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APPARATUS AND METHOD FOR FLASH EVAPORATING OILS

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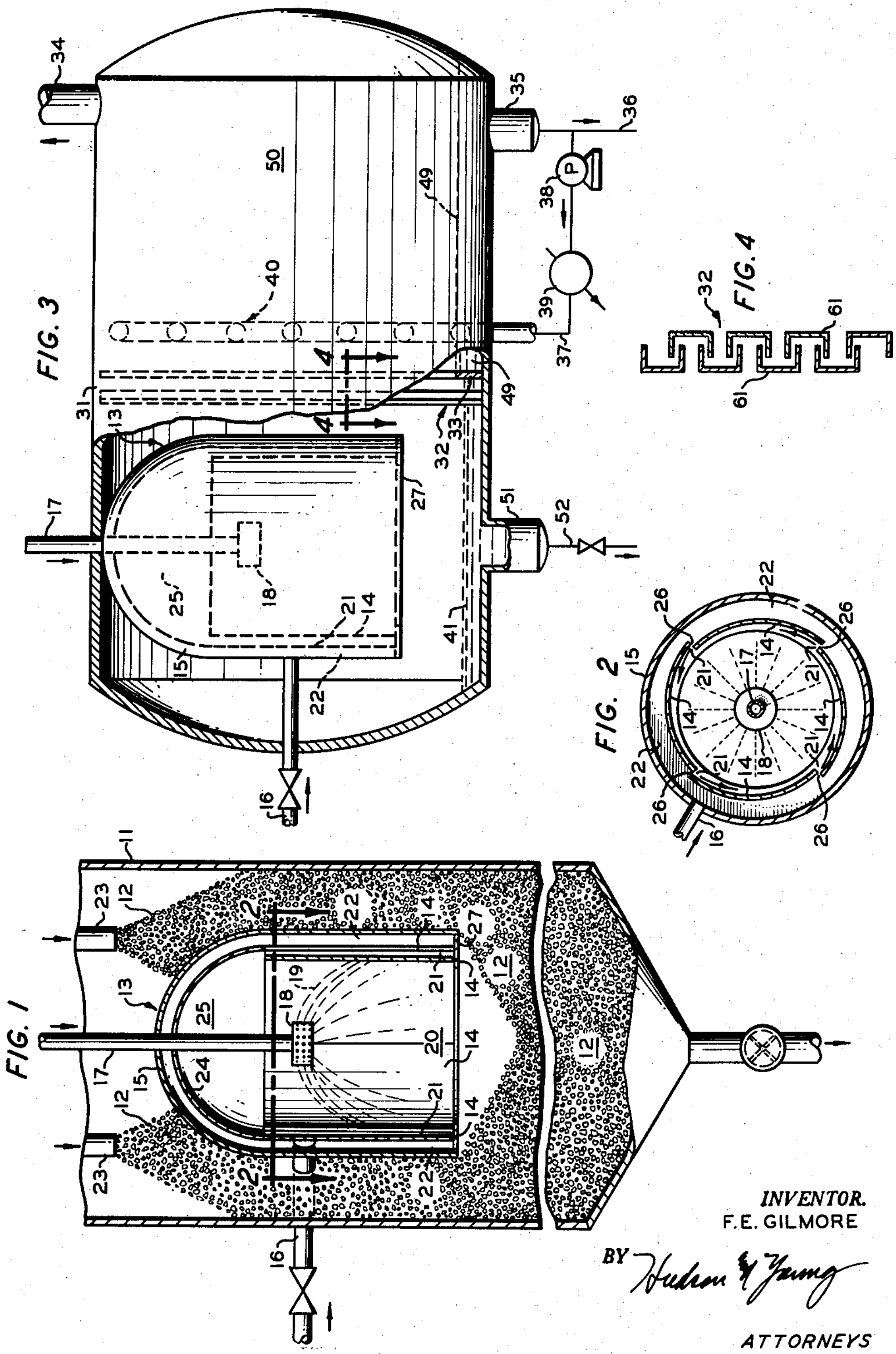

