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APPARATUS FOR THE CONTINUOUS CRACKING OF HYDROCARBONS

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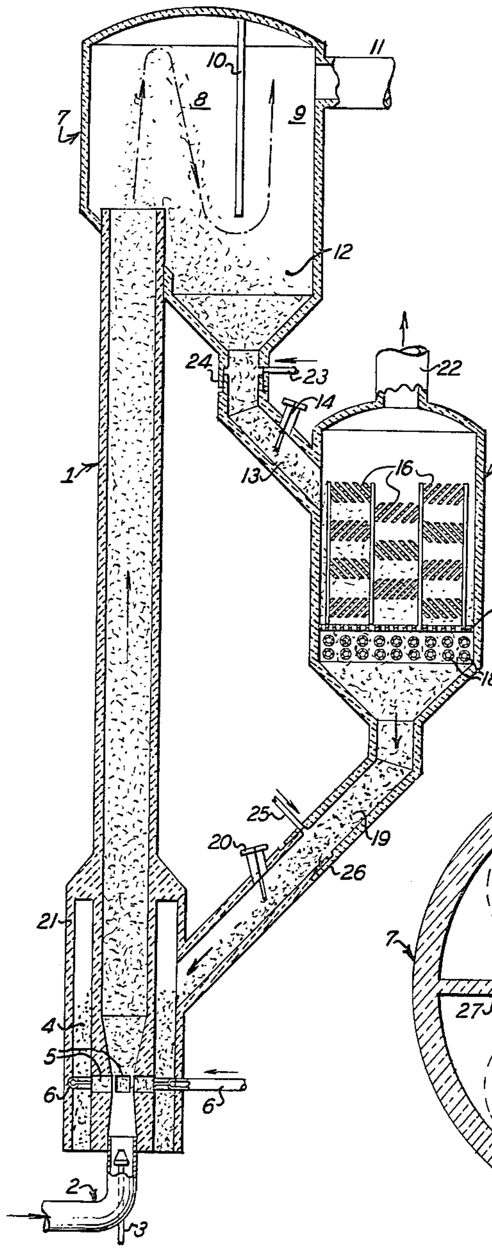

Fig. 1

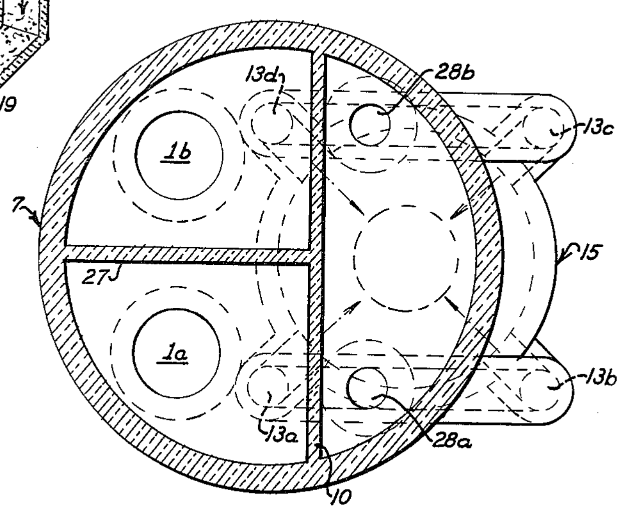

Fig. 2

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APPARATUS FOR THE CONTINUOUS CRACKING OF HYDROCARBONS

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6 Claims. (Cl. 23—284)

The present invention relates to an apparatus for the continuous cracking of hydrocarbons, and more particularly to such an apparatus employing highly heated fine-grained heat carrier material for this purpose.

A variety of different types of apparatus for the pyrolytic cracking of hydrocarbons into olefines is already known. An apparatus of the foregoing type may comprise a tubular cracking furnace or a device through which fine-grained heat carrier materials may be recycled for effecting the cracking. The latter type of apparatus has proved to be useful principally where dealing with high boiling fractions under stringent cracking conditions. In such an apparatus the carbon which is liberated during the cracking reaction is deposited principally on the heat carrier material and can be removed therefrom when this material is reheated for recycling. In the case of tubular cracking furnaces, on the other hand, the deposition of carbon in the tubes rapidly leads to overheating and to undue wear and destruction of the tubes.

