

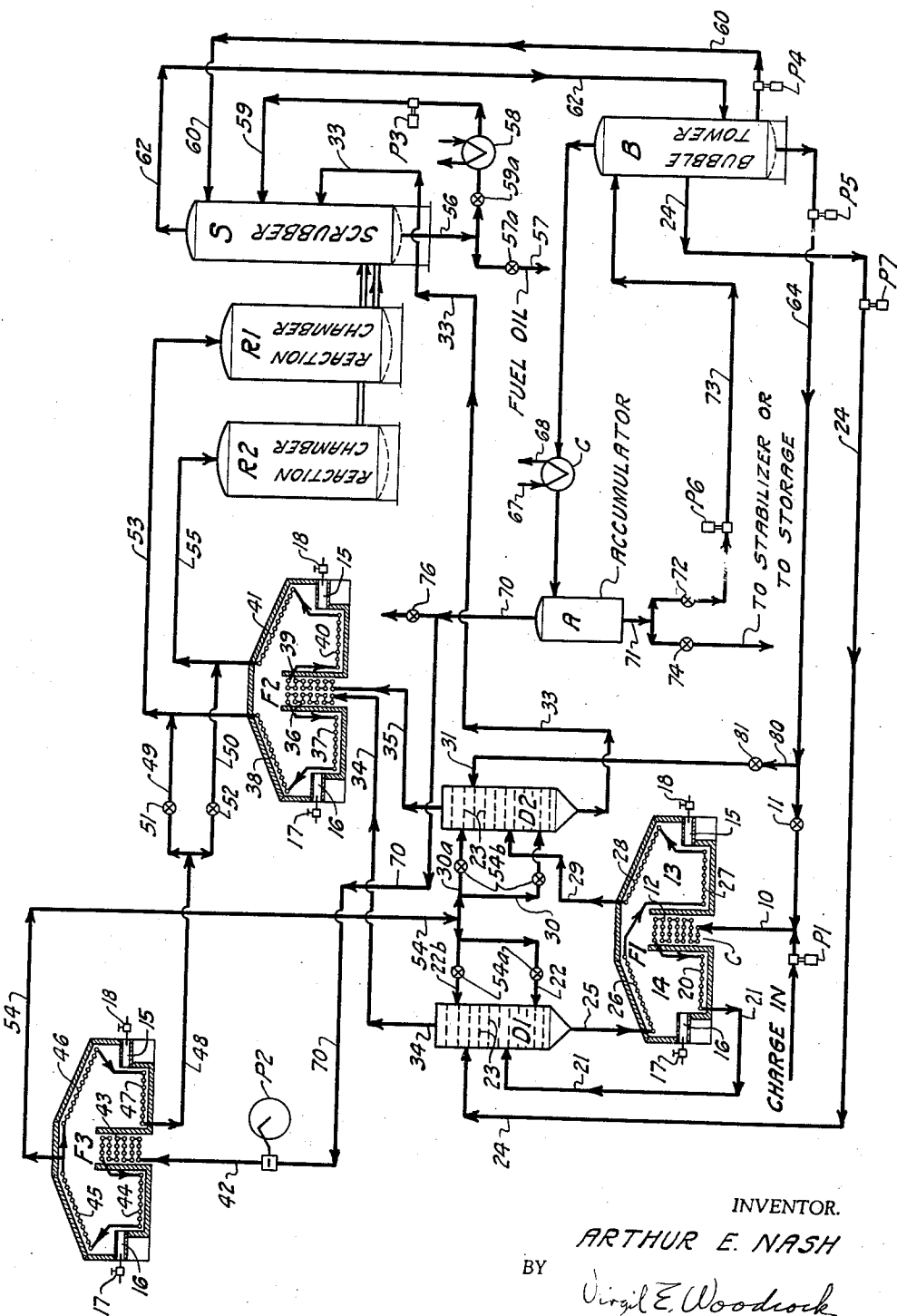
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VAPOR PHASE CRACKING SYSTEM

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## UNITED STATES PATENT OFFICE

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## VAPOR PHASE CRACKING SYSTEM

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9 Claims. (Cl. 196—60)

My invention relates to methods of and apparatus for converting hydrocarbon oils or petroleum, particularly in vapor phase, into oils of lower boiling points, utilizable for motor fuels, including gasoline, and has for an object the provision of a reliable means for increasing the yield of gasoline and anti-detonating characteristics obtained with charging stocks of widely different character.

