

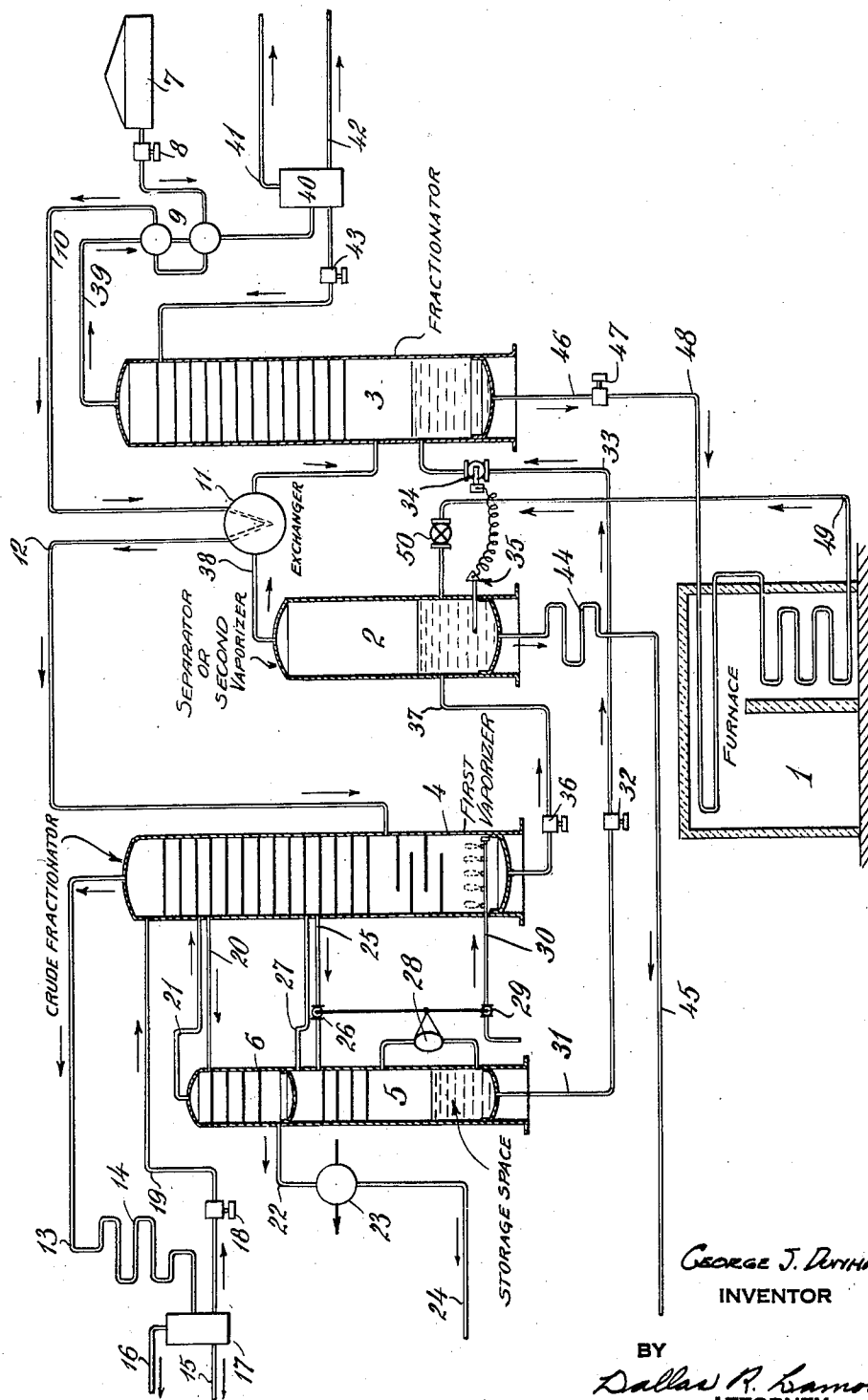
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PROCESS AND APPARATUS FOR THE DISTILLATION AND CONVERSION OF HYDROCARBONS

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## PROCESS AND APPARATUS FOR THE DISTILLATION AND CONVERSION OF HYDROCARBONS

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The present invention has to do with processes for the distillation and conversion of hydrocarbons. More specifically it has to do with processes wherein a crude charge oil is stripped or topped of its lighter portions followed by heat and pressure cracking of a selected portion of the remaining heavier oil, and has for its main purpose the provision of control means whereby the separate phases of such operations may be kept properly in step one with another.

