Aug. 27, 1946. H. Z. MARTIN 2,406,555

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

Filed Sept. 13, 1941 2 Sheets-Sheet 1

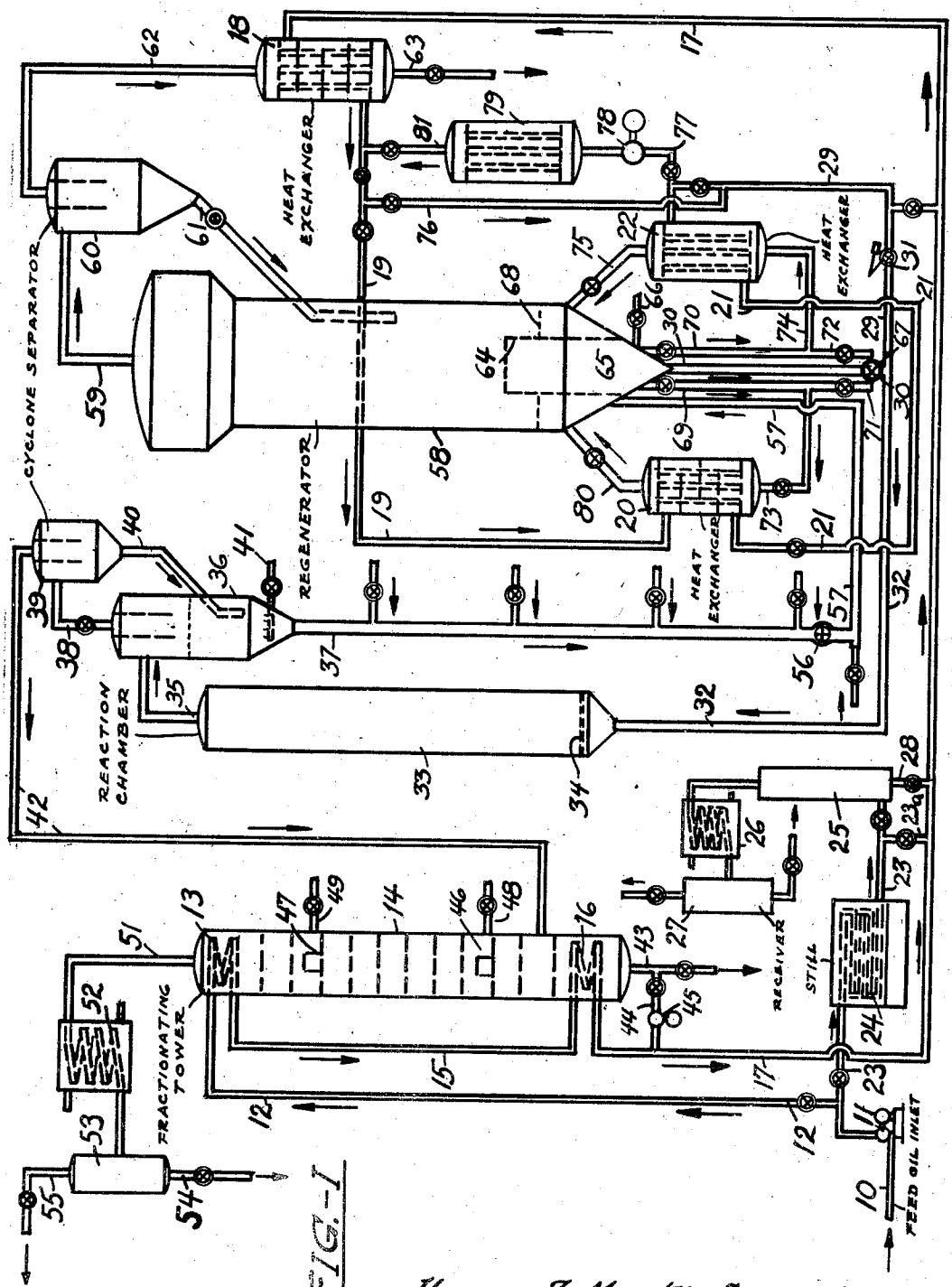


FIG. 1

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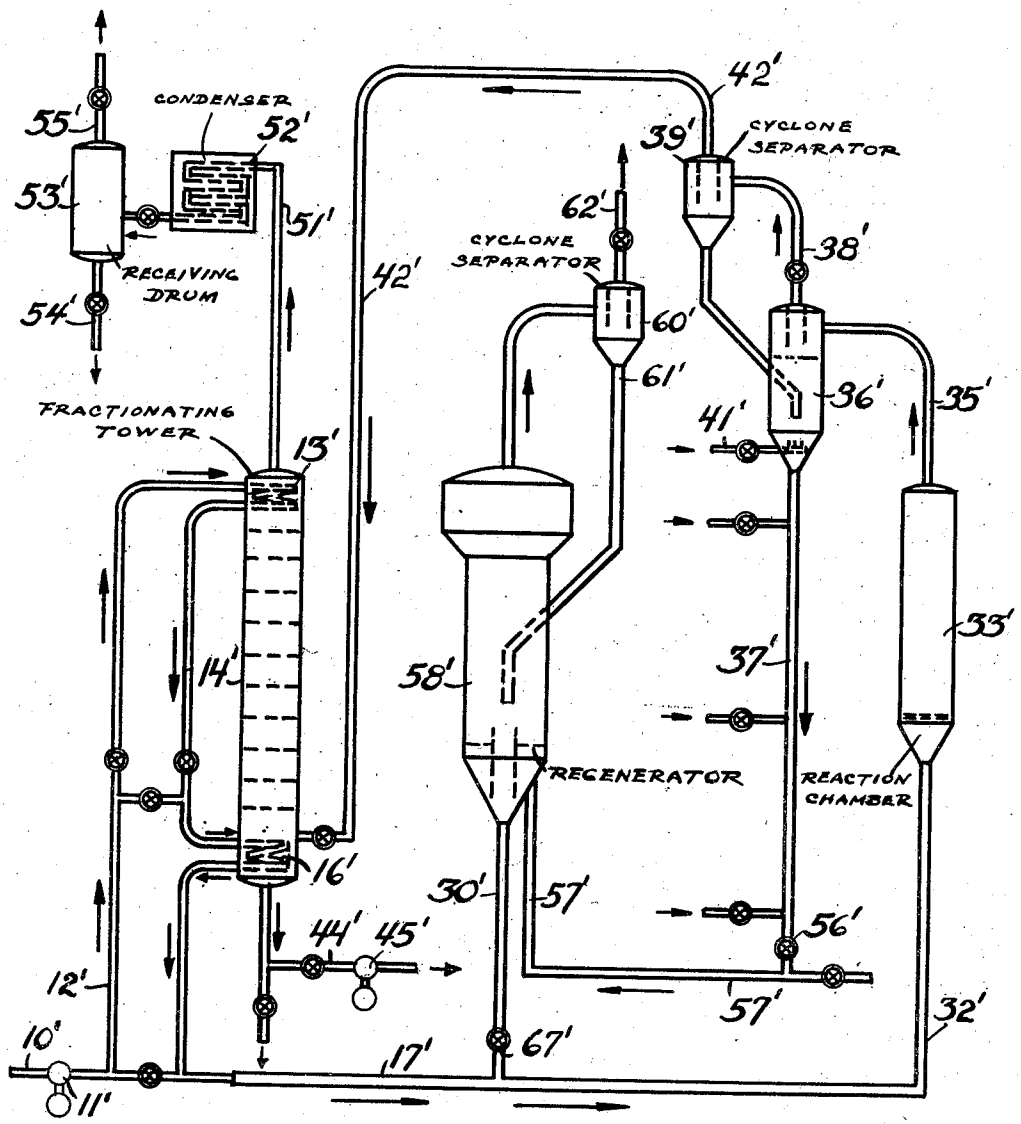


FIG.-II

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Patented Aug. 27, 1946

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UNITED STATES PATENT OFFICE

2,406,555

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

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Application September 13, 1941, Serial No. 410,657

3 Claims. (Cl. 196—50)

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This invention relates to the catalytic conversion of hydrocarbon oils and pertains more particularly to a process for converting heavy crude oils, such as topped or reduced crude or other residual oils, into motor fuel constituents.

It has been heretofore proposed to crack oils in the presence of a cracking catalyst to form gasoline of relatively high octane rating.

According to one general mode of operation, the oil in vapor form is passed through a cracking zone containing a fixed mass of catalyst, preferably in the form of pellets or molded units, located within the reactor and supported on a perforated tray or a plurality of trays. During the cracking process the activity of the catalyst rapidly depreciates due to the formation of carbonaceous deposits. In view of this, it is necessary in such operations to interrupt the cracking process frequently and regenerate the catalyst mass by burning the carbonaceous deposits therefrom. In order to avoid the formation of excessive coke deposits, which in turn reduces the productive capacity of the cracking chamber, it has been the practice to first distill and fractionate the crude oil and to pass only the clean vapors in contact with the catalyst and to reject a heavy residual fraction which tends to form excessive amounts of coke during the cracking process. This method of operating not only requires the provision of distilling equipment for preparing a clean feed stock for the cracking process but also requires the rejection of a substantial amount of the original feed in the form of a residue which is not normally suitable for cracking treatment for the production of high octane gasoline without additional processing. This rejected fraction may amount to from 5% to 40% of the original crude, depending upon the nature of the crude oil. This residual product in many cases is consequently marketed as a heavy fuel oil.