Externally heated tubular cracking reactors, however, have been successfully used for many years for the purpose of cracking low boiling hydrocarbon fractions under milder reaction conditions. For those hydrocarbon feeds which are gaseous and which boil at temperatures up to about 160 degrees C., pyrolytic cracking processes performed with recycled sand are likewise suitable. Such processes offer the incidental advantage that the composition of the unsaturated gases that are produced can be varied within very wide limits. Nevertheless, pyrolytic cracking reactors which employ recycled sand must be of simple, durable, and reliable construction.

It is an object of the present invention to provide an apparatus for the continuous cracking of hydrocarbons with the aid of highly heated fine-grained heat carrier material wherein the heat carrier material may be recycled for further use.

It is another object of the present invention to provide such an apparatus which is simple, durable, and reliable in construction and efficient in operation.

Other and further objects of the invention will become apparent from a study of the within specification and accompanying drawing in which,

FIG. 1 is a diagrammatic sectional view of an apparatus for the continuous cracking of hydrocarbons in accordance with the invention, illustrating the direction of flow of the highly heated, fine-grained heat carrier material passing through the system, and

FIG. 2 is an enlarged diagrammatic sectional view looking downwardly through an alternate apparatus in accordance with the invention having a plurality of flow paths for recycling the heat carrier material through the apparatus.

It has been found in accordance with the present invention that an apparatus for the continuous cracking of hydrocarbons with the aid of highly heated, fine-grained heat carrier materials may be provided which comprises a pneumatic elevator conduit for the fine-grained heat carrier material which increases in flow cross section in upward direction, the top end of the pneumatic elevator conduit communicating with a separation chamber of greater flow cross section than that of the elevator conduit, said separation chamber including a main chamber portion and an ancillary chamber portion separated at their top portions by a parting wall but communicating at a point below such parting wall, the bottom portion of the separation chamber sloping inwardly and communicating with a cracking reactor chamber, and a feed means for the pneumatic elevator conduit communicating with the reactor chamber to complete the cycle. The bottom portion of the separation chamber advantageously communicates with the cracking reactor chamber by means of a heat carrier material inlet channel and the reactor chamber communicates with the feed means for the pneumatic elevator conduit by means of a heat carrier material discharge channel. The feed means is located at the lower portion of the pneumatic elevator conduit and communicates therewith for cycling heat carrier material through the elevator conduit, the separation chamber and in turn the reactor in order to perform the cracking of hydrocarbons.

The feed means may also be provided with means for heating the fine-grained material during its passage upwards through the pneumatic elevator conduit so as to burn away any carbon disposed on the fine-grained material and at the same time to preheat the material to be used in the cracking reactor chamber.

Generally, the pneumatic elevator conduit is vertically arranged and has a cross section which uniformly or discontinuously increases in upward direction from the vicinity of the feed means to the separation chamber thereabove into which the carrier material is discharged. The separation chamber is preferably provided as a widened separation chamber so that the heat carrier material may be classified therewithin without undue wear and destruction of the separation chamber walls. The ancillary chamber portion is divided from the main chamber portion of the separation chamber by means of a parting wall extending from the top of the separation chamber downwardly towards its bottom portion. The lower portion of the separation chamber, i.e. including the main chamber portion and the ancillary chamber portion, may be constructed to form a collecting hopper for the carrier material which communicates by means of an inlet channel with the cracking reactor chamber. Any gases carried forward with the heat carrier material through the pneumatic elevator conduit may exit from the separation chamber by passage to the ancillary chamber portion and out a gas discharge outlet provided for this purpose.

The cracking reactor chamber is provided with internal baffle structures positioned so that the entering heat carrier material flows therethrough in counter-current direction to the flow of the hydrocarbon materials to be cracked. The actual cracking takes place in the vicinity of the internal baffle structures whereby the cracked hydrocarbon materials pass out of the reactor at the top end. The heat carrier material is returned from the reactor chamber to the pneumatic elevator conduit by means of a discharge channel and the feed means.

