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QUENCH-ELUTRIATOR VESSEL

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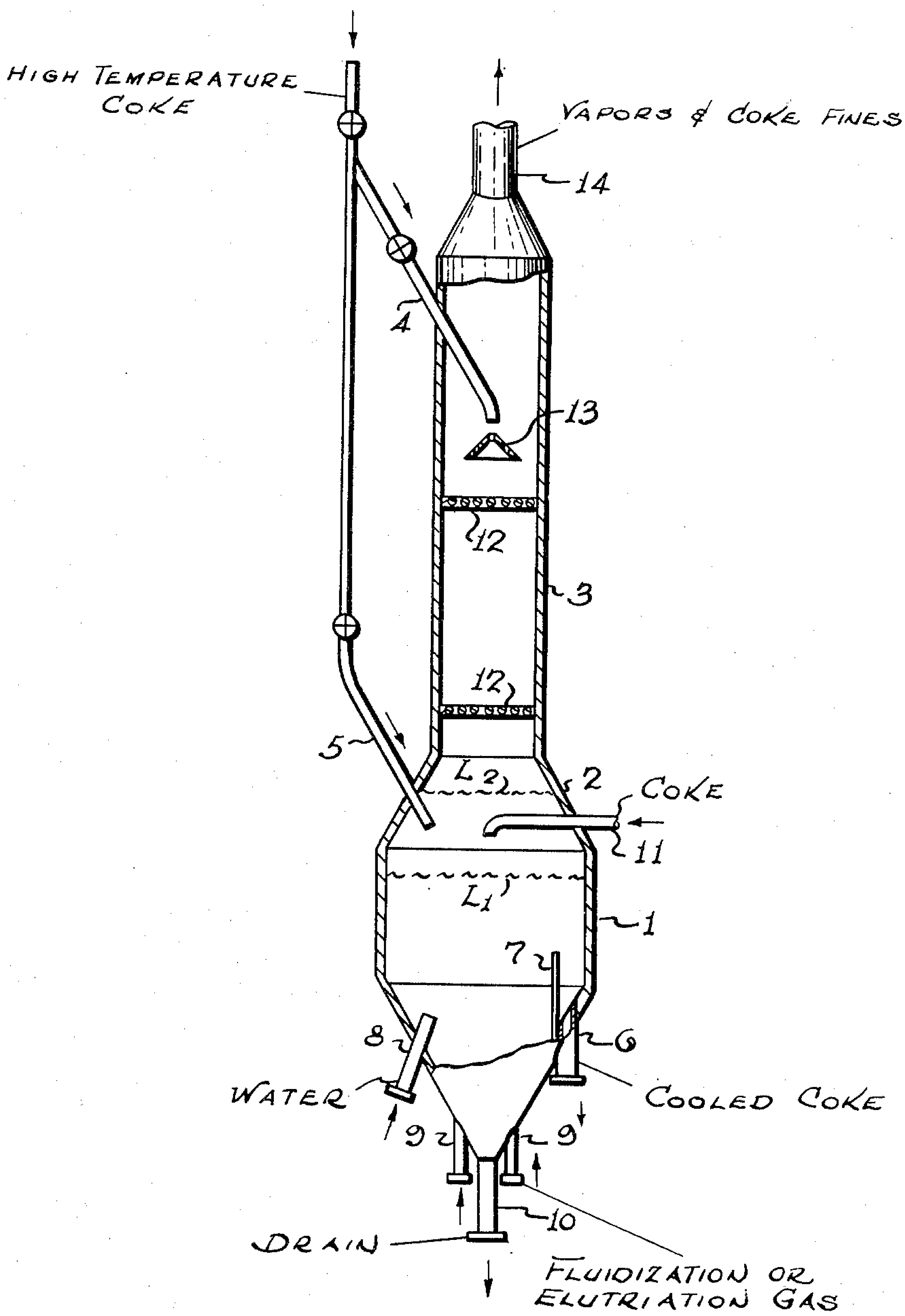