It is a further object of my invention to overcome disadvantages or difficulties arising when the charging stock has a wide boiling range, and this may be true whether it be a light, intermediate or a very heavy oil. With such a charging stock the range of boiling points of the vapors is so great that the higher temperature necessary to convert or crack the vapors of low boiling point is attended by overheating of the vapors of high boiling point, with resultant formation or deposition of carbonaceous material or coke. Otherwise stated, it is an object of my invention to derive from the charging stock a plurality of streams of vapors of different boiling point ranges, and to subject the separate streams of vapors individually to different temperatures or heating conditions best suited to their individual thermal and physical characteristics so that, when mixed with heated heat-carrier gas, they are cracked under optimum time-temperature conditions.

To this end, and further in accordance with my invention, the liquid oil or charging stock is subjected to temperatures such as to evolve therefrom vapors of low boiling point range, which are separated from the then remaining unvaporized or liquid oil; which residual oil is then subjected to a higher temperature, and within the range producing mild cracking of the residual oil thereby reducing its viscosity by chemically changing its composition; for example by mildly cracking the residual oil, a partial conversion of the heavier into lighter products is obtained. The said lighter products and the material vaporizable at the higher temperature are then separated to form a second vapor stream. The separately derived vapor streams are individually subjected to heating conditions or temperatures to raise each of them to within the range of its cracking temperature during time intervals insufficient for material cracking to occur, and before material cracking has occurred the vapor streams are separately brought into mixture with heat-carrier gas which is itself at a temperature above the cracking temperature of the more refractory stream of vapors and in quantity adequate quickly

to raise each stream to a fairly high cracking temperature, for example, to temperatures of the order of 985° F. to 1100° F. The carrier gas may be brought into mixture with each vapor stream within a plurality of reaction chambers, or equivalents, individual to the several vapor streams; or within the transfer lines leading to the reaction chambers; or in lieu of cracking or completion of cracking in transfer lines and/or reaction chambers, the carrier gas may be added to the vapor streams and both subjected to mild heating in tubular soakage banks of a furnace for completion of cracking.

Further in accordance with my invention, when as aforesaid, there are produced a plurality of vapor streams whose vapors are of materially differing boiling point ranges, these successive vaporizing operations are performed preferably in separate zones of different temperatures of a heating unit, preferably comprising a plurality of heating or firing chambers; one or more of the steps of superheating the vapors and heating of the heat-carrier gas may be effected in one furnace or in separate furnaces; and one or more of the steps of superheating the vapors and heating the carrier gas may be effected in the same furnace or furnaces in which one or more of the aforesaid vaporization steps are performed, it being desirable in each case to provide relatively independent control of the heat input to, and the outlet temperatures of, the respective streams of fluid undergoing heating.

Further in accordance with my invention, more complete separation of vapors from their attendant liquid oils is accomplished by introducing flash gas into each of the separating zones. The flash gas is preferably drawn or tapped off from a stream of heated carrier gas at a point within the heater so that its temperature is somewhat higher than, or approximately, that of the vapors within the particular separating zone.

My invention further resides in the general and specific methods and apparatus hereinafter described.

My present application is a continuation-in-part of my application S. N. 79,425, filed May 13, 1936, for "Vapor phase cracking system."

For a more complete understanding of my invention, reference should now be had to the drawing, in which I have diagrammatically illustrated a system in accordance with my invention, characterized by the provision of a plurality of vapor separators, reaction chambers, and heaters.

With respect to the furnaces herein described,

and their equivalents, for the purposes of my invention, it shall be understood that the tubes in each convection section are heated by convection; the floor tubes are disposed below and without the gas currents to be heated substantially solely by radiation; and the roof tubes are heated by radiation and convection. It shall further be understood that in addition to, or in lieu of one or separate reaction chambers, the carrier gas, and the superheated vapor streams, may, as a mixture of vapors and carrier gas, be subject to further heat in soakage or convection banks of a furnace or furnaces without increase in temperature but to effect soakage and so maintain reaction velocity; or materially all of the cracking of the vapors may be completed in the transfer lines which then carry the separate streams of vapors directly to the scrubber.

