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HYDROCARBON OIL CONVERSION

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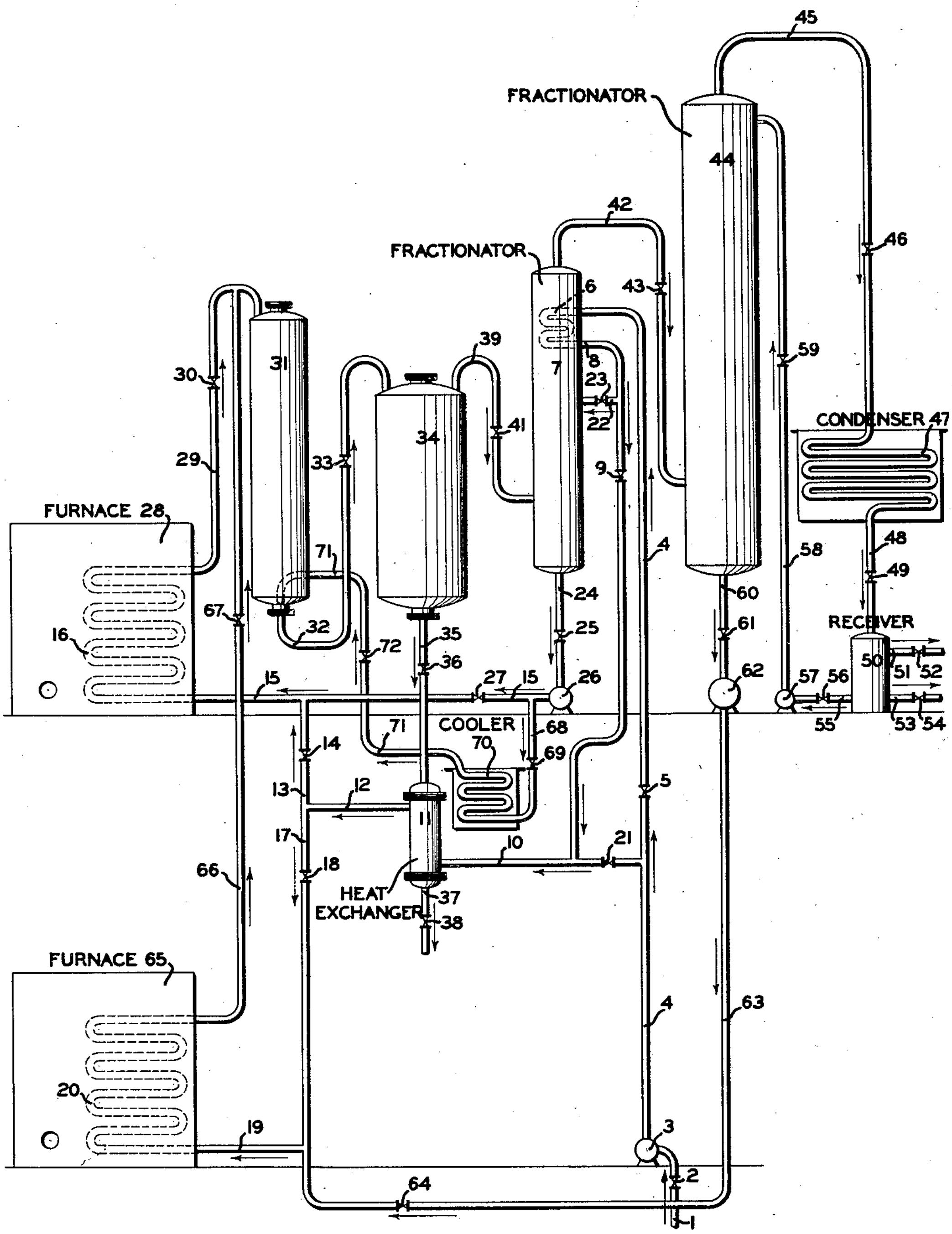

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HYDROCARBON OIL CONVERSION

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3 Claims. (Cl. 196—48)

This invention relates to the treatment of hydrocarbon oils and particularly refers to the conversion of relatively heavy oil or oils of inferior quality into lower boiling products or, in general, into products of a more valuable nature.

