March 4, 1952 W. W. WEINRICH 2,587,669

PROCESSING LIQUID HYDROCARBONS

Filed Jan. 3, 1950

Fig. 1

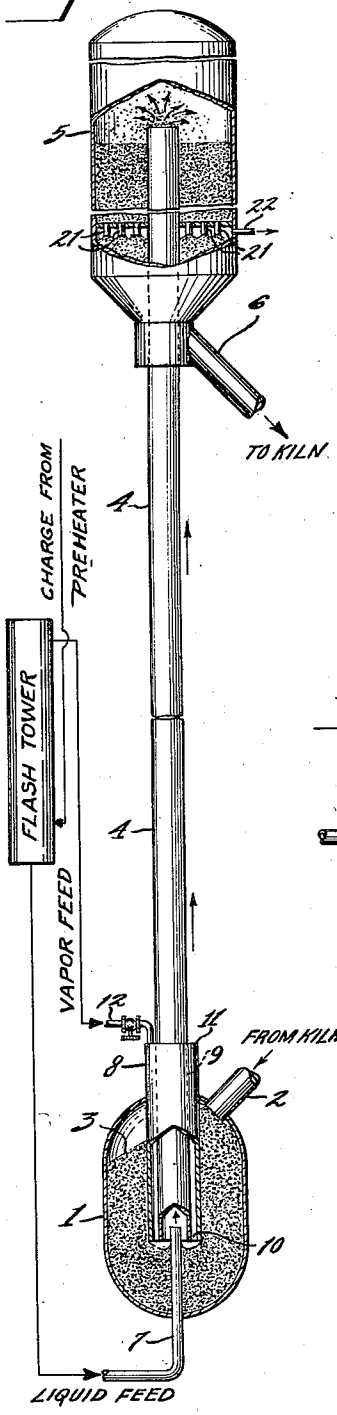


Fig. 2

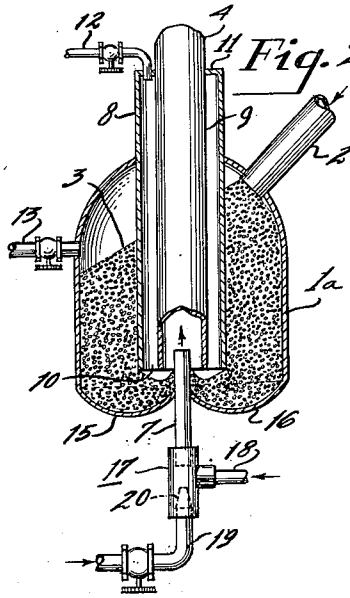


Fig. 5

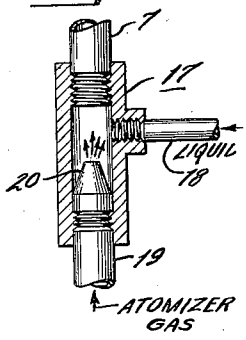


Fig. 3

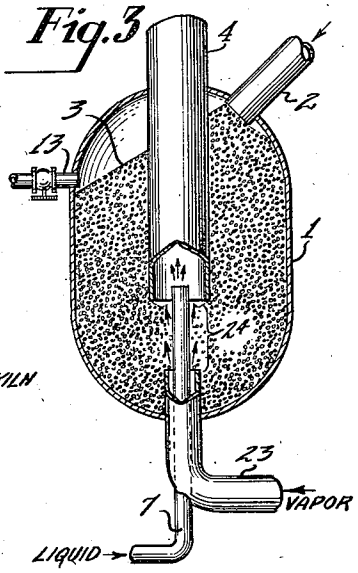
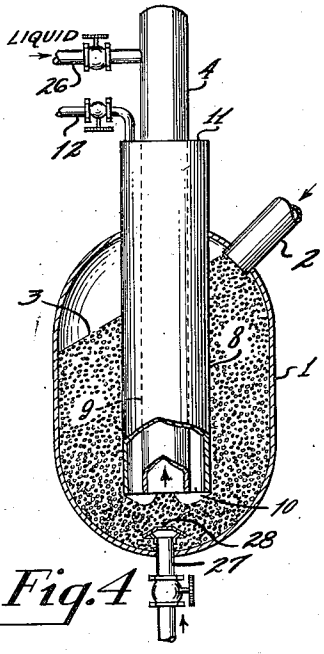


Fig. 4



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PROCESSING LIQUID HYDROCARBONS

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14 Claims. (Cl. 196—52)

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The present invention relates to systems and methods for conversion or other processing of hydrocarbons in contact with a granular contact mass and is particularly directed to improvements in the operation of such systems wherein the granular mass is circulated to and from a reaction zone or treating zone. The invention is especially concerned with those systems and operations wherein the granular contact mass during such circulation is elevated from a lower to an upper level in the system by a lifting fluid stream.