Generally, all the parts of the apparatus in accordance with the invention, during operation, are exposed to temperatures between 700 and 1,000 degrees C.; therefore those components which are in contact with the heat carrier material or with hot gases within the system are preferably provided with a highly refractroy brick lining. The apparatus may take the form of a sand cracker in accordance with the invention wherein a grain size of predominately 0.3 to 1.2 millimeters may be used with especially good results. Advantageously, such carrier materials are available in nature, the individual particles have the shape of rounded spheres or ellipsoids, the particles are hard and non-abrasive and they can sustain the temperatures of the reaction efficiently. Nevertheless, sand may be replaced by other heat carrier materials in accordance with the invention, including such other materials which at the same time have a catalytic effect. Among such materials, blast furnace slag of the above-mentioned grain size has been found particularly suitable.

Referring to the drawing, an apparatus is shown in FIG. 1 which, including a pneumatic elevator and heater **1** for heating and upwardly conveying the heat carrier material which in the embodiment of execution is sand. Elevator and heater **1** is conveniently constructed as a bricked shaft of circular or approximately circular cross section which widens along its entire length in the upward direction in discontinuous steps. Alternately, this widening may take place in a uniform manner if desired. Pre-heated air is blown into the bottom portion of the elevator and heater **1** by means of a centrally positioned pipe **2** and gaseous liquid or pulverulent fuels may be admitted through a pipe **3** at the same time whereby such fuel may be combusted in the presence of the pre-heated air. The feed means in accordance with the invention causes the heat carrier material disposed therewithin to pass into the hot air stream or stream of combustion gases upwardly flowing through the elevator and heater **1**. In this way the material is conveyed upwardly and simultaneously heated in the elevator **1** during its vertical ascent wihch generally represents a distance of between about 20 and 40 meters.

The rate of flow of the combustion gases in the upper portion of the ascending pipe elevator **1** is maintained between about 15 and 20 meters per second in the customary manner, the lower limit being used where smaller diameter pipes are employed, for example, those having diameters of 300–500 mm., while the upper limit is used where pipes having diameters of 1000–1400 mm. are employed.

Any deposits of carbon on the heat carrier material passing upwardly through the elevator **1** will substantially contribute to the reheating of the carrier material when these deposits are burned off. This is especially true where high boiling hydrocarbon fractions which are rich in carbon are being cracked.

It will be appreciated that the vertical pneumatic elevator in accordance with the apparatus of the invention combines the functions of conveying, reheating, and regenerating the heat carrier material for efficient cracking operations.

It is a matter of considerable significance that the elevated, highly heated sand be separated from the conveying and heating gases in such a way that the walls of the apparatus, and especially the walls of the separation device **7** will not be subjected to an objectionable amount of wear and that no considerable amount of abraded material will form. The separation device or separation chamber **7** which surmounts the elevator and which serves for separating and classifying the highly heated pneumatically elevated heat carrier material is constructed to meet this requirement. Thus, the vertical elevator shaft **1** discharges into a much wider separation chamber **7**, said chamber having more than 10 times and preferably more than 20 times the flow cross-sectional area of the shaft **1**.

In accordance with these dimensions, the velocity of flow of the conveying gases drops considerably in the separation chamber **7**. A parting wall **10** is disposed between the main chamber portion **8** of separation chamber **7** adjacent the top end of shaft **1** and the ancillary chamber portion **9** of separation chamber **7** so as to enforce a reversal of the direction of flow of the rising stream of conveying gases being discharged into chamber portion **8** from shaft **1**. This considerable reduction in the velocity of gas flow in conjunction with the reversal of the direction of flow causes the sand to be substantially deprived of its upward momentum. Accordingly, the sand drops out of the gas stream and collects in the lower portion of the main device **7** located below separation chamber portion **8** and ancillary chamber portion **9**. This lower portion is constructed so as to form a hopper for the collection of the heat carrier material to this hopper communicating both with the large main chamber portion **8** as well as with the smaller ancillary chamber portion **9**.

In this regard, according to the positioning of the parting wall **10**, the ancillary chamber portion **9** in which the hot combustion gases rise again and from which they leave through an outlet pipe **11**, will determine the cross sectional area of main chamber portion **8** and ancillary chamber portion **9** for adjusting the flow velocity of the gas. The dimensioning of chamber portion **9** is important because the upward velocity of the hot combustion gases passing therethrough is determined by the flow cross section. The upward velocity of the gas in turn determines the volume of dust or under-sized grain particles which will be entrained, and which in this manner will be removed from the bulk of the heat carrier material via outlet pipe **11**.

