



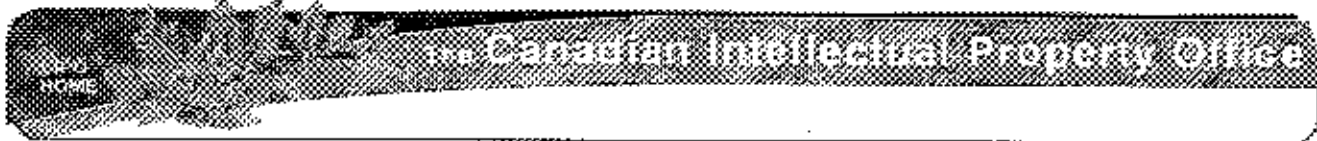
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(54) METHOD AND APPARATUS FOR REACTING CARBON CONTAINING GASEOUS COMPOUNDS IN THE PRESENCE OF A CATALYST

(54) METHODE ET APPAREIL POUR LA REACTION DE CARBONE CONTENANT DES COMPOSES GAZEUX EN PRESENCE D'UN CATALYSEUR

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This invention relates to an improved process and apparatus for effecting chemical reactions by contacting a gaseous carbon-containing reactant with a fluidized catalyst, and more particularly, it pertains to a method and means for catalytically cracking high boiling hydrocarbons to high quality gasoline product.

In fluid systems where the reactor is superimposed on the regenerator, it is necessary to operate the regenerator at a higher pressure than the reactor, and the difference in gaseous pressures of the two process zones is made up by means of a fluidstatic head exerted by a column of catalyst extending from the higher reactor to the lower regenerator. As a result of the higher pressure in the regenerator, the cost to construct and operate such a unit is higher than a system where the regenerator is above the reactor by reason that a larger blower for transporting regeneration gas is required, the size of the fractionating columns in the recovery system are larger by virtue that vaporous reaction product is being handled at a lower pressure, and compression costs in handling normally gaseous hydrocarbons in the recovery system are greater. Hence, there is an economic incentive to operate such a system with the regenerator above the reactor notwithstanding the problems which are present in a design involving the placement of a regenerator on a smaller reactor.

In systems where the regenerator is larger in size,

and the quantity of catalyst being circulated is high, it is very important to arrange the standpipe and riser within the smaller reactor to provide for free or unimpeded circulation of catalyst particles throughout the bed, and also to arrange for uniform withdrawal of catalyst therefrom. One of the problems involves the size of the riser by which catalyst is circulated from the reactor to the regenerator. From an economic standpoint, it is desirable to use all of the regeneration gas as the carrying medium for spent catalyst passing upwardly through the riser, however, the quantity of regeneration gas may be of such magnitude that the linear velocity in the riser might be sufficient to effect appreciable erosion and the diameter of the riser needed to accommodate such flow would take up considerable space within the reactor. Hence, it can be seen that there are serious problems in designing a system with the regenerator positioned vertically above the reactor, and these problems determine the success or failure of the system for commercial exploitation.

An object of this invention is to provide improved method and means for conducting chemical reactions with carbon-containing gaseous reactants in the presence of catalysts.

Another object is to provide an improved method and apparatus for converting hydrocarbons, especially for catalytically cracking high boiling hydrocarbons to gasoline material.

Other objects and advantages will be apparent from the following description and explanation thereof.

In accordance with the present invention, the method for conducting such chemical reactions comprises

contacting a gasiform chemical reactant with a dense fluidized bed of finely divided catalytic material in a reaction zone thereby producing a reaction product and contaminating the catalyst with carbonaceous material, withdrawing a portion of contaminated catalyst from the bed in the reaction zone and passing the same upwardly through a first vertical elongated confined zone as a suspension in an oxygen containing gas, passing the upflowing catalyst from the first confined zone to a regeneration zone which is in vertical alignment above said reaction zone, maintaining a dense fluidized bed of catalyst in said regeneration zone and passing thereto the remaining portion of oxygen containing gas which is required for the combustion treatment of the catalyst, passing regenerated catalyst from the regeneration zone downwardly through a plurality of vertical elongated confined zones to the reaction zone, and said plurality of confined zones are spaced symmetrically with respect to said first confined zone thereby permitting free circulation of catalyst within the reaction zone.

In the preferred embodiment of this invention the quantity of oxygen-containing gas carrying the upflowing catalyst is from 10 to 40% by volume of the total gas required for subsequent regeneration.

