

May 8, 1934.

L. C. HUFF

1,957,780

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

Filed March 24, 1930

2 Sheets-Sheet 1

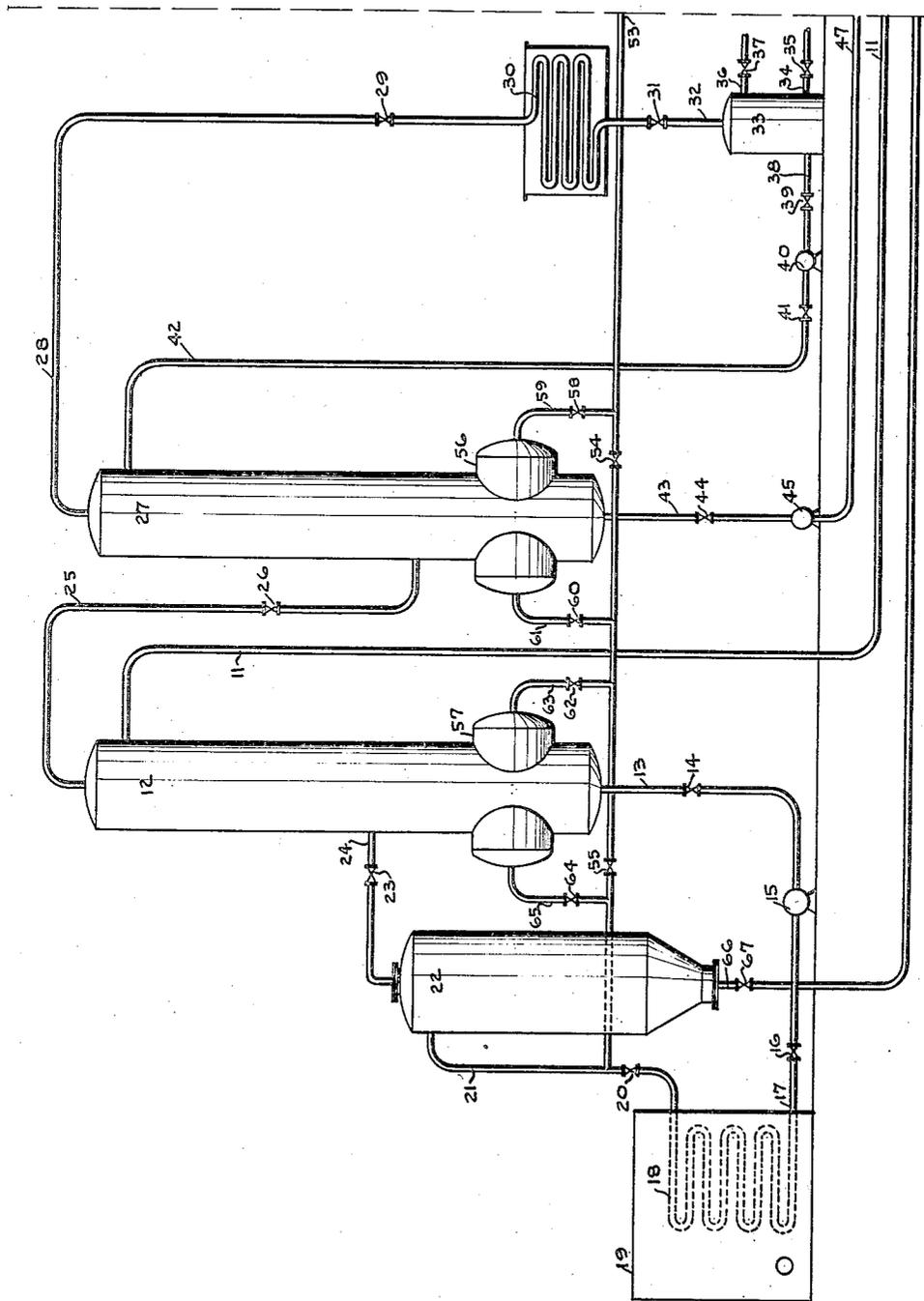


FIG. 1

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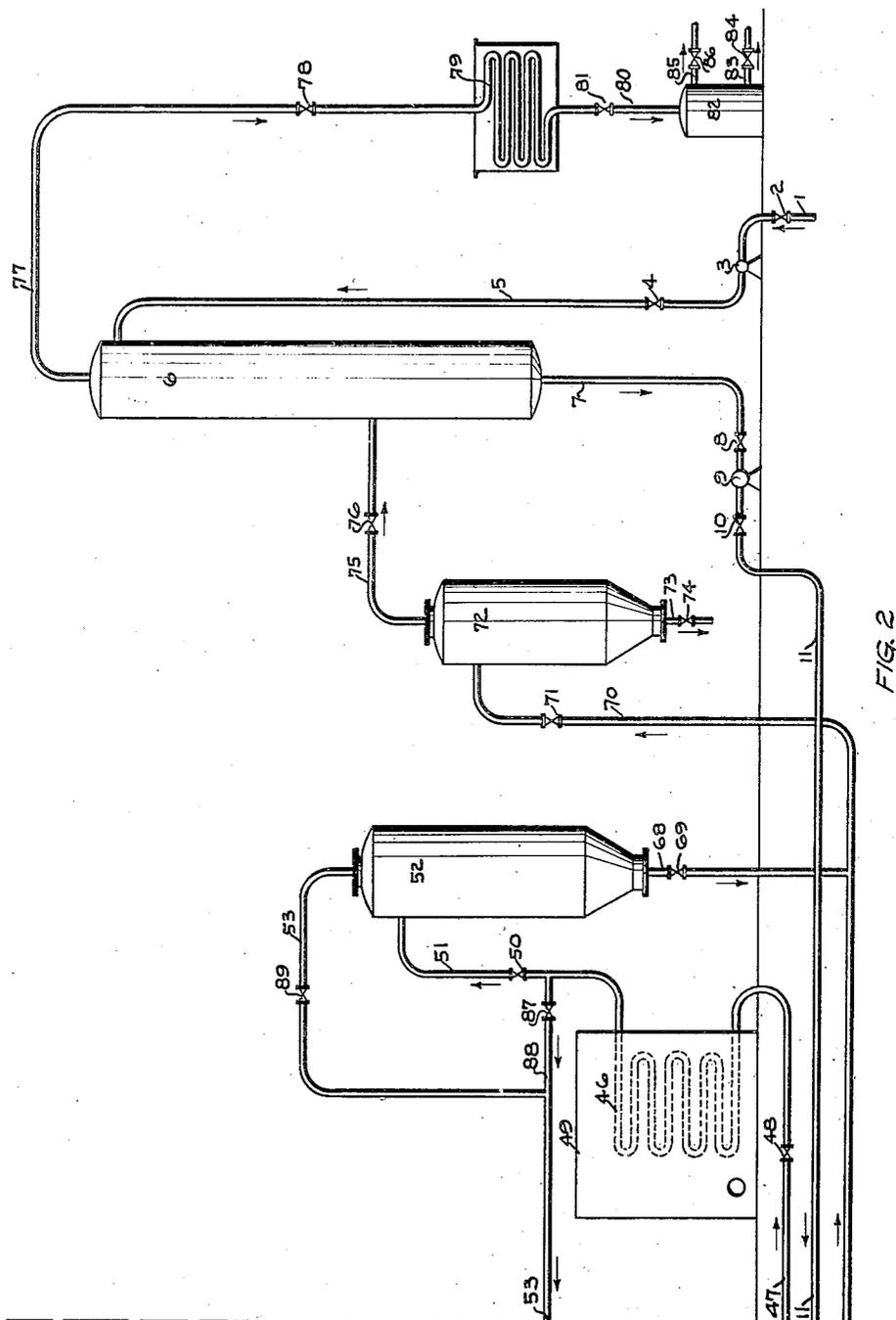


FIG. 2

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UNITED STATES PATENT OFFICE

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PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

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Application March 24, 1930, Serial No. 438,261

6 Claims. (Cl. 196—49)

This invention relates to the art of cracking hydrocarbon oils and is directed specifically to an improved process and apparatus comprising a primary and a secondary system in which intermediate products from the primary system are subjected to reconversion under more severe cracking conditions than those employed in the primary system.

