Sept. 25, 1945. J. W. JEWELL ET AL 2,385,446

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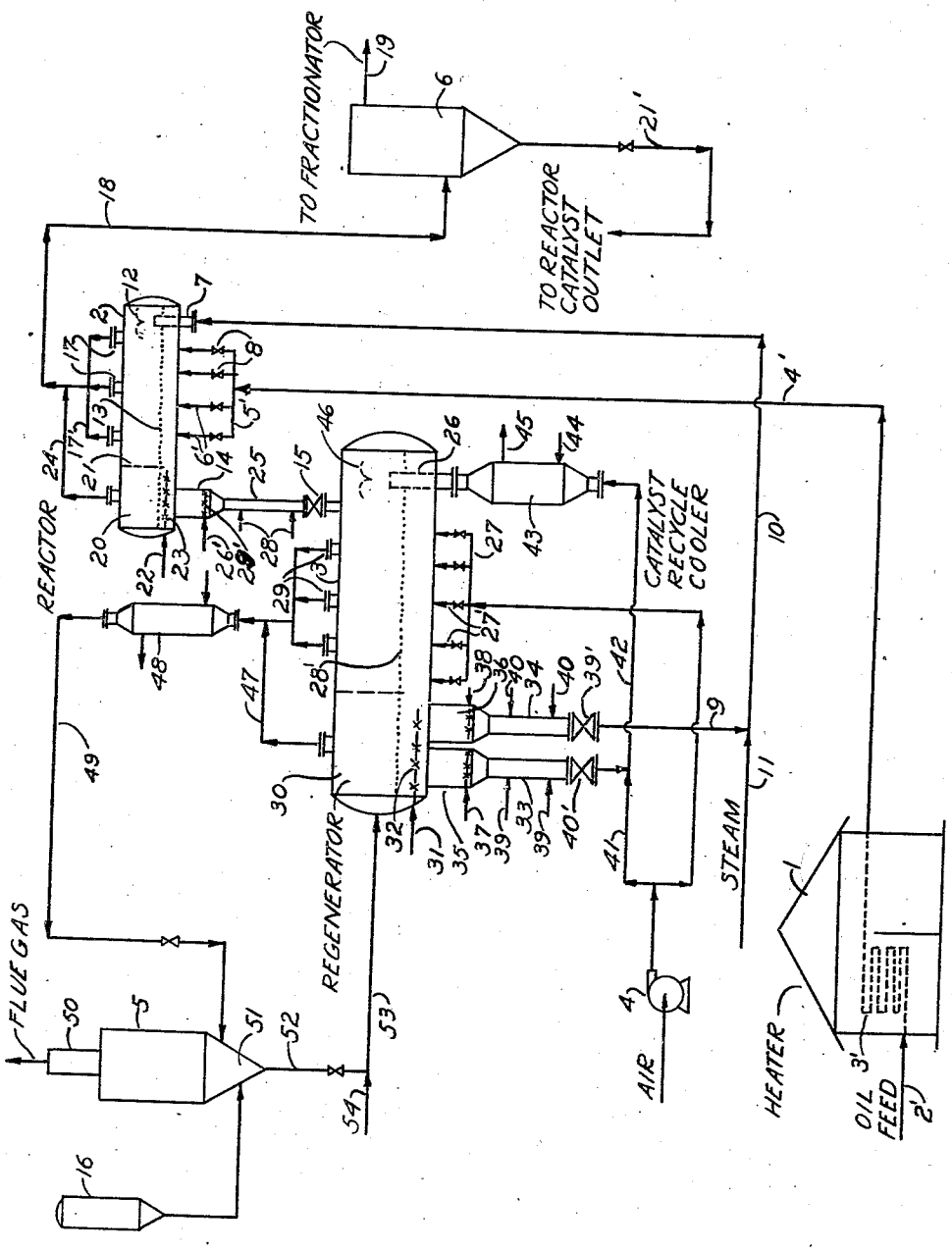
Filed Aug. 6, 1941



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Patented Sept. 25, 1945

2,385,446

UNITED STATES PATENT OFFICE

2,385,446

CATALYTIC CONVERSION OF HYDROCARBONS

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Application August 6, 1941, Serial No. 405,614

6 Claims. (Cl. 196—52)

The present invention relates to improvements in process and apparatus for effecting catalytic conversions. In its specific aspects, the invention is directed particularly to an improved continuous process of converting hydrocarbons by treatment over catalytic materials which become spent or deactivated during the conversion by the accumulation of carbonaceous material thereon, and which accordingly require periodic regeneration treatment to fit them for reuse in the conversion step. The catalytic conversion of high boiling hydrocarbons such as petroleum gas oil and the like into low boiling hydrocarbons within the gasoline boiling range is an example of the latter type of conversion reaction of outstanding importance.