The primary concepts of the present invention comprise separating the relatively light and the relatively heavy intermediate products resulting from the conversion of hydrocarbon oil and subjecting each to independently controlled conversion conditions in separate heating elements, thence commingling the heated products and subjecting the commingled materials to further conversion, thence separating the vapors and the residual products of conversion, subjecting the vapors to fractionation in primary and secondary fractionating stages, subsequently condensing, cooling and collecting the desirable light products of the operation.

As a feature of the invention a portion of the reflux condensate from the primary fractionating zone of the system alone or together with a portion of the raw oil charging stock may be cooled and returned to the reaction chamber for the purpose of cooling the products withdrawn from this zone to the subsequent vaporizing zone of the system. It is also contemplated returning the reflux condensate at any point before the introduction of the products from the reaction zone to the vaporizing zone including points before and after the reduction in pressure.

As another feature of the invention the raw oil charging stock may be preheated by indirect contact with the vapors in the primary fractionating zone and/or by indirect contact with the residual oil withdrawn from the vaporizing zone and may thence be supplied all or in part either to the primary or to the secondary heating element or a portion or all of the raw oil may, if desired, be fed directly into the primary fractionating zone to be fed therefrom together with reflux condensate from this zone to the primary heating element.

The attached diagrammatic drawing illustrates a specific embodiment of one form of apparatus utilizing the principles of the present invention. The following description of the drawing embraces also a description of the process of the invention as it may be practiced in the apparatus illustrated. Raw oil charging stock may be supplied through line 1 and valve 2 to pump 3 from which it may be fed through line 4 and valve 5 into preheating coil 6, which may be located within fractionator 7 and wherein the oil may be preheated by indirect contact with the relatively hot vapors in the fractionator. The preheated oil may thence pass through line 8 and valve 9 into line 10 and thence through heat exchanger 11, where it may be further preheated by indirect contact with the relatively hot residual oil from the system. The preheated oil may thence pass through line 12, line 13, valve 14 and line 15 into heating element 16 or from line 12 through line 17, valve 18 and line 19 into heating element 20 or partially in both directions. If desired, a portion or all of the raw oil may by-pass preheating coil 6 and may pass directly from line 4 to heat exchanger 11 through valve 21, in line 10. If desired, a portion or all of the raw oil, either in a relatively cold or in a preheated state, may pass into direct contact with the vapors in fractionator 7. This may be accomplished, for example, by diverting a portion or all of the preheated raw oil from line 8 through line 22 and valve 23 into fractionator 7. The raw oil introduced into fractionator 7 may assist fractionation of the vapors with which it is directly contacted in this zone and may pass together with the relatively heavy condensed components of the vapors through line 24 and valve 25 to pump 26 from which it may be fed through line 15 and valve 27 into heating element 16.

Heating element 16 may be located within any suitable form of furnace 28 and the oil supplied thereto may be heated to the desired conversion temperature under any desired pressure conditions and may pass through line 29 and valve 30 into reaction chamber 31. Preferably heating element 16 and reaction chamber 31 are both maintained under a substantial super-atmospheric pressure and the pressure employed in chamber 31 may be substantially equalized with or lower than that employed in the heating element. Both liquid and vaporous products may be withdrawn from chamber 31 through line 32 and valve 33 and may be introduced into vaporizing chamber 34 which is preferably maintained under a substantially reduced pressure relative to that employed in chamber 31 and wherein vapors may separate from the residual products.

Residual oil may be withdrawn from chamber 34 through line 35, valve 36, heat exchanger 11, line 37 and valve 38 to further cooling and storage or to any desired further treatment.

Vapors may be withdrawn from chamber 34 through line 39 and valve 41 to fractionator 7 wherein their relatively heavy insufficiently converted components may be condensed to be returned to heating element 16, as already described, for further conversion. Vapors from fractionator 7 may pass through line 42 and valve 43 to further fractionation in fractionator 44. The relatively light desirable vapors may be withdrawn from fractionator 44 through line 45 and valve 46, may be subjected to condensation and cooling in condenser 47, products from which may pass through line 48 and valve 49 to be collected in receiver 50. Uncondensable gas may be released from receiver 50 through line 51 and valve 52. Distillate may be withdrawn through line 53 and valve 54. A portion of the distillate may, if desired, be withdrawn from receiver 50 through line 55 and valve 56 to be recirculated by means of pump 57 through line 58 and valve 59 to the upper portion of fractionator 44 to assist fractionation of the vapors in this zone.