In some systems, the amount of carbonaceous material deposited on the catalyst is small, consequently, a low catalyst circulation rate is used. The present invention is particularly applicable to a system in which at least about 0.25 cubic feet of oxygen containing gas (measured at 60° F. and 760 mm. Hg) is required per pound of catalyst being circulated, or usually about 0.4 to 8

cubic feet per pound of catalyst, and the conditions of reaction warrant the employment of a catalyst to oil ratio, on a weight basis, of at least about 2 and up to about 20. In such systems, the quantity of oxygen containing gas re-

5 required for regeneration would necessitate the use of a large riser within the reactor, hence, in order that the superficial linear velocity of upflowing material in the riser be maintained below about 50-60 feet per second, and as low as

10 10 feet per second, which is the safe upper limit insofar as erosion is concerned, and the diameter of the riser be reasonable in relation to the reactor diameter; about 10 to 40% by volume of the total regeneration gas is used as the carrying medium for the spent catalyst; whereas the remainder is charged directly to the regenerator. This is an important

15 aspect of the present invention, because by proper use of the regeneration gas stream, the space available within the reactor for the catalyst bed is of suitable size and shape such that catalyst utilization is not seriously affected by stagnant portions of the bed due to poor circulation of catalyst within

20 the reaction zone. Accordingly, the riser is positioned centrally within the reactor, and it is about 1 to 10%, preferably about 2 to 5% of the reactor diameter size. In a preferred operation, the quantity of oxygen containing gas which is passed upwardly through the riser constitutes about

25 15 to 25 volume per cent of the total regeneration gas, and it provides a preferred linear velocity within the riser of about 20 to 40 feet per second. Hence, the size of the riser or vertical elongated confined zone for upward passage of spent catalyst from the reactor to the regenerator is dependent upon

30 the quantity of carrying gas used, and the size of the riser

has an effect on catalyst utilization or efficiency by reason of reaction space made available.

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In another aspect of this invention, the spent catalyst is stripped of volatile hydrocarbons by means of a gasiform stripping agent, e.g., steam, hydrogen, normally gaseous hydrocarbon, e.g., methane, ethane, propane, etc., in a stripping zone which surrounds the riser described above. The stripper can be a vertical, cylindrical, hollow means or vessel positioned concentrically with the riser but of larger diameter. The stripper has a cross-sectional area which is about 10 to 50%, preferably about 20 to 30% of the reactor cross-sectional area. The stripper stands about 40 to 80%, preferably about 50 to 75% the height of the reactor and it may be provided with louvers or suitable openings for passage of catalyst from the reactor bed to the stripper at various levels along the height thereof. The use of regeneration gas as carrying gas for the spent catalyst in the riser effects partial combustion of the carbonaceous deposit on the catalyst, consequently, the heat of combustion flows indirectly to the catalyst in the stripper. This can provide for improved stripping by maintaining the stripper at a higher temperature than the reactor bed, for example, about 5° to 20° F. higher.

The type of system contemplated under this invention is particularly applicable to a process in which the regenerator has a diameter of about 1.2 to 2 times greater than the reactor, and both vessels have an L/D ratio (length to diameter) falling in the range of about 0.25 to 3. The regenerated catalyst is returned to the lower positioned reactor by means of a plurality of vertical elongated confined zones

or standpipes which are positioned symmetrically in relation to the riser previously discussed. If a single standpipe is employed, there is uneven distribution of catalyst being circulated to the reactor bed, and since the reactor bed is not large relative to the catalyst being circulated, there is a great tendency for short-circuiting of regenerated catalyst directly to the spent catalyst riser. Where the catalyst bed is large relative to the quantity of catalyst being circulated, the freshly introduced catalyst has a better chance of being distributed throughout the bed before passing out again for regeneration. Hence, the present invention is particularly applicable to a system in which about 1 to 30 pounds of catalyst per hour is being circulated per pound of catalyst present in the reaction zone, preferably about 4 to 20, on the same basis. The standpipes can be 2, 3, 4 or more in number depending on the effective cross-sectional area needed for the reaction zone, and these are arranged symmetrically with respect to the riser. Each standpipe has a diameter which provides a catalyst flow rate of 100 to 500 lb/sq.ft/second, and it constitutes about 0.25 to 4% of the reactor diameter. Each of the standpipes is of smaller diameter than the riser.