In processes of the general type as above outlined, the incoming crude, heated by exchange heat from various subsequent portions of the process, is delivered into a vaporizing body and there stripped of its naturally occurring light fractions, which are subsequently fractionated to finished products. The stripped, topped, or reduced crude residue from this operation is then fed into a mixing zone, wherein it is heated by the excess heat in the reaction stream of a subsequent cracking reaction. This heat removes from the reduced crude a further fraction as vapors. This fraction comprises a gas oil cut, and the gas oils thus removed, after passage through and condensation in the fractionator of the cracking system, become fresh charge for the cracking step. The amount of gas oil stripped from the reduced crude fed to the mixing stage is governed by three things: first, the amount of heat in the cracking reaction stream; second, the amount of heat in the reduced crude; third, the degree of prior stripping of the reduced crude.

As the second and third variables are a function of the exchange heat picked up in the system, and as this exchange heat is derived largely from the first variable it is evident that proper correlation of the three is paramount for the most efficient operation.

I am aware of two present methods of attaining this control. The most common is by manually controlled valves on the various streams. The difficulty of governing these controls accurately is too obvious to require further comment. The second method makes use of less exchange heat than is available and controls the heat in the mixing zone by sending the reduced crude through a coil in a furnace on its way to the mixing zone. This either requires a separate furnace with the attendant expense of erection and operation, or a second coil in the cracking furnace. In either case exact control is difficult as furnaces are notably slowly responsive. In order to avoid these various difficulties, I have devised the control method herein disclosed.

It is an object of this invention to provide a

means of automatic control whereby combined crude and cracking operations may be kept in step, one with the other. It has for a further object the accomplishment of such control in such manner that the fullest advantage may be taken of exchange heat in order that savings in operation and first costs may be made. Also it has for objects the savings of attendance, the raising of operating efficiency by more accurate control, and such advantages as may hereinafter appear. When it is noted that the rate of cracking doubles for an increase in temperature of about 20°–30° Fahrenheit, it can easily be realized that equipment raising the accuracy of control of a reaction system by only a small margin can result in savings of a size out of proportion to the change in control accuracy.

All of these objects and advantages are attained by the combination and sequence of process steps, apparatus in which these process steps are carried out, and control means correlating the several parts and taking advantage of the physical condition of the material under treatment in the several locations as hereafter pointed out.

In order that the process and apparatus of the invention may be more clearly understood, reference is made to the drawing attached to and made a part of this specification.

In the drawing, 1 is a heater, 2 is a vaporizer and 3, 4, 5, and 6 are fractionators. Crude oil charge taken from storage tank 7 by pump 8 is passed through exchanger-condensers 9 and line 10 through exchanger 11. Heated to a temperature in the neighborhood of 600° F., it is discharged through line 12 into fractionator 4, where it flows over baffles, being freed by vaporization of the naturally occurring gasoline, kerosene, and a portion of the gas oil. The remainder of the crude flows into the storage space at the bottom of fractionator 4, there to be contacted with steam for the further production of gas oil. The naturally occurring gasoline separated in fractionator 4 passes overhead through line 13 and condenser 14 to receiver 15. Fixed gases are removed through line 16, product through line 17, and a portion of the product is returned as wet reflux for fractionator control by pump 18 through line 19.

The naturally occurring kerosene is removed from an intermediate point in the tower through line 20 into fractionator 6, and there stripped of light ends by contact with steam, (not shown) the vapors returning through line 21. The finished kerosene leaves through line 22, is cooled 55

by water in cooler 23 and passes to storage through line 24.

Gas oil separated in fractionator 4 is led through line 25 controlled by valve 26 to stripping column 5. Column 5 is shown as contained in the same structure as column 6, although they function separately and combination is merely for structural convenience. Vapors from this column are returned to fractionator 4 through line 27. In the bottom of fractionator 5 there is a storage space for stripped gas oil. Actuated by the liquid level in this storage space is a control device 28 which may optionally act either upon valve 26 in line 25 or upon valve 29 in steam line 30, or may act upon both in sequence. For instance, if the level in the storage space is decreasing, the control may either open valve 26 to admit more gas oil, the steam supply being constant; or the valve 26 being open it may open valve 29 to supply more steam and hence more gas oil. Or, as may preferably be the case, it may be so adjusted as to correct minor variations by manipulation of valve 26 and major variations beyond the capacity of valve 26 by manipulation of the steam supply. Specific means for this are well known in the art and require no comment.

The gas oil collected in the storage space in fractionator 5 is removed through line 31 by pump 32 and passed through line 33 into the storage space in the bottom of fractionator 3. Line 33 is controlled by valve 34, actuated by thermocouple 35 placed in the liquid in the bottom of vaporizer 2.

Crude oil residuum is taken from the bottom of fractionator 4 by pump 36 and passed through line 37 into vaporizer 2. There this residuum is contacted with the hot products of a cracking reaction later to be described; and by means of the excess heat of these reaction products is distilled and separated into an overhead distillate portion suitable for cracking stock and a liquid base of desired characteristics. The amount and temperature of the reaction products being essentially constant, the degree of this final stripping is, of course, controlled by the amount of residue introduced from fractionator 4, the temperature of this residue being for all practical purposes constant.

If the amount of residue is too great and stripping not as complete as desired, the temperature in vaporizer 2 is, of course, low. Thermocouple 35, noting this, acts through proper controllers not shown, (as they are well known in the art) to open valve 34, thus increasing the amount of gas oil withdrawn from fractionator 5. Control 28 in turn draws more gas oil from fractionator 4 and the amount of residue sent from fractionator 4 to vaporizer 2 is decreased and the proper equilibrium established.

Vapors from vaporizer 2 comprising light cracked hydrocarbon product from the cracking reaction, vaporous unconverted hydrocarbons from the cracking reaction, and fresh gas oil vapors from the residuum, pass overhead through line 38 and exchanger 11 into fractionator 3. This fractionator serves to separate and condense all portions heavier than the desired light cracked product. Product passes overhead through line 39 and condenser 9 to receiver 40. Fixed gases are removed through line 41 and product through line 42. A portion of product is returned by pump 43 as wet reflux for the control of fractionator 3.

Residue from vaporizer 2, comprising the combined heavy fractions from the crude and the

reaction stream, is removed through cooler 44 and line 45 to storage.

Condensate collected in the bottom of fractionator 3 is removed through line 46 by pump 47 and advanced through line 48 to the heating coils in furnace 1. Passing from the furnace through line 49 the reaction stream is released through valve 50 into fractionator 2. Dependent upon the nature of the crude oil originally charged and upon the character of the gasoline desired, the conditions in line 49 may range in temperature from 850° F. to 1100° F. and in pressure from 20 pounds per square inch to 500 pounds per square inch. For example, these conditions may be 900° F. and 500# per square inch at exit. The pressure in vaporizer 2 is substantially atmospheric, that is, atmospheric plus the flow resistance of the apparatus parts subsequent to vaporizer 2.

Accurate control of the vaporizer temperature is important. If the temperature be too low, valuable gas oil charging stock is allowed to remain in the residue, to be sold at fuel prices, or to be recovered by subsequent costly processes. If it be too high, secondary cracking will occur in vaporizer 2 with a corresponding production of coke which may appear in the residuum as "free carbon" and in more extreme cases deposit upon the walls of chamber 2 and cause early shut down of the operation. As the usual case, the bottom product of vaporizer 2 is made to certain sale specifications, as for road oil, and the viscosity, flash, and "free carbon" are of importance. Variations of a few degrees in temperature will sometimes alter these properties materially. In general, I have found that the optimum conditions of temperature in vaporizer 2 under atmospheric pressure range from 700° F. to 850° F., the level usually desired being between 750° F. and 800° F., determined by the type of bottoms product desired. Under these conditions, the operation in the vaporizer will extract from the residue all of the gas oil available for cracking, and produce a residue free from undesirable effects of overheating.

As an example of one of the process operations which may be carried out, I offer the following:

Mid-Continent Crude of a gravity of 36° A. P. I. may be charged, heated by exchange heat to approximately 600° F. and stripped in fractionator 4 of about 30% of naturally occurring gasoline, 10% of naturally occurring kerosene, and 10-20% of gas oil. From vaporizer 2 there is withdrawn, as a combined residue from the crude and cracking operation a residue amounting to approximately 20% of the crude charged. The gasoline produced by cracking and taken overhead from fractionator 4 amounts to approximately 40% based on crude. The combined yield of products thus obtained in a single operation may be summed up as: gasoline 60%, kerosene 10%, residuum 20%, fixed gas and mechanical loss 10%. The fresh gas oil charged through the cracking step amounts to approximately 50% of the crude as originally charged, and there is recycled with it, through the coil, an amount of recycle gas oil of similar physical nature ranging from one to five times the quantity of fresh charge dependent upon the characteristics of the cracked gasoline product desired.

It is apparent that the process of control set forth in the present disclosure is applicable not only to the system of cracking above described, or to any roughly similar one, but that it may be operated as a valuable adjunct to combina-

tion operations wherein the cracking process is one making use of a non-vaporizing soaking stage after the heating stage. In general it may be applied to any cracking system wherein the heat of the products of cracking may be used for the preparation of fresh charge.

In order that I may receive protection for this invention in its widest scope and equivalents, I desire that it be restricted only by such limitations as may appear in the following claims:

I claim:

1. That process for conducting a self-balancing combination operation of primary distillation and conversion of hydrocarbon oils which comprises the steps of heating a crude charge oil by exchange heat rejected from a cracking operation to vaporize therefrom all naturally occurring light fractions up to and including a portion of the gas oil fraction, discharging the heated crude oil into a first vaporizing zone and therein removing from it said light fractions, removing to condensation and storage without the system the vaporized fractions of lighter nature than gas oil, condensing the gas oil vapor and passing it to a gas oil storage space within the system, variably admitting steam to the said first vaporizing zone to variably vaporize therein a further portion of the gas oil, which further portion is condensed and collected in admixture with the first mentioned portion of gas oil; establishing a cracking system comprising a flowing restricted stream of oil heated to cracking temperatures under a super-atmospheric pressure, releasing such reaction stream to substantially atmospheric pressure in a separating zone, therein to separate into vapor and liquid, fractionating vapors from said separating zone to yield a cracked product for removal from the system and a fractionator condensate, collecting said fractionator condensate, combining therewith fresh gas oil from the gas oil storage space, passing the combined oils to and through the cracking zone as the principal charge thereof, passing residual crude charge oil from the first vaporizing zone to the separating zone, vaporizing a portion of it therein by heat from the cracking reaction stream, discharging combined crude residue and cracked residue in liquid form from said separating zone, controlling the temperature of the said separating zone, controlling the amount of vaporization of the crude charge performed therein and the amount of fresh gas oil previously removed to be mixed with fractionator condensate by automatically varying the amount of steam admitted to the first vaporizing zone in response to the temperature of the separating zone in such manner that a drop in temperature of the separating zone is responded to by an increase in steam fed to the first vaporizing zone, whereby more gas oil is separated from the crude residue at that point and a lesser vaporizing duty is imposed upon the said separating zone.