Referring to the drawing, the charging stock, oil in liquid phase, such as petroleum, topped crude petroleum, or components of petroleum whose portions to be cracked have suitable boiling point ranges, is introduced into furnace F<sup>1</sup>, or equivalent heating unit, through the line 10, by pump P<sup>1</sup>, generally in mixture with recycle stock from the cracking system, as indicated, and under the control of valve 11.

The charging stock is introduced into the heating unit or furnace F<sup>1</sup> under suitable pressure such as to maintain upon the entire system, or portions thereof in communication through pressure reducing means, a pressure or pressures, generally superatmospheric, suitable to or usually employed in connection with the particular operating conditions in view; and the pressure in line 10 is preferably from 250 to 400 pounds per square inch, or it may be more or less as may be desired, and as determined by the pressure desired upon the processing vessels and devices.

The charging stock passes first through tubes 12 in the convection zone or chamber C, disposed between the opposite ends of the furnace or between fire chambers 13 and 14, from both of which the furnace gases pass through chamber C to stack. Into fire chambers 13 and 14 hot combustion gases are discharged from combustion muffles or tunnels 15 and 16, each representing a horizontal series thereof, and respectively provided with burner structures 17 and 18 suited to the fuel to be burned, such as oil, gas, oil and gas, or equivalent, and each separately controllable and adjustable.

From the convection bank 12, the oil traverses the bank 20 of floor tubes, and through transfer line 21 is introduced into a flash drum or separator D<sup>1</sup> into which is introduced by line 22 flash gas heated in a manner hereinafter to be described to desired temperature, and having the effect in the separator to facilitate sharper or more complete separation of the vapors from the liquid oil by stripping them from the liquid and by causing the vapors to have a partial pressure less than the total pressure within the drum D<sup>1</sup>. To dry the vapors flash gas is introduced through line 22b before they leave the flash drum.

Further to assist or to facilitate sharper separation of the vapors, the separating drum D<sup>1</sup> may be provided with several baffle plates 23, and reflux of thermal and physical characteristics about the same as the vapors to be obtained from the separator may be introduced thereinto through line 24, which reflux also vaporizes and adds to the supply of dry vapor from separator D<sup>1</sup>.

The residual liquid oil or bottoms from separator D<sup>1</sup> flows through line 25, roof tubes 26 of

fire chamber 14, floor tubes 27 and roof tubes 28 of fire chamber 13, and thence by line 29 into the second separator or separating drum D<sup>2</sup>. During passage through tube banks 26—28, the temperature of the liquid is further elevated; and preferably elevated to bring the liquid residual oil to and to hold it at a mild cracking temperature for viscosity-breaking, which effects conversion or cracking of at least a part of the heavier stock into lighter boiling point fractions, thereby to increase the yield and amount of vapor obtainable from separator D<sup>2</sup>. Flash gas is introduced into separator D<sup>2</sup> by way of line 30 to strip the liquid of vapors and to reduce the partial pressure of the vapors. To dry the vapors flash gas is introduced through line 30a as the vapors leave drum D<sup>2</sup>. Reflux may be introduced through line 31, further to assist in the separation, and to introduce material which will itself contain vaporizable material to add to the supply of dry vapors issuing from separator D<sup>2</sup>. The residual liquid oil or bottoms from drum D<sup>2</sup> is preferably introduced by a line 33 into scrubber S, for cooling and scrubbing the vapors from the reaction chamber.

The vapor streams are respectively taken from separators D<sup>1</sup> and D<sup>2</sup> by way of lines 34 and 35, to be separately superheated; for example, the vapors from separator D<sup>1</sup> are introduced into convection tubes 36 of a heater or furnace F<sup>2</sup>, and in succession pass through the floor tubes 37 and roof tubes 38 of the left-hand fire chamber thereof, while the vapor stream of line 35 passes through convection bank 39 and then through floor tube bank 40 and roof tube bank 41 of the right-hand fire chamber. Since the right and left hand fire chambers, as viewed in the drawing, are separately fired from their respective horizontal series of combustion chambers, muffles or tunnels, 15 and 16, by suitably adjusting the burner structures 17 and 18 associated therewith, the temperature rise of each vapor stream may be and is separately controlled. Any desired temperature rise, for given conditions of flow, is readily obtained and in accord with my invention, each vapor stream is superheated to a temperature within the range of its cracking temperature, but during a time interval insufficient for substantial or material cracking to occur. As shown, the several banks of tubes are connected in series and the tubes of each bank are serially connected. To control the heating time, it is to be understood the tubes within each bank may be connected in groups in parallel with each other; the velocity of flow of the vapor streams may be increased; the tube size increased; and other expediciencies known to the art utilized to control the time the vapors remain at their cracking temperature and to maintain that time of such short duration no material cracking of the vapors occurs while undergoing heating. The cracking of the vapors of the separate streams is effected and completed while in mixture with heat carrier gas.