In this connection, it should be noted that conventional devices for the separation of heat carrier material have not proved to be entirely successful, because, in addition to the heat carrier material, they also collect dust as well as any abraded materials and permit these to be returned to the reactor. Consequently, the same are carried off together with the gaseous cracked product into subsequent processing equipment where such materials will deposit and give rise to troublesome difficulties. The deflection of the vertical pneumatic elevating shaft in horizontal direction has also been found to be impractical because of the resultant wear on the walls of the separation chamber as well as the excessive abrasion of the sand particles. These same disadvantages also occur when a separatory cyclone is employed through which the sand-charged entraining gas stream is tangentially passed.

In contrast thereto, in accordance with the invention, owing to the size of the separation chamber **7**, the upward velocity of the sand is quickly reduced to a safe degree. Moreover, the distance of the roof of the separation chamber **7** from the top end of the vertical elevator shaft **1** is arranged to exceed 5 meters and preferably amounts to about 6 to 7 meters. At this distance essentially no wear of the roof of the separation chamber **7** will occur, and it is even possible at this distance to provide an inspection window for optical control of the operation.

From the lower portion of the sand classifier and separation chamber or device **7**, which forms a collection hopper **12**, a narrow inlet channel **13** communicates with a cracking reactor chamber **15**. Channel **13** represents a form of constriction at the discharge end of the collecting hopper **12** down which the sand flows in the form of an unbroken column. Channel **13** is provided with a gate valve **14** for controlling the flow volume of highly heated sand which continuously flows along inlet channel **13** into reactor **15**. To compensate for thermal expansion, channel **13** is conveniently provided with an expansion joint **24** above valve **14**, said joint being preferably combined with an admission branch **23** for the introduction of a supplementary gas such as water vapor and thus serving as a dispersing means for such gas. By admitting a supplementary gas, such as water vapor, the existing sealing effect of the column of unbroken carrier material which separates the reaction gases in reactor **15** from the combustion gases in separation device **7** may be even further improved.

The inlet channel **13** for the fine-grained heat carrier material discharges into the upper portion of reactor **15**. Along its intermediate portion reactor **15** is equipped with internal baffle structures which may comprise several tiers of evenly spaced, juxtaposed, obliquely placed, parallel baffle slats **16**, the angle of inclination alternating from tier to tier. Preferably, the slats **16** are situated in separate units of several obliquely placed parallel baffle surfaces supported by a carrier grating **17**. The primary purpose of these structures is to cause a uniform circulating motion of the sand and hence a uniform reaction of the stock that is to be cracked with the highly heated fine-grained heat carrier material. It will be appreciated that only a very short period of residence is required for the pyrolytic cracking of hydrocarbons in the reactor.

Accordingly, in order to maintain a reaction period of between 0.2 and 0.6 second, such as is required for the production of unsaturated hydrocarbons, gas velocities of between 2 and 6 metres per second are necessary within the bed of sand in which the hydrocarbons are heated and converted. These velocities would otherwise cause a bed of sand in an unobstructed space containing no baffle structures to boil violently. As a result large vapor or gas bubbles would rise eruptively propelling the sand in upward direction. Such action would unduly disturb the uniform sensitive pyrolytic cracking reaction and in turn reduce the yield of the desired reaction products, such as olefins, with or without acetylene and the like.

In accordance with the apparatus of the invention, the aforementioned disadvantages are overcome in that baffles in the shape of flat bars or slats are provided within the reactor. Generally, these bars have a width of from 40 to 110 mm. and are placed in parallel relation with respect to one another at an angle of between 40 and 65 degrees with respect to the horizontal in such a manner that the projections of these bars on a horizontal plane will be closely adjacent leaving very small gaps therebetween or will be even slightly overlapping in arrangement. These bars may be assembled in the form of welded or integral units. Each unit in a tier is preferably spaced a given distance from the next unit so as to form a relative staggering of the units from tier to tier so as to provide a cover over the entire cross section of the reactor formed by these units. Intermediate the several tiers formed by the units empty intervening spaces 30 to 100 mm. in height are preferably provided. The flat parallel bars in consecutive tiers are suitably arranged in oppositely inclined direction for more efficient counter-current flow effects. By the foregoing arrangement, the formation of substantial gas bubbles or fountains of sand is completely avoided so that the reactor, equipped with these internal baffle structures, will be able to effect a steady cracking reaction of the hydrocarbons and in turn a consequent high yield of olefins.

