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METHODS AND APPARATUS FOR CONTACTING LIQUID
WITH GRANULAR CONTACT MATERIAL
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Fig. 1.

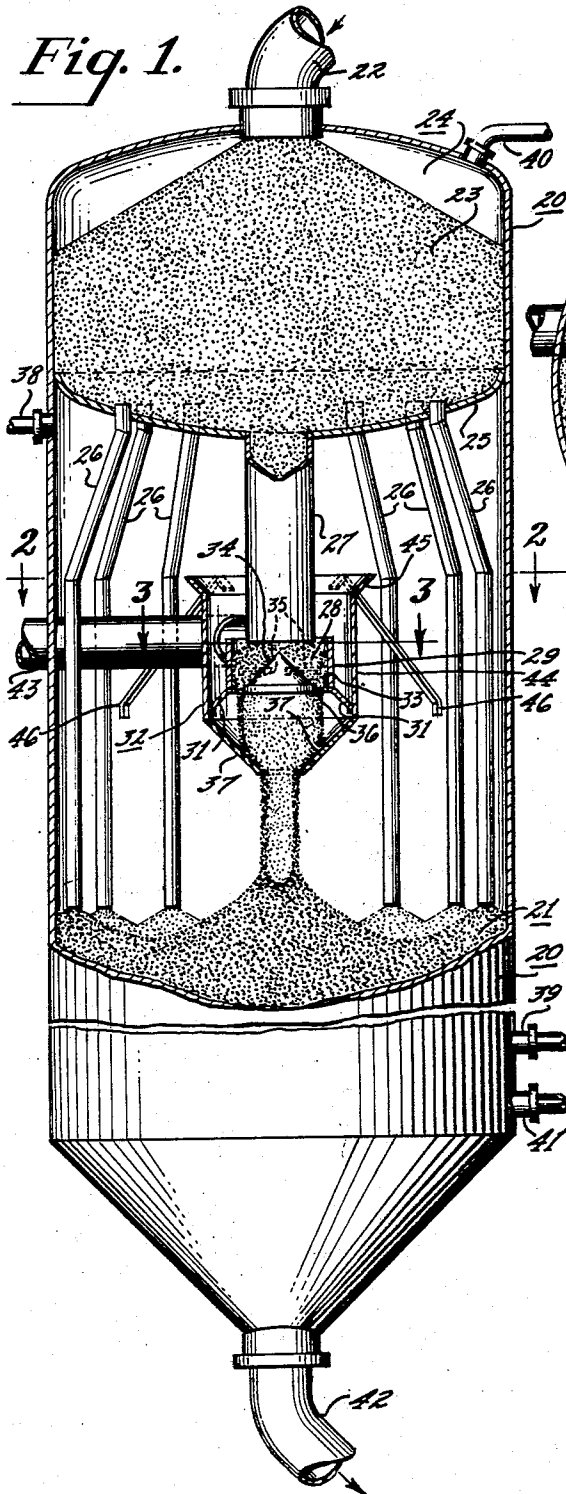


Fig. 2.

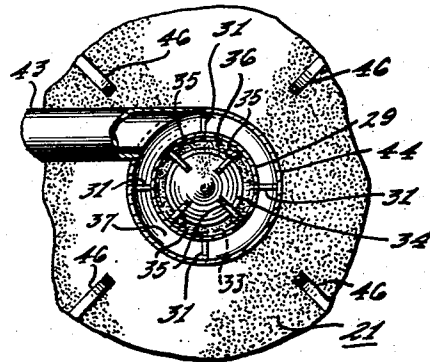
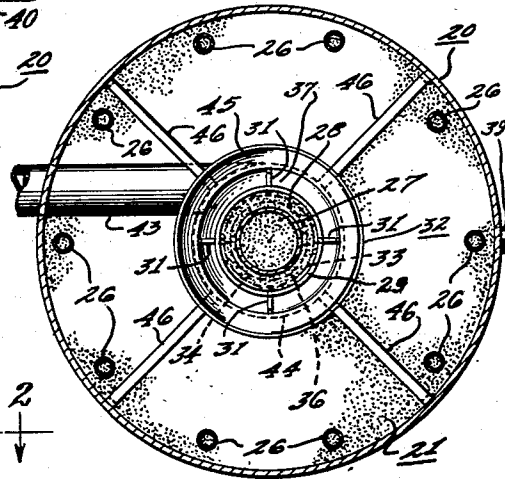


Fig. 3.