The term carrier gas, for brevity, includes gases resulting from a cracking process, including those resulting from the cracking system herein described, hydrocarbon gases, natural gas or steam, and in general, any gas or gaseous heat-vehicle, more particularly if it be of character which does not adversely affect the process or desired product by polymerization, chemical or other action.

The heat-carrier gas is introduced into a furnace F<sup>3</sup> through a supply line 42 leading from a gas compressor P<sup>2</sup> under such pressure as will cause it to have a pressure equal to or suitably related to the pressures of the vapor streams.

The carrier gas passes first through a bank of convection tubes 43, thence through floor tubes 44 and roof tubes 45 of the lefthand fire chamber, thence through roof tubes 46 and floor tubes 47 of the right hand fire chamber, and by transfer line 48 is introduced into lines 49 and 50, respectively including valves 51 and 52.

The temperature of the heat-carrier gas is raised above that of the more refractory vapor streams, the one from separator D<sup>1</sup> which passes through floor tubes 37 and roof tubes 38 and by transfer line 53 to reaction chamber R<sup>1</sup>, and may be of the order of from 1200° F. to 1300° F.

Instead of a separate bank of tubes within one of the heaters F<sup>1</sup>, F<sup>2</sup> or F<sup>3</sup>, I prefer to provide a line 54 connected into the heating tubes of heater F<sup>3</sup> at that point where the heat-carrier gas is at a temperature suitable for withdrawal and supply to the separators D<sup>1</sup> and D<sup>2</sup>. As shown, the flash gas, withdrawn from the heat-carrier gas after it has passed through floor tubes 44 and roof tubes 45, under the control of valves 54a and 54b passes into the separators D<sup>1</sup> and D<sup>2</sup>.

Within the transfer line 53 the heat-carrier gas is commingled with the more refractory stream of vapors which have been superheated to a temperature between 945° F. to 1065° F. The cracking reaction is immediately initiated and rapidly proceeds to completion; it may be substantially complete before the vapors in mixture with carrier gas reach the reaction chamber R<sup>1</sup>, or the cracking reaction may be completed within the reaction chamber R<sup>1</sup>.

Similarly and concurrently, the carrier gas supplied by line 50 is in transfer line 55 commingled with the less refractory vapor stream from roof tubes 41 and separator D<sup>2</sup>. The cracking reaction of the less refractory vapors, which have been superheated to about 930° F. to 975° F., is immediately initiated and may be completed within the transfer line 55, or the final stages of the cracking reaction may be completed within the second reaction chamber R<sup>2</sup>. In each case the temperature of the mixture is the optimum for the thermal characteristics of the vapor stream, and by varying the temperature of the superheated vapors, the amount of carrier gas or its temperature, temperatures for the mixtures are readily attained which will produce maximum formation of gasoline.

The reaction chambers R<sup>1</sup> and R<sup>2</sup> discharge the reaction products and gas into the scrubber S, from whose bottom is drawn off through lines 56 and 57 oil which is unsuitable for recycling through the system, and this may be utilized as fuel oil, placed in storage, or further processed for the production of asphalt and the like. Preferably, a part of the liquid oil, the division being determined by valves 57a and 59a from the bottom of the scrubber S is passed through a cooler 58, elevated in pressure by pump P<sup>3</sup>, and introduced into the scrubber by line 59 in the form of a spray thoroughly to contact and cool and scrub the reaction products within the scrubber. Additional cooling and scrubbing mediums, or reflux, may be introduced into the scrubber which contains a few trays or baffles (not shown); as for example, a stream of heavy material may be derived from bubble tower B, elevated in pressure by pump P<sup>4</sup>, and by line 60 introduced into the upper part of the scrubber, and descends countercurrently with the ascending vapors and gas; and a stream from the bottom of separator D<sup>2</sup> may be introduced by way of line 33.