It has been proposed, heretofore, to catalytically convert high boiling hydrocarbons such as gas oil to low boiling hydrocarbons within the gasoline boiling range by passing vapors of the high boiling hydrocarbons under suitable reaction conditions in contact with a stationary bed of a cracking catalyst disposed in a catalyst chamber. Pursuant to such processes, after the activity of the catalyst is decreased by reason of the formation of a carbonaceous deposit thereon to an extent where regeneration is necessary or desirable, the activity of the catalyst is restored by stopping the flow of oil vapor to the chamber and passing an oxygen-containing gas into the chamber in contact with the spent catalyst, thereby regenerating it in situ by combustion of the carbonaceous deposit. Although such processes are commercially practicable they are subject to a number of inherent limitations and disadvantages which are eliminated by the present invention. Among these are the intermittent nature of the operation, variations in product quality and quantity during the reaction period and difficulty in temperature control, particularly in the regeneration operation.

A primary object of my invention is the provision of a continuous process of effecting the catalytic conversion of hydrocarbons and analogous reactions, wherein the mentioned disadvantages of the intermittent type of operation are obviated, and which may readily be controlled and practiced in relatively inexpensive equipment. Various other objects, advantages and features of the invention will be apparent from the following detailed description thereof given in connection with the appended drawing wherein the figure is a diagrammatic illustration of a suitable arrangement of apparatus and process-flow for the practice of the invention as applied to the catalytic conversion of high boiling hydrocarbons such as petroleum gas oil, or the like, to low boiling hydrocarbons.

The principal units of the apparatus illustrated are: a heater 1 for supplying vaporized hydrocarbons at a temperature suitable for conversion, a reactor or conversion chamber 2 wherein particles of catalytic cracking material are contacted with the feed vapors undergoing cracking, a regeneration vessel or regenerator 3 wherein the particles of used or spent catalytic material are contacted with an oxygen-containing gas under conditions adapted to cause combustion of the carbonaceous deposit thereon, a blower 4 or other suitable means for supplying an oxygen-containing gas, such as air, to the regenerator, and gas-solid separating means 5 and 6 associated respectively with the reactor and regenerator for separating suspended particles from the effluent gases derived therefrom.

Pursuant to the present invention, a relatively dense concentrated phase or mass or catalytic particles is formed in the conversion zone or regeneration zone, or preferably both, and moved laterally in contact with the vaporous or gaseous component which travels upwardly through the laterally moving catalyst at a relatively low velocity. The conversion zone and regeneration zone preferably are constituted by horizontally elongated vessels of relatively great length compared to their width and depth, or diameter in the case of cylindrical vessels. Catalytic particles undergoing contact with the vaporous or gaseous component are supplied at one end portion of the elongated vessel and withdrawn at the opposite end portion. In the case of the conversion zone, the rate of addition of the fresh or regenerated catalyst particles thereto and the corresponding rate of withdrawal is such as to maintain the laterally moving dense mass at the desired average degree or level of catalytic activity. In the case of the regeneration zone, used or spent catalytic particles are added thereto and withdrawn at such a rate that the catalytic particles will remain in this zone for the period of time required to eliminate or reduce the carbonaceous deposit to the desired extent. The vaporous or gaseous component is supplied at such a rate that its upward velocity through the conversion and regeneration zone is adapted to maintain the mass of catalyst particles therein a readily flowable but relatively dense state. This condition of the mass of catalyst particles is such that it resembles a liquid in its flow characteristics and the aerated mass of catalyst in the in-

termediate portion of the zone is accordingly displaced and caused to flow laterally by the addition of catalytic particles at one end of the zone and withdrawal of corresponding amounts at the opposite end of the zone.

