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L. C. HUFF
METHOD AND RETORT FOR THE DISTILLATION OF
SOLID HYDROCARBONACEOUS MATERIALS

2,463,693

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2 Sheets-Sheet 1

Fig. 1.

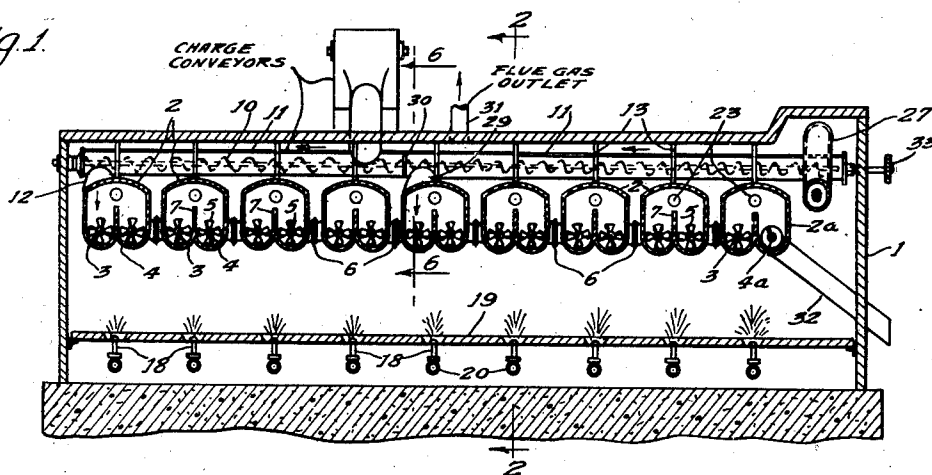


Fig. 2.

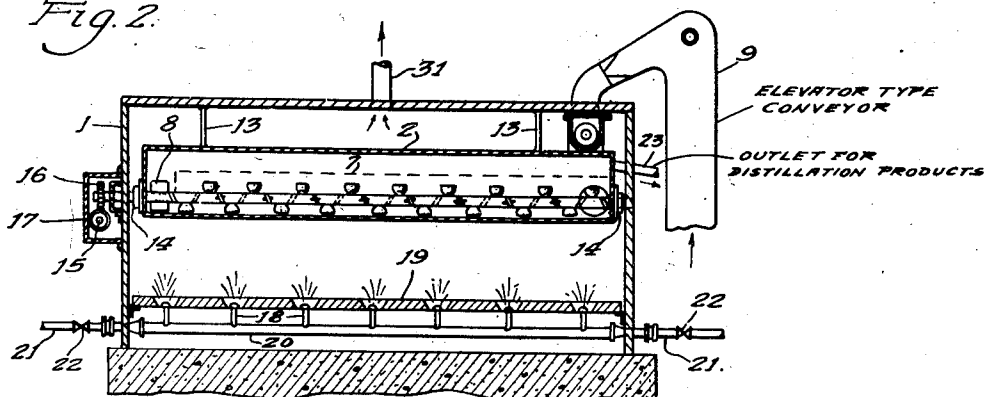


Fig. 3.

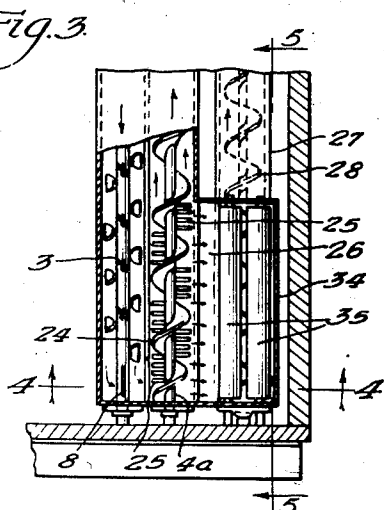
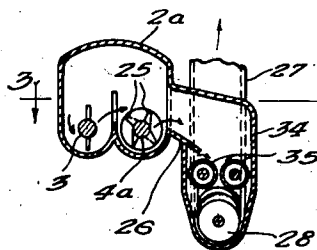


Fig. 4.