The cooled vapors from the scrubber pass by

way of line 62 into the bubble tower or fractionating column B, from whose bottom is drawn off liquid oil, elevated in pressure by pump P<sup>5</sup>, and by lines 64 and 10, and under the control of valve 11, recycled in mixture with the fresh feed or charge stock.

From the bubble tower B the desired reaction products and gas are discharged through a cooler or condenser C, in heat transfer relation with a suitable cooling medium entering, for example, at 67 and discharged at 68. From the cooler or condenser C the gas and liquid products are discharged into a gas separator and gasoline accumulator A, from which the gas is discharged through line 70 and to the gas compressor P<sup>2</sup>, or a part thereof, under control of valve 76, is sent to storage, or burned as fuel.

The liquid product, such as motor fuel, including gasoline, is drawn off through line 71. A part of the liquid product, under the control of valve 72, is elevated in pressure by pump P<sup>6</sup>, and by line 73 introduced into the bubble tower as reflux therefor. The remainder of the liquid product under the control of valve 74 is drawn off to storage or other destination, and preferably forms the supply for a stabilizer, or for further processing equipments.

The valves 74 and 76, by suitable adjustment, serve to retain a pressure upon the entire system of that magnitude desired as one of the several conditions under which the cracking or other steps are effected. Where reducing valve or valves is or are used at one or more points along the system for stepping down the pressure, the pressure backed up by valves 74 and 76 determines the pressure on the low-pressure side of the last reducing valve.

The methods and apparatus described provide greater yield of desired product, motor fuel and especially gasoline when producing a product of a given octane value or anti-knock characteristic, and procure a greater yield of a desired product for a system of given size. In accord with my invention less stock is recycled, which is to say, the amount or rate of conversion or cracking per pass or single traverse of the system is to an unusual degree increased.

By way of example, the particular charging stock, fresh feed, such as stripped or topped crude petroleum, may have an initial boiling point of about 350° F., and a gravity within the range of 19° A. P. I. to 25° A. P. I. Such stock which ordinarily is combined with recycle stock, is heated, vaporized and separated as described into the two streams of vapors, the first from separator D<sup>1</sup>, representing or comprising low boiling oil having an initial boiling point of about 350° F., and a gravity within the range between 25° A. P. I. and 35° A. P. I. and comprising about 45 to 50% of the charging stock, while the vapors of the second stream from separator D<sup>2</sup>, comprise or represent a heavier oil, for example having an initial boiling point of about 550° F., and a gravity within the range between 15 to 25° A. P. I. and comprising about 60 to 70% of the residual oil from separator D<sup>1</sup>, the second stream including lighter fractions resulting from the mild cracking or viscosity-breaking incident to the heating of the residual liquid oil from the separator D<sup>1</sup>, before its admission to separator D<sup>2</sup>. The residual liquid oil from separator D<sup>2</sup> having a gravity within the range of 5 to 15° A. P. I. is through line 33 introduced into the scrubber.

The light or more refractory vapors of lower boiling oil are, for example, then superheated to

a temperature between 945° F. and 1065° F., and the vapors of the heavier, less refractory stream are superheated to a temperature of the order of 930° F. to 975° F. Before material cracking of vapors has occurred, the carrier gas is introduced into the transfer lines 53 and 55 and, commingling with them, quickly elevates the vapors to a higher temperature, and produces immediate and complete cracking thereof. The cracking reaction is ordinarily completed in a very short time interval, for example, within an interval between about one-half a minute and two minutes. The carrier gas is preferably heated to a temperature between about 1150° F. and 1300° F., and to a temperature such that, when the carrier gas has been added to the vapors, the temperature of the mixture will then be best suited to the particular thermal and physical characteristics of each stream for production of the maximum amount of gasoline. For optimum conditions for the example here considered, the temperature of the mixture of the carrier gas and of the lighter, more refractory vapor stream may be between about 985° F. and 1100° F., and the temperature of the heavy, less refractory stream between about 950° F. and 1075° F., in part depending upon the octane value desired in the product, ordinarily high, as for example from 68 to 75.

After passage through the reaction chambers R1 and R2 the reaction products and gas, upon entering the scrubber S are thoroughly contacted by a cooling medium which scrubs and cleans and condenses from the reaction products heavier materials contained therein. A part of the cooling medium, derived from the outlet 56 from the bottom of the scrubber S, after passage through the cooler 58 is by pump P3 forced into line 59 which terminates within the scrubber in a spray head or nozzle (not shown), which sprays the cooling medium in countercurrent contact with the reaction products and vapors.