Following now the typical process flow illustrated by the drawing, the feed to the process for example a petroleum gas oil, or a similar high boiling hydrocarbon fraction, is introduced through line 2' to heating coil 3' in furnace 1 wherein it is vaporized and heated to a temperature suitable for the subsequent conversion operation. From furnace 1 the feed vapors are passed by transfer line 4' to a suitable vapor distributing means such as manifold 5'. From manifold 5' a plurality of branch valved feed lines 6' connect with the lower portion of reactor 2. The quantity of feed vapors introduced through each of the branch lines may be suitably independently regulated by the individual valves 8. Lines 6' and lines 27' preferably terminate in suitable distributing means such as a perforated spider or porous plates (not shown) to provide substantial uniform horizontal distribution of the vapor throughout the conversion zone.

Particles of a suitable catalytic cracking material, for example an activated clay such as "Super Filtrol" in finely divided or powdered condition is supplied at one end portion of reactor 2 through the catalyst inlet conduit 7. Reactor 2, as shown, consists of a cylindrical vessel of relatively great length, or elongated horizontally relative to its diameter. Fresh catalyst may be supplied through inlet 7, but in normal operation this catalyst will consist largely of previously regenerated hot catalyst withdrawn from regenerator 3 through line 9. From line 9 the regenerated catalyst is picked up by a stream of a suitable conveying fluid such as steam injected through line 11 and conveyed through transfer line 10 to the catalyst inlet 7. The quantity of the conveying fluid employed and the relative cross-sectional area of the transfer line 10 compared to the corresponding area of reactor 2 are such that the catalyst particles drop out of the stream of conveying fluid into the reactor. This separation may be facilitated by a baffle 12 disposed across the path of the flowing mixture of conveying fluid and catalyst particles introduced through inlet 7.

Vapors of the hydrocarbons undergoing treatment are admitted through lines 6' at the base of reactor 2 in such quantity that the mass of catalyst particles, the upper level of which is indicated by dotted line 13, is maintained in a readily flowable but relatively concentrated or dense condition. In this state the mass of particles assumes a condition resembling that of a liquid in its flow characteristics, and is caused to flow or be positively displaced laterally through the reactor by the addition of active or regenerated catalyst at one end portion of the reaction zone through inlet 7 and the withdrawal of used or spent catalyst from the opposite end portion of the reaction zone through the lower catalyst outlet 14 which communicates directly with the dense catalyst phase. The height of the upper level 13 of the dense catalyst phase is dependent upon the total quantity of catalyst in the system and the rate at which catalyst is withdrawn through the lower catalyst outlet 14, which rate is controlled by valve 15. Accordingly, level 13 may be maintained at any desired height by suitable control of the rate of withdrawal of catalyst through valve 15 and regulation of the total amount of catalyst contained in the system. The latter regulation may be accomplished by either adding catalyst from make up catalyst hopper 16 to the system or by withdrawing a quantity of circulated catalyst to storage as required. The level 13 is preferably maintained a substantial distance below vapor outlets 17, most suitably in the lower half of the reactor as indicated, in order to provide an ample catalyst-vapor disengaging space in the reaction zone above the dense catalyst phase. Under such conditions a relatively small portion of the circulated catalyst is carried out of the reaction zone by the vaporous reaction products withdrawn overhead from the reactor through outlet lines 17. Other conditions being fixed, the quantity of solid particles carried out with the vapors through lines 17 is dependent upon the height of level 13. For example, if valve 15 was completely closed level 13 would rise to an extreme limit where solid particles would be carried out through vapor lines 17 at the same rate as added through inlet 7. Conversely, by progressively increasing the distance between the vapor outlet and the level, the quantity of solid particles carried out overhead is progressively decreased to a lower limiting value. Pursuant to the present process, it is greatly preferred to maintain such conditions that only a relatively small quantity of solid particles is carried out with the effluent gaseous component since the equipment for recovering of such material from the gaseous component is thereby greatly simplified and reduced in cost.

From outlet lines 17 vaporous reaction products are passed by manifold 17' and line 18 to suitable means for recovering the residual quantity of catalyst particles remaining therein and thereafter to suitable recovery means for condensation and separation into the desired products.