Various hydrocarbon conversion or treating operations employ systems of the type above designated; for example in catalytic conversion of hydrocarbons using a moving bed of adsorptive granular catalyst as in cracking, desulfurization, reforming, etc. Other operations coming into consideration include those wherein a granular contact mass, having little or no catalytic activity, is employed chiefly as a means of transferring contained sensible heat to an oil to be processed, whether for the purpose of thermally cracking or precoking the oil, or for heating the same to required reaction temperature or to vaporization temperature in the case of previously unvaporized liquid oils. While certain aspects of the present invention are applicable to operations of the various types hereinbefore designated, the invention will be more particularly described in connection with the cracking of normally liquid hydrocarbons in contact with adsorptive catalysts to products of lower boiling point and lower molecular weight, such as products in the gasoline boiling range.

Normally liquid hydrocarbons when subjected to certain elevated temperatures, whether or not in the presence of a catalytically active mass, break down to form solid carbonaceous or hydrocarbonaceous deposits called "coke." As a general rule higher boiling hydrocarbons at a given cracking severity display a comparatively greater tendency to form coke deposits. Where such coke material is inherently or concomitantly formed as a result of contact of hydrocarbons at elevated temperature with catalyst or other adsorptive contact mass, the cokeable material is deposited in the contact mass, and can be periodically removed therefrom by transporting the thus contaminated mass, in the course of its circulation, to a regeneration zone wherein the mass is contacted at ignition temperature with oxygen-containing gas to effect combustion of the coke and resulting restoration of the mass for further use in the hydrocarbon processing operation. Accumulation of coke on contact mass which cannot be subjected to regeneration, or on parts of the

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apparatus as a result of coke-producing hydrocarbons remaining on the hot walls thereof, in many instances constitutes a severe problem, often to the extent of precluding practical adaptation of a processing technique that would otherwise be highly desirable from the standpoint of efficiency and economy of operation.

In catalyst circulating systems wherein the elevation of the catalyst is effected by a vapor stream in the presence of or containing hydrocarbons susceptible to undergoing reaction at prevailing high temperatures with the accompanying production of coke, such problems are particularly serious, because the deposition and accumulation of large quantities of coke in regions adjacent the zone of engagement of the vapor lift medium with the hot catalyst, may result in hampering the lift operation. This is especially true in systems in which it is desired to handle at least a portion of the hydrocarbons charged in liquid form, to take advantage of the heat content of the catalyst for vaporization of liquid, and particularly in handling of hydrocarbons which are not readily volatilized below coking temperatures. These drawbacks arising from coke accumulation when charging non-vaporized hydrocarbons to a vapor lift, are efficiently overcome by the novel arrangement and operating method of the present invention.

In accordance with the present invention, catalyst or other hot granular contact material is continuously supplied to a transfer zone or hopper to form a bed of the material at the foot of and surrounding a vertical lift conduit. A gas or vapor lift medium is passed into the bed of contact material under pressure so as to cause elevation of the contact material into the left conduit, and transportation through that conduit. Hydrocarbons to be converted or otherwise processed are admitted in liquid state directly within the lift channel to engage the upwardly moving contact material therein. Within the lower portion of the lift conduit and in the region to which the liquid hydrocarbons are admitted, the contact material is present in comparatively high concentration and is moving in its impelled path constantly upwardly in the lift channel; therefore the liquid hydrocarbons are subjected to conditions which favor complete and uniform distribution of liquid on the contact mass. By operating in this manner the coke that may be formed, as a result of subjecting the liquid hydrocarbons to the high temperatures prevailing in the vicinity of the lift hopper, is deposited in or on the contact material that is in positive upward motion and which can be subjected to regeneration as

required, thereby avoiding the possibility of forming interfering quantities of coke deposit within the lift hopper, as on the exposed walls thereof or on any stagnant or relatively slow moving contact material that may be present therein.

In typical procedures directed to the preparation of a charge stock for catalytic cracking, a bottoms fraction of crude oil or other high boiling fraction containing heavy ends which are not vaporized at the prevailing heating temperature, may be sent from the preheating furnace to a flash distillation zone, providing a vapor effluent and a high boiling liquid fraction. The system and operation of the present invention are advantageously adapted to the handling of both the liquid and vapor products from such flash distillation zone. Conveniently such vapor products may be employed as all or part of the lifting fluid for the granular contact mass, while the liquid hydrocarbons are introduced directly into the lift channel on the moving contact mass as above indicated. The vapor introduced into the transfer hopper for lifting or assisting in lifting of the granular solid contact material therein is, of course, not limited to such vaporous effluent from flash distillation, and may be any gas or vapor not incompatible with hydrocarbons, but is preferably hydrocarbon vapor and/or steam. When hydrocarbon vapors are employed as lifting fluid or to assist in lifting the granular catalyst or other contact mass, such vapors may comprise all or a part of the vaporous effluent from a tar separator or other flash distillation apparatus. The liquid hydrocarbons may comprise the non-vaporized fraction from flash distillation, preferably free from tars as such and from undesirable salts present in tar residues. Alternatively the liquid feed may be composed in whole or part of heavy liquid separated from products of cracking, either recycled from the particular cracking operation or from some other source.

The operation of the novel features of the invention will be better understood and other advantages thereof appreciated from the description which follows, read in connection with the accompanying drawings illustrating several alternative embodiments adapted for practice of the invention.

Figure 1 is a schematic diagram of a system for circulating catalyst or other contact mass, particularly illustrating the arrangement of the lift conduit and vessels directly communicating therewith.