The uniformity of the cracking reaction within reactor **15** may be further improved if the hydrocarbons which are to be cracked are blown into the sand bed from below by means of a plurality of nozzles which are more or less equi-distantly distributed across the entire cross sectional width of the reactor. In this way the hydrocarbons introduced will substantially evenly penetrate the bed of sand thereabove. These nozzles may be located on distributor pipes **18** each separately mounted for insertion and withdrawal. Pipes **18** are suitably constructed with a clear internal cross section which steadily diminishes toward the outer ends thereof. This ensures that the hydrocarbons, which may even be mixed with steam in certain cracking operations, will flow with sufficient velocity to the ends of the distributor pipes **18**. The internal cross section of pipes **18** may also be constructed so as to discontinuously diminish toward their outer ends. Advantageously, distributor pipes **18** may be insertable from one side or from two opposite sides of reactor **15**, each individually mounted with respect to the reactor **15** and each individually connected with the source of hydrocarbons which are to be cracked. Provision for steam connection may also be included. Of course, it will be realized that flanged connections may be used so that pipes **18** may be easily disengaged from the source of the hydrocarbons and the steam.

In the preferred form of construction in accordance with the invention, the reactor **15** is formed with conically tapering bottom portion which communicates with a discharge channel **19** for discharging the cooled heat carrier material from the reactor. The cracked reaction products, on the other hand, can escape upwardly through the opening **22** provided in the unobstructed space above the baffle slats **16**.

Reactor **15** contains a sufficient number of tiers of internal baffle structures so that the sand from inlet channel **13** will drop partly on the top of the bars or slats **16** and will flow partly between the same. Since the bars or slats **16** impede the free flow of sand and an intermixing of sand in lateral or horizontal direction, zones of different temperature may form within reactor **15**.

Parenthetically, it may be advisable in larger reactors in this connection to provide two or preferably even four inlet channels for the sand from the separation device hopper **12** into the reactor as shown in FIG. 2. These inlet channels **13*a***, **13*b***, **13*c***, and **13*d*** may, in the same way as shown in FIG. 1, conveniently be made of narrow ducts controllable by sliding valves for regulating the flow of sand so as to maintain an approximately uniform temperature level across the entire cross-sectional width inside the reactor **15**.

With respect to FIG. 1, the lower portion of reactor **15** communicates via discharge channel **19** with feed means **21** for feeding the fine-grained solid carrier materials back into the elevator shaft **1**. Discharge channel **19** in a similar manner with respect to inlet channel **13** is provided with a sliding gate valve **20** as well as with an expansion joint **26** for compensating thermal expansion. Moreover, a branch pipe **25** for the admission of a sealing gas may also be provided above gate valve **20** in the same way as is noted with respect to channel **13**.

Within the narrow channel **19** a moving, unbroken column is maintained above gate valve **20** which effects a reliable seal between reactor **15** and feed means **21**. By admitting a sealing gas above gate valve **20** is this regard any undesirable flow of gas through discharge channel **19** will be efficiently suppressed so that the exhausted heat carrier material can be simple gravity flow pass steadily into annular chamber **4** of the feed means **21**.

Annular chamber **4** surrounds the elevator shaft **1** communicating with the interior of shaft **1** by means of slots **5**. Openings **6** are defined in the external wall of annular chamber **4** opposite slots **5**. Openings **6** serve to supply additional conveying medium to force the recycled carrier material from annular chamber **4** into shaft **1**. The conveying medium passing through openings **6** in conjunction with slots **5** effects an even introduction of the sand into the shaft **1** in a gentle and steady manner. By appropriately controlling the volume of additional conveying medium, such as air or steam, which is thus introduced through openings **6**, the quantity of sand returned to elevator shaft **1** and in turn the volume of circulating sand may be conveniently regulated. Any adjustment of the volume of sand otherwise effected by means of gate valve **20** may, therefore, be dispensed with.