However, this residual fraction contains a substantial portion of oil which can be converted into high-grade gasoline with additional processing. For example, it has been the practice in some cases to subject this heavy residual fraction to a separate and independent cracking or viscosity breaking treatment to convert the same into the maximum of overhead vapors suitable for further cracking under conditions controlled for the production of improved octane gasoline. In other cases, it has been the practice to convert all of this residual fraction into overhead vapors suitable for further cracking with the exception of the coke residue. In the latter case,

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it has also been suggested to carry out the coking treatment in the presence of a relatively inert solid material which forms a carrier for the coke and from which the coke may be burned at frequent intervals. In other cases, when operating to form a coke residue it has been the practice to collect the coke formed in separate coking vessels from which the coke may be removed by mechanical means.

In all of the above cases, the treatment of this residual fraction for production of additional quantities of gasoline has required a considerable investment in additional equipment.

One of the primary objects of the present invention is to provide a process for catalytically cracking crude oils to the desired conversion in a single stage without the necessity of first separating a heavy residual fraction therefrom.

A further important object of the invention is to provide an improved process for cracking crude oils or residual oils which will require less equipment for a cracking plant of given capacity and for a given quantity of motor fuel produced.

A further secondary object of the invention is to provide an improved process and apparatus for cracking residual oils which will take better advantage of the heat liberated during the regeneration of the catalyst for carrying out the cracking process.

Other more specific objects of the invention will be apparent from the more detailed description thereinafter.

In accordance with the broader phases of the present invention, a crude residual fraction, such as a topped or reduced crude, or, in certain cases, the entire crude, is contacted with a hot adsorptive catalyst in subdivided state at a materially higher temperature level than the oil, the amount of catalyst being controlled with respect to the temperature thereof so that the oil upon contact with the catalyst is promptly converted into vapors, except for some residual oil which is completely adsorbed by the catalyst without causing the latter to become tacky or sticky. The resulting mixture, therefore, consists of relatively dry oil vapors and discrete particles of catalyst containing the heavy constituents adsorbed therein.

The resulting dispersion of catalyst powder containing the residual constituents adsorbed therein and the oil vapors is then passed through a cracking chamber in which the desired conversion is accomplished.

As distinguished from viscosity breaking operations of the type hereinbefore described, the

present invention contemplates the conversion of a substantial portion amounting to at least 30% of the residual oil into gasoline constituents of high octane quality.

The cracking process is preferably carried out under conditions such that the catalyst is retained within the cracking zone for a period substantially longer than the length of time the oil vapors are retained within the cracking zone. This makes possible a greater utilization of the catalyst between regenerations and permits retaining the catalyst within the cracking zone until its activity has dropped to a point where regeneration of the catalyst is desired.

This retention of the catalyst within the cracking zone for a period substantially longer than the time of residence of the oil vapors therein can be accomplished by passing the dispersion upwardly through a vertical cracking chamber and regulating the velocity of the oil vapors so that there is a decided tendency for the catalyst to settle or separate from the oil vapors. By regulating the velocity of the oil vapors within the controlled limits, a dense phase of catalyst can be retained within the cracking chamber and at the same time the oil vapors may be utilized as a transfer medium for the introduction of the catalyst therein.

Following the cracking process, the catalyst is separated from the cracked products either within or without the cracking zone and the cracked products fractionated in a conventional manner to segregate the desired products.

The catalyst so separated is then regenerated to remove the carbonaceous deposits formed during the cracking treatment. The regeneration of the catalyst is preferably carried out at the maximum premissible temperature which will avoid permanently impairing the activity of the catalyst so as to make available for the cracking operation the maximum amount of heat liberated during the regenerative treatment and the catalyst so regenerated is immediately contacted with the oil while at substantially its maximum regenerating temperature. In order to operate the regenerating chamber at the maximum temperature level, it is important to avoid localized overheating of the catalyst within the regenerating zone. This is accomplished, according to one of the specific phases of the invention, by constantly agitating or churning the catalyst within the regenerating zone, and, according to one of the additional phases of the invention, this agitation or churning is accomplished by the flow of the regenerating gas through the regenerating zone as hereinafter described. While this method of regeneration has been previously proposed, it finds particular application in the present process wherein it is important to operate the regenerating zone at the maximum temperature level without local overheating in order to make available the maximum heat from the regeneration for the cracking process.