Two types of systems can be used for this invention, namely, one in which the regenerator is directly superimposed on the reactor and termed, for convenience, as the "single head" system, and the other one involves positioning the regenerator above the reactor such that air can circulate between the vessels and termed, for convenience, as the "two head" system. For reasons of strength in structure, the two vessels are interconnected mechanically by means of an intervessel means or structure which can be, for example,

an inverted cone containing suitable openings for passage of air. This is a necessary expedient since the regenerator is the larger vessel, and care should be taken to avoid any tendencies for the vessels to move in position, other than
5 by expansion through changes in temperature. The single head structure is more economical and structurally superior in regard to systems in which the diameter of the regenerator is not more than about 25 feet. Below such diameters, the amount of metal expansion incurred can be reasonably accommodated by
10 using metal thicknesses in vessel structure which can be fabricated and handled without excessive cost and without incurring unreliable vessel quality which may render the vessel unsuitable. At greater diameters than the limited stated above, a two headed system is used preferably.

15 In connection with regenerators having diameters greater than about 30 feet, the problem of distribution of reactant material becomes important. The use of a grid plate is not desirable because it expands considerably more than
20 the metal of the vessel, since the vessel is insulated interiorly; whereas the grid plate is exposed directly to high temperature materials. Consequently, a grid plate can cause structural failure, hence, it is not useful for large size regenerators, i.e., of larger diameter than mentioned above. For the purpose of distribution, a foraminous means
25 is employed which is about 10% to 30% of the cross-sectional area of the regenerator, and it completely envelopes or seals the opening of the riser such that material can only pass through the openings or holes therein. Specifically, the foraminous means can be a cylindrical section with a
30 spherically shaped cover plate containing a plurality of

openings. The foraminous means will be designed to create a pressure drop of about 0.15 to 2.5 psi., preferably about 0.25 to 1.5 psi. The air which is charged directly to the regenerator bed is distributed by means of a torus means
5 containing a series of openings for passage of the regeneration gas in a circular fashion around the foraminous means. In this manner, excellent distribution of gas and catalyst is obtained.

The present invention has particular application
10 to a hydrocarbon conversion process in which it is contemplated employing a regenerator which contains more catalyst than the reactor. In this connection, the regenerator catalyst bed is usually about 2 to 5 times as much, on a weight basis, as the reactor catalyst bed. This
15 invention is especially adapted for catalytic cracking of high boiling hydrocarbon oils. The high boiling hydrocarbon oils have an initial boiling point of about 400 to 600° F., and an end point of about 700 to about 1300° F. The API gravity of the high boiling hydrocarbons ranges from about
20 10 to about 40°. The high boiling hydrocarbons are, for example, gas oils, reduced crude, vacuum distillates, solvent decarbonized residual oils, etc. The high boiling hydrocarbon is cracked at a temperature of about 850 to about 950° F. At this time, the reaction pressure is maintained in the
25 range of about 1 atmosphere to about 50 psig., more usually, about 5 to about 25 psig. The quantity of oil which is processed relative to the quantity of catalyst which is present in the reaction zone is measured as the weight space velocity and, in general, it is about 0.25 to about 15, more usually
30 about 0.5 to about 5. The catalyst to oil ratio, on a weight

basis, falls within the same range specified above, namely, about 2 to about 25, more usually, about 5 to about 10. The catalyst to be used for the cracking step is a suitable cracking catalyst, usually the catalyst is a siliceous material such as one containing silica in the amount of about 50 to about 100% by weight, more usually, about 70 to about 95% by weight. The silica can be used in admixture with another catalytic component, the other catalytic component is, for example, alumina, zirconia, boria, magnesia, etc.

As a result of catalytically cracking the high boiling hydrocarbon oil carbonaceous material is deposited on the catalyst. Hence, the catalyst is subjected to a regeneration treatment at a temperature of 700° to about 1200° F., more usually, about 1000° to about 1150° F. The pressure of regeneration varies in the same range as the reaction pressure. The catalytic material is burned by means of an oxygen containing gas, e.g., air or a diluted air stream. Prior to the regeneration treatment, the catalyst may be subjected to stripping by means of a gasiform stripping agent. The stripping treatment serves to remove occluded volatile materials and to desorb such hydrocarbons contained by the catalyst. The stripping treatment is effected, in general, at a temperature of about 800° to about 1000° F., more usually, about 875° to about 950° F. By virtue that the stripping zone surrounds the riser in which regenerated catalyst is carried upwardly by means of an oxygen containing gas, the heat of combustion generated by burning with the oxygen containing gas is transferred indirectly to the stripping zone such that the temperature of the stripper is about 3 to about 50° greater than the reaction temperature, more usually, about

5 to about 20° greater on the same basis. The gasiform stripping agent which is used for this purpose can be, for example, steam, flue gas, carbon dioxide, normally gaseous hydrocarbons, e.g. methane, ethane, propane, etc.

