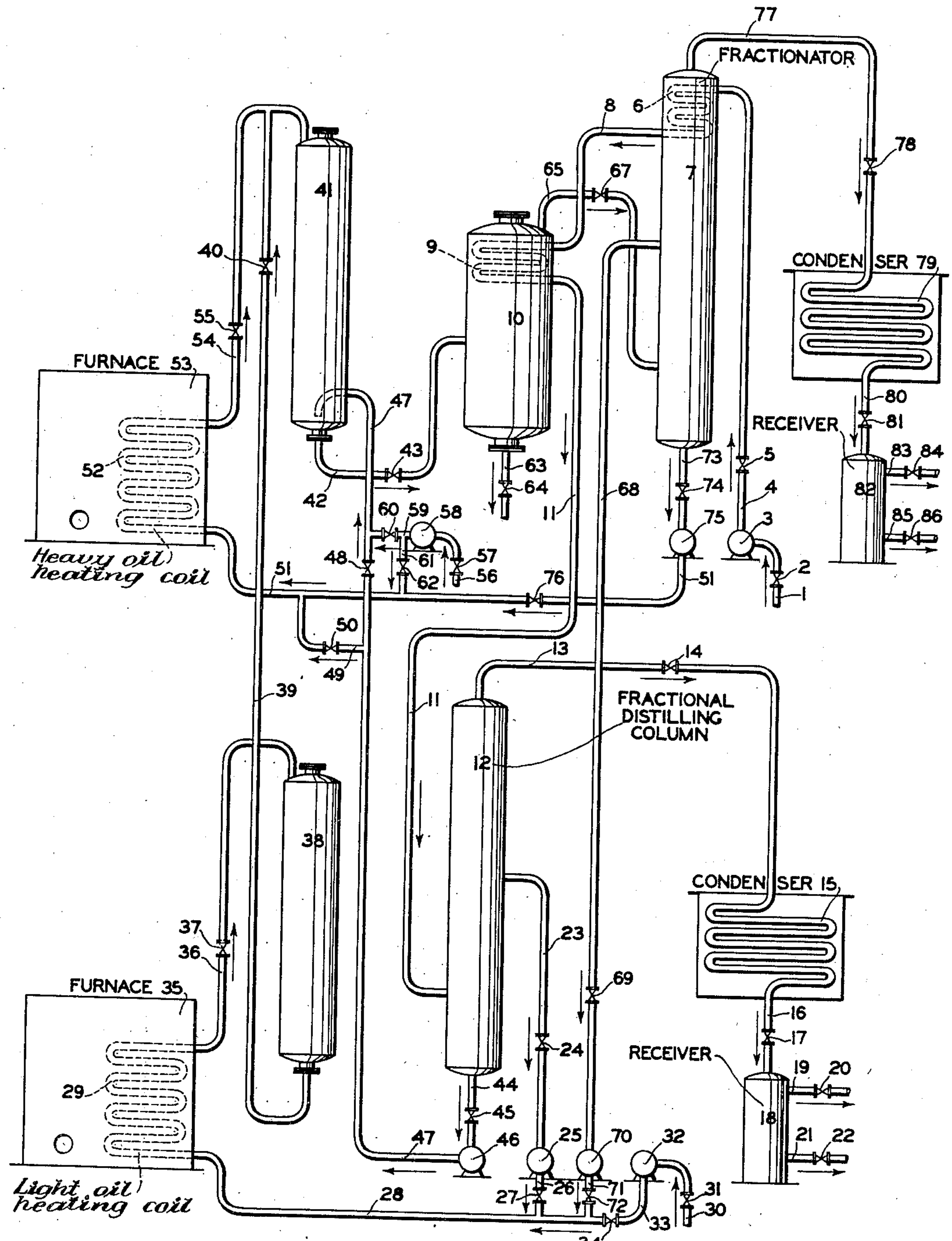
Aug. 2, 1938. J. B. HEID 2,125,564

CONVERSION OF HYDROCARBON OILS

Filed Oct. 12, 1934



INVENTOR
JACOB BENJAMIN HEID
BY Lee J. Gary
ATTORNEY

Patented Aug. 2, 1938

UNITED STATES PATENT OFFICE

2,125,564

CONVERSION OF HYDROCARBON OILS

Jacob Benjamin Heid, Chicago, Ill., assignor to Universal Oil Products Company, Chicago, Ill., a corporation of Delaware