From manifold 17' the vaporous reaction products may be passed by line 18 to a suitable gas-solids separating equipment, such as cyclones or the like, indicated diagrammatically by the numeral 6. From separator 6 the vaporous reaction products are passed by line 19 to a fractionator or similar apparatus of conventional design and hence not illustrated. Separated residual catalyst withdrawn from separator 6 may suitably be returned to the catalyst stripping zone 20 in reactor 2 by catalyst return line 21'.

After passing in contact with the hydrocarbon vapors, the fluid mass of spent catalyst particles is preferably subjected to a stripping operation to remove adsorbed or entrained hydrocarbon vapors therefrom prior to the passage of these particles to the regeneration stage. This stripping operation may suitably be effected in a distinct stripping zone 20 within the reactor and defined by the space between the end of the reactor and baffle 21. A suitable aerating and stripping medium such as steam is supplied to the lower portion of this stripping zone by line 22 to a steam ring or other suitable distributing means 23 disposed in the lower portion of the stripping zone. The stripping medium is supplied in such quantities that it passes through the mass of catalyst particles at a velocity of about the same magnitude or less than that of the oil vapors undergoing conversion. The stripping medium and stripped vapors may suitably be withdrawn overhead from the stripping zone through line 24 and combined with the vaporous reaction products in line 18.

Spent catalyst may be suitably withdrawn from

the base of the reactor through a valved catalyst standpipe 25. Standpipe 25 is preferably provided with an enlarged portion 14 at the upper end thereof to which an aerating and stripping medium may be introduced through line 26' and distributor 29' for the purpose of maintaining the withdrawn catalyst in a readily flowable condition and also to effect additional stripping action. Additional aerating fluid is preferably introduced at suitably spaced points along the length of standpipe 25 through lines 28 to maintain the catalyst therein in a readily flowable condition.

As illustrative of suitable operating conditions in the practice of the invention as applied to the catalytic conversion of a petroleum gas oil feed stock to low boiling hydrocarbons within the motor fuel boiling range, there is given in the following Table A suitable conditions for such a unit based upon a feed capacity of 10,000 bbls./day of the gas oil feed. The catalyst for this operation consisted of an activated clay known commercially as "Super Filtrol" in a finely divided or powdered condition, that is, of a fineness sufficient to pass a 100 mesh screen and consisting largely of particles of indiscriminately mixed sizes smaller than 100 microns in average diameter.

Table A

Gas oil feed, bbls./day	10,000
Steam feed, lbs./hr.	13,000
Reactor dimensions (*a*) length, ft.	50
Reactor dimensions (*b*) diameter, ft.	12
Feed weight ratio of catalyst to oil	5
Oil feed temperature, °F.	900
Catalyst feed temperature, °F.	980
Outlet temperature catalyst and vapor, °F.	900
Reactor pressure, lbs./sq. in.	7.0
Vapor velocity, ft./sec.	0.56
Ratio of weight of oil fed/hr. to wt. of catalyst in reactor (w/hr./w)	3.8
Catalyst time, seconds	200
Catalyst concentration:	
(*a*) Reactor, lbs./cu. ft.	25
(*b*) Reactor outlet, grains/cu. ft.	20
Horizontal catalyst velocity, ft./sec.	0.25

The regeneration operation is preferably effected in accordance with the same principles as the conversion stage, except that in the latter case the gaseous component contacted with the catalytic particles consists of an oxygen-containing gas such as air. Also, in the regeneration stage a portion of the regenerated catalyst is preferably recycled to the regeneration zone with intervening cooling of the recycled stream of catalyst for the purpose of temperature control within the regeneration zone. Optionally, a similar recycle stream of used catalyst may be employed if desired in connection with reactor 2 with intervening heating of this recycled stream of spent catalyst, or cooling, as desired for the purpose of temperature control within the conversion zone or for varying the average degree of catalytic activity of the catalyst mass.

Spent catalyst may be suitably introduced into regenerator 3 by catalyst standpipe 25 leading directly thereto whereby the transfer of catalyst from the reactor to the regenerator is effected entirely by gravity flow. The entering stream of spent catalyst particles meets and is intimately mixed with the stream of cooled recycled catalyst introduced through catalyst inlet 26. An oxygen-containing gas, preferably air, is introduced at the base of the regenerator through manifold 27 and branch valved lines 27'. Air is supplied through lines 27' in such quantity that the mass of catalyst particles thereabove is maintained in a freely flowable but relatively dense state. In this case similar to that prevailing in the conversion zone the mass of relatively dense aerated catalyst resembles a liquid in its flow characteristics and is positively displaced laterally through the regeneration zone by the addition of catalyst particles at one end portion and the withdrawal of catalyst particles at the opposite end portion.