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APPARATUS AND METHOD FOR FLASH EVAPORATING OILS

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22 Claims. (Cl. 208—48)

This invention relates to a method and apparatus for the flash evaporation of oils. In one aspect it relates to a method and apparatus by which hot feed oil is flash vaporized for feeding as charge stock to a high temperature vapor phase catalytic or noncatalytic process. In another aspect it relates to a method and apparatus for vacuum flash vaporizing such hydrocarbon oils as high boiling gas oils and topped crude oils in a vacuum chamber to obtain gas oils overhead and heavy residual oils as bottom products.

The problem of vaporizing high boiling oils without formation of excessive carbonaceous deposits exists in many industrial processes. It is acute in many processes which involve preparation of vaporous feed materials for high temperature vapor phase reactions.

Methods have been devised for vaporizing hot feed oils inside a high temperature reaction chamber, as for example, a catalytic cracking reactor, but such methods have heretofore usually resulted in formation of deposits of carbonaceous matter on the equipment. The accumulation of such deposits after a time necessitates shutdowns and cleaning of equipment.

I have devised apparatus and a method by which high boiling oils and even topped crude oils are vaporized with the formation of substantially no solid carbonaceous matter in the form of deposits requiring deactivation of processing equipment for cleaning. I have furthermore devised a method and apparatus for the vacuum flashing of such heavy oils as topped crude oils without substantial carbon deposition.

An object of my invention is to provide an apparatus and a method for flash vaporizing high boiling oils without production of appreciable carbonaceous deposits.

Another object of my invention is to provide such apparatus and method for superatmospheric or subatmospheric flash vaporizing of high boiling oils without producing appreciable carbonaceous deposits.

Still another object of my invention is to provide an apparatus and method by which hot oils are flash vaporized within catalytic and noncatalytic high temperature vapor phase reaction vessels without formation of carbonaceous deposits requiring equipment deactivation for cleaning or at least minimizing the frequency of such equipment deactivation periods.

Still other objects and advantages of my invention will be obvious to those skilled in the art upon reading the following description, which taken with the attached drawing, forms a part of this specification.

I accomplish these and other objects by providing a vaporizer comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with said first shell, said second shell being disposed a spaced distance from said first shell so as to provide an annular space therebetween, an annular ring attached to the lower ends of said first and second shells in such a manner as to close the annular space therebetween, at least one upright slot in the said second shell disposed therein in such a manner

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that a fluid flowing from said annular space, enters the space within said second shell in a direction substantially tangential to the inner wall of said second shell, means to introduce steam into said annular space and a nozzle for spraying oil feed into said space within said second shell.

I further provide a method for flash vaporizing a difficultly vaporizable hot oil comprising introducing steam tangentially into a vaporizing zone in such a manner as to form a layer of steam of high concentration flowing around the inner surface of the containing wall of said zone, introducing hot oil to be flash vaporized into said zone as a spray directed toward said layer of steam and removing steam containing oil vapors from said zone.

In the drawing, Figure 1 is an elevational view, partly in section, of a portion of a reaction vessel illustrating my invention.

Figure 2 is a sectional view taken on the line **2—2** of Figure 1.

Figure 3 is an elevational view, partly in section, illustrating another embodiment of my invention.

Figure 4 is a sectional view taken on the line **4—4** of Figure 3.

Referring to the drawing and specifically to Figure 1, reference numeral **11** identifies the wall of a containing vessel. I will describe my vaporizer apparatus as applied to a catalytic conversion operation carried out in the vessel in which my vaporizer is situated merely as an example of its construction and use. It is to be understood, however, that the vaporizer is also used for the production of vapors for noncatalytic conversion in the vaporizer containing vessel, or in the production of vapors in one vessel for catalytic or for noncatalytic conversion in another vessel. My vaporizer, under some conditions, is also used in pebble heater conversion vessels.