Figures 2, 3 and 4 are enlarged partial views in vertical section of different modifications of details of the transfer hopper and the lower portion of the lift conduit. Figure 5 is an enlarged view of an additonal detail.

Referring now particularly to Figure 1, there is shown a transfer hopper 1, into which catalyst or other solid granular contact material is continuously admitted through a run down conduit 2, to form a bed within the hopper maintained at a substantially constant level as indicated at 3. Rising vertically from the transfer hopper 1 is a lift conduit 4, having its inlet end in the illustrated embodiment at some distance below the maintained bed level indicated at 3.

The lift conduit 4 has its upper terminus within a separating or disengaging vessel 5, which vessel is provided with a discharge conduit 6 at or near the bottom thereof.

A liquid feed line 7 passes upwardly through the bottom of the hopper 1 and terminates within the lift conduit 4, above the bottom of that conduit. The conduit 4 is surrounded by a concentric sleeve or housing 8, which terminates at its lower end approximately at or near the level of the bottom periphery of the lift conduit 4. There is thereby formed between the outer wall of conduit 4 and the inner wall of sleeve 8 an annular chamber 9, which is open at its bottom end 10 and sealed at its top end 11. The top end of the sleeve is in communication with a vapor supply line 12. At an upper portion of the hopper 1 there may also be provided a vapor inlet line as indicated at 13 (see Fig. 3) for purposes which will hereinafter appear. It will be understood that the sleeve 8 may be formed in other than cylindrical shapes and need not completely surround the lift conduit.

Details of the hopper 1 and its associated parts are better shown in the enlarged views of Figures 2, 3 and 4. Referring now particularly to Figure 2, as illustrated, the bottom of hopper 1*a* is shaped to conform in contour substantially with the path of flow of the contact mass in the hopper when passing down the hopper and reversing direction to pass upwardly into the lift conduit 4. With a hopper bottom of approximately this shape the quantity of non-moving or relatively slowly moving contact mass in the hopper is reduced to a practical minimum.

The liquid feed line 7 may be simply a pipe having an open end terminating within the conduit 4 and discharging a stream comprising liquid hydrocarbons into that conduit. If desired, the stream thus introduced through line 7 may contain some vapor materials such as steam or vaporized hydrocarbons. In some instances it may be preferred to discharge the liquid hydrocarbons into the conduit 4 in atomized condition. One suitable arrangement for effecting atomization, accordingly, is illustrated in Figure 2 and shown in greater detail in Figure 5. Thus the feed line 7 may be provided with a T-coupling 17 or other pipe fitting having a lateral opening communicating with a liquid supply line 18 and a connecting branch for reception of a vapor supply line as shown for instance at 19. The vapor supply line 19 may be equipped with a discharge nozzle 20 of reduced cross section. Admission of an atomizing gas or vapor through line 19 approximate the intersection of line 18 will cause atomization of the liquid introduced through line 18 and consequent discharge as an atomized stream through feed line 7.

In the operation of the embodiment illustrated in Figures 1 and 2 the lift vapors, such as steam and/or hydrocarbon vapors are introduced at the required pressure and in required quantity through line 12 into the annular zone 9 between the sleeve and the lift conduit. These vapors flow downwardly in the annular zone and issue through the bottom 10 of the zone as an annular stream, which flows to a level somewhat below the lower end of conduit 4. These vapors then reverse their direction of flow and pass upwardly into the lift conduit 4. In doing so the vapors contact granular material from the bed in hopper 1 (or 1*a*) adjacent the lower ends of sleeve 8 and conduit 4, and lying in the vapor path, causing the granular material to pass beneath the lower periphery of conduit 4 and upwardly into that conduit. The granular material is then impelled upwardly in the conduit 4 by the vapors passing through that conduit, and is discharged from the upper end of the conduit into the disengaging vessel 5. Because of the expanded

cross section of the vessel 5, the vapors discharged therein from conduit 4 lose velocity to the extent that the granular material is no longer supported thereby and the granular material settles down to accumulate as a bed in the vessel 5.

Liquid hydrocarbons introduced through line 7 into the lift conduit 4 contact the upwardly moving mass of granular material. In practical operation such granular material will be at an elevated temperature and will transfer heat to the liquid hydrocarbons, thus heating the same to desired temperature and effecting vaporization of these hydrocarbons, which may be accompanied by conversion to some extent to cracked products with concomitant deposition of coke.

To prevent upward flow of a portion of the hydrocarbon vapors through the bed of catalyst in the hopper 1 (or 1a) and toward the space above the catalyst level 3, a gas pressure may be maintained above that level substantially equal to or slightly above the pressure of the vapors at the outlet 10 of the annular chamber. For this purpose seal gas, which may be steam or other inert gas, admitted into the catalyst inlet leg 2 may be introduced at a suitable pressure so that a portion of the gas flows concurrently with the catalyst and down that leg, entering the space above the catalyst level in the hopper. Alternatively or in addition, such seal gas might be introduced directly into the hopper above the catalyst level by means of the valve-controlled inlet line 13. The use of steam for this purpose has the advantage of providing at least a portion of the steam that may be desired to be employed as process steam added to the hydrocarbon conversion reaction.