Having set forth the general nature, objects and advantages, the invention will be described in more detail in which reference will be made to the accompanying drawings wherein—

Fig. I is a diagrammatic illustration of an apparatus suitable for carrying the invention into effect, and

Fig. II is a similar view of a simplified apparatus wherein the total heat requirements for carrying out the process are obtained by direct contact with hot catalyst.

Referring to Fig. I, the reference character 10 designates a charge line through which the oil to be processed is introduced into the equipment. This oil may be, as previously described, a residual oil, such as a crude petroleum, or a residual petroleum, such as a topped or reduced crude from which some of the lower boiling constituents, such as gasoline, kerosene or part of the gas oil, have been initially distilled. The oil so introduced is preferably initially preheated by heat exchange with hot products from the process. For example, the oil so introduced may be forced by feed pump 11 through line 12 to a trimming coil 13 located in the top of product fractionator 14 in which the cracked products are fractionated. The oil after passing through the coil 13 may be passed through line 15 to a second heat exchange coil 16 located in the bottom portion of the fractionating tower 14 or in a heat exchanger associated with the bottom portion of the fractionating tower. The oil after passing through the second preheating coil 16 may then be passed through line 17 to a heat exchanger 18 wherein it passes in heat exchange relation with spent regenerating gases removed from the regenerating zone, as hereinafter described. The oil after passing through the heat exchanger 18 is passed through line 19 to a heat exchanger 20 where it passes in indirect heat exchange relation with hot catalyst undergoing regeneration.

The oil after passing through heat exchanger 20 is transferred through line 21 to a second heat exchanger 22 wherein it picks up additional heat from hot catalyst undergoing regeneration as later described.

When operating on total crudes containing substantial amounts of gasoline, it may be desirable in some cases to first distill the straight-run gasoline. For example, in lieu of passing the crude oil in heat exchange with cracked products in the product fractionator 13, crude oil introduced through line 10 may pass through line 23 to a crude still 24 wherein the oil is heated to a temperature of from 400° F. to 600° F., sufficient to vaporize the lower boiling fractions. The preheated oil then discharges into a separating chamber 25 wherein the vapors formed separate from the remaining liquid. The vapors in separator 25 pass overhead to a condenser 26 wherein the straight-run gasoline vapors or other low boiling vapors are liquefied. Products from condenser then pass to a distillate receiver 27. Liquid is withdrawn from separator 25 through line 28 which merges with feed line 17.

The oil during its passage through the heat exchangers and crude still hereinbefore described, or any combination thereof, is preferably preheated to a temperature of from 400° F. to an incipient cracking temperature, such as, for example, to a temperature of from 700° F. to 800° F. The oil after being preheated to a temperature of from 400° F. to 800° F. by passing through one or more of the various heat exchangers is passed through line 29 into which hot regenerated catalyst is charged through line 30.

In some cases it may be desirable to maintain the oil during passage through the heat exchanger equipment under a pressure considerably above the operating pressure within the cracking zone. To this end, the line 29 may be provided with a reducing valve 31 preferably located at a point preceding the catalyst discharge line 30. For example, the pressure on the oil passing through the preheating equipment may range between 50 and 500 pounds per square

inch, whereas the cracking is preferably carried out below 100 pounds per square inch, although somewhat higher pressures may be employed in some cases.

The amount of catalyst introduced into the oil stream is regulated to vaporize a portion of the oil while retaining the remainder in liquid phase. The amount of unvaporizable residue, however, should not be in excess of that which can be completely adsorbed by the catalyst particles without causing the catalyst particles to become adhesive and form a tacky, sticky mass. The amount of such catalyst introduced into the oil vapors will depend upon the temperature of the catalyst and the temperature of the oil at the place the catalyst is mixed with the oil.

The amount of catalyst introduced into the oil stream may range between 1 and 45 parts of catalyst per part of oil by weight, depending upon the nature of the oil, temperature of the catalyst, the degree of pretreatment and other factors. In most cases the ratio will be between 5 and 20.

This catalyst may comprise any adsorptive material capable of catalytically effecting the cracking operation. Such material may comprise, for example, natural clays or clays which have been activated by suitable treatment, such as with acid, to remove impurities which may affect the cracking or regenerative properties of the catalyst. In lieu of the natural material such as clays, the catalyst may consist of synthetic adsorbent materials, such as, for example, synthetic gels of silica and alumina or silica and magnesia, alumina, boric oxide and others.