Two general classes of cracking systems, namely the liquid-vapor-phase process and the vapor-phase process are in general use and are sufficiently well known in the art to require little explanation here. Generally speaking, however, vapor-phase systems employ higher temperatures and lower relative pressures than those employed in most liquid-vapor-phase systems. Furthermore vapor-phase cracking is generally applied more successfully to the conversion of lighter and more refractory charging stocks than those commonly used in liquid-vapor-phase systems.

In the present invention a primary and a secondary system are employed. When relatively heavy or easily cracked oils are to be used as charging stock, conditions in the primary system preferably correspond to liquid-vapor-phase cracking conditions. When the charging stock is relatively light oil and/or when it is desired to employ more severe cracking conditions, the primary system may be operated under conditions of temperature and pressure corresponding to or approximating vapor-phase cracking conditions. The heating element of the primary system handles raw oil charging stock to the process preferably in a preheated state and in combination with certain intermediate products from the process. Temperatures employed in the heating element of the secondary system are preferably higher than those employed in the primary system and the pressure may be higher or lower or substantially the same, as desired. The heating element of the secondary system handles an intermediate product from the process which is more refractory to cracking than the raw oil charging stock.

Treatment of the raw oil charging stock and certain intermediate products from the process in a primary system and retreatment of certain more refractory intermediate products from the process under more severe cracking conditions in a secondary system are among the salient features of my invention.

Another feature of my invention provides for the introduction of the hot re-cracked vapors from the secondary system of the process into

the stream of heated products from the heating element of the primary system of the process.

By combining the re-cracked vapors from the secondary system with the products from the heating element of the primary system before entering the reaction zone of the primary system, my process permits further reaction of the combined products as well as subsequent combined fractionation of vapors from both systems and combined condensation, cooling and collection of the desired light products from both systems.

The present invention provides for the re-vaporization of any desirable light gasoline-like products entrained in the intermediate products to be reprocessed. This is accomplished by re-boiling reflux condensate from the primary and from the secondary fractionating towers of the process by indirect contact and heat exchange with vapors from the reaction chamber of the secondary system.

Another feature of the present invention provides for the flash distillation of the combined residual products from the reaction chambers of the primary and secondary systems.

The attached drawings serve to illustrate one specific form of apparatus in which my improved process may be practiced. This is a diagrammatic illustration and is not drawn to scale.

Referring to the drawings, Figs. 1 and 2, raw oil charging stock for the process introduced through line 1 and valve 2, may be fed by means of pump 3 through valve 4 and line 5 to the flash dephlegmator 6. Preheated raw oil and reflux condensate from flash dephlegmator 6 may pass through line 7 and valve 8 to pump 9 which feeds the oil through valve 10 and line 11 to the first fractionating tower 12. The preheated raw oil and reflux condensate from flash dephlegmator 6 thus fed into fractionating tower 12 is further preheated by direct contact with the hot ascending vapors in this zone and serves to assist fractionation, condensing certain heavy portions of the vapors in tower 12 and mixing therewith the bottom of tower 12 to form the combined feed charging stock for the primary system. This combined feed passes through line 13 and valve 14 to pump 15 which supplies the oil through valve 16 and line 17 to the primary heating element 18.

Heating element 18 is located in a suitable furnace 19 and oil passing through this primary heating element is heated to the desired outlet temperature under the desired pressure conditions. The heated products are discharged

through valve 20 and line 21 into the reaction chamber 22.

Vapors from reaction chamber 22 may pass through valve 23 and line 24 to the first fractionating tower 12 where they are subjected to the first or primary fractionating step. Vapors persisting after fractionation in tower 12 may pass through line 25 and valve 26 to be subjected to final fractionation in a second fractionating tower 27.