The vapors entering the lift conduit 4 together with vapors formed in that conduit by vaporization and conversion of the liquid feed introduced through line 7 are discharged together with the catalyst into the disengager vessel 5. Unvaporized liquid, if there be any, will be adsorbed on the catalyst, and will be vaporized or converted by remaining in contact with the catalyst in the accumulated bed thereof formed in the vessel 5, during gravitation of that bed toward the discharge outlet of that vessel. The vapor products discharged at the top of the lift, pass downwardly through the catalyst bed in the vessel 5 and are subjected to further conversion thereby; the vaporous conversion products being disengaged from the catalyst in passing over a suitable solid-gas disengaging means 21, which may be in the form of a tube sheet having short depending tubes therein, or the well known cup or channel disengager. The vapors thus disengaged are discharged from the bottom of the vessel 5 by means of a discharge line 22 from which they flow to apparatus for separation into desired fractions and further processing as desired. Below the disengaging means 21 the catalyst enters the discharge conduit 6 through which it may flow to a suitable kiln for regeneration by combustion of the coke in the catalyst. Before admission to the kiln, it will be understood, the catalyst will be subjected to a purging operation to remove adsorbed liquids and vapors. The catalyst in discharge conduit 6 instead of being sent directly to a kiln may be transported to another reaction vessel for further contact with hydrocarbons from an independent source and/or with a desired portion of the hydrocarbons in the vapor effluent discharged through line 22. In any case the catalyst is ultimately regenerated and returned in regenerated form from the kiln through the catalyst inlet conduit 2 for repetition of the described cycle.

In an alternative processing arrangement employing the apparatus illustrated in Figures 1 and 2 the vapors admitted to the annular chamber 9 may consist of steam or light hydrocarbon gases, and if desired crackable hydrocarbons may be admitted as the atomizing gas into the fitting 17 through line 19. In operations wherein hydrocarbons are admitted through line 12 it may be preferred to employ steam as the atomizing gas admitted through line 19; such steam assists in vaporization of the liquid hydrocarbons.

In the modification shown in Figure 3 the lift gas, which may consist of or contain vaporized hydrocarbons, is supplied principally through a jet 23 at the bottom of the hopper 1, terminating in an outlet spaced vertically from the bottom of conduit 4 and providing therebetween a gap 24 into which the granular mass continuously flows, and is picked up by the ejected vapors discharged through jet 23 and lifted thereby into the conduit 4. Again, as in the previously described embodiment, the liquid hydrocarbons are admitted into the lift conduit through the liquid supply line 7, which may be brought in concentrically through the larger pipe 23, as illustrated, or may be otherwise brought into the hopper through the bottom or a side wall thereof. A valve controlled vapor supply line 13 may also be provided as in the previously described embodiments for the introduction of additional vapors into the hopper 1. Thus, the line 13 may be utilized for the introduction of steam or other inert gas or vapor to prevent migration of hydrocarbons introduced through line 23, thus preventing possible coking on the walls of the hopper. Instead of steam, hydrocarbons of comparatively low coking tendency as compared with the less refractory heavy ends of the oil, may be introduced through line 13, steam being introduced through jet 23.

Instead of bringing the liquid feed in concentrically into the bottom of the lift conduit 4, in an alternative arrangement as illustrated in Figure 4, the liquid hydrocarbons may be introduced through one or more laterally intersecting pipes 26 at a level above the bottom of the lift conduit. Such pipes 26 may be simply provided with an open end at the discharge outlet thereof into the conduit 4, or may be equipped with screened heads or diffuser nozzles.

As further illustrated in Figure 4, the total requirement of lifting vapor in arrangements employing the sleeve 8 surrounding the lift conduit 4, need not be supplied through line 12, but an auxiliary vapor inlet may be provided, as shown at 27, to pass vapors upwardly through the catalyst bed. Thus the vapors admitted through line 27 mingle with the vapors discharged from the annular chamber 9 passing together upwardly into the conduit 4 and effecting elevation of the granular contact material engaged by these vapors. By regulating the rate and quantity of vapors respectively admitted through lines 12 and 27 efficient control of the circulation rate of the contact material can be maintained. The vapors introduced through lines 12 and 27 may be of the same or different composition; for instance steam may be admitted through one of these lines and hydrocarbons vapors through the other. The line 27 may be an open ended pipe or may be provided with a

diffuser head of suitable design. As shown at 28, the discharge outlet of the pipe may be provided with a suitable baffle or screen to prevent granular material from falling into the pipe.

Common to all of the described embodiments, the introduction of the more readily cokeable liquid hydrocarbons into initial contact with the catalyst or other granular material takes place in the lift conduit proper or closely adjacent thereto in the channel traversed by granular material that is already positively directed in its upward path for entry into the lift conduit, thereby avoiding the possibility of undesired coke accumulation within the hopper 1 (or 1a), and rendering unnecessary the elaborate precautions that might otherwise be required to safeguard against the building up in a comparatively short period of an accumulation of coke in the hopper to an extent interfering with the lifting operation. By restricting the liquid introduction to the lift channel and particularly to within the lower portion of the lift conduit, the liquid thus admitted contacts the catalyst in (1) comparatively dense phase, yet (2) at a point or zone at which all of the catalyst is moving positively upward in a path of fixed lateral boundary delineated or prescribed by the diameter of the surrounding wall of the lift conduit. These two conditions prevailing at the point or zone of liquid introduction are further explained below.