5 In order to provide a better understanding of the present invention, reference will be had to the accompanying drawings which form a part of this specification.

In the drawings:

10 Figure 1 is a specific example of a double head system;

Figure 2 is a specific example of a single head system; and

15 Figure 3 is a specific illustration of a cross-sectional view along a plane A-A' in Figure 1 with the omission of the cyclone separator.

A specific embodiment of the invention is shown in Figure 1, in which a reaction vessel 10 supports a regeneration vessel 11 by means of an intervessel structure 12. The entire system is in turn supported by a steel and concrete foundation 13, upon which reaction vessel 10 rests. The entire reaction vessel and regeneration vessel assembly may weigh 480 tons empty and when they contain the usual process amounts of catalyst, the apparatus and contents may ordinarily weigh about 795 tons or over. Such an assembly may have a height above ground to the top of the regeneration vessel 11 of 135 feet. Both reaction and regeneration vessels must ordinarily be constructed cylindrically with spherical or semispherical upper and lower ends because, in addition to structural strains, they are operating under elevated temperatures and pressures, a temperature of about 1080°F. and

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about 8 psig. being typical for the interior of the regeneration vessel 11 and a temperature of about 900° F. and about 19 psig. being typical for the interior of reaction vessel 10. Both vessels are ordinarily lined with about 4 inches of refractory concrete so that under operating conditions the external metal surface exposed to free circulation of atmospheric air will not exceed 200° F. or 300° F., while the metal surface enclosed within the intervessel structure will not exceed the temperature of the air enclosed within that structure by more than 100°F. or 200°F. Because of the huge weights and because of the large dimensional changes with temperature, the two vessels and their interconnecting apparatus must be massive and yet capable of relative movement. Intervessel structure 12 is preferably shaped like part of an inverted cone. A number of large holes 14 are provided in the structure 12 so that air may freely circulate between the bottom of regeneration vessel 11 and the top of reaction vessel 10. Preferably, the space between the ends of the two vessels within intervessel structure 12 is maintained at a temperature not in excess of about 400°F. by the circulation of air.

In the specific embodiment illustrated, the lower part of the reaction vessel 10 is divided into an annular reaction zone 15 and a centrally positioned cylindrical stripping zone 16 by means of a vertical cylinder or well 17 extending from the bottom of reaction vessel 10 up to about its mid-elevation. The horizontal cross-section of the stripping zone should be between about 15% and 40% of the horizontal cross-section of the reaction zone 15. The two zones communicate with each other by means of horizontal slots 18 in the walls of cylinder 17. Slots 18 are disposed at more than one eleva-

tion so that the vessel may operate when filled with catalyst to various depths, however, slots 18 are located near the bottom of the zones 15 and 16 so that they are almost always substantially below the upper surface of the catalyst beds contained therein. The slots 18 are shielded by means of lower baffles 19 which extend obliquely downwards (in the direction of flow) from reaction zone 15 to stripping zone 16, and extend along the lower edge of slots 18 to shield them from upflowing vapors and to prevent crossover of gases between the two zones. At maximum level, some catalyst will flow from zone 15 into zone 16 by way of overflow over the upper edge of cylinder 17.

Circulation of catalyst between regeneration vessel 11 and reaction vessel 10 is accomplished by means of a cylinder upflow conduit 20 and a pair of downflow conduits 21 and 22. Conduits 21 and 22 are arranged symmetrically with respect to conduit 20, and each of said conduits 21 and 22 is spaced equidistantly from well 17 and the vertical side of reactor 10. Conduit 20 opens at its lower end in the lower part of stripping zone 16; at its upper end it enters the bottom of regeneration vessel 11 and opens into the interior of a relatively small distributor vessel 23. The weight of conduit 20 is supported at a bushing in the lower end of regeneration vessel 11. The part of conduit 20 which extends through the cooled space between the two vessels includes an expansion joint 24 of the bellows type.