Further to increase the yield of desirable products, it is desirable to take a side stream from the bubble tower B by way of line 24, the side stream having physical characteristics, particularly a boiling range substantially corresponding with that of the vapor stream taken from the separator D1. Included in the line 24 is a pump P7 to elevate the side stream to a pressure sufficient for entry into the separator D1. The side stream 24 serves as a temperature control for the separator D1, and aids in securing a sharper separation of the desired vapors from the charging stock. Substantially all of the side stream, recycle or reflux, is vaporized. Similarly, a part of the bottoms from the bubble tower may be introduced into the second separator D2 by way of lines 64 and 80, valve 81, and line 31 to control the temperature at the top thereof, and to comprise reflux therefor. By introducing both of the stocks or streams aforesaid directly into the separators, the quantity of vapors in the respective vapor streams 34 and 35 may be increased without corresponding increase in the charge to convection bank 12, which makes for increased throughput, less demand on the heater F1 and in general increased yield of desirable products.

By the method and apparatus illustrated, the vapors of the individual streams are more homogeneous than in the case where a single stream of vapors is derived from the charging stock, especially when of wide range of boiling point, including relatively low and high boiling components. The vapors of each of the streams are

cracked or treated at a temperature and under attendant conditions better suited to their particular physical and thermal characteristics. Maximum cracking or conversion is procured without overcracking or coking of the heavier components of the charging stock to be cracked, and without undercracking or incomplete conversion of its lighter or lower boiling components.

Employment of heating units or furnaces of the character and for the purposes herein described greatly increases the economy or efficiency of operation; the control of application of heat for any step of the process or any part of the system is improved; and the several controls of heat application with respect to each other yields an overall or inclusive control of improved flexibility, from which follow greater efficiency of operation, improvement in or control of characteristics of product, and with respect to the carrier gas, a continuous flow thereof, controllable as to its rate of flow in comparison to the rate of flow of the vapors to be cracked, and with delivery of heat to the vapors and to the reaction chamber, or equivalent, at a constant and controllable rate per unit of time, as distinguished from the operation of stoves and particularly regenerative furnaces of which it is characteristic that there is direct heat transfer from hot refractories to the carrier or cycle gas instead of the indirect heat transfer thereto through the tubes of the heaters or furnaces in which fuel is continuously burned to generate heat and combustion gases. In the stoves the carrier gas fluctuates in temperature, and therefore, requires compensating fluctuation in rate of flow in an endeavor to procure heat input into the reaction chamber at substantially constant rate per unit of time. Whereas, in accord with my invention the carrier gas is heated in a continuously flowing stream by passing it through a furnace in indirect heat-transfer with combustion gases, whose heat is indirectly transferred to the carrier gas through the walls of the tubes; the tubes themselves, depending on their location and position with respect to the currents of gases as already explained, receiving heat substantially solely by radiation, and by combined radiation and convection from the combustion gases.

While I have shown a particular embodiment of my invention, it will be understood that I do not limit myself thereto, since many modifications may be made, and I therefore contemplate by the appended claims to cover any such modifications as fall within the spirit and scope of my invention.

What I claim is:

1. The method of cracking hydrocarbon oil in vapor phase which comprises heating the oil in liquid phase in a restricted stream to vaporization temperature, separating therefrom a first overhead stream of vapors, further heating the residual oil in liquid phase to a higher vaporization temperature, separating therefrom a second overhead stream of vapors of boiling point higher than that of the vapors of said first stream, separately superheating the vapor streams by indirect heat-transfer from combustion gases, the first stream to a temperature substantially above the temperature of said second stream, heating a continuously flowing stream of heat-carrier gas above the cracking temperature of said first stream of vapors by passing it through a furnace in indirect heat-transfer with combustion gases, and commingling said carrier gas with each of said separately superheated vapor streams in

quantity adequate to elevate each said stream to a temperature best suited to the thermal and physical characteristics of the vapors thereof for maximum cracking of each vapor stream into products suitable for motor fuel.