When my invention is applied to a catalytic conversion operation vessel **11** is a catalytic reaction or conversion chamber in which is disposed a bed of catalyst **12**, as for example, a moving bed of catalyst. Tubes **23** are catalyst inlet tubes for introduction of regenerated catalyst into vessel **11**. A flash unit **13**, which is also termed an evaporator, is positioned within the catalyst chamber as illustrated.

This flash unit or evaporator **13** is shaped like an inverted cup and has an outer shell **15** and an inner shell **24**. The annular space between these shells or walls is identified by reference numeral **22**. Figure **2** is a cross section of this evaporator taken along the line **2—2** of Figure 1 and illustrates clearly the construction of the evaporator. The upper portion **25** of the inner shell **24** is the shape of an inverted cup or of a bell and is concentric with the upper portion of the outer shell **15**. The lower portion of the inner shell **24** is composed of a plurality of plates **14**, the cross sections of which are substantially circular arcs. As illustrated in Figures 1 and 2, there are four plates **14** making up this portion of the inner shell **24**. Each plate **14** is arranged with respect to each adjacent plate in such a manner that fluid from the annulus **22** enters the space within the inner shell **24** in a direction at least substantially tangent to said inner wall. Steam is injected from pipe **16** into the annulus **22** and it flows substantially in the form of sheets **21** through the openings **26** between successive plates **14** into the evaporator. An annular ring **27** is attached to the lower edges of shell **15** and plates **14** so that all steam will be forced to leave the annulus **22** by way of the slots **26**.

Hot oil feed to the reaction vessel, with or without added steam, flows from a source, not shown, through pipe **17** and spray nozzle **18**. The preferred type of spray nozzle 18 is one which causes the stream of hot feed issuing therefrom to whirl thereby throwing the liquid as a fine mist 19 outwardly toward the inner wall of the flash chamber but allowing the vapor 20 to pass downward along the vertical axis of the flash chamber. Steam passing through slots 26 enters the flash chamber tangentially causing the contents of the chamber to rotate or whirl about the vertical axis, with the speed of rotation decreasing toward the axis. This method of steam inlet causes the entire inner wall as represented by plates 14 to be blanketed with rapidly moving steam, usually superheated, to promote heating and evaporation of the liquid feed spray. A portion of the superheat of the steam results from heat received from the hot catalyst, usually, but not necessarily surrounding the portion of the steam inlet pipe 16 which is inside the vessel and a portion of the outerwall of the evaporator 13 (illustrated in the drawing).

As a result of this method of steam injection the concentration of steam is greatest at the inner surface of the plates 14 and gradually becomes less toward the axis of the evaporator. As a result of this mode of operation the sprayed liquid mist is progressively evaporated in regions containing greater concentrations of steam and, if desired, higher temperatures. The decreased partial pressure effect so obtained results in a high rate of evaporation for a given steam rate. Furthermore, the steam flowing around the evaporator inner walls greatly diminishes the deposition of carbonaceous matter thereon because of the characteristic effect of steam in reducing carbon formation during cracking, and the steam jacketed chamber prevents the plates 14 from getting sufficiently hot to crack oil reaching it. This steam furthermore insures that oil not vaporized will enter the catalyst below the evaporator without first contacing meal parts sufficiently hot to promote noncatalytic cracking and deposition of carbon. The steam introduced into the vessel has, of course, an inlet temperature sufficiently below the catalyst temperature as to maintain the plates 14 at a temperature below that which would cause the above mentioned noncatalytic cracking and deposition of carbon.

The temperature of the steam is furthermore intended to be sufficiently low that any oil, such as the more difficultly vaporizable and/or nonvaporizable portion of a topped crude oil, which does reach the surface of plates 14, will not be cracked with the simultaneous formation of carbon thereon but will remain as a liquid and flow generally downward by gravity and finally enter the catalyst.