The temperature at the top of fractionating tower 27 is preferably regulated by means which will be described later so that only material boiling within the range of motor fuel will remain vaporized at the top of this tower. These gaso-line-like vapors may pass through line 28 and valve 29, may be subjected to condensation and cooling in condenser 30, thereafter passing through valve 31 and line 32 to be collected in receiver 33.

The condensed distillate from receiver 33 may be withdrawn to storage, to further treatment or elsewhere through line 34 controlled by valve 35. Uncondensed gas is withdrawn from receiver 33 through line 36 controlled by valve 37. A portion of the condensed distillate from receiver 33 may be withdrawn through line 38 and valve 39 and fed by means of pump 40 through valve 41 and line 42 to the top of fractionating tower 27 where it is used to cool the vapors therein, by direct contact, to the desired outlet temperature.

Reflux condensate from the bottom of the second fractionating tower 27 may pass through line 43 and valve 44 to pump 45 which supplies this oil as charging stock to the secondary heating element 46 through line 47 and valve 48.

Secondary heating element 46 is located in a suitable furnace setting 49. Cracking conditions imposed on the oil passing through heating element 46 will usually be more severe than those employed in heating element 18 and are sufficient to cause substantial reconversion of the reflux condensate from the second fractionating tower 27 which comprises the charging stock for this heating element. Products from heating element 46 may pass through valve 50 and line 51 into reaction chamber 52, or when desired, chamber 52 may be by-passed by opening valve 87 in line 88 and closing valve 50 in line 51, valve 69 in line 68 and valve 89 in line 53.

Vapors from reaction chamber 52 or from line 88, as the case may be, may pass through line 53 and valves 54 and 55 into line 21 where they mix with the stream of heated products from heating element 18, the combined products thence passing into reaction chamber 22. All or any portion of the hot vapors from line 53 may be passed through either of the heat exchanger 56 in the bottom section of fractionating tower 27 or heat exchanger 57 in the bottom section of fractionating tower 12 or through both. This is accomplished by regulation of valves 54 and 55 in line 53, valve 58 in line 59, valve 60 in line 61, valve 62 in line 63 and valve 64 in line 65. The hot vapors passing through heat exchangers 56 and 57 furnish heat for reboiling the reflux condensate in the fractionating towers 27 and 12 respectively.

Unvaporized products from reaction chambers 22 or 52 or both may be withdrawn by well known means, not shown, from the respective chambers and from the system. Unvaporized products from either or both chambers 22 and 52 may be withdrawn respectively through line 66 controlled by valve 67 and through line 68 controlled by valve

69 and may be fed through line 70 and valve 71 into the flash distilling chamber 72. It will be understood that residual products from either reaction chamber or from both chambers 22 and 52 may be passed through valve 71, where the pressure preferably is substantially reduced, and will thus be subjected to flash distillation in chamber 72.

Products unvaporized in the flash chamber 72 may be withdrawn to storage or elsewhere through line 73 controlled by valve 74. Vapors from chamber 72 may pass through line 75 and valve 76 into the flash dephlegmator 6 where they are subjected to fractionation and where raw oil may be introduced in direct contact therewith as above described. Vapors from the top of flash dephlegmator 6 may pass through line 77 and valve 78, may be subjected to condensation and cooling in condenser 79 thereafter passing through line 80 and valve 81 to be collected in receiver 82. Condensed distillate from receiver 82 may be withdrawn through line 83 controlled by valve 84 and uncondensed gas from receiver 82 may be withdrawn through line 85 controlled by valve 86.

Operating pressures ranging from sub-atmospheric to high superatmospheric pressures of say 2000 pounds per square inch more or less, may be utilized throughout either the primary or the secondary system of the process or both. Substantially equalized or differential pressures may be employed in the primary and secondary systems as well as between various parts of either or both systems. Temperature conditions in both heating elements may range for example from 700 to 1300° F., more or less, but preferably higher temperature conditions are employed in the primary heating element than those utilized in the secondary heating element.