Peter H. Spitz
Thomas G. Reiter
Richard E. Whall
Inventors

By J. C. Small
Attorney

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QUENCH-ELUTRIATOR VESSEL

Peter H. Spitz, New Rochelle, N. Y., and Thomas A. Reiter, Roselle, and Richard E. Whall, Rahway, N. J., assignors to Esso Research and Engineering Company, a corporation of Delaware

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This invention pertains to a process and apparatus for the cooling and classification of high temperature, finely divided solids. More particularly this invention is concerned with a method of quenching and elutriating, i. e., classifying by suspension in a gasiform medium, high temperature coke produced in a hydrocarbon oil fluid coking process. According to the present invention, cool, relatively coarse coke may be withdrawn as product from a coking process, while finer coke particles are selectively retained in the system.

Recently it has been proposed to coke hydrocarbon oils such as petroleum residua by injecting them into a coking vessel containing a fluidized bed of high temperature finely divided solids, e. g., coke, sand, spent catalyst, pumice and the like. In the coking vessel, the oil undergoes pyrolysis in the fluidized bed, evolving lighter hydrocarbons and depositing carbonaceous residue on the solid particles. The necessary heat for the pyrolysis is supplied by circulating a stream of the fluidized solids through an external heater, generally a combustion zone, and back to the coking vessel. This fluid coking process is more fully depicted in co-pending application, entitled, "Fluid Coking of Heavy Hydrocarbons and Apparatus Therefor," S. N. 375,088, filed August 19, 1953, by Pfeiffer et al.

In a typical fluid coking process, the net product coke over that required for combustion is withdrawn from the process and cooled by direct quench with water, without specific arrangements. This product coke ordinarily will have the same particle size and size distribution as that within the process. It is, however, preferable to selectively withdraw coarser particles from the process and to retain the smaller particles or coke fines in the system. By retaining the finer particles, the requirements and thus the cost of providing seed particles or coke growth nuclei is greatly reduced. More effective control over the particle size distribution of product coke is also achieved.

An object of the present invention is to present the art with a method and apparatus for cooling and classifying high temperature finely divided solids. A specific object of the present invention is to propound a method of quenching and elutriating high temperature particulate coke produced in a petroleum oil coking process whereby relatively coarse coke is withdrawn as product and finer coke particles are selectively retained in the system.

Broadly, this invention is applicable to any process wherein it is necessary to cool and classify high temperature particulate solids. Thus this invention may be applied to various processes, particularly processes utilizing the fluidized solids technique, such as shale distillation, catalytic cracking, lime burning, ore roasting, coal coking, coal gasification, etc.

In essence, the objects of this invention are attained by withdrawing finely divided solids at a relatively high temperature from such a process, forming a fluidized bed of solids in the lower portion of a combination quench-elutriator zone, injecting a vaporizable coolant into the fluidized bed to quench the solids and to generate vapor, utilizing the vapor so formed to entrain solids from the bed and to classify or elutriate the solids, and returning the finer, classified, solids to the process.

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The coarser solids are continuously removed from the fluidized bed.

The more specific objects of this invention are obtained by quenching and elutriating coke withdrawn from a hydrocarbon oil fluid coking system in a vessel of novel design. Essentially the preferred quench-elutriator vessel of this invention consists of two sections—a broader bottom section wherein high temperature coke is quenched to about 300° F. in a dense phase by water sprays, thereby generating steam, and a narrow upper elutriating section wherein the quench steam generated below is accelerated to a higher velocity than at the lower section and is used to classify the coke particles. A preferred design is to connect the upper and lower portions of the vessel with an intermediate, frusto-conical, portion whereby more perfect control of the degree of classification may be attained. Degree of classification is the percentage of desired fine material above a specified size present in the solids withdrawn overhead.