The height of the catalyst level 28' is controlled in accordance with the same principles of operation described for level 13, so that under preferred conditions a relatively small quantity of catalyst particles is withdrawn overhead with the regeneration gases through regeneration gas outlets 29.

A stripping zone 30 is provided at the catalyst outlet end of the regenerator similar to stripping zone 20 for the purpose of stripping oxygen-containing gases from the regenerated catalyst. A suitable stripping medium such as steam is supplied to zone 30 through line 31 and distributing means 32.

The regenerated catalyst is withdrawn in two separate streams through catalyst standpipes 33 and 34. Standpipes 33 and 34 may each be provided at the upper end portion thereof with an enlarged section 35 and 36, respectively, similar to 14 and provided with means 37 and 38 for introducing a stripping gas thereto. Standpipes 33 and 34 are further provided with lines 39 and 40, respectively, spaced at suitable points along their length for introducing steam or other aerating medium to maintain the catalyst therein in a freely flowable condition.

From valve 39' in catalyst standpipe 34 regenerated catalyst is forwarded to the conversion zone through transfer line 10 as previously described. From the catalyst standpipe 33, the quantity of regenerated catalyst withdrawn is that required for temperature control within the regeneration zone 3. Dependent upon the type of catalyst or contact material employed there is normally a maximum regeneration temperature which should not be exceeded, for example in the case of a cracking catalyst consisting of an activated clay of the "Super-Filtrol" type this temperature is normally taken as about 1100 to 1150° F.

Recycled catalyst is fed by valve 40' from catalyst standpipe 33 into a stream of a conveying fluid, suitably air derived from compressor 4, through line 41 and passed by line 42 through a heat exchanger 43 through which a cooling medium is circulated by lines 44 and 45. In exchanger 43 the stream of recycled catalyst is cooled to a temperature adapted to provide the desired temperature control during the regeneration operation. A baffle 46 may be provided at the outlet of catalyst inlet 26 to subserve the same purpose as baffle 12.

Gaseous combustion products are withdrawn overhead from regenerator 3 through outlets 29 and are passed to a suitable gas-solids separating system to separate catalyst particles suspended therein. The quantity of catalyst carried overhead, as in the case of the reaction zone, is preferably maintained at a relative low amount thereby greatly simplifying the recovery system necessary for the separation of this material from the gas component. The stripping medium and stripped gases existing from zone 30 may suitably be combined with the effluent gas from

outlets 29 by line 47. The effluent regeneration gas may be passed through a cooler or heat exchanger 48 prior to passage to the gas-solids separating system, although this cooling step may optionally be omitted. From heat exchanger 48 the gas mixture passes by line 49 to a suitable gas-solids separator 5 such as a Cottrell precipitator, a cyclone separator, or the like, wherein the small quantity of suspended solids may be suitably separated. In separator 5, the flue gas is withdrawn overhead through line 50 and the separated solids are withdrawn at the bottom through hopper 51. Any required amount of make up catalyst may be supplied to hopper 51 from fresh catalyst hopper 16. From hopper 51 the recovered catalyst is returned by catalyst standpipe 52 to the regenerator by transfer line 53 to which a suitable conveying fluid such as steam is supplied by line 54.

Operating conditions suitably maintained in the regeneration stage of the process are illustrated by the conditions tabulated in the appended Table B for a regeneration operation corresponding to the conversion operation given in Table A.