Another advantage of my invention is in the action of the double wall of the vaporizer because steam introduced through, say pipe 16, into the annulus 22 between the walls tends to maintain the temperature of the inner wall well below a cracking and/or solid carbonaceous matter forming temperature which of course exists in the mass of catalyst in a catalytic process reaction chamber, and in a mass of hot pebbles in a noncatalytic pebble heater reaction chamber. While the temperature of the steam is increased on passing through the vaporizer the steam nevertheless maintains at least the inner wall of the vaporizer below that at which solid carbonaceous matter forms.

Figure 1 has been described above as applied to a catalytic process wherein the vaporizer vaporizes an oil and the vapors and any unvaporized liquid flow downward and enter the downward moving bed of hot catalyst. My evaporator is also used in vaporizing hot oils within a pebble heater reaction chamber, as mentioned hereinabove. In a pebble heater reactor chamber employed for noncatalytic cracking of, for example, hydrocarbon oils, the operation of my evaporator is similar to its operation when used within a catalytic cracking chamber. The evaporator then produces a vaporous feed with little to no residual liquid and free from solid carbonaceous matter for noncatalytic reaction within the mass of hot pebbles.

When employed for the production of vaporous feed for catalytic and noncatalytic reactions, as above described, my evaporator is operated within a vessel maintained at a relatively high temperature and under superatmospheric pressure conditions. My evaporator is equally applicable in operations involving subatmospheric pressures, i. e., under vacuum.

In plant practice and for large capacity operations it is usually desirable to employ more than one evaporator 13 is a catalytic conversion or pebble heater vessel. When using more than one evaporator they are usually installed at the same level.

Figure 3 illustrates the application of my evaporator to the vacuum vaporization of such oils as topped crude oils. In this embodiment the vaporizer apparatus 13 is disposed as illustrated in one end of a horizontally disposed tank 31. This evaporator 13 is similar to the corresponding evaporator shown in Figure 1, i. e., it is made up mainly of outer shell 15, and the upper inner wall 25, and plates 14 of inner shell 24. These plates 14 are disposed relative to one another as illustrated in Figure 2. Annulus 22 is provided between the outer shell 15 and the inner elements 14 and 25. Hot oil feed from a source, not shown, passes through pipe 17 and is sprayed through spray nozzle 18 in the same manner as in Figure 1, that is, liquid spray or mist is thrown outwardly and at least substantially radially toward plates 14 while vapors flow downward axially with respect to the evaporator 13. In the distillation of topped crude oils to produce distillate gas oils there is usually at least a minor amount of asphalt or tar containing material which, of course, remains as unvaporized bottoms. This latter material is thrown outwardly by the spray nozzle 18 and that portion which does not vaporize impinges against plates 14 where it collects as liquid and runs downward by gravity and drips from plates 14 forming a lake of residuum 41. This residuum 41 is withdrawn from the system via leg 51 and a pipe 52 for such disposal as desired. The mechanism of the vaporization of topped crude oil components in vessel 31 is substantially the same as disclosed relative to Figure 1. As oil droplets are thrown out radially from the spray nozzle 18 they encounter progressively higher concentrations of steam, that is, the partial pressure of the oil vapors becomes less and less, which condition is conducive to rapid vaporization of the oil. Steam of course, is introduced via pipe 16 and flows into the annulus 22 from which it flows through slots 26 (Figure 2) as sheets or streams of steam 21.

Pipe 34 leads from vessel 31 to a guard chamber, if necessary, and thence to a vacuum producing means, not shown.

Steam and hydrocarbon vapors leaving the bottom open end of the vaporizer 13 pass through a baffle assembly 32 composed of vertically arranged angle irons, or channel irons 61, the latter being illustrated in cross section in Figure 4. Entrained mist which might possibly contain residuum components is separated from vapors as the latter pass through the baffle assembly. Compartment 50 is a condensing section in which cool oil is sprayed from spray apparatus 40 into the hot oil vapors and steam which have passed through the baffle assembly 32.