The catalyst introduced into the oil stream should be in subdivided state, the size of the particles ranging from a fine powder, such as 400 mesh or finer, up to relatively coarse granules, such as from 5 to 10 mesh.

The resulting dispersion consisting essentially of oil vapors which have been vaporized by contacting with the hot catalyst and by reduction in pressure through the reducing valve 31 and the catalyst containing the unvaporizable constituents of the oil adsorbed therein is passed through line 32 to the cracking chamber 33 which is preferably in the form of a vertical tower through which the dispersion is forced to pass in an upward direction against the force of gravity. The lower portion of the cracking chamber 33 may be provided with a perforated plate 34 below which is a portion of reduced diameter. The velocity of the oil stream passing upwardly through the cracking chamber 33 is preferably controlled so that the catalyst contained in the stream of oil vapors tends to settle from the gas stream. As a result, the density of the catalyst within the reactor is materially greater than is the density in the stream of oil in the feed line 32 leading thereto. The density in the reactor, for example, may range from 5 to 20 pounds per cubic foot in cases of activated clays, whereas the density of the stream passing to the reactor may be from 1 to 10 pounds per cubic foot. The velocity of the oil vapors passing through the reactor may be from 1 foot to 5 feet per second and the time of residence of oil vapors within the reactor may be from 5 to 50 seconds. The temperature within the cracking zone may be controlled within a substantial range, such as from 850° F. to 1100° F. and preferably between 900° F. and 1000° F. Higher temperatures normally give less coke for a given conversion but require more catalyst at a given regeneration temperature to supply the heat.

The stream of cracked products and oil vapors after passing through the cracking chamber 33 is passed through line 35 to a primary separator 36 for the separation of the catalyst from the cracked vapor products. This separator may be of any conventional type suitable for segregation of solids from gases and has been illustrated in the form of a cyclone separator. The catalyst removed from the cracked products during passage through the primary separator 36 discharges into a vertical tube 37 from whence it is passed to a regenerating chamber, as later described.

The cracked vapors after having the bulk of the catalyst removed therefrom in the primary separator 36 may be passed through line 38 to a secondary separator 39 for further removal of the catalyst material. The catalyst separated in the secondary separator 39 discharges through line 40 into the bottom section of the primary separator 36 where it mixes with catalyst separated in the primary cyclone 36. The bottom portion of the primary separator 36 may be provided with sufficient volume to form a storage hopper capable of maintaining a reserve supply of catalyst for the process. Steam or other stripping gas may be introduced into the bottom of the separator 36 through line 41 to strip volatile cracked products from the catalyst before passing the same to the regenerating zone.

The cracked vapors after passing through the secondary separator 39 may be passed to additional cyclones, electrical precipitators, bag filters, or other separators (not shown) for further purification. The cracked products after separation from the catalyst are passed through line 42 to the product fractionator 14 wherein the cracked products are fractionally condensed to segregate the insufficiently cracked constituents as condensate. The heavy condensate formed in the bottom section of the fractionating tower 14 is withdrawn therefrom through line 43 and may be removed from the system or it may be combined with fresh feed through line 44 and pump 45 for further cracking treatment. This material may contain traces of the catalyst employed in the cracking operation which are not completely removed in the separating equipment. By recycling this fraction to the cracking equipment, the catalyst contained therein may be returned to the process. One or more condensates formed in the fractionating tower 14 may be collected in trap-out trays 46 and 47 and removed from the system through lines 48 and 49, respectively. For example, a Diesel, heating or furnace oil may be collected in the top trap-out tray 47 and a gas oil fraction may be collected in the trap-out tray 46.

The cracked vapors remaining uncondensed in the product fractionator 14 and containing the bulk of the gasoline constituents formed during the cracking operation pass overhead through line 51 to a product condenser 52 in which the gasoline constituents are liquefied. Products from the condenser 52 pass to a receiver 53 in which the liquid formed in the condenser 52 segregates from normally gaseous constituents formed during the cracking operation. The liquid distillate separated in the product receiver 53 may be withdrawn therefrom through line 54 and the normally gaseous constituents may be withdrawn through line 55 and passed to a suitable absorption or recovery equipment for removing normally liquid constituents entrained therein.

Returning to column 37 receiving spent catalyst

separated from the cracked products in separators 36 and 39, the spent catalyst discharges downwardly through column 37 through a control valve 56 into a stream of oxidizing gas passing through line 57 and is carried by means of the gas into the bottom portion of a regenerating chamber 58 in which the catalyst is regenerated by removing combustible deposits formed during the cracking process.