Table B

Spent catalyst, lbs./hr	632,840
Cooled recycled catalyst, lbs./hr	900,000
Ratio by weight recycled to spent catalyst	1.43
Inlet temperature, spent catalyst, °F	900
Inlet temperature, recycled catalyst, °F	700
Outlet temperature of catalyst and gas, °F	1,000
Regenerator dimensions:	
(*a*) Length, ft	72
(*b*) Diameter, ft	20
Regenerator gas velocity, ft./sec	0.5
Air feed, lbs./hr	91,000
Catalyst concentration:	
(*a*) Regenerator, lbs./cu. ft	23
(*b*) Outlet gas, grains/cu. ft	20
Wt. percent of coke produced based on oil feed	5.0
Coke percent by wt. on spent catalyst	1.3
Carbon percent by wt. on regenerated catalyst	0.7
Catalyst contact time, seconds	615
Pressure in regenerator, lbs./sq. in	7
Horizontal catalyst velocity, ft./sec	0.12

Certain variable operating conditions in the practice of the process may follow and be controlled pursuant to conventional practice in the art with respect to the particular conversion or treating reaction involved. For example in the application of the process to the vapor phase catalytic cracking of high boiling hydrocarbons to low boiling hydrocarbons within the motor fuel boiling range, such factors as the selection of suitable charging stock, catalytic material, conversion temperatures, pressures, and the like, may be determined in accordance with conventional practice in this particular art.

The rate of fresh catalyst feed is dependent upon the desired average catalytic activity of the dense phase of catalyst in the conversion zone, and fresh catalyst is continually added at a rate adapted to maintain such activity at the desired value as the conversion proceeds. Used catalyst is withdrawn at the same average rate as fresh catalyst is added, therefore, the average time a catalyst particle remains in the reactor (catalyst resident time) is determined by the catalyst feed rate and may be calculated by dividing the weight of catalyst in the reactor by the catalyst feed rate per minute.

The weight of catalyst in the reactor is dependent upon the concentration of the dense phase and the height of the upper level of this phase. In the application of the process to the catalytic cracking of high boiling hydrocarbons it is preferred to maintain the ratio of the weight of oil fed per hour to the weight of catalyst in the reaction zone (w/hr./w) within the range of about 1.0 to 25.0 and preferably within the more restricted range of about 2.5 to 10.0. Also, in this case it is preferred to utilize a catalyst to oil feed rate ratio within the range of 0.5:1 to 20:1 and preferably within the more restricted range of 2:1 to 8:1.

The velocity of the gaseous component preferably maintained in the practice of the process is dependent upon the character of the catalytic particles employed with respect to such factors as their individual size, shape and density. The gaseous component should be maintained at a velocity of sufficient magnitude to aerate the mass of catalyst particles to an extent sufficient to maintain them in a readily flowable condition. Further, the maximum velocity must not be in excess of that velocity below which a relatively dense or concentrated phase of the catalyst particles is produced in the solids-vapor contact zone. At relatively high vertical gas velocities the catalyst particles may be suspended in the stream of gas and carried along therewith at a velocity approaching that of the gas particles. At relatively low vertical gas velocities the effect of the phenomenon known as "slip" becomes pronounced and in the zone of such low velocities the solid catalytic particles accumulate, thereby producing a relatively dense or concentrated phase. In the practice of the present process lateral internal recycle is avoided. The avoidance of such recycling is provided by the horizontally elongated configuration of the conversion and regeneration zones, and the relative thinness of the bed of catalyst compared to its length. Under these conditions, it is apparent that the carbonaceous content of the laterally moving bed is progressively increased in the direction of flow in the conversion zone, and that the converse is true in the regeneration zone. Accordingly, the quantities of the gaseous component admitted through each of the valved lines 6 and 27' may be adjusted with respect to the carbon concentration of the catalyst above the individual gas inlets.

Since reactor 2 and regenerator 3 are of uniform diameter the average lateral velocity of the particles therethrough will be substantially uniform. This velocity may be varied to advantage in certain instances by modifying the cross-sectional area in various parts of the reaction vessel, for example, by gradually increasing this area in the direction of lateral flow the velocity of the catalyst particles will be progressively lower in the direction of flow. Likewise the thickness of the catalyst bed may be varied in different parts of the reaction zone by suitably contouring the bottom of the reaction vessel. This same effect may also be produced by inclining the reaction vessel whereby the bed will be so disposed that it gradually increases or decreases in thickness in the direction of flow dependent upon whether the inlet end of the reaction vessel is made higher or lower than the outlet end.