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METHODS AND APPARATUS FOR CONTACTING LIQUID WITH GRANULAR CONTACT MATERIAL

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9 Claims. (Cl. 196—52)

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The present invention relates to systems and methods for the conversion of liquid hydrocarbons by contacting such hydrocarbons with granular contact material. Typical of the conversion processes and systems to which the invention is applicable is the cracking of relatively high boiling liquid hydrocarbons to gasoline using granular absorptive hydrocarbon cracking catalyst or the viscosity breaking or coking of such hydrocarbons using relatively catalytically inert granular solids of the type known as heat carriers.

The use of higher boiling fractions of the crude oil, such as tar separator bottoms, reduced crudes, heavy fuel oil and the like, as charging stock for the preparation of gasoline and/or light fuel oil presents difficulties due to the ease with which such fractions thermally decompose to form coke whether or not volatile cracked products are also formed. For example, many of such fractions coke up the tubes of heating furnaces when heated to temperatures of 850° F. or above and hence, even if vaporizable at temperatures of 900° to 1000° F., cannot be handled as vapor because such a practice would result in too frequent shutdowns of the heating equipment. As a consequence, it has been the practice to contact such charging stocks in liquid form with hot granular contact material under conditions such that the liquid hydrocarbons are decomposed to volatile products with an attendant formation of a hydrocarbonaceous deposit (which includes very heavy, non-vaporizable hydrocarbons) on the contact material. The hydrocarbonaceous deposit on the contact material further decomposes during the conversion period to form volatile hydrocarbons and coke, the latter being removed by combustion with an oxygen containing gas during a subsequent regenerative operation.

The prior art has diligently and actively sought methods for efficiently contacting liquid hydrocarbons with moving granular contact material under conditions that insure even distribution of the liquid on the total mass of contact material. A commercially successful method involves projecting liquid hydrocarbons toward a sheet-like curtain of falling particles of granular contact material, which curtain has such a density and thickness as to intercept the liquid hydrocarbons directed thereto, as disclosed and claimed in copending application Serial No. 766,714, filed August 6 1947, in the name of Reuben T. Savage, now Patent No. 2,548,912.

This method is successful in effecting contact between liquid hydrocarbons and moving contact material, an atomizing nozzle of one of several special designs being used to project hydrocar-

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bons. However, it was discovered that the conditions of contact changed when the stream of hydrocarbons passing through the nozzle contained varying amounts of vapor, such as are within the necessary range of commercial operation, and led to undesirable effects, due principally to variable flow through the nozzle. At excessive nozzle velocities, the contact material in the curtain is subject to outward displacement with resultant particle-to-particle and particle-to-wall collision resulting in attrition. At very low nozzle velocities, the liquid fails, at least in part, to reach the curtain and hence is not distributed on the contact material as desired. These difficulties are overcome by the present invention in which the dispersion of the liquid hydrocarbons and the velocity at which the liquid hydrocarbons contact the contact material are independent of the physical properties and amount of the liquid hydrocarbons, thus providing an improved and more flexible method of operation.

In accordance with the present invention, I flow a stream of fluid comprising gas and liquid hydrocarbons to and in a laterally confined zone within the conversion or cracking zone in such a manner that the stream of fluid rotates in said confined zone and concentrates or separates the liquid hydrocarbons at the periphery of the confined zone. The separated liquid flows downwardly into contact with particles of contact material. As described below, I can flow separated liquid hydrocarbons convergently toward the center of a confined zone so as to contact the outer periphery of an annular stream or layer of contact material flowing within said confined zone.

The principles involved in the present invention are set forth in detail below in connection with the description of the drawing in which the application of a preferred embodiment of the present invention to a catalytic cracking system is shown. It is to be understood that this preferred embodiment and the application of the invention to a catalytic cracking system are to be regarded as illustrating the present invention rather than restricting its scope.