Under normal operating conditions, it has been found that a certain amount of attrition and bursting of the grains of sand actually occurs in the elevating and heating shaft. This effect is more pronounced, the greater the cross sectional area of the elevator shaft. Therefore, with respect to larger plant apparatus, it is preferable to maintain the diameter of the elevator shafts below 1,000 to 1,500 mm. and instead to preferably provide two or even three elevator shafts to contribute the desired larger capacity flow cross section. In FIG. 2, these separate elevator shafts (**1*a*** and **1*b***) are so arranged that each is fed by means of a separate discharge channel **19** (not shown) from the reactor **15** wherein the sand moves along a continuous unbroken column. In the same way each shaft is provided with separate means for the admission of preheated air and fuel (not shown).

The multiple number of elevator shafts as in the embodiment of FIG. 2 are conveniently connected with a common large separation and collection chamber **7** at their top ends which effects the separation of the sand from the conveying gas in the aforedescribed manner. It has been found particularly suitable to provide the wide separation chamber with a corresponding number of parting walls between respective elevator shafts. These walls will prevent the sand from falling back into a non-operating shaft in the event less than all the shafts are in use at the time. Thus, as shown in FIG. 2, parting wall **27** is disposed between and above elevator pipes **1***a* and **1***b* to prevent sand from falling back into a non operating one in the event only one shaft is in use at a time. The sand passes via separate hoppers for each pipe **1***a* and **1***b* to corresponding conduits **28***a* and **28***b*. Conduit **28***a* in turn bifurcates to form separate inlet channels **13***a* and **13***b* while conduit **28***b* in the same way forms inlet channels **13***c* and **13***d*. Channels **13***a*, **13***b*, **13***c* and **13***d* are provided with gate valves (not shown) and are connected correspondingly to the top portion of reactor **15**. Discharge channels **19** (not shown) connect the bottom of reactor **15** to each of pipes **1***a* and **1***b* as aforedescribed.

It will be understood that reactor **15** may be fitted with means for injecting steam or pre-heated water above the internal baffle structures so that the cracked gases may be immediately quenched upon their formation. This precaution prevents the formed, unsaturated hydrocarbons from undergoing further undesired reaction.

The sand cracking reactor is connected with a plant for the subsequent processing and purification of the generated cracked products which emerge at outlet **22**. (See FIG. 1.) Means may be provided for removing the dust from the heating gases which emerge at outlet **11**, such as a cyclone. Moreover, the perceptible heat involved in these operations where initial temperatures of from 700 to 1,000 degrees C. may be used may be recovered by heat exchange means for pre-heating the conveying air and the generation of steam where such is required or desired.

Advantageously, the sand cracking reactor apparatus of the invention exhibits superior flow characteristics and is applicable in large scale installations. The reactor permits a high yield of olefins to be obtained even where hydrocarbons of differing composition ranging from ethane to heavy distillates and even crude oil are used. As a result of the flexibility of temperature control, the yields of different olefins can be preselected advantangeously so as to adapt to prevailing market conditions. The apparatus of the invention is extremely reliable in operation, can be constructed in large units and by comparison with conventional cracking plants is highly adaptable and economical in operation.

In accordance with a preferred embodiment of execution, the separation chamber is provided with a flow cross sectional area which is more than 10 times, and preferably more than 20 times, the flow cross sectional area of the elevator shaft. In like manner, the roof of the separation chamber is more than 5 meters and preferably about 6–7 meters above the top end of the vertical elevator shaft. When using sand, having a grain size of predominately 0.3 to 1.2 mm. and temperatures between 700 and 1,000 degrees C., efficient operation is attained, especially where the rate of flow of the combustion gases in the upper portion of the elevator shaft or shafts is maintained between 15 and 20 meters per second, the elevator shaft has a vertical distance of between 20 and 40 meters and a diameter of 300–1400 mm., and the separation chamber has a total flow cross-sectional area more than 10 times, and preferably more than 20 times, the total cross sectional area of the elevator shaft or shafts as well as a distance of more than 5 meters, and preferably about 6–7 meters, between the separation chamber roof and the top end of the elevator shaft or shafts. Thus, the length of the elevator shaft may be from about 14.3 to 132 times the diameter thereof.