Any of the various known types of cracking catalyst may be utilized in the practice of the invention. The preferred catalysts are those of the

silica-alumina, or silica-magnesia type adapted to produce a satisfactory yield of high octane gasoline. Either silica-alumina catalyst consisting of activated clay prepared by the acid treatment of natural clays, for example the commercial product "Super-Filtrol" or a synthetically prepared silica-alumina catalyst such as those disclosed in copending applications of Robert Ruthruff, Serial Nos. 305,472 and 305,473, both filed November 21, 1939, may be employed. The catalyst is preferably employed in finely divided or powdered condition, for example with particles ranging from about 1 to 100 microns. However, granular catalyst particles may be employed, and in this instance a mixture of granular and powdered catalytic material is preferred.

From the above description of the process it will be apparent that it fully accomplishes the primary object of the invention, namely the provision of a continuous process which eliminates the various defects of an intermittent operation and which may be readily and effectively controlled and practiced in relatively inexpensive apparatus. A specific advantage of the process is that it allows independent adjustment of catalyst feed rate, vapor velocity and amount of catalyst present in the conversion and regeneration zones. A further advantage is the relatively low pressure drop in the system which materially reduces the cost of necessary auxiliary equipment. Powder losses in the system are relatively low and the process permits the satisfactory use of relatively simple and inexpensive gas-solids recovery equipment.

While the method has been described particularly in connection with the catalytic conversion of high boiling hydrocarbons to low boiling hydrocarbons within the gasoline boiling range, for which purpose the method is especially advantageous, it will be apparent to those skilled in the art that the method may be applied to other types of catalytic hydrocarbon conversion reactions, such as the catalytic reforming of naphtha fractions under conditions such as described in Belchetz application Serial No. 348,605, and to chemical reactions and treating operations generally involving the step of contacting vapors with powdered or comminuted solids. These and various other modifications in the illustrative embodiments of the invention described in the foregoing will be apparent to those skilled in the art, and the scope of the invention is accordingly not to be restricted except as required by the claims appended hereto.

We claim:

1. A continuous cyclic process of catalytically converting high boiling hydrocarbons into low boiling hydrocarbons within the motor fuel boiling range, which comprises introducing particles of an active catalytic cracking material into a cracking zone, flowing the particles laterally through said zone, introducing vapors of the hydrocarbons undergoing conversion at the bottom of said zone and flowing the vapors upwardly therethrough in contact with the mass of said laterally flowing catalytic particles at a velocity adapted to maintain said mass in an aerated, readily flowable but relatively dense state, withdrawing the vaporous cracked products overhead from said reaction zone, withdrawing spent catalytic particles from said reaction zone in a stream separate from said vaporous reaction products, introducing the particles of spent catalytic material into a regeneration zone, flowing the particles laterally through said zone, introducing an oxygen-containing gas at the bottom of said regeneration zone and flowing the gas upwardly therethrough in contact with the mass of said laterally flowing catalytic particles under conditions adapted to cause combustion of the carbonaceous deposit and at a velocity adapted to maintain said mass in an aerated readily flowable but dense state, withdrawing the gaseous regeneration products overhead from said regeneration zone, withdrawing the regenerated particles of catalyst from said regeneration zone in a stream separate from the gaseous regeneration products, and re-introducing said regenerated catalyst into said cracking zone.

2. In a process for the catalytic cracking of hydrocarbons wherein particles of a catalytic cracking material are continuously passed through a cracking zone in contact with the vapors undergoing cracking, thereby accumulating a deactivating deposit of carbonaceous material thereon, the method of regenerating the spent catalyst for reuse in said cracking process, which comprises introducing the particles of spent catalytic cracking material into a regeneration zone, flowing the particles laterally through said zone, introducing an oxygen-containing gas at the bottom of said regeneration zone and flowing the gas upwardly therethrough in contact with the mass of said laterally flowing catalytic particles under conditions adapted to cause combustion of the carbonaceous deposit and at a velocity adapted to maintain said mass in an aerated readily flowable but dense state, withdrawing the gaseous regeneration products overhead from said regeneration zone, and withdrawing the regenerated particles of catalyst from said regeneration zone in a stream separate from the gaseous regeneration products.