In the drawing:

Figure 1 is a vertical view of a vessel containing a moving bed of solid particles with portions of the vessel broken away for a better view of the relationship of the parts;

Figure 2 is a transverse section of the vessel illustrated in Figure 1 taken along the lines 2—2 showing the relationship of the parts of the apparatus at this level.

Figure 3 is a transverse section of a gas-liquid

separating device shown in Figures 1 and 2 as taken along the lines 3—3 in Figure 1.

Shown in Figure 1 is a closed vertical elongated reaction housing or vessel indicated generally at 20 which housing comprises a contact or cracking chamber or zone containing a downwardly moving bed of solid particles or hydrocarbon cracking catalyst, as indicated generally at 21. Fluent solid particles in the size range of from about 0.05 to about 0.5 inch and comprising freshly regenerated solid hydrocarbon cracking catalyst, such as acid activated montmorillonite clay, synthetic silica-alumina gel in pellet or bead form or other solid refractory compositions known by those skilled in the art to be hydrocarbon cracking catalysts, are introduced to housing 20 by conduit 22 at the top thereof and form a bed 23 in a catalyst introduction, storage or sealing chamber 24 in the top of the housing above horizontal baffle or tube sheet 25 as shown. Part of the particles in bed 23 flow from storage chamber 24 to the cracking or contacting chamber through conduits 26, which are arranged equidistantly from the center of tube sheet 25, onto the surface of bed 21. Another portion, preferably the major portion, such as from 50 to 90 percent, and in some cases all of the particles, flow through conduit 27.

Particles discharge from the end of conduit 27, to form a bed 28, the end of conduit 27 terminating within the cracking zone or chamber (which may be considered as having its upper limit at tube sheet 25) and above the surface of bed 21. The sides of bed 28 are confined by a cylindrical baffle or wall 29 which is supported and positioned by braces 31 within a surrounding gas-liquid separation member or device indicated generally at 32. Affixed to the bottom of cylindrical wall 29, as by welding, is a circular ring 33. Positioned concentrically in the center of the inner periphery of ring 33 is a conical baffle 34 positioned with its apex upward. Conical baffle 34, which is supported by braces 35, has a circular outer periphery which is smaller than the inner periphery of ring 33, these two members cooperating to define an annular particle metering zone, passageway or discharge orifice 36.

Annular passageway 36 has a lesser discharge capacity than that of conduit 27 so that the particles of catalyst move from bed 23 to passageway 36 in choked or compact flow. The width and area of annular passageway 36 are selected so that an amount of catalyst discharges therefrom sufficient to adsorb the liquid hydrocarbons later contacted and/or provide adequate heat capacity for the desired vaporization of such hydrocarbons. The particles of catalyst discharge from passageway 36 and fall downwardly and unobstructedly to the frusto-conical bottom wall 37 of device 32. Because wall 37 converges and is open at the bottom, the particles travel in a converging path until they reach the bottom of wall 37 where they fall freely and unobstructedly downwardly to the surface of bed 21. The upper surface of wall 37 may be smooth so that the wall acts as a deflecting baffle down which the particles slide or roll freely. Alternatively, obstructions to particle flow, such as a grating, may be placed on the upper surface of wall 37 so as to create a thick, relatively slow moving layer of particles, which flows down the bottom wall.

Hydrocarbon vapors produced by contact with the catalyst in a manner described below, to-

gether with any hydrocarbon vapors introduced to the top of the conversion zone through conduit 38, pass downwardly through bed 21 and are disengaged from the bed of particles at the bottom of the cracking zone or chamber by methods known to the art. The disengaged vapors are withdrawn through conduit 39 for appropriate processing for the production of gasoline and/or light fuel oil and other products. The hydrocarbon vapors are confined within the cracking zone or chamber by introducing a sealing gas such as steam, inert flue gas and the like, to storage or sealing chamber 24 through conduit 40 at a pressure slightly above the pressure in the cracking zone. A portion of the sealing gas passes upwardly through the compact column of catalyst in conduit 22 while the remainder passes downwardly through the compact columns of catalyst in conduits 26 and 27.