In a lift pipe of uniform cross section at a given mass circulation rate, the catalyst concentration at any level within the pipe will vary inversely with the catalyst velocity at that level. Just below the entrance to the lift pipe the catalyst is changed in its direction of movement and an upward force imparted thereto so that the catalyst is accelerated in upward direction from zero velocity in that direction to a positive velocity during a comparatively short distance of travel within the lift conduit. The acceleration then tapers off, but the velocity is progressively increasing to reach a maximum at or adjacent the top outlet of the conduit, so that the concentration of the catalyst at a given uniform mass flow rate is thus constantly decreasing. Accordingly the highest catalyst concentration within the lift conduit prevails near the bottom of the conduit. The point of liquid introduction between the ends of the lift conduit is preferably one at which the catalyst concentration is at least equal to 10% of the apparent bulk density of the catalyst in a random packed bed thereof. By so choosing the point of liquid introduction, ordinarily, there will still remain a path of travel of the catalyst or other contact mass within the lift conduit of sufficient length to assure good distribution of the liquid on the upwardly moving granular mass, which liquid may be adsorbed therein or adhere thereto as a surface film, and without having free liquid as such discharged from the conduit, or remaining on the walls of the conduit to deposit coke thereon. The same considerations apply in arrangements employing a lift conduit that is tapered or otherwise constructed of increasing diameter in a direction toward the top thereof. In such instances, however, although adequate catalyst concentration may be had at levels higher up in the lift conduit than in the case of a lift of uniform cross-section, the introduction of the liquid is preferably at a point sufficiently low that the liquid has adequate time and distance to become well distributed in the catalyst prior to its discharge from the conduit, so that no liquid oil as such is carried over in the disengaging vessel 5.

It is also given as a condition that the liquid introduction is at a point or zone at which all of the catalyst is moving positively upward. Immediately below the bottom of the lift conduit and over a short projected cross section of that conduit constituting a part of the lift channel, positive movement of all the catalyst is established. The lift channel therefore comprises not only the catalyst path within the lift conduit surrounded by the conduit wall, but includes a zone of substantially the same lateral dimension for a short distance below the foot of the lift conduit. This distance may vary to some extent with the vapor velocity and with the relative position of the bottom of the sleeve 8 with respect to the bottom of the lift conduit for this type of vapor lift inlet; or may vary with the length of the gap 24 in the types of inlet systems illustrated in Figure 3. In either case the zone in which positive upward movement of catalyst is assured includes that distance below the bottom of the lift conduit proper, no greater than approximately one-fourth the diameter of the lift conduit, which zone is therefore embraced within the designation "lift channel." By thus distributing the introduced liquid on the contact mass that has entered or is entering the lift conduit, coke formed from such liquid will be carried on the contact mass and will be ultimately burned in regeneration of the mass.

The total quantity of liquid hydrocarbons introduced into the lift certainly should not exceed the amount that can be adsorbed by the catalyst or will adhere to the contact mass supplied to the zone of solid-liquid contact. In practical operation, even in the case of adsorbent catalyst, the point of saturation of the hot catalyst with liquid hydrocarbons, will not be the determining factor in fixing the maximum ratio of liquid oil to catalyst, since conditions of desired heat transfer to achieve thermal balance in such practical operations may limit the total amount of liquid that can be charged, to a figure well below such point of saturation of the catalyst. For instance a typical pelleted catalyst having a porosity say of 50 volume percent can theoretically adsorb an amount of liquid oil substantially equal to one half the apparent pellet volume of the catalyst, given sufficient time, and not taking into account continuous vaporization of the oil with or without accompanying cracking. In practical operation, however, the amount of liquid oil charged should not exceed about ⅓ of the catalyst volume, and in fact taking into consideration the relative temperature differential between the oil and the catalyst that is most convenient in such operation, and considering also the heat required and the reaction temperatures desired to be maintained in the principal conversion reactor, the amount of liquid oil charged will be preferably below ¼ of the catalyst volume. The quantity of vaporized hydrocarbons charged in addition to the liquid hydrocarbons, will depend upon the operating conditions established for the principal reaction zone (compact moving bed reactor) including the selected catalyst to total hydrocarbon ratio as one of these conditions. Such additional vaporized hydrocarbons may be introduced, entirely or only in part into the lift conduit, as previously described, to serve as lifting vapors, and additional hydrocarbons may be brought into the compact bed reactor, if needed to make up the required hydrocarbon to catalyst ratio.

As a general rule, practice of the invention does not necessitate a departure from the usual processing conditions used in conventional systems for carrying out hydrocarbon conversion reactions, for instance those employing gravitating compact beds of catalyst or other contact mass, as in catalytic cracking of hydrocarbons to gasoline, catalytic reforming of naphthas to products of improved quality, or corresponding non-catalytic operations wherein the granular contact mass is relied upon chiefly for heat transfer.