3. A continuous cyclic process of catalytically converting high boiling hydrocarbons into low boiling hydrocarbons within the motor fuel boiling range which comprises introducing particles of an active catalytic cracking material into one end portion of a cracking zone, introducing vapors of the hydrocarbons undergoing conversion at the bottom of said zone and flowing the vapors upwardly therethrough in contact with the mass of catalytic particles thus introduced at a velocity adapted to maintain said mass in a condition approximating a liquid in its flow characteristics, withdrawing the vaporous cracked products overhead from said reaction zone, withdrawing spent catalytic particles from said reaction zone at an end portion opposite the point of introduction and in a stream separate from said vaporous reaction products, introducing the particles of spent catalytic material into a regeneration zone, flowing the particles laterally through said zone, introducing an oxygen-containing gas at the bottom of said regeneration zone and flowing the gas upwardly therethrough in contact with the mass of said laterally flowing catalytic particles under conditions adapted to cause combustion of the carbonaceous deposit and at a velocity adapted to maintain said mass in a condition approximating a liquid in its flow characteristics, withdrawing the gaseous regeneration products overhead from said regeneration zone, withdrawing the regenerated particles of catalyst from said regeneration zone at an end portion opposite the point of introduction and in a stream separate from the gaseous regeneration products, and re-introducing said regenerated catalyst into said cracking zone.

4. In a process for the treatment of hydrocarbon vapors with solid contact agents wherein par-

ticles of the solid contact agent are continuously passed through a treating zone in contact with the vapors undergoing treatment, thereby accumulating a deactivating deposit of carbonaceous material thereon, the method of regenerating the spent contact agent for reuse in the treating process which consists in introducing the particles of spent contact material into a regeneration zone, flowing the particles laterally through said zone, introducing an oxygen-containing gas at the bottom of said regeneration zone and flowing the gas upwardly therethrough in contact with the mass of said laterally flowing contact particles under conditions adapted to cause combustion of the carbonaceous deposit and at a velocity adapted to maintain said mass in a readily flowable but dense condition approximating a liquid in its flow characteristics, withdrawing the gaseous regeneration products overhead from said regeneration zone, and withdrawing the regenerated particles of contact agent from said regeneration zone in a stream separate from the gaseous regeneration products whereby said mass is caused to flow laterally through the regeneration zone.

5. A continuous cyclic process of treating hydrocarbon vapors with solid contact agents wherein the contact agent accumulates a combustible deactivating deposit incident to such treatment, which comprises introducing particles of an active contact material into a treating zone, flowing the particles laterally through said zone, introducing vapors of the hydrocarbons undergoing treatment at the bottom of said zone and flowing the vapors upwardly therethrough in contact with the mass of said laterally flowing particles at a velocity adapted to maintain said mass in a readily flowable but relatively dense state, withdrawing the vaporous treated products overhead from said treating zone, withdrawing deactivated particles from said treating zone in a stream separate from said vaporous treated products, introducing the particles of deactivated material into a regeneration zone, flowing the particles laterally through said zone, introducing an oxygen-containing gas at the bottom of said regeneration zone and flowing the gas upwardly therethrough in contact with the mass of said laterally flowing particles under conditions adapted to cause combustion of the deactivating deposit thereon and at a velocity adapted to maintain said mass in a readily flowable but relatively dense state, withdrawing the gaseous regeneration products overhead from said regeneration zone, withdrawing the regenerated particles of contact material from said regeneration zone in a stream separate from the gaseous regeneration products, and re-introducing said particles regenerated into said treating zone.

6. A continuous cyclic process of treating vapors with solid contact agents wherein the contact agent accumulates a combustible deactivating deposit incident to such treatment, which comprises introducing particles of an active contact material into a treating zone, flowing the particles laterally through said zone, introducing the vapors undergoing treatment at the bottom of said zone and flowing the vapors upwardly therethrough in contact with the mass of said laterally flowing particles at a velocity adapted to maintain said mass in a readily flowable but relatively dense state, withdrawing the vaporous treated products overhead from said treating zone, withdrawing deactivated particles from said treating zone in a stream separate from said vaporous treated products, introducing the particles of deactivated material into a regeneration zone, flowing the particles laterally through said zone, introducing an oxygen-containing gas at the bottom of said regeneration zone and flowing the gas upwardly therethrough in contact with the mass of said laterally flowing particles under conditions adapted to cause combustion of the deactivating deposit thereon and at a velocity adapted to maintain said mass in a readily flowable but relatively dense state, withdrawing the gaseous regeneration products overhead from said regeneration zone, withdrawing the regenerated particles of contact material from said regeneration zone in a stream separate from the gaseous regeneration products, and re-introducing said particles regenerated into said treating zone.

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