A ring dam 33 is attached to the inner wall of the vessel to serve as a retainer to keep residuum in the vaporizer end of the vessel so it can be removed via leg 51 and pipe 52. Gas oil condensed in the condensing section 50 drops out to form a lake of oil 49. This oil is withdrawn from the system via leg 35 and pipe 36, that portion being required for condensing liquid is passed through pipe 37 by pump 38, through cooler 39 and is sprayed through oil sprayer 40. That portion of the gas oil not required for condensing purposes is removed from the system through pipe **36** as clean gas oil for such disposal or use as desired.

If desired, the cooler **39** is operated to cool the oil flowing through pipe **37** to such a temperature that steam will not be condensed to water in the condensing zone **50**. If, however, for any reason it is desired to condense steam in zone **50** for lightening the load on the vacuum producing means, it is merely necessary to regulate the temperature and/or the flow of the plant cooling water or other coolant to the cooler. In the operation of the vaporizer under vacuum conditions, as illustrated in Figure 3, considerably less steam will be required than when operating under superatmospheric pressures, as will be realized by those skilled in the art.

The vaporizer assembly in either embodiment is obviously rigidly held in place by structural elements.

Materials of construction for my vaporizer are in general selected from among those commercially available. Consideration is given as regards operating pressures when constructing the apparatus.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto.

I claim:

1. A vaporizer comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with said first shell, said second shell being disposed a spaced distance from said first shell so as to provide an annular space therebetween, an annular ring attached at the lower ends of said first and second shells in such a manner as to close the annular space therebetween, the lower end of said second shell being open, at least one upright slot in said second shell disposed therein in such a manner that a fluid flowing from said annular space through said slot enters the space within said second shell in a direction substantially tangential to the inner wall of said second shell, means to introduce steam into said annular space and a nozzle for spraying oil feed into said space within said second shell.

2. A vaporizer comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with and at a spaced distance from said first shell so as to form an annular space therebetween, an annular ring attached to the lower portions of said first and second shells in such a manner as to close the annular space therebetween, the lower end of said second shell being open, said second inverted cup-shaped shell comprising at least a generally cylindrical sidewall, a generally vertical slot in said cylindrical sidewall in such a manner that fluid passing from said annular space into the space within said second shell enters said space in said second shell in a direction substantially tangent to the inner surface of said cylindrical sidewall, means to introduce steam into said annular space, and means to spray hot oil to be vaporized into said space within said second shell.

3. A vaporizer comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with and at a spaced distance from said first shell so as to form an annular space between said first and second shells, a generally annular ring attached to the lower ends of said first and second shells in such a manner as to close the annular space therebetween, the lower end of said second shell being open, said second inverted cup-shaped shell comprising, in combination, a bell-shaped dome and a generally cylindrical sidewall attached at its upper end to the lower edge of said dome, said generally cylindrical sidewall being formed as at least one spiral with the ends thereof overlapping and forming at least one slot therebetween in such a manner that fluid passing from said annular space into the second cup-shaped shell enters said second shell in a direction substantially tangent to the inner surface of said generally cylindrical sidewall, means to introduce steam into said annular space and means to spray hot oil to be vaporized into said space in said second shell.

4. A vaporizer comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with and at a spaced distance from said first shell so as to form an annular space between said first and second shells, a generally annular ring attached to the lower ends of said first and second shells in such a manner as to close the annular space therebetween, the lower end of said second shell being open, said second inverted cup-shaped shell comprising, in combination, a bell shaped dome, a plurality of curved plates forming substantially a hollow cylinder, the upper edges of said curved plates being attached to the lower edge of said dome, the lower edges of said curved plates being attached to said annular ring, one corresponding upright edge of each curved plate overlapping the adjacent upright edge of the next successive curved plate to provide a slot between adjacent edges of each successive pair of plates in such a manner that fluid passing from said annular space through said slots passes through said slots in a direction substantially tangent to the inner surfaces of the respective curved plates and in the same direction, means to introduce steam into said annular space and means to spray hot oil to be vaporized into said second shell.

5. An apparatus for cracking hydrocarbons in the presence of solid particulate material comprising, in combination, a reaction vessel, at least one means to vaporize liquid hydrocarbon feed in said vessel, a bed of solid particulate material in said vessel, means to introduce solid particulate material into said vessel and means to remove said material in such a manner that said material contacts substantially only the outer surface of said means to vaporize liquid hydrocarbon feed, said means to vaporize liquid hydrocarbon feed in said vessel comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with and at a spaced distance from said first shell so as to form an annular space between said first and second shells, a generally annular ring attached to the lower ends of said first and second shells in such a manner as to close the annular space therebetween, the lower end of said second shell being open, said second inverted cup-shaped shell comprising, in combination, a bell-shaped dome and a generally cylindrical sidewall attached at its upper end to the lower edge of said dome, said generally cylindrical sidewall being formed as a spiral with the ends thereof overlapping and forming at least one slot therebetween in such a manner that fluid passing from said annular space into the second cup-shaped shell enters said second shell in a direction substantially tangent to the inner surface of said generally cylindrical sidewall, means to introduce steam into said annular space and means to spray hot oil to be vaporized into said space in said second shell.

6. An apparatus for flash vaporizing a difficulty vaporizable oil comprising, in combination, a vaporizer vessel, means in communication with said vessel to produce a vacuum therein, at least one means to flash vaporize said oil in said vessel, means to withdraw unvaporized residuum from said vessel, a condenser in said vessel to condense flash vapors and means for withdrawing condensate from the vessel, said means to flash vaporize said oil in said vessel being near one end thereof and comprising, in combination, a first inverted cup-shaped shell, a second inverted cup-shaped shell disposed within and in general concentric with and at a spaced distance from said first shell so as to form an annular space between said first and second shells, a generally annular ring attached to the lower ends of said first and second shells in such a manner as to close the annular space therebetween, the lower end of said second shell being open,

said second inverted cup-shaped shell comprising, in combination, a bell shaped dome and a generally cylindrical sidewall attached at its upper end to the lower edge of said dome, said generally cylindrical sidewall being formed as a spiral with the ends thereof overlapping and forming at least one slot therebetween in such a manner that fluid passing from said annular space into the second cup-shaped shell enters said second shell in a direction substantially tangent to the inner surface of said generally cylindrical sidewall, means to introduce steam into said annular space and means to spray hot oil to be vaporized into said space in said second shell.

7. A method for flash vaporizing a difficultly vaporizable hot oil comprising introducing steam tangentially into a vaporizing zone through the entire vertical side wall length thereof in such a manner as to form a layer of steam of high concentration flowing around the inner surface of said side wall, spraying hot oil to be flash vaporized in a direction from the axis of said zone toward said layer of steam adjacent said wall whereby the oil spray contacts steam of progressively higher concentration as the sprayed oil approaches the wall of said zone and removing steam containing oil vapors from said zone.

8. The method of claim 7 wherein the vaporizing operation is carried out under superatmospheric pressure.

9. The method of claim 7 wherein the vaporizing operation is carried out under subatmospheric pressure.

10. A method for flash vaporizing a difficultly vaporizable hot oil comprising introducing steam tangentially into a vaporizing zone through the entire vertical side wall length thereof in such a manner as to form a layer of steam of high concentration flowing around the inner surface of said side wall, spraying hot oil to be flash vaporized in a direction from the axis of said zone toward said layer of steam adjacent said wall whereby the oil spray contacts steam of progressively higher concentration as the sprayed oil approaches the wall of said zone, removing steam containing oil vapors and withdrawing unvaporized oil collected by gravity from said wall of said zone as separate products.

11. A method for flash vaporizing at least a portion of a difficultly vaporizable hydrocarbon oil with formation of a minimum amount of solid carbonaceous matter comprising maintaining a helically rotating layer of steam adjacent the inside surface of the inner vertical wall of a double-walled vaporizing zone by passing steam from a space intermediate the walls of said zone tangentially through the inner wall throughout its entire vertical length into said zone, spraying hot oil to be vaporized in a direction from the axis of said zone toward said layer of steam, introducing steam at a temperature sufficiently high to vaporize the more easily vaporizable portion of said oil but below a temperature at which unvaporized oil forms solid carbonaceous matter into said space as the second mentioned steam, and removing unvaporized oil and a hot mixture of steam and oil vapors separately from said zone.