As catalysts for hydrocarbon cracking operations there may be employed the known siliceous and other cracking catalysts including acid-activated clay pellets or synthetic silica-alumina in the form of cylindrical or spherical pellets (beads), of a size range designated as granular as distinguished from finely divided powders of up to 100–200 mesh size. Such granular catalyst or other solid contact mass is characterized by the property of forming compact beds through which gases and vapors can be passed upwardly at practical operating velocity without significantly disturbing the bed, as distinguished from finely divided powders which are impelled or form "fluidized" beds by passage of gases or vapors therethrough at considerably lower velocity. The granular catalyst or other contact mass employed in practice of the present invention should generally be of a size greater than about .05 inch in major dimension, and up to about 0.5 inch.

In installations wherein the chamber **5** is employed to accumulate the contact mass as a bed of sufficient height to serve as a gravitating bed reactor, this chamber should be maintained at sufficient pressure above atmospheric that the vapor products discharged through line **22** can be sent to further processing without necessitating pressure boosting. Generally the pressure at the discharge line **22** should be in the order of at least about 6 pounds per square inch gauge, so that with a pressure drop of about one pound or more through the bed in vessel **5**, the pressure above the bed would be at least 7 pounds per square inch or more. Efficient and smooth operation of the lift and adequate solids concentration for adsorption of the liquid hydrocarbon feed is generally had under conditions providing a pressure drop of about 1 to about 12 pounds per square inch in the lift conduit **4**, so that the pressure in hopper **1** immediately below the conduit **4** will be the sum of the pressures prevailing at the discharge end of the lift conduit and the pressure drop in that conduit. The required pressure in hopper **1** thereby determines the pressure of introduction of vapors through line **12** or line **23**.

The disengaging vessel **5** need not be operated to accumulate a bed of granular contact material of significant height. For example, the tube sheet or other partition **21** may be omitted and the discharge conduit **6** may be of such diameter as to be capable of transporting the granular material at a rate in excess of the discharge rate of conduit **4**. In such arrangements the conduit **6** will be only partly filled with granular material and all or part of the vapors disengaged in vessel **5** may be sent concurrently with the catalyst or other granular contact through conduit **6** to the principal hydrocarbon reactor, which will generally be of the gravitating compact bed type. A portion of the vapors from the disengaging vessel **5** may be withdrawn overhead separately from the granular material, and sent to the same hydrocarbon conversion reactor as the granular material discharged through conduit **6**, or to some other processing or storage vessel, as desired. In these arrangements wherein the disengaging vessel **5** connects directly with a hydrocarbon conversion reactor, the pressure in the disengaging vessel should advantageously be higher than that prevailing at the reactor inlet.

Example I

The following example illustrates a typical operation in the practical adaptation of the invention as applied to processing about 2000 barrels of oil per day as fresh feed. The arrangement is based on the use of a unit comprising a 12 inch diameter lift conduit of about 200 feet in height.

An East Texas crude oil is fractionated and the bottoms fraction constituting about 40% of the total crude separated. This fraction, having a gravity of 23.7° A. P. I. and an initial boiling point of 425° F., 80% boiling up to 1014° F.; is admitted at appropriate tempera ure to a flash vaporization zone, such as a conventional tar separator, operating at a temperature of 850° F. at a pressure of about 17.5 p. s. i. gauge, steam being admitted to the zone at the rate of about 24.7 pounds per barrel of oil charged. All of the vaporized hydrocarbons and steam withdrawn overhead are sent to the lift hopper to operate as vapor lift medium, entering the hopper at about the flash distillation temperature. The non-vaporized hydrocarbons, constituting about 37.5% of the oil charged to the flash distillation zone, are removed as a bottoms fraction and sent to a vacuum flash distillation zone to remove the heavy tars and salt contaminants. The vacuum distillation zone is operated at a pressure of about 100 mm. of mercury and steam is added thereto at the rate of approximately 2.9 pounds per barrel of oil. About one-fifth of the original 40% bottoms fraction of the crude oil, is discharged as tar bottoms from the vacuum distillation zone, while the overhead therefrom is permitted to condense and pumped as liquid feed (23.4° A. P. I. gravity) to the lift through line **7**. On the basis of an original 2,000 barrels per day charged to the flash distillation zone, this will provide for introduction into the lift about 1250 barrels of hydrocarbon vapors at the stated temperature plus the added steam, and about 350 barrels of liquid feed at about 650° F. Freshly regenerated synthetic silica-alumina bead catalyst at about 1000° F. enters the lift at a rate giving a weight ratio of catalyst to oil of 6 to 1. The pressure at the foot of the lift is maintained at about 15 p. s. i. gauge and at the discharge outlet of the lift, in the disengaging vessel **5**, at about 11 p. s. i. gauge.

With the average reaction temperature in the gravitating bed reaction zone at 850° F., average pressure of 10 p. s. i. gauge, and a space rate of 7 pounds of oil per pound of catalyst in the reaction zone per hour, the products are as follows:

	BPSD [1]	Lbs./Hr.
C_4 free Gasoline (375° F. @ 90%)	590	
Cracked Products heavier than gasoline	878	
C_4 cut	160	
Dry gas		840
Coke burnoff		640

[1] Barrels per stream day.