2. The method of cracking hydrocarbon oil in vapor phase which comprises heating the oil in liquid phase in a restricted stream to vaporization temperature, separating therefrom a first overhead stream of vapors, further heating the residual oil in liquid phase to a temperature producing mild cracking thereof and viscosity-breaking, separating therefrom a second overhead stream of vapors of boiling point somewhat higher than that of the vapors of said first stream, separately superheating said vapor streams to temperatures within the range of their said cracking temperatures during time intervals insufficient for material cracking to occur, heating a continuously flowing stream of heat-carrier gas above the cracking temperature of said first stream of vapors by passing it through a furnace in indirect heat-transfer with combustion gases, and commingling said carrier gas with each of said separately superheated vapor streams in quantity to elevate the respective vapor streams to temperatures best suited to them for the production of products suitable as motor fuel.

3. The method of cracking hydrocarbon oil in vapor phase which comprises heating charge oil in liquid phase in a restricted stream to a temperature adequate to produce substantial vaporization thereof, in a zone of reduced pressure separating the oil into an overhead stream of vapors and a stream of residual oil, further heating the residual oil in liquid phase to a temperature adequate to viscosity-break the residual oil, separating said residual oil into a second overhead vapor stream and into a second stream of residual oil, separately superheating the vapor streams to temperatures respectively within the cracking temperatures of vapors thereof during time intervals insufficient for material cracking to occur, in a furnace burning fuel to generate hot combustion gases, heating a continuously flowing stream of heat-carrier gas above the cracking temperature of said first stream by passing it through said furnace in indirect heat-transfer with said combustion gases, in reaction zones commingling said carrier gas with each of said separately superheated vapor streams quickly to elevate each of them to temperatures best suited to the vapors of said streams for the production of products suitable as motor fuel, in a scrubbing zone receiving the cracked vapors from said reaction zones, applying cooling oil to said cracked vapors, withdrawing oil in liquid phase from the scrubbing zone, and after cooling it reintroducing at least a part of it into said scrubbing zone as said cooling oil.

4. The method of cracking hydrocarbon oil in vapor phase which comprises heating the oil in liquid phase in a restricted stream to a temperature within the range of its vaporization temperature, in a zone of reduced pressure separating the oil into an overhead stream of vapors and a stream of residual liquid oil, further heating said residual oil to a temperature sufficiently high mildly to crack said residual oil so that a substantial portion thereof will vaporize in a separating zone having a pressure substantially the same as that in said first separating zone, in said second zone separating from the mildly cracked oil a second overhead stream of vapors of boiling point higher than that of the vapors

of said first stream, separately superheating the vapor streams, the first-named stream to a temperature substantially above the temperature of said second stream, in a furnace heating a continuously flowing stream of heat-carrier gas above the cracking temperature of said first-named stream of vapors by indirect heat exchange with combustion gases generated within said furnace, and commingling said carrier gas with each of said separately superheated vapor streams in quantity to elevate the temperatures to those best suited to their thermal and physical characteristics for the production of products suitable for motor fuel of high octane number.

5. A system of cracking hydrocarbon oil comprising a plurality of vapor separators respectively provided with an inlet, an overhead vapor outlet and a liquid oil outlet, means including a furnace and a first bank of tubes therein for connecting the liquid oil outlet of one vapor separator to the inlet of a second vapor separator, means for conducting oil at vaporization temperature to the first of said separators, the liquid oil therefrom passing through said first bank of tubes and into said inlet of said second separator after material elevation of its temperature, means forming reaction zones, means including a furnace and banks of tubes therein individual to said separators and respectively within separate fire chambers for separately conducting the vapors from said separators to said reaction zones, said vapors during passage through their respective banks of tubes receiving heat to elevate them to temperatures within the range of their respective cracking temperatures, means including a furnace and at least one bank of tubes for heating a heat-carrier gas above the discharge temperature of any of said separate streams of said oil vapors, and means for commingling within said reaction zones said carrier gas and said separately superheated oil vapors to produce simultaneous substantial cracking of said oil vapors at temperatures best suited to said vapors.