Conduit 20 is so arranged that it is completely interdependent of the upper end of the reaction vessel 10. A seal between the conduit 20 and the upper end of reaction vessel 10 is provided by the bellows type expansion joint 24, the upper

extremity of which is sealed to the external surface of
conduit 20 and the lower extremity of which is supported by and
is sealed to the upper end of the reaction vessel 10. This
seal arrangement permits movement of the conduit 20 in either
an upward or a downward direction through the upper end of the
reaction vessel 10 and the space enclosed between the ends of
the two vessels by the intervessel structure 12.

The movement for which expansion joint 24 is provided
occurs when the temperature of the various parts of the
apparatus are changed from atmospheric temperature when the
apparatus is not in operation to the elevated temperatures
resulting from the normal operating conditions for which the
apparatus is designed. Typical conditions during operation
might be 100°F. to 200°F. for the metal of the intervessel
structure 12, 400°F. to 600°F. for the upper end of the reac-
tion vessel 10 and the lower end of the regeneration vessel
11, and 950°F. to 1100°F. for the temperature of the upflow
conduit 20.

The total differential movement of the upflow conduit
20 between its support point at the lower end of the regenera-
tion vessel 11 and the valve seat 28 at its lower extremity
varies the relatively hot and cold positions of the valve seat
28. The flow of material into the upflow conduit 20 from the
stripping zone 16 is dependant upon the size of the opening
between the reciprocal valve 27 and its seat 28. This valve is
controlled in such a manner that its opening will give the de-
sired flow rate regardless of the movements of its seat due to
expansion resulting from change in temperature of the various
portions of the apparatus.

Arrangement of the downflow conduits 21 and 22 with

their expansion joints 25 and 26, their valves 29 and 30, and their valve seats 31 and 32 is similar to that of the upflow conduit previously described.

5 Conduits 21 and 22 are similarly suspended from the lower end of regeneration vessel 11 and are also provided with expansion joints 25 and 26. Their intake is from the bottom of regeneration vessel 11 in an annular space external to distributor vessel 23. Their outlets are near the bottom of reaction zone 15, somewhat higher than the inlet of upflow conduit 20, but sufficiently low so as to discharge regenerated catalyst
10 into reaction zone 15 at a point sufficiently low to avoid immediate flow of fresh regenerated catalyst into stripping zone 16 by way of the louvered slots 18.

15 Upflow through conduit 20 and downflow through conduits 21 and 22 are controlled by plug valves which seat against annular seats on the lower end of the respective conduits, said valves being vertically reciprocable in the bushings in the bottom of reaction vessel 10. Vertically reciprocable valve 27 is centrally positioned and seats against annular valve seat 28
20 in the lower end of upflow conduit 20, while solid stem valves 29 and 30, similarly reciprocable in the bottom of reaction vessel 10, seat against valve seats 31 and 32 in the lower ends of downflow conduits 21 and 22 respectively. Distribution vessel 23 is a centrally located, vertical cylinder and closed
25 at its lower end by the bottom of reaction vessel 11 and having at its upper end a convex surface 33 which is provided with numerous relatively small openings 34. Distributing vessel 23 serves to discharge spent catalyst entrained in regenerating gases upwardly into a mass of catalyst undergoing regeneration.
30 Such a mass is indicated by the numeral 35. Distributor vessel

23 discharges the spent catalyst and regenerating gas (usually
air) into catalyst mass 35 at a point somewhat above the
bottom thereof, so that regenerated catalyst being withdrawn
from the bottom of catalyst mass 35 is less likely to entrain
5 undesirable amounts of oxygen or other regenerating gas
constituents. Additional regenerating gas is introduced into
the lower part of catalyst mass 35 by means of a distribution
ring. Distribution ring 36 is a hollow toroid which circum-
scribes distribution means 23 and provides an annular space
10 therebetween. Regenerating gas introduced into the interior
of distribution ring 36 by way of pipe 37 escapes into catalyst
mass 35 by means of numerous small holes 38 in the upper sur-
faces of distribution ring 36.

Flue gases rise from the upper surfaces of catalyst
15 mass 35, entraining considerable amounts of the powdered
catalyst undergoing regeneration. Most of this entrained
catalyst settles out of the rising flue gases as they pass up-
wardly through the usual 20 feet of settling space above the
catalyst mass 35 within regeneration vessel 11. The flue gases
20 then pass through a cyclone separating system 39, returning
additional entrained catalyst to catalyst mass 35 by way of
diplegs 40. The flue gases then pass out of regeneration
vessel 11 by way of line 41 and stack 42, which extends upward-
ly from regeneration vessel 11 to a distance which is safely
25 above adjacent operating equipment (about 150 feet above the
ground, in a typical case).