In the foregoing example a virgin oil fraction was charged as liquid feed to the lift. In an alternative operation the vapor overhead from the flash distillation zone is used as lift medium as before, but the liquid feed constitutes recycled

heavy catalytic gas oil separated from the cracked products. Since such recycle fraction is ordinarily more refractory than virgin oil, more severe cracking conditions might be employed, if desired; or the conditions may be those obtaining about the same amount of coke to be burned off as in the preceding operation. The latter operation is described in the following example.

Example II

The catalytic gas oil is pumped as liquid and introduced into the lift through line 7 at 700° F., the lift vapors from flash distillation entering at about 850° F. Freshly regenerated synthetic silica alumina bead catalyst is admitted to the hopper at 1000° F. or somewhat above. Under approximately the same cracking conditions as employed in the previous example, but employing 625 bbls./day of liquid feed at about 700° F., there are obtained the following products:

	BPSD	Lbs./Hr.
C_4 free gasoline (375° F. @ 90%)	630	
Catalytic gas oil (boiling above gasoline)	462	
C_4 cut	165	
Dry gas		955
Coke burnoff		640

It will be understood that the operating conditions above set out are merely illustrative and may be varied over a fairly wide range. Thus, the regenerated catalyst will usually be admitted to the lift at a temperature above that of the oil, say at about 900–1100° F. to take advantage of the heat content of the catalyst. At high catalyst to oil ratios the liquid feed may be admitted to the lift at temperatures as low as 400–500° F., while in some cases the liquid feed may be at temperatures as high as 900° F., or above. In certain operations, the entire liquid bottoms from flash distillation may be sent directly to the lift without removal of the heavy tars. Various other sources of liquid feed may be used, such as slop oil from a lube refining operation.

Since the vaporization of the liquid hydrocarbons takes place essentially within the lift conduit, the vapors thus produced do not significantly influence the catalyst circulation rate. Accordingly, uncontrolled changes in catalyst flow rate that might result from variation in the nature or condition of the liquid feed, if it were vaporized in the lift hopper, are avoided.

The term "apparent bulk density" as herein employed, has reference to the weight of a random packed volume of the granular contact mass. In the case of silica-alumina bead catalyst of about 0.12 inch diameter that has been in use and maintained at equilibrium activity, the apparent bulk density is about 46 pounds per cubic foot.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim as my invention:

1. The method which comprises continuously supplying hot granular contact material to a transfer zone to form a compact bed of said material in said zone, passing a gaseous stream compatible with hydrocarbons into said bed under pressure to cause elevation of a portion of the contact material and suspension in said gaseous stream, directing the gaseous stream and contact material suspended therein into a vertical elongated channel commencing below the top level of said bed, flowing the gaseous stream past the contact material in said channel to impel the contact material vertically upward in said channel, admitting into said channel liquid hydrocarbons to directly engage the upwardly moving contact material therein, said liquid hydrocarbons being admitted to a lower portion of said channel and in a region wherein said contact material is present in relatively high concentration as compared with higher regions of said channel, whereby said liquid hydrocarbons are completely and uniformly distributed on said contact material, the contact material in said bed and directed into said channel being at a temperature sufficiently high to cause coking of said liquid hydrocarbons; whereby the coke produced as a result of conversion of said liquid hydrocarbons at the temperature prevailing within said transfer zone and in said channel is deposited substantially entirely on the moving contact material.

2. The method of treating liquid hydrocarbons which comprises engaging hot granular contact mass with a vapor stream to effect elevation of said mass into and through an elongated vertical channel under the impelling influence of said vapor stream, said vapor stream being compatible with hydrocarbons, distributing liquid hydrocarbon oil on the vertically moving contact mass at a level within said channel at which said contact mass is present in suspension in the vapor stream in an average concentration of not less than 10% of the apparent bulk density of said mass, said contact mass being at a higher temperature than said liquid oil, transferring heat from the contact mass to the oil to effect vaporization of the oil within said channel, discharging the contact mass and oil vapors thus formed into an expanded disengaging area, maintaining engagement between said oil vapors and said contact mass thereafter to effect at least partial conversion of said vapors to lower boiling hydrocarbons, discharging the contact mass into a heating zone and heating the same in said zone to restore the temperature of said mass, and returning the thus heated contact mass to further engagement with said elevating vapor stream.

3. The method in accordance with claim 2 wherein the quantity of liquid oil distributed on said contact mass is not in excess of that quantity which will be converted to vapors prior to discharge of said contact mass into said disengaging zone.

4. The method in accordance with claim 2 wherein said liquid oil comprises hydrocarbons boiling above the range of gasoline.

5. The method in accordance with claim 4 wherein a portion of said hydrocarbons boiling above the range of gasoline are converted to gasoline during contact with said contact mass, thereby concomitantly depositing coke on said contact mass, and said heating of the contact mass in the heating zone is effected by combustion of the coke thereon.

6. The method in accordance with claim 2 wherein the quantity of liquid oil distributed on said contact mass is not in excess of one-third by weight of the contact mass.