6. A system of cracking hydrocarbon oil in vapor phase comprising a vapor separator having a liquid inlet, an overhead vapor outlet and a liquid outlet, means connected to said liquid inlet for conducting oil at vaporization temperature to said separator, tubular heat-absorbing means connected to said vapor outlet for superheating the oil vapors to at least their cracking temperature during a time interval insufficient for material cracking thereof to occur within said tubular means, a second vapor separator having a liquid inlet an overhead vapor outlet and a liquid outlet, means for conducting oil in liquid phase from said liquid outlet of said first-named separator to said liquid inlet of said second separator and including a second tubular heat-absorption structure for further elevating the temperature of said oil in liquid phase, means connected to said vapor outlet of said second separator and including a third tubular heat-absorbing structure for superheating said vapors to at least their cracking temperature during a time interval insufficient for material cracking thereof to occur within said third structure, means forming reaction zones, means for heating a heat-carrier gas above the cracking temperature of the more refractory of said oil vapors comprising a fourth tubular heat-absorption structure, means for deriving from said fourth structure gas at approximately the temperature of the liquids entering said separators and for delivering said gas to said separators to assist vaporization of oil therein, and means for

commingling the carrier gas within said reaction zones with each of said separately superheated vapors to effect substantial cracking thereof at temperatures best suited to the individual vapor streams.

7. The method of cracking hydrocarbon oil in vapor phase which comprises heating charge oil in liquid phase in a restricted stream to a temperature adequate to produce substantial vaporization thereof, in a zone of reduced pressure separating the heated oil into a first overhead stream of vapors and a first stream of residual oil, further heating the residual oil in liquid phase to a temperature adequate to viscosity-break the residual oil, in a second zone separating said viscosity-broken oil into a second overhead stream of vapors of boiling point higher than that of the vapors of said first stream and a second stream of residual oil of low A. P. I. gravity, separately superheating the vapor streams to temperatures respectively within the ranges of cracking temperatures of the vapors thereof during time intervals insufficient for material cracking to occur, heating a continuously flowing stream of heat-carrier gas above the cracking temperature of said first vapor stream by passing it through a furnace in indirect heat exchange with combustion gases, in reaction zones commingling said carrier gas with each of said separately superheated vapor streams quickly to elevate each of them to a temperature best suited to the vapors thereof for the production of products suitable as motor fuel and to maintain them at said elevated temperatures until completion of the cracking reaction, immediately thereafter introducing said vapors and gas into a scrubbing zone, and in said scrubbing zone intimately spraying said vapors and said gas with a scrubbing and cooling medium comprising at least in part said second stream of residual oil.

8. The method of cracking hydrocarbon oil in vapor phase which comprises heating the oil in liquid phase to raise it to vaporization temperature, in a first zone separating therefrom an overhead stream of vapors, further heating the residual oil to raise it to a higher temperature of vaporization, separating therefrom a second overhead stream of vapors and a second stream of residual oil, said second vapor stream having a boiling point higher than that of said first-named vapor stream, separately superheating said

streams of vapors, the first-named stream to a materially higher temperature than said second stream, heating heat-carrier gas to a temperature above the temperature of said first-named vapor stream by passing it through a furnace in indirect heat-transfer with combustion gases, in reaction zones commingling said carrier gas with said superheated vapor streams to supply heat to effect substantial cracking of said vapors at temperatures best suited to the individual streams thereof, after completion of the cracking of said vapors intimately contacting them with a cooling and scrubbing oil at least in part comprising said second residual oil stream, thereafter fractionating the reaction products to produce an overhead stream of products suitable as motor fuel and a side stream of characteristics similar to the vapors leaving said first separating zone, and introducing said side stream into said first separating zone as reflux therefor.

9. A system of cracking hydrocarbon oil comprising heating units, each having separate fire chambers and a common convection chamber, means individual to said fire chambers for producing therein currents of hot combustion gases which pass into and through their associated convection chamber, a first bank of tubes within one of said convection chambers, means for conducting oil through said first bank of tubes, a separator having an inlet receiving the oil from said first bank of tubes and an overhead vapor outlet, means for conducting flash gas to said separator including a second bank of heat absorbing tubes within one of said fire chambers for elevating the temperature of said flash gas passing to said separator, means including a third bank of tubes within a second of said fire chambers for heating the oil vapors from said separator to a temperature within the range of their cracking temperature, means forming a reaction zone for receiving said oil vapors after said elevation of their temperature, means for heating a heat-carrier gas above the temperature of said superheated oil vapors comprising a bank of floor tubes and a bank of roof tubes within a third of said fire chambers, and means for commingling said carrier gas and said oil vapors to produce substantial cracking of said oil vapors within said means forming said reaction zone.

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