Regenerated catalyst leaves the bottom of catalyst
mass 35 through downflow conduits 21 and 22 and enters a reac-
tion mass of annular shape in the lower part of reaction vessel
30 10 and indicated there by the number 43. Hydrocarbons to be

converted are introduced (usually in liquid form) through a substantial number of jet nozzles 44 in the bottom of reaction vessel 10. There are usually 20 or 30 of these nozzles and they are ordinarily about 1 to 2 inches in internal diameter. The hydrocarbons vaporize almost instantly as they enter the bed of hot catalyst 43 and undergo conversion as they pass upwardly through the mass of catalyst. The converted vapors rise from the upper surface of catalyst mass 43, lose some entrained catalyst by settling in the space above mass 43 within reaction vessel 10, lose further entrained catalyst by passage through a cyclone separating system 45, and then pass out of reaction vessel 10 by way of line 46, which carries the reaction product vapors to a fractional distillation tower in which the various conversion products are recycled or separated.

Using the equipment described in Figure 1, the following specific conditions are employed.

Regenerator diameter, ft.	32'
Regenerator length, ft.	30'
Reactor diameter, ft.	20'
Reactor length, ft.	35'
Conduit 20, diameter, ft.	3'
Conduit 21, diameter, ft.	1½'
Conduit 22, diameter, ft.	1½'
Stripper diameter, ft.	10'
Stripper length, ft.	20'

Reaction conditions

	Reactor temperature, °F.	900
	Reactor pressure, psig.	19
	Regenerator temperature, °F.	1080
5	Regenerator pressure, psig.	8
	Weight space vel., $W_0/hr/W_0$	1.5
	Catalyst to oil ratio	12
	Vol.% air charged to Conduit 20	25
	Reactor catalyst, %oms	80
10	Linear Vel. in Conduit 20, ft/sec.	40
	Oil feed, rate, barrels/day	11,610
	Feed gravity, °API	25
	Stripper temperature, °F.	910
	Silica-alumina catalyst	

15 Figure 2 contains a specific illustration of a single head system involving the principals of the present invention. In this drawing, the numerals employed designate similar apparatus parts which were described in connection with Figure 1. The significant difference between Figure 1 and Figure 2 is that in 20 Figure 2, the single partition 55 is a means of dividing the regenerator. This method of fabrication is used where the regenerator is not more than about 25 ft. in diameter. In the specific example given in Figure 2, the regenerator is 19 ft. in diameter and the reactor is 13 ft. in diameter. The L/D 25 ratio for the regenerator is 0.7 and the L/D ratio for the reactor is 1.3. Conduits 21 and 22 are of the same length and diameter and each conduit has a diameter of 1.2 ft. Conduit 20 which serves as a riser for the spent catalyst has a diameter of 1.9 ft. and the air stream which is used as a carrying means 30 for the regeneration gas constitutes about 20% by volume of

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the total regeneration gas. The linear velocity of the total upflowing material in conduit 20 is 4.5 ft. per second. Stripping well 17 has a diameter of 6 1/2 ft. and it comprises about 25% of the reactor cross-sectional area.

5 Figure 3 is a cross-sectional view of the reactor in Figure 1. It is to be noted that conduits 21 and 22 are spaced symmetrically with respect to the central riser or conduit 20. Further, it should be noted that conduits 21 and 22 are spaced equidistantly from the wall of well 17 and the wall of reactor
10 10. By this arrangement of apparatus parts within the reactor, a free circulation of catalyst within the reaction zone is provided and thereby catalyst efficiency is maintained at a high level and there is little danger of the formation of stagnant portions of catalyst therein.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus comprising in combination a vertical elongated reaction means, a vertical elongated regeneration means of enlarged cross-sectional area relative to said reaction means situated above said reaction means and in vertical alignment therewith, a vertical elongated upflow means situated centrally within said reaction means, said upflow means having its upper end in open communication with said regeneration means and the lower end suspended within the bottom part of said reaction means, a plurality of vertical elongated downflow means situated within said reaction means in symmetrical relation with said upflow means, each of said downflow means having the upper end in open communication with said regeneration means and the lower end suspended within the bottom part of said reaction means, means for supplying fluid to said upflow means, and means for supplying fluid to said reaction means.
2. The apparatus of claim 1 which includes a vertical stripping means situated centrally within said reaction means and surrounding the upflow means with the bottom end thereof being connected to the bottom of the reaction means and the upper end thereof being in open communication with the reaction means at a substantial distance from the upper end of said reaction means, the plurality of vertical downflow means being situated within said reaction means in symmetrical relation with said upflow means and outside of said stripping means.
3. The apparatus of claim 1 which is further character-

ized by the upflow means comprising about 1 to about 10% of the diameter of the reactor and each of the downflow means has a diameter of about 0.25 to about 4% of the reactor.