7. The method in accordance with claim 2 wherein said vapor stream engaging said contact mass comprises hydrocarbon vapors from distil-

lation of a liquid hydrocarbon oil fraction and said liquid oil distributed on said mass comprises at least a part of the unvaporized residue of such distillation.

8. The method of hydrocarbon conversion which comprises engaging a hot granular adsorptive contact mass with a vapor stream compatible with hydrocarbons, to effect elevation of said contact mass into and through an elongated vertical channel, admitting hydrocarbons in liquid state into said channel to contact said granular mass for heat exchange therewith thereby effecting at least partial vaporization of said hydrocarbons within said channel, and separating the contact mass from said vapors beyond said channel, said liquid hydrocarbons being introduced into said channel at a locus wherein the contact mass is in positive upward motion and is present in sufficiently high concentration to adsorb the liquid hydrocarbons contacted therewith, and the sensible heat content of said contact mass is sufficient to effect vaporization of said liquid hydrocarbons and to effect at least partial cracking of said liquid hydrocarbons to lower boiling products.

9. The method of hydrocarbon conversion which comprises vertically moving hot freshly regenerated granular cracking catalyst through an elongated transportation zone under the impelling influence of a hydrocarbon-containing vapor stream, the concentration of catalyst within said transportation zone decreasing in the direction of movement of said catalyst, admitting hydrocarbons in liquid state within said transportation zone directly into contact with said vertically moving catalyst and at a locus in said zone wherein the catalyst concentration is at least equal to 10% of the apparent bulk density of the catalyst to effect distribution of the liquid oil in the catalyst, said liquid hydrocarbons being at a temperature below that of the catalyst, maintaining contact between said liquid hydrocarbons and said catalyst in said transportation zone for a time sufficient to effect complete vaporization of said liquid hydrocarbons by heat exchange with catalyst within said transportation zone, and contacting the hydrocarbon vapors thus formed with the catalyst beyond said transportation zone to further crack said vapors into lower boiling products with accompanying deposition of coke in said catalyst, regenerating the coked catalyst and returning the regenerated catalyst for engagement with the transporting hydrocarbon-containing vapor stream.

10. The method of hydrocarbon conversion which comprises continuously supplying hot freshly regenerated granular catalyst at hydrocarbon conversion temperature to a transfer zone to form a compact bed of catalyst in said zone, passing a vapor stream compatible with hydrocarbons into said bed under pressure to effect elevation of catalyst from said bed, directing said stream and the catalyst elevated thereby into a confined vertical elongated transporting zone and flowing said stream past the catalyst within said zone to impel said catalyst vertically upward through said elongated zone to a disengaging zone wherein said stream and catalyst are separated, introducing hydrocarbons in liquid state into a lower portion of said transporting zone and into engagement with upwardly moving catalyst therein, maintaining contact between hydrocarbons and catalyst in said transporting zone for a period sufficient to vaporize liquid hydrocarbons and partially convert vapor and liquid hydrocarbons to lower boiling products, and again contacting a mixture of said vaporized hydrocarbons and lower boiling products thus formed with the catalyst after discharge into said disengaging zone to effect further conversion of at least a part of said mixture into lower boiling hydrocarbons; the catalyst being contaminated with coke formed by conversion of hydrocarbons in contact therewith, being then separated from hydrocarbons and regenerated by combustion of the coke therein to provide hot freshly regenerated catalyst at hydrocarbon conversion temperature for supply to said transfer zone.

11. The method in accordance with claim 10 wherein said liquid hydrocarbons are introduced at a rate not in excess of the liquid hydrocarbon adsorption capacity of the catalyst at the temperature and catalyst concentration prevailing in the region within said transporting zone wherein said liquid hydrocarbons are introduced.

12. The method in accordance with claim 10 wherein the rate of introduction of liquid hydrocarbons into said transporting zone is related to the rate that the catalyst is supplied to said zone and to the heat content of said catalyst, such that the total heat content of the catalyst is sufficient to supply the heat required for vaporization of the liquid hydrocarbons and for the endothermic heat of reaction for the said conversion of the hydrocarbons.

13. The method in accordance with claim 10 wherein said catalyst and said liquid hydrocarbons are supplied to said transporting zone at rates such that the weight ratio of catalyst to liquid hydrocarbons is at least 3/1.

14. The method which comprises subjecting a heavy hydrocarbon oil fraction to flash distillation in the presence of steam to obtain a vapor effluent comprising relatively light hydrocarbons and an unvaporized liquid residue comprising relatively heavier hydrocarbons, introducing said vapor effluent containing steam and said light hydrocarbons in vapor state into a bed of hot freshly regenerated catalyst under pressure to impel catalyst from said bed upwardly into and through a confined transporting zone, admitting at least a portion of said relatively heavier hydrocarbons in liquid state into said transporting zone to engage upwardly moving catalyst in said zone, said relatively heavier hydrocarbons being admitted at a lower portion of said transporting zone and in a region therein where the catalyst concentration is relatively dense, so that any liquid hydrocarbons unvaporized by contact with the catalyst are adsorbed therein during movement of the catalyst in said confined transporting zone, and whereby coke formed by conversion of hydrocarbons in said transporting zone is substantially entirely deposited on catalyst in said transporting zone.

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