As a specific example of one of the many operations possible with my process in an apparatus such as above described:

A 32° A. P. I. gravity gas oil forms the raw oil charging stock for the process and is fed substantially as above described to the primary heating element 18. The combined feed, comprising reflux condensate from the first fractionating tower 12 combined with preheated raw oil and reflux condensate from flash dephlegmator 6 fed overhead to tower 12, is subjected in heating element 18 to a temperature of approximately 850° F. under an imposed pressure of approximately 200 pounds per square inch. Pressure is reduced at valve 20 to approximately 80 pounds per square inch but the products passing through line 21 into chamber 22 may be at a temperature of about 900° F., due to the addition to the products from heating element 18 of hotter vapors from reaction chamber 52 of the secondary system.

The pressure in reaction chamber 22 is maintained at approximately 80 pounds per square inch and a substantial portion of the combined products introduced thereto are vaporized and pass to dephlegmator 12 for the first fractionating step, reflux condensate from which is retreated in the primary heating element and vapors from which are subjected to secondary fractionation in tower 27.

Both fractionating towers are maintained under a substantially equalized pressure of 80 pounds per square inch and reflux condensate from fractionating tower 27 is subjected at about this same pressure in heating element 46 to an outlet temperature of approximately 1050° F.

Reaction chamber 52 is likewise maintained at approximately 80 pounds pressure per square inch and a portion of the vapors in this chamber are used to reboil and strip the reflux condensate from both fractionating zones of its entrained gasoline-like constituents by indirect heat exchange in heat exchangers 56 and 57. All of the vapors from chamber 52 eventually pass into line 21 to combine with the products from heating element 18.

The unvaporized residual products from reaction chamber 22 and 52 are combined and together subjected to flash distillation at a reduced pressure of approximately 30 pounds per square inch.

Approximately 65% of gasoline may be recovered from the above outlined operation. This is a blend of vapor-phase and liquid-phase cracked products and may show an anti-knock value equivalent to a 50-50 blend of benzol and straight-run gasoline.

Approximately 10% of heavy residual material may be produced in flash chamber 72 and about 15% of distillate corresponding roughly in characteristics to heavy gas oil may be recovered from the flash distilling system.

I claim as my invention:

1. A hydrocarbon oil cracking process which comprises passing the oil through a heating zone and heating the same therein to cracking temperature under sufficient superatmospheric pressure to retain a substantial portion thereof in the liquid phase, discharging the heated oil into a vapor separating zone and separating the same therein into vapors and unvaporized oil, subjecting the separated vapors to primary and secondary dephlegmation thereby forming primary and secondary reflux condensates, returning the primary reflux condensate to said heating zone for retreatment therein, passing the secondary reflux condensate to a second heating zone and heating the same therein to vapor phase cracking temperature under a lower pressure than is maintained on the oil in the first-mentioned heating zone, combining resultant vapor phase cracked vapors with the vapors produced in said first-mentioned heating zone and separating zone to be subjected to the primary and secondary dephlegmation therewith, flash distilling said unvaporized oil by pressure reduction, dephlegmating the flashed vapors thus formed and supplying resultant flash reflux to the first mentioned heating zone in admixture with fresh charging oil and said primary reflux condensate, and finally condensing as a product of the process the vapors uncondensed by the secondary dephlegmation.

2. A hydrocarbon oil cracking process which comprises passing the oil through a heating zone and heating the same therein to cracking temperature under sufficient superatmospheric pressure to retain a substantial portion thereof in the liquid phase, discharging the heated oil into a vapor separating zone maintained under lower pressure than said heating zone, and separating the same therein into vapors and unvaporized oil, subjecting the separated vapors to primary and secondary dephlegmation thereby forming primary and secondary reflux condensates, returning the primary reflux condensate to said heating zone for retreatment therein, passing the secondary reflux condensate to a second heating zone and heating the same therein to vapor phase cracking temperature under a lower pressure than is maintained on the oil in the first-men-

tioned heating zone, introducing resultant vapor phase cracked vapors to the low pressure separating zone to combine with the vapors separated therein and to pass with the latter to the primary and secondary dephlegmation, flash distilling said unvaporized oil by pressure reduction, dephlegmating the flashed vapors thus formed and supplying resultant flash reflux to the first mentioned heating zone in admixture with fresh charging oil and said primary reflux condensate, and finally condensing the vapors uncondensed by the secondary dephlegmation.