The particles of catalyst thereafter pass downwardly through a purging zone in which they are contacted with steam, spent flue gas or other inert non-oxidizing gases introduced through conduit 41 through gas distribution devices known to the art (not shown in the drawings). The purging gas also serves to confine the hydrocarbon vapors to the conversion zone in a similar manner to that described above in connection with chamber 24. The purged catalyst, which contains a deposit of coke, is removed from housing 20 through conduit 42 and sent to a regeneration zone in which the coke deposit is removed by contact under combustion conditions with an oxidizing gas, the regenerated catalyst being returned to housing 20 for further use therein.

In accordance with the embodiment of the invention shown in the drawing, a stream of fluid comprising gas, the nature of which is described below, and liquid hydrocarbons is passed from the exterior of vessel 20 to the cracking chamber through a conduit 43 which communicates with the interior of gas-liquid separation device 32. Conduit 43 can enter the cracking chamber in any convenient manner; for example, as shown in Figure 1, where it enters the cracking chamber horizontally through the side thereof. As shown in Figures 2 and 3, conduit 43 is positioned so that the stream of fluid passing therethrough enters the interior of gas-liquid separation device 32 tangentially to the upper vertical cylindrical wall 44 of device 32, which wall terminates at its upper end in a small outwardly flaring section 45. Support braces 46 are attached to the top flaring section 45 so as to support and position the device concentrically with respect to the annular particle metering passageway 36, the latter being spaced from wall 44.

Because of the tangential method of introduction, the stream of gas and liquid hydrocarbons introduced to gas-liquid separation device 32 rotates therein so that the liquid hydrocarbons are thrown against the wall or periphery thereof by centrifugal force. The separated liquid hydrocarbons flow down the sides of wall 44, which serves to laterally confine the zone in which the gas and liquid hydrocarbons are separated, and thence to the frusto-conical bottom 37 where they flow inwardly as well as downwardly. As the liquid hydrocarbons flow down bottom 37 in centrally converging flow, they contact the particles of catalyst falling downwardly from annular passageway 36 and are at least partially vaporized by the particles which are at a temperature, such as about 50 to 500° F., higher than

that of the liquid hydrocarbons. The portion of the liquid hydrocarbons that are vaporized flows upwardly out of the top of gas-liquid separation device 32 and then downwardly to and through bed 21 as previously described. Any unvaporized liquid hydrocarbons are absorbed by the absorptive particles of catalyst.

As stated above, gas and liquid hydrocarbons to be cracked are introduced to conduit 43. Such liquid hydrocarbons are not vaporizable at the temperature existing in the stream of fluid in conduit 43, as, for example, hydrocarbon fractions having initial boiling point and/or dew point above about 850° F. The gas can be gaseous or vaporous hydrocarbons or any gas that is readily available, cheap and unreactive with hydrocarbons, such as steam, spent flue gas, nitrogen and the like, although steam is preferred, or a mixture of hydrocarbon vapors or gas and unreactive gas may be employed. Suitable hydrocarbon vapors may include those from the same source as that of the liquid hydrocarbons; thus, for example, a wide cut portion of crude oil may be heated to produce liquid and vapors. Alternatively, the hydrocarbon vapors or gases can be from a separate source or process, such as from the same or other cracking processes, and can include light hydrocarbons, such as propane or butane. The gas and liquid hydrocarbons may be at the same or different temperatures when blended, if from different sources, or they may be blended and thereafter heated together.

As can be seen in Figure 1, the particles fall only a short distance, such as 6 to 18 inches, from annular particle metering zone 36 onto the surface of the inwardly converging bottom 37 of device 32 and thereafter flow a short distance, such as from about 0.5 to 3 feet, onto the surface of bed 21. Under these conditions, the distance from which the particles fall is such that the velocity of the falling particles, due to acceleration by gravity, is low when they impinge on either metallic surface 37 or on the relatively static particles on the surface of bed 21. Indeed the total distance over which gravity exerts its full force (from annular passageway 36 to the surface of bed 21) is relatively short and hence the maximum velocity of the particles is low. The resulting impact is small, with a consequent low rate of attrition of the particles, which are fragile when the impact is too great. As a result, the present invention achieves efficient contact with the liquid hydrocarbons and catalyst particles under conditions such that the rate of attrition of the particles is desirably low.