12. A method for feeding a difficultly vaporizable hydrocarbon oil in the vapor state to a high temperature hydrocarbon cracking zone comprising introducing steam tangentially into a vaporizing zone through the entire vertical side wall length thereof in such a manner as to form a layer of steam of high concentration flowing around the inner surface of said side wall, spraying said hydrocarbon oil in a heated condition in a direction from the axis of said zone toward said layer of steam, and flowing a mixture of steam and oil vapors from said vaporizing zone directly into said hydrocarbon cracking zone maintained under conditions to crack said oil vapors.

13. In the method of claim 12 wherein said cracking zone is a catalytic cracking zone.

14. In the method of claim 12 wherein said cracking zone is a noncatalytic cracking zone.

15. In the method of claim 12 wherein said cracking zone is a noncatalytic pebble heater cracking zone.

16. A method for the vapor phase cracking of a difficultly vaporizable hydrocarbon oil comprising maintaining a helically rotating layer of hot steam adjacent the inner wall of an oil vaporizing zone by injecting hot steam tangentially into said zone through the entire vertical side wall length thereof, said vaporizing zone being disposed within a vapor phase hydrocarbon oil cracking zone, spraying said hydrocarbon oil in a heated condition in a direction from the axis of said vaporizing zone toward said layer of steam, introducing particulate material at least at a desired hydrocarbon cracking temperature into the upper portion of said cracking zone and adjacent said vaporizing zone, passing steam and oil vapors from said vaporizing zone into contact with said particulate material and withdrawing particulate material and cracked vapors from said cracking zone.

17. In the method of claim 16 wherein said particulate material is catalytic particulate material.

18. In the method of claim 16 wherein said particulate material is noncatalytic particulate material.

19. A method for the vapor phase cracking of a difficultly vaporizable hydrocarbon oil comprising maintaining a helically rotating layer of hot steam adjacent the inside surface of the inner vertical wall of a double-walled oil vaporizing zone by passing hot steam from a space intermediate the walls of said zone tangentially through said inner wall into said zone throughout its entire vertical length, said vaporizing zone being disposed within a vapor phase hydrocarbon oil cracking zone, introducing hot steam from outside said cracking zone into said space intermediate the walls of said vaporizing zone, spraying said hydrocarbon oil in a heated condition in a direction from the axis of said vaporizing zone toward said layer of steam, introducing particulate material at least at a desired hydrocarbon cracking temperature into the upper portion of said cracking zone and adjacent said vaporizing zone, passing steam and oil vapors from said vaporizing zone into contact with said particulate material whereby vapor phase cracking occurs and withdrawing particulate material and cracking zone effluent vapors from said cracking zone.

20. In the method of claim 19 wherein said particulate material is catalytic particulate material.

21. In the method of claim 19 wherein said particulate material is noncatalytic particulate material.

22. A method for flash vaporizing a difficultly vaporizable hot oil comprising heating a flash vaporizing zone by maintaining a body of steam in contact with the outer surface of a wall defining said flash vaporizing zone, passing steam from said body of steam tangentially through said wall into said zone throughout its entire vertical length in such a manner as to form a layer of steam flowing around the inner surface of said wall, said layer of steam being of progressively higher concentration from the axis of said zone to the inner surface of said wall, spraying hot oil to be flash vaporized in a direction from said axis toward said layer of steam in such a manner that the sprayed oil passes through the layer of steam in the direction of said progressively higher concentration, and removing steam containing oil vapors from said zone.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,868,714 January 13, 1959

Forrest E. Gilmore

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

Column 3, line 35, for "contacing meal" read -- contacting metal --; column 4, line 12, for "is a" read -- in a --; column 6, line 59, for "difficulty" read -- difficultly --.

Signed and sealed this 25th day of August 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

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Commissioner of Patents