2. That process for conducting a self-balancing combination operation of primary distillation and conversion of hydrocarbon oils which comprises the steps of heating a crude charge oil by exchange heat rejected from a cracking operation to vaporize therefrom all naturally occurring light fractions up to and including a portion of the gas oil fraction, discharging the heated crude oil into a first vaporizing zone and therein removing from it said light fractions, removing to condensation and storage without the system the vaporized fractions of lighter nature than gas oil, condensing the gas oil vapor and passing it

to a gas oil storage space within the system, variably admitting steam to the said first vaporizing zone to variably vaporize therein a further portion of the gas oil, which further portion is condensed and collected in admixture with the first mentioned portion of gas oil; establishing a cracking system comprising a flowing restricted stream of oil heated to cracking temperatures, releasing such reaction stream to a separating zone, therein to separate into vapor and liquid, fractionating vapors from said separating zone to yield a cracked product for removal from the system and a fractionator condensate, collecting said fractionator condensate, combining therewith fresh gas oil from the gas oil storage space, passing the combined oils to and through the cracking zone as the principal charge thereof, passing residual crude charge oil from the first vaporizing zone to the separating zone, vaporizing a portion of it therein by heat from the cracking reaction stream, discharging combined crude residue and cracked residue in liquid form from said separating zone, controlling the temperature of the said separating zone, controlling the amount of vaporization of the crude charge performed therein and the amount of fresh gas oil previously removed to be mixed with fractionator condensate by automatically varying the amount of steam admitted to the first vaporizing zone in response to the temperature of the separating zone in such manner that a drop in temperature of the separating zone is responded to by an increase in steam fed to the first vaporizing zone, whereby more gas oil is separated from the crude residue at that point and a lesser vaporizing duty is imposed upon the said separating zone.

3. Apparatus for the combined distillation and cracking of hydrocarbons comprising a crude oil charging line, heating means therefor to impart heat for separation of naturally occurring light fractions and a portion of the gas oil, a first vaporizer wherein such fractions may separate, means connecting said charging line with said vaporizer, means for introducing steam to said vaporizer to separate a further portion of gas oil, fractionating means to classify fractions so separated, condensing means for such fractions, collecting means for said gas oil; a cracking system comprising a coil, means for heating said coil and a second vaporizer connected to said coil, a fractionator, means connecting said second vaporizer with said fractionator, means connecting said fractionator with said heated coil, means for transferring gas oil from the gas oil collecting means to the second fractionator, means for transferring crude residue from the first vaporizer to the second vaporizer, temperature sensitive means in the second vaporizer, a valve in said gas oil transferring means actuated by such temperature sensitive means whereby an increase in rate of gas oil transfer follows a drop in vaporizer temperature, and means actuated by change in rate of gas oil transfer whereby the steam introduced to the first vaporizer is altered to maintain the required supply of gas oil and the desired temperature of the second vaporizer.

4. An apparatus for distilling and converting hydrocarbons comprising a charging line for conveying crude charge oil to the system, heat exchangers inserted in such charge line wherein incoming crude may be heated by the condensation and cooling of products of the system, a primary vapor separator into which said charge line is connected, fractionating means connected to said first vapor separator, condensing means

for the products of said fractionator, means within the system wherein condensed gas oil may be collected, a liquid level control on said collection means, means for admitting steam to said first vapor separator, an operative connection between said liquid level control and said steam admission means whereby a decrease in level of collected gas oil will be responded to by admission of more steam to said first vapor separator through said steam admission means; a cracking system comprising a coil, means for heating said coil, and a second vapor separator connected to said coil, a second fractionator connected to said second vapor separator, means for collecting gas oil condensed in said second fractionator, means for transferring fresh gas oil from the fresh gas oil collecting means to the second gas oil collecting means, means whereby the combined gas oil from the second named collection means may be transferred to the cracking coil as charge therefor, means for transferring crude residue from the first vapor separator to the second vapor separator, means for discharging residual oils from the second vapor separator, temperature sensitive means in the second vapor separator, a valve inserted in the means for transferring gas oil from the first gas oil collecting means to the second gas oil collecting means, and an operative connection between said temperature sensitive means and said valve whereby a decrease in temperature of the second vaporizer is responded to by an increase in rate of transfer of gas oil from the first gas oil collecting means to the second gas oil collecting means.

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