In addition to the vessel design, the present invention comprises a method of controlling elutriation of the coke without increasing the amount of elutriating gas, specifically steam, required over and above that obtained from quenching the hot coke. This is important because the steam carrying the elutriated fines must be returned to some part of the hot system where it tends to increase the number or size of cyclones and therefore the cost of recovery equipment.

Control of the degree of classification is obtained in two ways. In a preferred embodiment of the invention, the hot coke is introduced into the upper and lower portions of the quench vessel. By controlling the relative amounts of the coke so introduced the amount of solids loading per volume of elutriating gas is regulated and the degree of classification is regulated.

A second control feature of the present invention is to regulate the amount of solids entrained from the fluidized solids bed in the lower portion of the vessel, and thereby regulate the solids loading in the elutriating zone. The amount of entrainment from the bed is dependent upon the velocity of the fluidizing gas through the upper portion of the fluid bed and through the dense-dilute phase interface between the dense phase bed and the dilute solids suspension phase above the bed. The velocity of the fluidizing gas may be varied by introducing varied amounts of an extraneous fluidizing gas to the base of the quench vessel or by varied amounts of quench liquid into the fluidized bed. Preferably, however, the extent of entrainment from the bed is regulated by varying the areas of the dense dilute phase interface as this will affect the fluidizing gas velocity at this point without altering the fluidizing gas velocity in the lower portions of the fluidized bed. The area of the interface of the fluid bed is changed by controlling the position of the interface along an intermediate frusto-conical portion of the vessel between the quench and elutriation zones. As the position of the interface is moved upwardly along the upwardly converging conical portion, by increasing the amount or volume of fluidized solids in the lower portion, the area of the interface is decreased. In this manner, the amount of entrainment of particles from the bed in the ascending vapors, and the degree of elutriation is readily controlled.

A variation of the invention is also contemplated. Instead of maintaining a fluidized bed of solids in the lower portion, a slurry of the solids may be maintained and coarser solids may be withdrawn as a slurry. This is advantageous in that relatively high-boiling volatilizable media such as a light petroleum oil may be used as the coolant and to furnish the elutriating medium.

Although it is contemplated that the present invention will be used to classify solids according to size, in some instances the classification can be made on the basis of particle density and/or size if the particles do not have a uniform unit density.

The attached drawing, forming a part of this specification, shows a preferred embodiment of the present invention which is particularly adapted to achieve the objects of the invention.

Referring now to the drawing, a quench-elutriator vessel is shown, typified by a vessel **1**, of enlarged diameter adapted to contain a fluidized bed of coke particles and an elutriating standpipe **3**, of lesser diameter wherein coke particles are classified by selective entrainment.

The coke supplied to the quench vessel can be withdrawn from any point within a hydrocarbon oil fluid coking system. It is preferred, however, to withdraw coke which has just been heated, i. e., burned in a combustion zone, to bring it to a temperature of about 1000°–1800° F., e. g., 1050°–1250° F. Although the invention is operable on coke of a wide particle size range, it is contemplated that it will usually be applied to coke having particle size of approximately 0 to 1000 microns. This coke from a fluid coking process usually has a fairly uniform particle density, normally about 90 lbs./cu. ft., but it can vary from 40 to 150 lbs./cu. ft.

As a rule, the quench-elutriator vessel will operate at about the pressure of the fluidized systems which may be 13 to 50 p. s. i. a.

The high temperature coke is introduced into the upper or elutriating portion of the quench vessel by line **4** and into the lower portion by line **5**. 0 to about 100% of the coke introduced into the vessel may be passed through line 4. A fluid bed of the coke having a density of 25 to 65 lbs./cu. ft. is maintained in the lower portion at a temperature above the boiling point of water, e. g., 220° to 600° F. Water in amounts of 0.1 to 0.5 pound per pound of solids introduced into the vessel is injected into this fluid bed through a nozzle **8**. This generates steam which fluidizes the bed and passes upwardly through the vessel with some entrainment of solids from the bed. Additional fluidization gas may be admitted to the lower portion by lines **9** to adjust the superficial gas velocity to about 0.2 to 5 ft./sec. in the bed. These connections can be used for injecting additional steam for elutriation, if necessary.

The ascending steam flows countercurrently to the descending solids introduced by line 4. By proper adjustment of velocity, which can range from 3 to 20 ft./sec., coke fines are elutriated or stripped from the descending solids and are conveyed upwardly along with the steam through line **14**.

For maximum efficiency, it is preferred that the ratio of the cross-sectional area of the vertical elutriating conduit to that of the fluid bed vessel be 0.1 to 0.5 and that the elutriating conduit have a length over diameter ratio of 2 to 8, or more.

Cool, relatively coarse coke is withdrawn from the fluid bed by line **6** as a product and will usually amount to 30 to almost 100% of the coke charged to the vessel. Baffle **7** maintains a quiescent area around the coke withdrawal point.

To effect even dispersion of the particles through the ascending steam, various distributing or mixing means may be used in the elutriation zone. Thus distributing grids **12** promote a more efficient co-mingling of the steam and solids. Other arrangements may be used, such as perforated plates, horizontal and vertical baffles, etc. Baffle **13** is used to inhibit flow of the steam upwardly into pipe 4 and to initially distribute the solids issuing from the pipe. Holes are provided in baffle **13** to allow solids to be introduced into the area immediately below the baffle.

In some applications of this invention, it may be desired to introduce all of the solids into either the elutriating section or the quench section of the quench-elutrator vessel. By introducing the solids into the fluid bed of the quench section and causing entrainment therefrom, a much finer degree of classification will be obtained.

A special feature of this invention, in its preferred form, is to construct the quenching vessel in such a manner that an intermediate portion **2** is tapered or frustoconical in shape. This allows control of the solids entrainment from the fluid bed, as before described. By controlling the pseudo-liquid level or dense-dilute phase interface of the fluid bed, with respect to this tapered portion, the velocity of the fluidization gases in the upper portion of the bed is controlled, due to the upwardly converging vessel walls which cause the area of the interface to vary and thus the entrainment from the bed is controlled. The level of the dense fluid bed can be held below the conical portion **2** as illustrated by level L_1 or along it, as illustrated by level L_2. The entrainment of the particles from the fluid bed itself increases as the pseudo-liquid level of the bed moves up along the taper towards the position L_2. By increasing the entrainment, the amount of solids removed overhead through line **14** is increased.

The steam and solids removed overhead can be returned to the coking system at any desired point. The steam, along with the fines, may be returned to the base of the coking vessel in order that the steam may be used as fluidization steam. Alternately, the steam and fines may be introduced into the dilute phase above the fluidized bed in the coking vessel.

When a fluid bed burning or combustion vessel is used in conjunction with a petroleum oil fluid coking vessel, as in the previously referred to Pfeiffer et al. application, it is preferred to withdraw the solids to be cooled and classified from the dense phase bed of the burner and to admit the contents of line 14, i. e., the finer particles, elutriated from the bed, to the dilute phase above the burner bed instead of the contents of the line into the coking vessel. This practice reduces the load on the fractionation or separating equipment handling the hydrocarbon vapors from the coker.

Pipe **11** may be used to introduce coke withdrawn from low points in the main coke circulation system and from the base or cone of the burner vessel, as during start-up after the unit has been shut down.

As a specific example of the present invention, for a quench-elutriator vessel, as shown in the attached drawing, having a lower portion 5′6″ in diameter and an upper portion 2′8″ in diameter and 12 ft. long; 115 cu. ft. of coke having a fluidized density of 38 lbs./cu. ft. is retained in the fluidized bed at a superficial fluidizing steam velocity of about 1.5 ft./sec. and a temperature of 300° F. 20,000 lbs. of coke per hour at a temperature of 1125° F. and a particle density of 90 lbs./ft.^{3} is introduced into the quench-elutriator vessel. 0.25 lb. of water per pound of solid introduced in the vessel, at a temperature of 85° F., is sprayed into the fluid bed. The vessel is operated at a pressure of 6 p. s. i. g. Under these conditions, the steam will have a velocity of about 7 ft./sec. in the elutriating zone at a solids loading of about 1.83 lbs./cu. ft. 33% of the coke introduced into the vessel is withdrawn overhead with the elutriating steam at a temperature of 700–1100° F. and the remainder removed from the fluid bed as coarse coke product.