The relatively heavy insufficiently converted components of the vapors subjected to fractionation in fractionator 44 may be condensed in this zone and may pass through line 60 and valve 61 to pump 62 from which they may be fed through line 63, valve 64 and line 19 to heating element 20 for further conversion.

Heating element 20 may be located within any suitable form of furnace 65 and the oil supplied to this zone may be heated, preferably to a more severe conversion temperature than that employed in heating element 16, and the heated oil may pass through line 66 and valve 67 into line 29 where it may commingle with the stream of heated oil discharged from heating element 16, passing therewith into chamber 31. The pressure employed in heating element 20 may be substantially the same or may be higher than that employed in chamber 31.

If desired, a portion of the relatively heavy reflux condensate or reflux condensate and raw oil, as the case may be, from fractionator 7 may be diverted from line 15 and may pass through line 68, valve 69, cooler 70, line 71 and valve 72 into chamber 31 preferably being introduced into the lower portion of the reaction chamber for the purpose of cooling the products withdrawn through line 32 and valve 33 to vaporizing chamber 34.

Pressures employed within the system may range from substantially atmospheric to superatmospheric pressures as high as 2000 pounds or more per square inch. Conversion temperatures employed may range from 800 to 1200° F., more or less. The preferred range of conversion conditions employed in the primary heating element are from 850 to 960° F. and from 100 to 350 pounds per square inch or thereabouts. Substantially this same pressure range may be employed in the reaction chamber although pressure in this zone may be of substantially the same or lower than that employed in the heating element. Conversion conditions employed in the secondary heating element may range preferably from 900 to 1200° F., more or less, with pressures ranging from about 100 to approximately 350 pounds per square inch. Substantially reduced pressure relative to that employed in the reaction chamber are preferably maintained in the vaporizing, fractionating, condensing and collecting portions of the system. The range of pressures in these zones is preferably of the order of substantially atmospheric to approximately 100 pounds super-atmospheric pressure per square inch.

As a specific example of the operation of the process of the present invention at 31° A. P. I. gravity Pennsylvania topped crude is the raw oil charging stock which after preheating, in both of the means illustrated in the drawing, is supplied to the primary heating element together with relatively heavy reflux condensate from the primary fractionator of the system. A temperature of about 900° F. and a pressure of about 300 pounds per square inch are maintained in the primary heating element. This pressure is substantially equalized in the reaction chamber and is reduced in the subsequent vaporizing, fractionating, condensing and collecting equipment to a substantially equalized pressure of about 40 pounds per square inch. Relatively light reflux condensate from the secondary fractionator of the system is subjected in the secondary heating element to a temperature of approximately 940° F. under a superatmospheric pressure of about 350 pounds per square inch, the pressure being reduced, of course, to about 300 pounds per square inch prior to the introduction of these heated products into the reaction chamber. A sufficient quantity of the relatively heavy reflux condensate from fractionator 17 is recycled to the lower portion of the reaction chamber to insure a temperature of about 800° F. in the vaporizing chamber. This operation may yield approximately 62 percent of motor fuel having an anti-knock value approximately equivalent to a blend of 55 percent benzol and 45 percent Pennsylvania straight-run gasoline. In addition, about 30 percent of marketable fuel oil may be produced, the other products being uncondensable gas and a relatively small percentage of coke or carbonaceous material.

As an example of another type of operation, the charging stock is a 48° A. P. I. gravity Pennsylvania distillate containing a substantial proportion of straight-run gasoline of poor antiknock value. This material is preheated and supplied, together with relatively light reflux condensate from the secondary fractionator of the system, to the secondary heating element where it is subjected to a temperature of approximately 950° F. under a super-atmospheric pressure of about 350 pounds per square inch. Reflux condensate from the primary fractionator is subjected in the primary heating element to a temperature of approximately 900° F. under a super-atmospheric pressure of about 300 pounds per square inch. A pressure of about 300 pounds per square inch is maintained in the reaction chamber and a reduced pressure of approximately 50 pounds per square inch is maintained in the succeeding portions of the system. As in the preceding example a sufficient quantity of relatively heavy reflux condensate is returned to the lower portion of the reaction chamber to cool the products entering the vaporizing chamber to a temperature of approximately 800° F., this reduced temperature being due, however, in part to the pressure reduction between these two elements. This operation may yield approximately 87 percent of motor fuel having an anti-knock value approximately equivalent to a blend of 70 percent benzol and 30 percent Pennsylvania straight-run gasoline. The only other products are about 6 percent of residual oil and about 7 percent of uncondensable gas, the coke production being negligible.

I claim as my invention:

1. A hydrocarbon oil cracking process which comprises passing the oil in a restricted stream through a heating zone and heating the same therein to cracking temperature under pressure, discharging the heated oil into the upper portion of an enlarged reaction zone maintained under cracking conditions of temperature and pressure, removing the liquid and vaporous reaction prod-

ucts from the lower portion of the reaction zone and discharging the same into a vaporizing zone maintained under lower pressure than the reaction zone, separating the reaction products into vapors and residue in the vaporizing zone, subjecting the vapors to primary and secondary dephlegmation thereby forming primary reflux condensate and a lighter secondary reflux condensate, commingling a sufficient quantity of said primary reflux condensate with the reaction products being withdrawn from the lower portion of the reaction zone to effect substantial cooling of said products, continuously supplying another portion of said primary reflux condensate to the heating zone, passing said secondary reflux condensate through a second heating zone and heating the same therein to higher cracking temperature than the oil in the first-mentioned heating zone, discharging the thus heated reflux condensate into the upper portion of the reaction zone, and finally condensing the dephlegmated vapors.

2. A hydrocarbon oil cracking process which comprises passing the oil in a restricted stream through a heating zone and heating the same therein to cracking temperature under pressure, discharging the heated oil into the upper portion of an enlarged reaction zone maintained under cracking conditions of temperature and pressure, removing the liquid and vaporous reaction products from the lower portion of the reaction zone and discharging the same into a vaporizing zone maintained under lower pressure than the reaction zone, separating the reaction products into vapors and residue in the vaporizing zone, subjecting the vapors to primary and secondary dephlegmation thereby forming primary reflux condensate and a lighter secondary reflux condensate, commingling a sufficient quantity of said primary reflux condensate with the reaction products being withdrawn from the lower portion of the reaction zone to effect substantial cooling of said products, said quantity of the primary reflux condensate being forced under applied pressure into the lower portion of the reaction zone in the direction of discharge of the reaction products therefrom, continuously supplying another portion of said primary reflux condensate to the heating zone, passing said secondary reflux condensate through a second heating zone and heating the same therein to higher cracking temperature than the oil in the first-mentioned heating zone, discharging the thus heated reflux condensate into the upper portion of the reaction zone, and finally condensing the dephlegmated vapors.

3. A hydrocarbon oil cracking process which comprises passing the oil in a restricted stream through a heating zone and heating the same therein to cracking temperature under pressure, discharging the heated oil into the upper portion of an enlarged reaction zone maintained under cracking conditions of temperature and pressure, removing the liquid and vaporous reaction products from the lower portion of the reaction zone and discharging the same into a vaporizing zone maintained under lower pressure than the reaction zone, separating the reaction products into vapors and residue in the vaporizing zone, dephlegmating the vapors in direct contact with charging oil for the process thereby forming a mixture of charging oil and reflux condensate, cooling a portion of said mixture and forcing the same under applied pressure into the lower portion of the reaction zone in the direction of discharge of the reaction products therefrom, continuously supplying another portion of said mixture to the heating zone, further dephlegmating said vapors out of direct contact with charging oil to form a relatively light and clean secondary reflux condensate, passing said secondary reflux condensate through a second heating zone and heating the same therein to higher cracking temperature than the oil in the first-mentioned heating zone, discharging the thus heated reflux condensate into the upper portion of the reaction zone, and finally condensing the dephlegmated vapors.

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