The volume of gas utilized to carry the liquid hydrocarbons as a stream is preferably relatively large compared to the volume of the liquid hydrocarbons so as to produce a considerable velocity of the stream of fluid in conduit 44 and hence a considerable velocity of rotation in device 32. In vessels of commercial size where the diameter of wall 44 is from 2 to 4 feet and the diameter of bed 21 is from 4 to 20 feet, efficient separation of the liquid hydrocarbons is achieved when the linear velocity of the stream of fluid entering device 32 is preferably more than 10 feet per second, such as from about 20 to 100 feet per second. Such velocities may be employed over a wide range of ratios of vapor volume to liquid volume, such as from about 10 to 1000. The effectiveness of the present invention over a wide range of vapor volume to liquid volume is extremely advantageous in that, without any physical changes in the apparatus, the amount of liquid

hydrocarbons charged can be quickly varied, without loss in efficiency of contact or undesirable side effects such as high catalyst attrition rates.

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. In a hydrocarbon conversion process wherein granular contact material is contacted with hydrocarbons, at least partially in a liquid phase, while gravitating through a conversion zone, the method for contacting the liquid hydrocarbons with said contact material which comprises the steps of: introducing a confined stream comprising gas and liquid hydrocarbons into a laterally confined separating zone centrally positioned in the upper region of said conversion zone, discharging separated gas from the upper end of said separating zone into said conversion zone, passing separated liquid hydrocarbons downwardly and inwardly as a circumferentially-complete hollow liquid stream toward a central discharge outlet at the lower end of said separating zone, said hollow liquid stream flowing as an inwardly-moving supported layer in at least the lower portion of its path through said separating zone, introducing said contact material centrally into said separating zone as an annular curtain of freely-falling particles at a level below the level of hydrocarbon introduction, passing said curtain of contact material concentrically downward within said hollow liquid stream and depositing the same onto said inwardly-moving supported layer of liquid hydrocarbons, and discharging said contact material containing liquid hydrocarbons as a freely-falling stream from said central discharge outlet into said conversion zone.

2. A method as defined in claim 1 wherein said gas and liquid hydrocarbons introduced into said separating zone are caused to rotate about a vertical axis at a velocity sufficient to form said circumferentially-complete hollow liquid stream and to separate said gas therefrom by centrifugal action.

3. A method as defined in claim 2 wherein said centrifugal action is effected by introducing said stream of gas and liquid hydrocarbons tangentially into said separating zone as a high-velocity stream.

4. A method as defined in claim 1, in which said freely-falling stream of contact material discharged from said discharge outlet of the separating zone is deposited on the surface of a compact moving bed of said contact material.

5. A method as defined in claim 4, in which said contact material is at a temperature sufficient to vaporize at least a portion of said liquid hydrocarbons upon deposit of said freely-falling contact material onto said inwardly moving layer of liquid hydrocarbons, and wherein all the gaseous material is passed downwardly through said moving bed.

6. In a fluid-solid contacting vessel, the combination of a contacting chamber, contact material inlet means extending into the upper region of said chamber and being arranged to discharge contact material downwardly in an annular stream, contact material outlet means at the lower end of said chamber, a cylindrical member concentrically surrounding and spaced from said contact material inlet means and being

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in open communication at its upper end with said chamber, said cylindrical member extending above and below said contact material inlet means and having a lower converging wall portion terminating in a central opening axially aligned with and spaced a distance below said contact material inlet means, said opening being of substantially smaller diameter than the annular locus of discharge from said contact material inlet, and fluid inlet means extending through the wall of said chamber and into said cylindrical member and arranged to discharge horizontally and tangentially within the latter at a level above said contact material inlet, and gas outlet means in the lower region of said chamber.

7. Apparatus as defined in claim 6, in which said contact material inlet means is a vertical conduit extending downwardly into said contacting zone from a contact material supply chamber located above said contacting chamber,

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and including means at said contact material inlet for metering the flow of contact material in said annular stream.

8. The steps of claim 1 characterized in that said gas comprises steam.

9. The steps of claim 1 characterized in that said gas comprises hydrocarbon vapors.

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