For the above conditions, the following table presents the approximate extent of classification that may be obtained.

Table

Percent Retained on Mesh Size Indicated	Charge	Coarse Product
48	19.0	23.0
60	52.0	59.0
80	87.5	91.0
100	93.5	96.0
200	99.7	99.9

Although a circular conduit is preferred for the elutriating section, it is conceivable that other shapes, such as restangular, may be used. Further, although the elutriating section has been described as being substantially vertical, there are advantages, in some applications, to inclining the elutriating conduit or pipe from about 1° to 60° or more. By doing this, coarser solids will be refluxed downwardly in a relatively dense phase along the lower portion of the inclined conduit, while the finer solids are stripped from the descending solids stream and conveyed upwardly. Such an inclined section may be constructed in multiple and/or cascade arrangements.

In another variation of the present invention, the elutriating zone may be of the same diameter as the quenching zone and means may be placed in the elutriating zone to restrict the vapor passageway and increase the vapor velocity. Thus, large, unfluidizable particles or packing may be placed in the elutriating of classifying zone to promote the separation of the coarse and fine particles. Alternately, vanes, inclined tubes or baffles, etc. may also be used.

Having described the invention, what is sought to be protected by Letters Patent is concisely set forth in the following claims.

What is claimed is:

1. In a hydrocarbon oil fluid coking system wherein oils are pyrolytically upgraded by contact with high temperature particulate coke in a coking vessel, wherein particulate coke is circulated from said coking vessel to a combustion vessel adapted to contain a fluidized bed of particulate coke and back to supply heat for the pyrolysis, and wherein hydrocarbon vapors and coke are withdrawn from said system as product, the improvement for the elutriating of coke fines from and the quenching of said coke removed as product comprising a vertically disposed circular conduit having an enlarged lower portion adapted to contain a bed of fluidized particulate solids, an upper portion of lesser cross-sectional area than said lower portion and a frustoconical portion intermediate between said upper and lower portion, conduit means for withdrawing coke from said system and introducing said coke into said upper and lower portions, conduit means for introducing water into said lower portion, conduit means for withdrawing vapors and coke fines from said upper portion and conduit means for removing particulate solids from said lower portion.

2. The apparatus of claim 1 comprising baffling means located in said upper portion.

3. The apparatus of claim 1 when said apparatus includes conduit means for withdrawing coke from said fluidized bed of said combustion vessel and introducing said coke into said vertically disposed circular conduit, and also includes conduit means for withdrawing vapors and coke fines from said upper portion and introducing said vapors and coke fines into the dilute phase suspension above said fluidized bed of said combustion vessel.

4. The apparatus of claim 1 when the ratio of cross-sectional area of said upper portion to said lower portion is in the range of 0.1 to 0.5 and said upper portion has a length over diameter ratio in the range of 2 to 8.

5. In a hydrocarbon oil conversion process wherein an oil is pyrolytically upgraded by contact with high temperature fluidized particulate coke in a coking zone and wherein said particulate coke is circulated to an external combustion zone containing a fluidized bed of coke and back to maintain a reaction temperature, said coke having a size in the range of about 0 to 1000 microns and a density in the range of 40 to 150 pounds/cu. ft., a method of selectively retaining coke fines in said process while withdrawing cool coke as product which comprises passing a first portion of particulate coke from said fluidized bed of coke in said external combustion