The velocity of the oxidizing gas passing through the regenerating chamber 58 is preferably adjusted to permit the catalyst particles to form into a relatively dense bed of catalyst within the regenerating chamber through which the regenerating gas must pass. By regulating the velocity of the regenerating gas passing through the regenerating chamber within certain limits, the catalyst bed or mass within the regenerating chamber may be made to assume the appearance of a violently boiling liquid so that the catalyst particles are continuously and thoroughly mixed. As a result, a substantially uniform temperature may be maintained throughout the full depth of the catalyst mass and localized overheating can be avoided. The velocity of the regenerating gas passing through the regenerator may be of the order of from ½ to 10 feet per second, depending upon the size of the catalyst particles, density and other factors. For example, when employing activated clays having a particle size between 200 and 400 standard mesh, the velocity of the regenerating gas passing through the regenerator should be between 1 and 5 feet per second to obtain the above-mentioned results.

The spent regenerating gas after passing through the regenerator 58 is removed overhead through line 59 and is passed to a separator 60 in which catalyst powder entrained in the gas is separated from the regenerating gases. The catalyst powder collected in the separator 60 is removed through line 61 and returned to the regenerator 58. The regenerating gas after passing through the separator 60 passes through line 62 to the heat exchanger 18 through which it may pass in indirect heat exchange relation with the fresh feed, as previously described. The regenerating gas is removed from the heat exchanger 18 through line 63 and may be passed to additional separating equipment, such as an electrical precipitator (not shown) for removing final traces of catalyst powder. This regenerating gas may also be passed to a waste heat boiler or other heat recovery equipment (not shown).

Referring again to the regenerator 58, the bottom section of the chamber is provided with a vertical, circular partition wall spaced from the outer wall of the chamber to form a central compartment or hopper 65 for collecting regenerated catalyst for return to the cracking zone. Steam or other inert stripping gas may be introduced into the bottom of the hopper 65 through line 66 to remove regenerating gas from the catalyst before returning the catalyst to the cracking process and to maintain the catalyst in a fluidized condition. The bottom of the center hopper or compartment 65 is in open communication with catalyst tube 30 which in turn discharges into the oil feed line through a control valve 67.

The stream of regenerating gas and spent catalyst from the cracking process passing through line 57 is introduced into the regenerating chamber 58 in the annular space between the circular portion 64 and the outer wall of the regenerating chamber. An annular perforated plate 68 may be provided above the inlet for the incoming stream of catalyst and regenerating gas. The annular space below the perforated plate will then form a distributing zone for the catalyst-gas suspension passing onto the main body of the regenerating chamber. It is sometimes desirable to introduce the incoming stream at a plurality of points around the annular space to improve distribution.

As previously set forth, it is sometimes of advantage to transfer heat from hot regenerated catalyst to the fresh oil feed in indirect heat exchangers 20 and 22, although this step may be omitted in many cases, as later described. To this end hot regenerated catalyst collected in the central hopper 65 of regenerating chamber 58 may be withdrawn through tubes 69 and 70 and discharged into a stream of regenerating gas such as air or inert gas introduced through lines 71 and 72, respectively, which carries the hot catalyst through lines 73 and 74 into heat exchangers 20 and 22 where it passes in indirect heat exchange with fresh feed as previously described. The suspension of hot regenerating gas after passing through heat exchangers 20 and 22 is returned to the regenerating chamber through lines 80 and 75 below the perforated plate 68.

The invention, as previously described, involves the step of preheating the oil by indirect contact with hot catalyst and then contacting with hot catalyst to complete the heating. While this method of operating has definite advantages in many cases, the invention also contemplates the omission of the preheating step by indirect heat exchange in catalyst heat exchangers 20 and 22. When operating in this manner, heat exchangers 20 and 22 may be omitted or a part or all of the feed oil after passing through heat exchanger 18 may be by-passed around the heat exchangers 20 and 22 through line 76.

Fig. II illustrates a simplified form of apparatus wherein the total heat requirements for the cracking operation are supplied by direct injection of hot catalyst removed from the regenerating zone into the oil stream.

Referring to Fig. II, for purposes of simplicity and brevity parts corresponding to those shown in Fig. I have been identified by prime numbers.

In Fig. II, the oil to be charged, which may be a topped crude or any type of feed stock mentioned hereinbefore, is introduced into the system at substantially atmospheric temperature through line 10'. The oil with or without being first preheated by passing in heat exchange with products undergoing fractionation in heat exchange coils 13' and 16' is transferred through line 17' into which the hot solid material is introduced through conduit 30' provided with a control valve 67'. The resulting mixture of oil and solids then passes through conduit 32' to the reaction chamber 33' of construction similar to reaction chamber 33 shown in Fig. I. The flow of the mixture through the reaction chamber and subsequent separating and fractionating equipment is the same as that illustrated in Fig. I.