3. A hydrocarbon oil cracking process which comprises passing the oil through a heating zone and heating the same therein to cracking temperature under sufficient superatmospheric pressure to retain a substantial portion thereof in the liquid phase, discharging the heated oil into a vapor separating zone and separating the same therein into vapors and unvaporized oil, subjecting the separated vapors to primary and secondary dephlegmation thereby forming primary and secondary reflux condensates, returning the primary reflux condensate to said heating zone for retreatment therein, passing the secondary reflux condensate to a second heating zone and heating the same therein to vapor phase cracking temperature under a lower pressure than is maintained on the oil in the first mentioned heating zone, passing at least a portion of the resultant vapor phase cracked vapors in indirect heat exchange relation with said secondary reflux condensate to reboil the latter prior to its introduction to said second heating zone, combining the vapor phase cracked vapors with the vapors produced in said first-mentioned heating zone and separating zone to be subjected to the primary and secondary dephlegmation therewith, and finally condensing as a product of the process the vapors uncondensed by the secondary dephlegmation.

4. A hydrocarbon oil cracking process which comprises passing the oil through a heating zone and heating the same therein to cracking temperature under sufficient superatmospheric pressure to retain a substantial portion thereof in the liquid phase, subsequently discharging the heated oil into an enlarged zone wherein vapors are formed and removing the vapors and unvaporized oil therefrom, subjecting the vapors to primary fractionation, and returning resultant primary reflux condensate to said heating zone for retreatment therein, further fractionating the hydrocarbons uncondensed by said primary fractionation to form a liquid fraction of lower boiling point than the primary reflux condensate, passing said fraction to a second heating zone and heating the same therein to vapor phase cracking temperature under a lower pressure than is maintained on the oil in the first-mentioned heating zone, introducing resultant vapors from said second heating zone into the heated oil discharged from the first-mentioned heating zone, flash distilling said unvaporized oil by pressure reduction, fractionating the flashed vapors thus formed and supplying resultant flash reflux to the first-mentioned heating zone in admixture with fresh charging oil and said primary reflux condensate, and finally condensing the fractionated vapors.

5. A hydrocarbon oil cracking process which comprises heating the oil to cracking temperature under pressure in a primary heating zone, separating the heated oil into vapors and unvaporized oil under pressure, subjecting the sepa-

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rated vapors to primary and secondary dephlegmation, thereby forming primary reflux condensate and secondary reflux condensate, finally condensing the dephlegmated vapors, flash distilling the unvaporized oil by lowering the pressure thereon, dephlegmating the flashed vapors to condense heavier fractions thereof, combining such fractions with at least a portion of said primary reflux condensate and supplying the resultant mixture to the primary heating zone for retreatment therein, subjecting a substantial portion of said secondary reflux condensate to vapor phase cracking in a second heating zone, and combining resultant vapor phase cracked products from the second heating zone with cracked products from the primary heating zone.

6. In the cracking of hydrocarbon oil wherein the oil is heated to cracking temperature under pressure in a primary heating zone and thence discharged into an enlarged reaction zone maintained under cracking conditions of temperature and pressure and wherein further reaction of the oil takes place; the method which comprises removing vapors from the reaction zone and subjecting the same to primary and secondary dephlegmation thereby forming primary reflux condensate and secondary reflux condensate, finally condensing the dephlegmated vapors, removing unvaporized oil from the reaction zone and flash distilling the same by lowering pressure thereon, dephlegmating the flashed vapors to condense heavier fractions thereof and combining such fractions with said primary reflux condensate, supplying the resultant mixture to the primary heating zone for retreatment therein, subjecting a substantial portion of said secondary reflux condensate to vapor phase cracking in a second heating zone, and combining resultant vapor phase cracked products from the second heating zone with cracked products from the primary heating zone.

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