zone to the upper portion of an elutriation zone, passing a second portion of particulate coke from said fluidized bed of coke in said external combustion zone to the lower portion of said elutriation zone, said elutriation zone comprising an enlarged lower portion adapted to contain a fluidized mass of said particulate coke, a tapered intermediate portion and an elongated upper portion of lesser cross-sectional area than said enlarged lower portion, maintaining a fluidized mass of particulate coke in said lower portion at a temperature above the boiling point of water, introducing water into said lower portion whereby quantities of steam are produced thereby fluidizing said mass at a velocity in the range of 0.2 to 5 ft./sec., controlling the entrainment of coke particles from said fluidized mass in said steam responsive to the pseudo-liquid level of said fluidized mass along said tapered intermediate portion, passing said steam upwardly along with entrained coke particles through said upper portion at a velocity in the range of 3 to 20 ft./sec. whereby coke fines are selectively elutriated, passing said steam and coke fines from said upper portion to the dilute phase above said fluidized bed of coke in said external combustion zone and withdrawing relatively cool coke in amounts in the range of 30 to about 100% of the coke charged to said elutriation zone from said lower portion as product.

6. Apparatus of the type described for the classification and cooling of high temperature particulate solids, comprising an enlarged vessel of circular cross-section adapted to contain a bed of fluidized solids, an elongated circular conduit superposed on said enlarged vessel connected thereto by a conical frustrum, inlet means for admitting high temperature particulate solids to said enlarged vessel, means for maintaining a fluidized bed of particulate solids in said enlarged vessel, means for injecting a vaporizable liquid into said enlarged vessel, means for withdrawing vapors and entrained solids from the upper portion of said elongated circular conduit and means for withdrawing particulate solids from said fluidized bed.

7. Apparatus of claim 6 wherein said elongated circular conduit is inclined 1° to 60° from the vertical.

8. Apparatus of the type described for the classification and cooling of high temperature particulate solids, comprising an enlarged vessel of circular cross-section adapted to contain a bed of fluidized solids, an elongated circular conduit superposed on said enlarged vessel connected thereto by a conical frustrum, the ratio of cross-sectional area of said circular conduit to that of said enlarged vessel being in the range of 0.1 to 0.5 and the length over diameter ratio of said elongated circular conduit being in the range of 2 to 8, inlet means for admitting high temperature particulate solids to said enlarged vessel, means for maintaining a fluidized bed of particulate solids in said enlarged vessel, means for injecting a vaporizable liquid into said enlarged vessel, means for withdrawing vapors and entrained solids from the upper portion of said elongated circular conduit, and means for withdrawing particulate solids from said fluidized bed.

9. Apparatus of claim 8 comprising in addition thereto distributing means located in the lower portion of said elongated conduit whereby vapors and solids are more perfectly contacted.

10. A process for classifying high temperature particulate solids which comprises maintaining a fluid bed of particulate solids in the lower portion of a quench-elutriation zone, said quench-elutriation zone comprising an upper elutriation portion of reduced cross-sectional area and an intermediate tapered portion connecting to said lower portion, introducing a vaporizable liquid coolant into said bed to form vapors, said bed being maintained above the vaporization temperature of said coolant, introducing high temperature particulate solids into said lower portion, flowing said vapors along with solids

entrained from said bed upwardly through said elutriation portion at an increased velocity sufficiently low to permit relatively coarse solids to de-entrain while controlling the amount of entrainment from said bed responsive to the area of the upper surface of said bed, said area being varied by regulating the position of said surface with respect to said tapered portion, whereby the degree of classification is controlled, recovering fine solids entrained in said vapors overhead from said elutriation portion, and withdrawing cooled relatively coarse solids from said bed.

11. The process of claim 10 wherein said elutriation portion is inclined 1° to 60° from the vertical.

12. The process of claim 10 which comprises admitting a portion of said high temperature particulate solids into

the upper portion of said elutriation portion, and further controlling the degree of classification obtained responsive to the amount of high temperature particulate solids so admitted to said elutriation portion.

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