In this case, the amount of hot catalyst introduced into the relatively cool oil stream passing through transfer line 17' is sufficient to heat the oil to the desired cracking temperature and to supply the necessary heat for the cracking process. Expressed in another way, the amount of solid material so introduced is controlled to obtain the desired heating. The actual amount of solid material may be of the order of from 10 parts of solid material per part of oil up to 50 or more parts of solid material per part of oil.

For example, when cracking an East Texas reduced crude at a temperature of about 950° F. and regenerating the solid material at a temperature between 1150° F. and 1200° F., the amount of solid material introduced into the oil stream will be of the order of from 15 to 20 parts of solid per part of oil.

By comparing the amount of equipment shown in Fig. II with that illustrated in Fig. I, it will be evident that a material saving in the equipment cost may be realized by operating the process in such manner that the total heat requirements for the operation are supplied by direct injection of hot catalyst removed from the regenerating zone into the oil stream. For example, the cost of the preliminary heating furnaces and the catalyst heat exchangers can be avoided by operating as illustrated in Fig. II.

When supplying all of the heat from regeneration to the oil by direct injection of hot catalyst into the oil feed, a greater amount of catalyst must be added to the oil than is the case when a part of the heat is supplied by indirect heat exchange in heat exchangers **20** and **22**. Expressed in another way, when operating without the heat exchangers **20** and **22** substantially all of the heat liberated during regeneration, except that taken out by regenerating gas, must be absorbed by the catalyst passing to the feed oil. Consequently, when operating in this manner the amount of hot catalyst added to the oil must be such that the amount of catalyst employed in proportion to the amount of coke formed in the cracking zone is sufficient to absorb substantially all the heat liberated during regeneration.

In some cases the amount of catalyst necessary to supply the heat requirements for the cracking process may result in excessive catalyst losses and cause excessive cracking resulting in the formation of undesirable amounts of low-grade products, such as gas and coke. In such cases a part of the catalyst may be replaced by relatively inert heat absorbent materials such as pumice, fuller's earth, bauxite, diatomaceous earth, and sand which have little if any catalytic influence on the reaction. The amount of such inert solids may range from 0 to 90% of the total solids circulated, depending upon a number of factors, such as the nature of feed stock, amount of coke formed, activity of the catalyst, temperature of cracking and of regeneration, rate of circulation and other factors. For example, when cracking an East Texas reduced crude at a temperature of 980° F. with acid-treated clay wherein about 5.5% of the oil is converted to carbon which is retained on the solids, approximately 45 parts of solids heated to 1050° F. by regeneration will be required to preheat the oil from room temperature to final cracking temperature and for supplying the necessary heat for cracking. In such a case it will be desirable to replace a part of the catalyst with less expensive inert material. It will be understood, however, that by regenerating at a higher temperature or by employing feeds which produce less coke under a given set of conditions the amount of solids necessary to supply the heat can be materially reduced. As a further example, when regenerating at 1150° F. rather than 1050° F. the amount of solids to supply the required heat may be reduced from 45 parts to about 20 parts, other conditions being the same.

In some cases, the amount of heat liberated during the regeneration may be more than sufficient to carry out the cracking operation. In such cases a portion of the oil after circulating through the heat exchangers **20** and **22** may be passed through line **77** and pump **78** to an additional heat exchanger **79** which may be in the form of a waste heat boiler.

The oil after passing through the heat exchanger **79** is transferred through line **81** to line **19** and is returned to the inlet side of heat exchangers **20** and **22**.

The pressure necessary to transfer the catalyst from the regenerating chamber to the oil stream in line **32** is developed, according to the preferred embodiment of the invention, by constructing the catalyst conduit **30** of such height that the combined height of the catalyst within the regenerator and in the conduit **30** is sufficient to build up hydrostatic pressure somewhat in excess of the pressure on the oil vapors at the point of entry of the catalyst therein. Likewise the pressure necessary to transfer the catalyst into the regenerating gas stream in line **57** may be developed by constructing the feed conduit of a height or elevation sufficient to build up a hydrostatic pressure somewhat in excess of the pressure on the regenerating gas at the point of entry of the spent catalyst therein. This will insure proper flow of regenerating gas and oil and prevent by-passing of oil into the regenerating zone and vice versa. In order to transmit the pressure through the standpipes or catalyst feed conduits **30** and **37**, the catalyst should be maintained in a freely flowing state therein. In some cases a fluidizing gas may be introduced at one or more spaced points along the conduits to maintain the catalyst in fluidized condition. It may also be desirable to introduce a fluidizing gas at all points in the system where the catalyst is segregated from the gas stream.