Application October 12, 1934, Serial No. 748,032

9 Claims. (Cl. 196—48)

The present invention provides an improved process for the topping and cracking of hydrocarbon oils. More particularly it refers to the selective conversion of relatively low-boiling and high-boiling fractions of a charging oil of relatively wide boiling range together with selected intermediate conversion products of the process and, when desired, other charging oils of narrower boiling range similar to the respective selected fractions with which they are subjected to conversion.

In one specific embodiment, the invention comprises subjecting hydrocarbon oil charging stock of relatively wide boiling range to fractional distillation by means of heat recovered by indirect heat exchange with hot vaporous conversion products of the process, condensing and collecting any desired low-boiling fractions, such as gasoline of good antiknock value, resulting from said fractional distillation, subjecting selected intermediate fractions of the charging stock, recovered by said fractional distillation, to conversion conditions of elevated temperature and superatmospheric pressure in a heating coil and communicating enlarged reaction chamber, withdrawing both vaporous and liquid conversion products in commingled state from the reaction chamber and introducing the same into a separate enlarged reaction chamber also maintained at superatmospheric pressure wherein they commingle and are subjected to further conversion with other heated products supplied to this zone, as will be later more fully described, commingling selected high-boiling fractions of the charging stock, recovered by said fractional distillation, with the vaporous and liquid conversion products withdrawn from said separate reaction chamber and introducing the commingled materials into a reduced pressure vaporizing chamber wherein further vaporization of the liquids is accomplished, removing residual liquid from said vaporizing chamber, subjecting vaporous products from the vaporizing chamber 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 desired end-boiling point to condensation, collecting and separating the resulting distillate and gas, returning said selected low-boiling fractions of the reflux condensate to the first mentioned heating coil for further conversion, subjecting said high-boiling fractions of the reflux condensate to independently controlled conversion conditions of elevated temperature and superatmospheric pressure in a separate heating coil and introducing the heated products therefrom into said separate reaction chamber.

As a modification of the specific embodiment of the invention above described, the selected high-boiling fractions of the charging stock may be subjected to conversion together with the high-boiling fraction of the reflux condensate in the last mentioned heating coil. The various alternative provisions of the invention are, however, not to be considered equivalent but may be chosen to suit the particular oils undergoing treatment and to obtain the desired results.

It is also within the scope of the present invention, when desired, to employ, in addition to the hydrocarbon oil charging stock of relatively wide boiling range which is subjected to fractional distillation, one or more separate charging stocks of different characteristics. A secondary low-boiling hydrocarbon oil charging stock may be supplied, for example, to the first mentioned heating coil for conversion, together with the selected intermediate fractions of the charging stock and low-boiling fractions of the reflux condensate. A secondary relatively high-boiling hydrocarbon oil may be supplied, for example, to the second mentioned heating coil for conversion, together with the high-boiling fractions of the reflux condensate or may, when desired, be commingled with the vaporous and liquid conversion products from said separate reaction chamber supplied to the vaporizing chamber with which high-boiling fractions of the primary (relatively wide boiling range) charging stock are also commingled.

A more comprehensive understanding of the present invention and its relatively broad scope and applicability to various charging stocks may be had from the following description of one preferred method of operation of the process of the invention as it may be accomplished in an apparatus such as illustrated in the accompanying diagrammatic drawing.

Hydrocarbon oil charging stock for the process, comprising an oil of relatively wide boiling range, such as, for example, crude petroleum, topped crude, or the like, is supplied through line 1 and valve 2 to pump 3 wherefrom it is fed through line 4 and valve 5 into and through heat exchanger coil 6 located within fractionator 7 wherein it may be heated by indirect contact and heat exchange with the vaporous conversion products of the process undergoing fractionation in this zone, the charging stock passing, in the case here illustrated, from coil 6 through line 8 into and through coil 9 located within vaporizing chamber 10 wherein additional heat is supplied to the charging stock from the vaporous conversion products in this zone, the heated charging stock passing thence through line 11 into fractional distilling column 12 wherein it is subjected to fractional distillation and separated, in the case here illustrated, into selected low-boiling, intermediate and high-boiling fractions. It will be understood, that when desired, heating of the charging stock for the purpose of effecting its fractional distillation may be assisted in any other well known manner, not illustrated, or, when desired other well known means of heating may be utilized in conjunction with either or both of the specific means of heat exchange illustrated.