4. The apparatus of claim 1 which is further characterized by having the regeneration means superimposed on the reaction means such that each of said means is separated by a single partition and the regeneration means has a diameter not greater than about 25 feet and the L/D of each of said means falls in the range of about 0.2 to 3.

5. The apparatus of claim 1 which is further characterized by having the regeneration means superimposed on said reaction means and said intervessel means is provided with openings for free circulation of air therein.

6. The apparatus of claim 1 or 2, which includes expansion means associated with each downflow means and situated within the reaction means such that the lower end is suspended in the bottom part of the reaction means and the upper end is sealed to said downflow means.

7. The apparatus of claim 1 or 2, which includes a foraminous distribution means situated centrally on the bottom of the regeneration means and of substantially reduced cross-sectional area relative thereto and a circular distribution means circumscribing said foraminous means and forming an annular zone therewith within the bottom part of said regeneration means, the upflow means having its upper end in open communication with said foraminous means.

8. A process for chemical reaction which comprises contacting a gasiform chemical reactant with a dense fluidized bed of finely divided catalytic material in a reaction zone thereby producing a reaction product and contaminating the catalyst with carbonaceous material, withdrawing a portion of contaminated catalyst from the bed

in the reaction zone and passing the same upwardly through a first vertical elongated confined zone as a suspension in an oxygen-containing gas, the quantity of oxygen containing carrying gas being about 10 to 40% by volume of the total gas required for subsequent regeneration, passing the up-flowing catalyst from the first confined zone to a regeneration zone in vertical alignment above said reaction zone, maintaining a dense fluidized bed of catalyst in said regeneration zone and passing thereto the remaining portion of oxygen-containing gas being required for the regeneration treatment of the catalyst by combustion, passing regenerated catalyst from the regeneration zone downwardly through a plurality of vertical elongated confined zones to the reaction zone, and said plurality of confined zones being spaced symmetrically with respect to said first confined zone thereby permitting free circulation of catalyst within the reaction zone.

9. A process for chemical reactions which comprises contacting a gasiform chemical reactant with a dense fluidized bed of finely divided catalytic material in a reaction zone thereby producing a reaction product and contaminating the catalytic material with carbonaceous material, withdrawing a portion of contaminated catalyst from the bed in the reaction zone and passing the same upwardly through a first vertical elongated confined zone in a suspension in an oxygen-containing gas, the quantity of oxygen-containing carrying gas being about 10 to about 40% by volume of the total gas required for subsequent regeneration and the linear velocity of the upflowing gaseous suspension of catalyst in the confined zone being about 10 to about 60 feet per second, passing the upflowing catalyst from the first confined zone to a regeneration zone in

vertical alignment above said reaction zone, said regeneration zone contains about 2 to about 5 times as much catalyst as the reaction zone, maintaining a dense fluidized bed of catalyst in said regeneration zone and passing thereto the remaining portion of oxygen-containing gas being required for the regeneration treatment of the catalyst by combustion, passing regenerated catalyst from the regeneration zone downwardly through a plurality of vertical elongated confined zones to the reaction zone and said plurality of confined zones being spaced symmetrically with respect to said first confined zone thereby permitting free circulation of catalyst within the reaction zone.