To avoid reducing and building up pressures on the catalyst passing back and forth from the regenerating chamber to the cracking chamber, it is of advantage to operate both the cracking and the regeneration process at substantially the same pressure level except for the pressure drop inherent in the flow, and it is also of advantage to maintain the pressure drop through the system at a minimum so as to reduce the height of tubes **37** and **30** employed for developing the required pressure. The passage of the cracked vapors and regenerating gas through the cracking and regenerating zones at a low velocity as previously described, tends to reduce the pressure drop, since the pressure drop on a moving gas stream increases as the square of the velocity.

It will be understood that the height of the feed conduits **30** and **37** does not depend on total pressure on the system but the pressure drop through the system and the pressure differential between the cracking and regenerating zones so that any desired total pressure may be maintained in the circuit.

In some cases the amount of coke formed during the cracking operation may be insufficient to generate the required heat during regeneration to preheat, vaporize and carry out the cracking process. In such cases, additional heat may be supplied to the regenerator either by external heating or by adding a combustible fuel into the stream of regenerating gas. However, in most instances the amount of coke formed during the cracking treatment will be sufficient for heating the oil.

The present invention also contemplates absorbing the excess heat formed during regeneration by admixing with the catalyst a relatively

inert material capable of absorbing substantial quantities of heat liberated during the cracking process. This inert adsorbent material can be utilized for carrying heat from the regenerator 58 to the cracking equipment.

Having described the preferred embodiment of the invention, it will be understood that it embraces such other variations and modifications as come within the spirit and scope thereof.

What is desired to be protected by Letters Patent is:

1. In a process of catalytically converting residual oils containing constituents unvaporizable without substantial decomposition into motor fuel wherein the oil is cracked in the presence of a solid adsorbent catalyst in subdivided form and the catalyst regenerated at a temperature higher than the cracking temperature; the method which comprises passing the residual oil to be cracked in indirect heat exchange relation with regenerated catalyst to thereby preheat said oil and cool said catalyst, returning said cooled regenerated catalyst to the regenerating zone, mixing said oil with regenerated catalyst while said catalyst is at substantially the regenerating temperature, adding sufficient catalyst to said oil to supply all of the additional heat necessary for cracking said oil and completely adsorb all oil constituents remaining unvaporized at the mixing temperature, passing the resulting mixture through a cracking zone, maintaining said oil vapors within said cracking zone to obtain the desired cracking thereof, separating the cracked products from the catalyst and fractionating the cracked products to segregate the desired fraction therefrom.

2. A process for the catalytic cracking of heavy residual oils containing a substantial portion of constituents unvaporizable without decomposition to form lower boiling hydrocarbons in the motor fuel boiling range which comprises passing a stream of said residual oil through a cracking zone, introducing a stream of hot regenerated catalyst while said catalyst is at substantially regenerating temperature into said stream of oil while said oil is at a temperature below active cracking temperature, the amount and temperature of the catalyst so introduced being sufficient to heat said oil above 900° F. and completely absorb the unvaporizable constituents contained therein to thereby form a relatively dry suspension of oil vapors and catalyst, maintaining the oil vapors in contact with the catalyst within said cracking zone for a period sufficient to crack at least 30% thereof into motor fuel constituents, continuously separating a stream of finely divided catalyst containing solid combustible deposits from the oil vapors, thereafter fractionating the oil vapors to segregate a motor fuel fraction therefrom, continuously passing a stream of said catalyst separated from said oil vapors into a regenerating zone, passing a stream of oxidizing gas upwardly through said zone at a velocity limited to form a dense, turbulent bed of catalytic material and oxidizing gas in the bottom section of said regenerating zone, burning combustible deposits from the finely divided catalyst within said regenerating zone to thereby heat said catalyst to a temperature above the temperature maintained in said cracking zone but below the deactivation temperature of said catalyst, the density and turbulence of the catalytic material within said regenerating zone being sufficient to maintain a substantially uniform temperature throughout the regenerating zone, continuously withdrawing a stream of regenerated catalyst from the regenerating zone and continuously returning said catalyst to said oil stream while at substantially its regenerating temperature.

3. In the process defined by claim 2, the further improvement in the method of circulating the catalytic material through said cracking and regenerating zones which comprises maintaining a vertical column of said catalyst being introduced into said oil stream of a height sufficient to generate a pressure at least equal to the pressure on the oil stream at the point of introduction of said catalyst therein and maintaining the catalyst within said column in a free flowing fluidized state.

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