When the charging stock subjected to fractional distillation in column 12 contains any appreciable quantity of desirable low-boiling fractions such as motor fuel or low-boiling motor fuel fractions of good antiknock value they may be removed as fractionated vapors from the upper portion of column 12, together with any gas produced by the distilling operation, through line 13 and valve 14 to be subjected to condensation and cooling in condenser 15. The resulting distillate and gas passes through line 16 and valve 17 to collection and separation in receiver 18. Uncondensable gas may be released from the receiver through line 19 and valve 20. Distillate may be removed from receiver 18 through line 21 and valve 22 to storage or to any desired further treatment. This product may, when desired, be commingled with the motor fuel conversion products of the process to form the final motor fuel product. Also, when desired, a regulated portion of the distillate collected in receiver 18 may be recirculated by well known means, not illustrated, to the upper portion of column 12 to serve as a refluxing and cooling medium in this zone.

Selected intermediate fractions of the charging stock, including any motor fuel components of poor antiknock value as well as higher boiling materials such as, for example, naphtha, kerosene, or kerosene distillate, light gas oil and the like may be withdrawn from one or a plurality of suitable intermediate points in column 12 and in the case here illustrated are directed through line 23 and valve 24 to pump 25 by means of which they are fed through line 26, valve 27 and line 28 to conversion in heating coil 29.

When desired, a separate hydrocarbon oil charging stock, preferably of relatively low-boiling characteristics, such as, for example, straight-run gasoline or other motor fuel or motor fuel fractions of poor antiknock value, naphtha, kerosene or kerosene distillate, pressure distillate, pressure distillate bottoms, light gas oil or the like may be supplied through line 30 and valve 31 to pump 32 by means of which it is fed through line 33, valve 34 and line 28 to conversion in heating coil 29, together with the selected fractions of the primary charging stock from column 12 supplied to this zone, as previously described, as well as selected intermediate conversion products of the process of relatively low-boiling characteristics which are supplied to this zone, as will be later more fully described.

Heating coil 29 is located within a furnace 35 of any suitable form by means of which the oil passing through the heating coil is brought preferably to a relatively high conversion temperature at substantial superatmospheric pressure and the heated products are discharged from heating coil 29 through line 36 and valve 37 into reaction chamber 38.

Chamber 38 is also preferably maintained at a substantial superatmospheric pressure which may be substantially the same or somewhat lower than that employed at the outlet from heating coil 29 and, although not indicated in the drawing, this zone is preferably insulated to prevent the excessive loss of heat therefrom by radiation in order to accomplish continued conversion of the heated products supplied to this zone and particularly their vaporous components. In the case here illustrated, both vaporous and liquid conversion products are withdrawn from the lower portion of chamber 38 through line 39 and are directed through valve 40, in this line, into reaction chamber 41 which, like reaction chamber 38, is preferably insulated and operated at a substantial superatmospheric pressure so that additional continued conversion of the products from chamber 38 as well as continued conversion of the other products supplied to this zone, as will be later more fully described, may be accomplished in chamber 41. Both vaporous and liquid conversion products are also withdrawn, in the case here illustrated, in commingled state from the lower portion of chamber 41 through line 42 and valve 43 and are introduced into vaporizing chamber 10.

Selected high-boiling fractions of the charging stock comprising the bottoms resulting from said fractional distillation in column 12 including the fractions of the primary charging stock boiling above the range of the selected fractions supplied to heating coil 29, as previously described, may be withdrawn from the lower portion of column 12 through line 44 and valve 45 to pump 46 by means of which they are fed through line 47 and valve 48 and, in the case here illustrated, are introduced into the lower portion of chamber 41 to commingle therein with the stream of vaporous and liquid conversion products withdrawn from this zone and supplied, as previously described, to vaporizing chamber 10. It is also within the scope of the present invention, although not illustrated, to introduce all or a regulated portion of the selected high-boiling fractions of the charging stock from column 12 into the reaction chamber at any other desired point or plurality of points in this zone, depending upon the degree of conversion to which it is desired to subject said high-boiling fractions of the charging stock. All or a regulated portion of this material may also, when desired, be introduced either into line 42 or directly into chamber 10 at any desired point, although means for accomplishing this are not shown in the drawing.

In another embodiment of the invention which may be employed, particularly in case the high-boiling fractions of the primary charging stock subjected to fractional distillation in column 12 are suitable for conversion in a heating coil without the danger of excessive coke formation therein, said high-boiling fractions may be diverted from line 47 through line 49 and valve 50 and directed through line 51 to conversion in heating coil 52.

When desired, a secondary charging stock of relatively high-boiling characteristics may be supplied through line 56 and valve 57 to pump 58 by means of which it is fed through line 59 and may be directed, all or in part, through valve 60 and supplied either alone or together with the high-boiling fractions of the primary charging stock from column 12 through line 47 into reaction chamber 41 or a regulated portion or all of the high-boiling secondary charging stock, when such is employed, may be directed from line 59 through line 61, valve 62 and line 51 to conversion in heating coil 52. It is also within the scope of the invention to supply regulated amounts of high-boiling secondary charging stock to any desired point in reaction chamber 41 other than that illustrated in the drawing and/or to introduce the same into line 42 or directly into vaporizing chamber 10 at any desired point, although means for accomplishing this are not illustrated.

Heating coil 52 is located within a furnace 53 of any suitable form and the oil supplied thereto is brought to the desired conversion temperature preferably at a substantially superatmospheric pressure following which it is discharged through line 54 and valve 55 into reaction chamber 41 to commingle therein and be subjected to further conversion therein and be subjected to further conversion with the heated products from reaction chamber 38 supplied to chamber 41, as previously described.

Vaporizing chamber 10 is preferably operated at a substantially reduced pressure relative to that employed in reaction chamber 41 by means of which further vaporization of the liquid conversion products as well as any other liquids supplied to this zone, as previously described, is accomplished. Residual liquid remaining unvaporized in chamber 10 may be withdrawn therefrom through line 63 and valve 64 to cooling and storage or to any desired further treatment. The vaporous products supplied to chamber 10, as well as any vapors evolved and remaining uncondensed in this zone, may be directed therefrom through line 65 and valve 67 to fractionation in fractionator 7.

The components of the vapors supplied to fractionator 7 boiling above the range of the desired final light distillate product of the process are condensed in this zone as reflux condensate and in the case here illustrated the reflux condensate is separated by fractional condensation in column 7 into selected relatively low-boiling and high-boiling fractions.

The selected low-boiling fractions of the reflux condensate which may comprise, for example, such materials as high-boiling motor fuel fractions of poor antiknock value, pressure distillate bottoms, light gas oil and the like may be withdrawn from any suitable intermediate point or plurality of points in fractionator 7 and in the case here illustrated are directed from fractionator 7 through line 68 to pump 70 by means of which they are fed through line 71, valve 72 and line 28 to further conversion in heating coil 29.

The high-boiling fractions of the reflux condensate formed in fractionator 7 may be withdrawn from the lower portion of this zone through line 73 and valve 74 to pump 75 by means of which they are fed through line 51 and valve 76 to further conversion in heating coil 52 either alone or together with high-boiling fractions of the primary charging stock from column 12 and/or secondary charging stock of relatively high-boiling characteristics.

Fractionated vapors of the desired end-boiling point, preferably comprising materials within the boiling range of motor fuel and of good antiknock value are withdrawn, together with uncondensable gas produced by the cracking operation from the upper portion of fractionator 7 through line 77 and valve 78 and are subjected to condensation and cooling in condenser 79. The resulting distillate and gas is directed through line 80 and valve 81 to collection and separation in receiver 82. Uncondensable gas may be released from the receiver through line 83 and valve 84. Distillate may be removed from receiver 82 through line 85 and valve 86 to storage or to any desired further treatment. When desired, a regulated portion of the distillate collected in receiver 82 may be recirculated by well known means, not shown in the drawing, to the upper portion of fractionator 7 to serve as a cooling and refluxing medium to assist fractionation of the vaporous products in this zone.

In operating the process of the present invention the following conditions are illustrative of those producing the best results. Fractional distillation of the primary charging stock (charging stock of relatively wide boiling range) may be accomplished by heating the same to a temperature ranging, for example, from 450° to 750° F., and at any desired pressure from substantially atmospheric to 200 pounds, or more, per square inch. The first described heating coil to which selected intermediate fractions of the primary charging stock, selected low-boiling fractions of the reflux condensate and, when desired, secondary charging stock of low-boiling characteristics are supplied for conversion may utilize an outlet temperature ranging, for example, from 900° to 1,050° F., preferably with a superatmospheric pressure at this point in the system of from 200 to 1,000 pounds, or thereabouts, per square inch. The pressure employed in the first reaction chamber succeeding the light oil heating coil may be substantially the same or somewhat lower than that employed at the outlet from said heating coil and may range, for example, from 100 pounds per square inch up to substantially the same pressure as that employed in the heating coil. Substantially the same or somewhat lower pressure may also be employed in the second reaction chamber to which products from the first reaction chamber and from the heavy oil heating coil are supplied. The pressure in the second reaction chamber is, however, no greater than that employed in the heavy oil heating coil which may, when desired, be appreciably less than that employed in the first reaction chamber. The heavy oil heating coil to which high-boiling fractions of the reflux condensate are supplied for conversion, either alone or together with high-boiling fractions of the primary charging stock and/or secondary charging stock of high-boiling characteristics, may utilize an outlet conversion temperature ranging, for example, from 800° to 950° F., preferably with a superatmospheric pressure, measured at the outlet from the heating coil, of from 100 to 500 pounds, or more, per square inch. The vaporizing chamber is preferably operated at a substantially reduced pressure relative to that employed in the second reaction chamber and may range, for example, from substantially atmospheric to 100 pounds, or thereabouts, per square inch superatmospheric pressure. The fractionating, condensing and collecting portions of the cracking system may employ pressures substantially the same or somewhat lower than that employed in the vaporizing chamber.

Following is an example of one specific method of operation of the process of the present invention and the results obtainable therefrom. The method of operation and results given, however, are not to be construed as a limitation upon the invention inasmuch as they are given only for the purpose of illustration. A charging stock of relatively wide boiling range comprising a California crude of about 27.5° A. P. I. gravity is subjected to fractional distillation by heating the same to a temperature of approximately 600° F., at substantially atmospheric pressure, the heat required for such distillation being recovered from within the cracking system. About 18 percent of the charging stock, comprising gasoline fractions boiling up to approximately 340° F. which are of satisfactory antiknock value, is recovered as the overhead distillate product from the distilling operation. Intermediate fractions of the charging stock, about 93 percent of which boil within the range of 340° to 550° F., are subjected in the light oil heating coil of the system to a conversion temperature, measured at the outlet therefrom, of approximately 970° F., with a superatmospheric pressure, at the outlet from the heating coil, of approximately 500 pounds per square inch. Substantially the same pressure is maintained in the first reaction chamber succeeding the light oil heating coil. Low-boiling fractions of the reflux condensate produced within the system having a boiling range of substantially 390° to 540° F., are returned to the light oil heating coil for further conversion, together with the intermediate fractions of the charging stock. High-boiling fractions of the charging stock and high-boiling fractions of the reflux condensate are subjected in a separate heating coil to an outlet conversion temperature of approximately 930° F. at a superatmospheric pressure of about 350 pounds per square inch and the heated products from this zone are introduced, together with the products from the first reaction chamber, into a separate reaction chamber also maintained at a superatmospheric pressure of about 350 pounds per square inch. Both vaporous and liquid conversion products from the second reaction chamber are introduced into a reduced pressure vaporizing chamber maintained at a superatmospheric pressure of about 50 pounds per square inch, from which residual liquid is withdrawn, and the vaporous products are subjected to fractionation for the formation of reflux condensate and the recovery of desirable low-boiling fractions comprising the overhead vaporous products which are condensed to form the final light distillate conversion product of the process. This operation will produce, in addition to the 18 percent, or thereabouts, of the straight-run gasoline recovered by the distilling operation, about 57 percent, based on the topped crude, of cracked motor fuel having an antiknock value equivalent to an octane number of approximately 72 and about 30 percent of good quality residual liquid suitable as fuel, the remainder being chargeable, principally, to uncondensable gas and loss.

I claim as my invention:

1. In a process for the conversion of hydrocarbon oils wherein relatively low-boiling and relatively high-boiling oils are subjected to independently controlled conversion conditions of elevated temperature and superatmospheric pressure each in a separate heating coil and communicating reaction chamber, the improvement which comprises withdrawing both vaporous and liquid conversion products from the reaction chamber succeeding the light oil heating coil and passing the same through the reaction chamber to which the heated products from the heavy oil heating coil are directly supplied, withdrawing liquid and vaporous conversion products from the last mentioned reaction chamber, subjecting the latter to further vaporization at substantially reduced pressure, subjecting the vaporous products, including those evolved by said further vaporization, to fractionation, whereby their insufficiently converted components are condensed as reflux condensate and separated into selected relatively low-boiling and high-boiling fractions, returning selected relatively low-boiling and high-boiling fractions of the reflux condensate, respectively, to the light oil and heavy oil heating coils for further conversion, subjecting fractionated vapors of the desired end-boiling point to condensation and recovering the resulting products.

2. A process of the character defined in claim 1 wherein hydrocarbon oil charging stock for the process of relatively low-boiling characteristics is supplied to the light heating coil.

3. A process of the character defined in claim 1 wherein hydrocarbon oil charging stock for the process of relatively high-boiling characteristics is supplied to the heavy oil heating coil.

4. A process of the character defined in claim 1 wherein hydrocarbon oil charging stock for the process of relatively high-boiling characteristics is supplied to the vaporizing chamber.

5. A process of the character defined in claim 1 wherein hydrocarbon oil charging stock for the process of relatively high-boiling characteristics is supplied to the reaction chamber to which the heated products from the heavy oil heating coil are directly supplied.

6. A process of the character defined in claim 1 wherein selected fractions of relatively low-boiling and high-boiling characteristics are separated from hydrocarbon oil charging stock for the process of relatively wide boiling range, said selected low-boiling fractions being supplied to the light oil heating coil and said selected high-boiling fractions being supplied to the heavy oil heating coil.

7. A process of the character defined in claim 1 wherein selected fractions of relatively low-boiling and high-boiling characteristics are separated from hydrocarbon oil charging stock for the process of relatively wide boiling range, said selected low-boiling fractions being supplied to the light oil heating coil and said selected high-boiling fractions being supplied to the reaction chamber.

8. A process of the character defined in claim 1 wherein selected fractions of relatively low-boiling and high-boiling characteristics are separated from hydrocarbon oil charging stock for the process of relatively wide boiling range, said selected low-boiling fractions being supplied to the light oil heating coil and said selected high-boiling fractions being supplied to the vaporizing chamber.

9. In a process for the conversion of hydrocarbon oils wherein relatively low-boiling and relatively high-boiling oils are subjected to independently controlled conversion conditions of elevated temperature and superatmospheric pressure each in a separate heating coil and communicating reaction chamber, the improvement which comprises withdrawing both vaporous and liquid conversion products from the reaction chamber succeeding the light oil heating coil and passing the same through the reaction chamber to which the heated products from the heavy oil heating coil are directly supplied, withdrawing

liquid and vaporous conversion products as a mixture from the last-mentioned reaction chamber and separating said mixture into vapors and residue in a reduced pressure vaporizing chamber, subjecting said vapors to fractionation whereby their insufficiently converted components are condensed as reflux condensate and separated into selected relatively low-boiling and high-boiling fractions, returning selected relatively low-boiling and high-boiling fractions of the reflux condensate, respectively, to the light oil and heavy oil heating coils for further conversion, subjecting fractionated vapors of the desired end-boiling point to condensation and recovering the resulting products.

JACOB BENJAMIN HEID.