What is claimed is:

1. Apparatus for the continuous cracking of hydrocarbons with the aid of highly heated fine-grained heat carrier material, which comprises a pneumatic elevator conduit for fine-grained heat carrier material which increases in flow cross-section in upward direction and which is provided immediately and directly within the lower end portion thereof with upwardly directed fuel injector means for heating heat carrier material within said conduit, the top end of said pneumatic elevator conduit communicating with a separation chamber of greater flow cross-section than that of said elevator conduit, a downwardly extending parting wall being provided in said separation chamber and positioned to divide the top portion of said separation chamber into a main chamber portion adjacent said top end of said pneumatic elevator conduit and an ancillary chamber portion remote from said top end of said elevator conduit, said ancillary chamber portion communicating with said main chamber portion below said parting wall and along the portion of said separation chamber where separation of waste gas from fine-grained heat carrier material takes place, a waste gas discharge outlet being provided at the top portion of said ancillary chamber portion, the bottom portion of said separation chamber sloping inwardly and communicating with a cracking reactor chamber by means of a heat carrier material inlet channel, means in said reactor chamber for introducing hydrocarbon to be cracked into said reactor chamber remote from said heat carrier material inlet channel and means in said reactor chamber for recovering cracked hydrocarbon products from said reactor chamber adjacent said heat carrier material inlet channel, said reactor chamber communicating directly with feed means for said pneumatic elevator conduit by means of a heat carrier material discharge channel, said feed means communicating directly with the lower portion of said elevator conduit adjacent said means for heating heat carrier material within said conduit, for cycling heat carrier material upwardly through said elevator conduit while simultaneously heating the same therewithin, and thence through said separation chamber and said reactor for the cracking of hydrocarbons and finally through said feed means for return to said elevator conduit.

2. Apparatus according to claim **1** wherein said reactor chamber is provided with internal baffle means for passage therethrough of heat carrier material from said inlet channel to said discharge material channel in countercurrent flow with respect to the hydrocarbon material to be cracked, said baffle means including a plurality of vertically spaced apart tiers of laterally spaced, obliquely arranged sets of parallel slats, the angle of inclination of the surfaces of said slats alternating in consecutive tiers.

3. Apparatus according to claim **2** wherein distributor nozzle means are provided in said reactor chamber below said baffle means for introduction of said hydrocarbon material to be cracked, said nozzle means being individually insertable and withdrawable with respect to said reactor chamber, and outlet means in said reactor above said baffle means for recovering cracked hydrocarbons from said reactor.

4. Apparatus according to claim **1** wherein said feed means includes an annular chamber surrounding the lower portion of said pneumatic elevator conduit and communicating therewith by a plurality of slots defined in said pneumatic elevator conduit, said annular chamber being provided along its periphery with radially inwardly directed annular conveying medium inlet means at an axial level adjacent said slots for forcing heat carrier material disposed in said annular chamber radially inwardly through said slots, the bottom end of said pneumatic elevator conduit being provided below the axial level of said slots with upwardly directed central conveying medium inlet means communicating immediately and directly therewith for forcing heat carrier material entering radially through said slots upwardly through said pneumatic elevator conduit, the upwardly directed fuel injector heating means being positioned concentrically within said conveying medium inlet means at said bottom end of the elevator conduit for heating said heat carrier material within said elevator conduit.

5. Apparatus according to claim **1** wherein a plurality of pneumatic elevator conduits is provided, all said conduits communicating with a common separation chamber at their top ends, the flow cross section of said separation chamber being greater than the combined flow cross-sections of said pneumatic elevator conduits, said separation chamber, in turn, communicating with said cracking reactor chamber by means of a plurality of heat carrier material inlet channels, said reactor chamber in turn communicating with a plurality of feed means by means of a plurality of heat carrier material discharge channels, and said plurality of feed means in turn communicating with the lower portions of said plurality of pneumatic elevator conduits, each of said conduits being provided immediately and directly within the

lower end portion thereof with upwardly directed fuel injector heating means for heating heat carrier material during its ascent through each conduit.

6. Apparatus according to claim **5** wherein said common separation chamber is provided with parting walls between the points where the corresponding top ends of said pneumatic elevator conduits communicate with said separation chamber.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,215,505 November 2, 1965

Paul Schmalfeld et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, line 1, for "Paul Schalfed" read -- Paul Schmalfeld --; column 2, line 65, for "refractroy" read -- refractory --; column 3, line 28, for "wihch" read -- which --; column 6, line 39, for "is" read -- in --; line 42, for "be" read -- by --; column 8, line 38, before "elevator" insert -- pneumatic --.

Signed and sealed this 28th day of June 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents