comprises introducing hydrocarbon oil charging stock for the process, comprising an oil of relatively wide boiling range, into said vaporizing chamber whereby it is subjected to vaporization and thereby separated into selected relatively low-boiling and high-boiling fractions, withdrawing non-vaporous residual liquid conversion products and non-vaporous high boiling fractions of the charging stock from the vaporizing chamber, introducing the same into a coking zone and reducing the same therein to substantially dry coke, introducing vaporous products from the coking zone into the vaporizing chamber, fractionating the vaporous products from the vaporizing chamber and separating selected relatively low-boiling and high-boiling fractions therefrom, returning the last-named high-boiling fractions to said heating coil for further conversion, subjecting the last-named low-boiling fractions to independently controlled conversion conditions of higher cracking temperatures and superatmospheric pressure in a separate heating coil, introducing a regulated portion of the heated products from said separate heating coil into the coking zone for the purpose of assisting the coking operations and supplying the remaining portion thereof to the vaporizing chamber, and finally condensing the fractionated vapors.

2. In a process for the conversion of hydrocarbon oils wherein intermediate conversion products of the process are subjected to conversion conditions of cracking temperature and superatmospheric pressure in a heating coil and communicating reaction chamber, both vaporous and liquid conversion products withdrawn from the reaction chamber and introduced into a reduced pressure vaporizing chamber wherein separation of vaporous and liquid conversion products is accomplished the improvement which comprises introducing hydrocarbon oil charging stock for the process, comprising an oil of relatively wide boiling range, into said vaporizing chamber whereby it is subjected to vaporization and thereby separated into selected relatively low-boiling and high-boiling fractions, withdrawing non-vaporous residual liquid conversion products and non-vaporous high-boiling fractions of the charging stock from the vaporizing chamber, heating the same to a cracking temperature under non-coking conditions in a separate heating coil, introducing the heated oil into a coking zone and reducing the same therein to substantially dry coke, supplying vaporous products from the coking zone to the vaporizing chamber, fractionating the vaporous products from the vaporizing chamber and separating selected relatively low-boiling and high-boiling fractions therefrom, returning the last-named high-boiling fractions to said heating coil for further conversion, subjecting the last-named low-boiling fractions to independently controlled conversion conditions of higher cracking temperatures and superatmospheric pressure in a separate heating coil, introducing a regulated portion of the heated products from said separate heating coil into the coking zone for the purpose of assisting the coking operation

and supplying the remaining portion thereof to the vaporizing chamber, and finally condensing the fractionated vapors.

3. A conversion process which comprises heating hydrocarbon oil to cracking temperature under pressure in a heating coil and subsequently introducing the same to a separating chamber, introducing charging oil for the process to said chamber and partially distilling the same therein, removing unvaporized oil from the separating chamber and distilling the same to coke in a coking chamber, introducing vapors from the coking chamber into the separating chamber, removing vapors from the separating chamber and fractionating the same to form a relatively heavy reflux condensate and a lighter reflux condensate, supplying the heavy reflux condensate to said coil, heating the lighter reflux condensate in a second heating coil to higher cracking temperature than the oil in the first-named coil, discharging separate portions of the heated products from the second coil into the separating chamber and into the coking chamber, and finally condensing the fractionated vapors.

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