10. In a process for effecting chemical reactions where a gasiform hydrocarbon reactant is contacted with a dense fluidized bed of catalytic material in a reaction zone thereby producing a reaction product and contaminating the catalyst with carbonaceous material and volatile hydrocarbons, withdrawing a portion of contaminated catalyst from the bed of the reaction zone and passing the same upwardly through a first vertical elongated confined zone as a suspension in an oxygen-containing gas, passing the suspension of catalyst from the first elongated confined zone to a regeneration zone which is situated in vertical alignment above said reaction zone, maintaining a dense fluidized bed of catalyst in the regeneration zone for the regeneration treatment of the catalyst by combustion of the carbonaceous material with the oxygen-containing gas, and passing the regenerated catalyst downwardly through a plurality of elongated confined zones to the reaction zone, the improvement which comprises first passing the spent catalyst from the catalyst bed in the reaction zone to a stripping zone which surrounds said elongated confined zone and contacting the same with a

gasiform stripping agent for the removal of volatile hydrocarbons, passing the stripped catalyst from the stripping zone to the first elongated confined zone and carrying the same upwardly by means of an oxygen-containing gas in a quantity constituting about 10 to about 40% by volume of the total gas being required for subsequent treatment in the regeneration zone, passing the gaseous suspension of stripped catalyst to the regeneration zone wherein it is contacted with additional oxygen-containing gas which is required for complete regeneration treatment, and then passing regenerated catalyst downwardly through a plurality of vertical elongated confined zones for recirculation of the reaction zone, and said plurality of confined zones being spaced symmetrically with respect to said first confined zone and outside of said stripping zone thereby permitting free circulation of catalyst within the reaction zone.

11. The process of claim 9 which is further characterized by employing for catalyst circulation about 0.05 to about 0.5 cubic feet of oxygen-containing gas per pound of catalyst being circulated and about 4 to about 20 pounds of catalyst per hour being circulated per pound of catalyst which is present in the reaction zone.

12. The process of claim 9 wherein the chemical reaction is the catalytic cracking of high boiling hydrocarbon oils.

FIG. 1

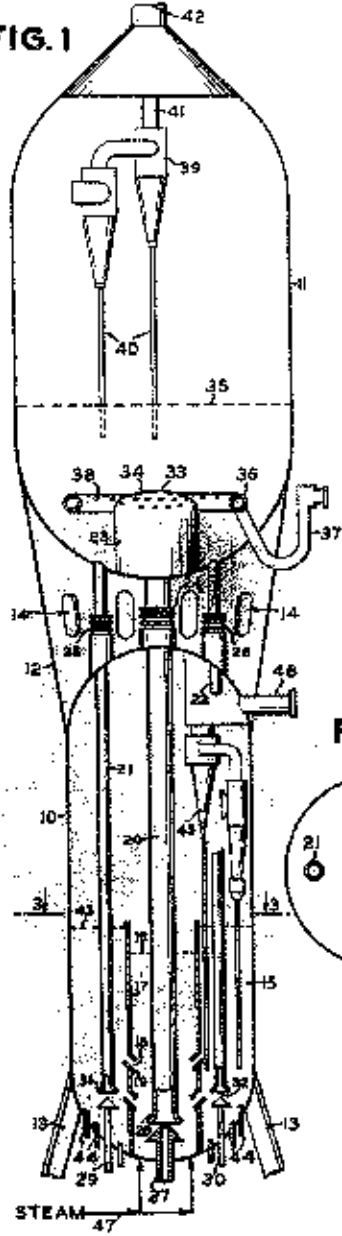


FIG. 2

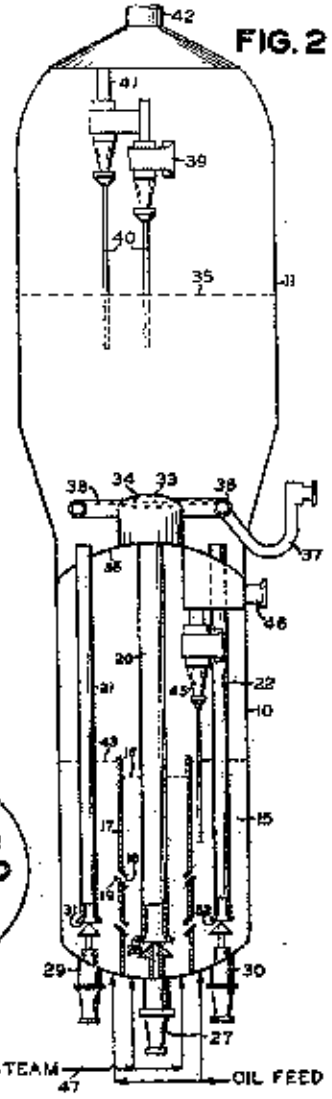
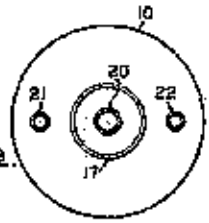


FIG. 3



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