Inventor:
Lymar C. Huff
By: Maynard P. Venema
Attorney:

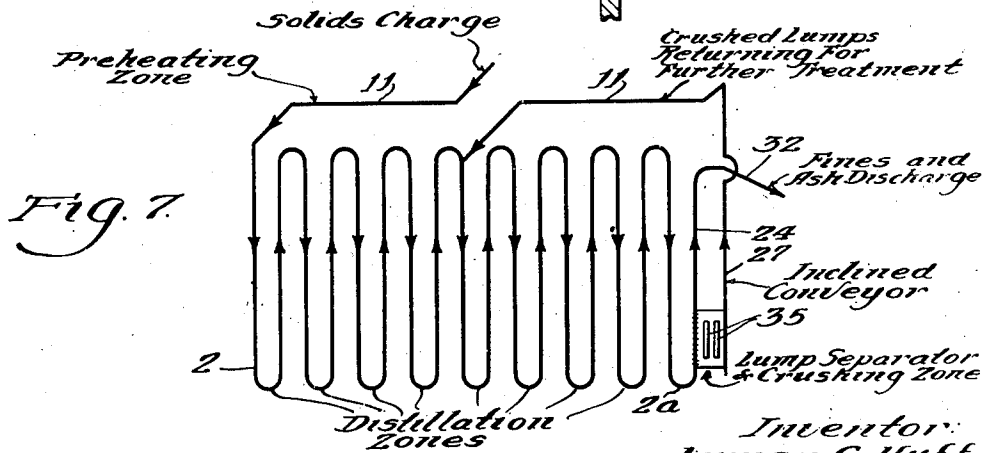
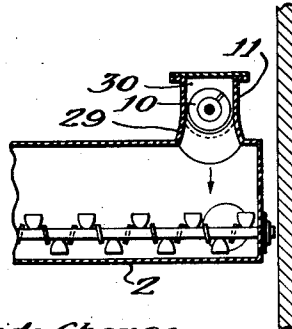
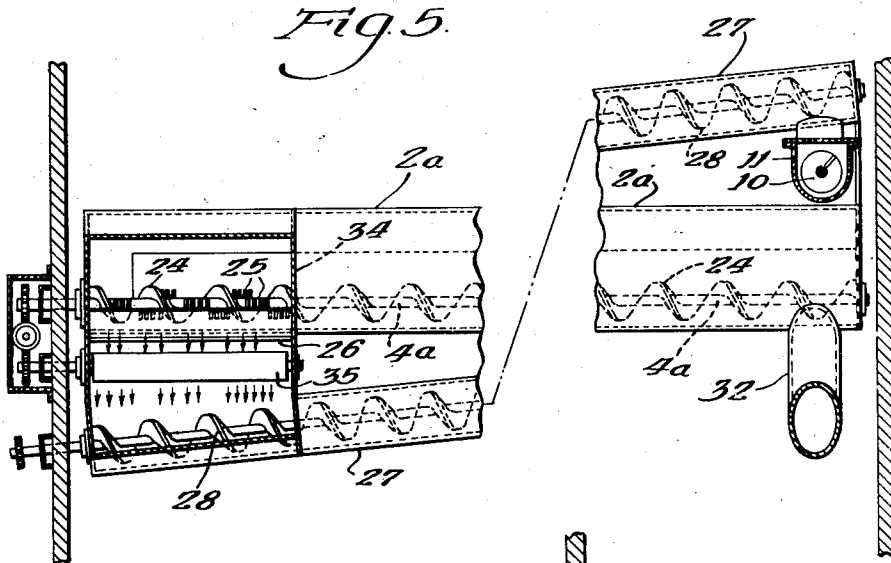
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Inventor:
Lynan C. Huff
By: Maynard P. Pennington
Attorney

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METHOD AND RETORT FOR THE DISTILLATION OF SOLID HYDROCARBONACEOUS MATERIALS

Lyman C. Huff, Evanston, Ill., assignor to Universal Oil Products Company, Chicago, Ill., a corporation of Delaware

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10 Claims. (Cl. 202—118)

1

This invention relates to an improved type of distilling retort and an improved method of distillation for oil shales, tar-sands, coal and other solid types of hydrocarbonaceous materials.

Broadly, the invention comprises an improved method for recovering vaporous and volatile matter from crushed carbonaceous solids by conveying them serially through a plurality of adjacently disposed distillation zones, passing hot gases in heat exchange relationship with the distillation zones and withdrawing distillation products independently from each of the distillation zones. Large pieces or lumps of only partially spent solid material are separated from the fines in the last of the series of distillation zones and recycled to one of the intermediate distillation zones for reheating, while the fine material is discharged from the last distillation zone and from the retort.

It is an object of this invention to effect an efficient and continuous method of distilling vaporous material from solid hydrocarbons such that the distillation products are recovered without being contaminated by combustion gases or other direct heating gases.

A second object of the invention is to provide recycling means for the larger pieces of solid material from which additional volatile material may be removed.

Another object, is to provide a number of contact zones, in a heated retort, through which the carbonaceous material is passed serially and from which distillation products may be progressively withdrawn at various temperature stages, without subjecting the lighter vapors to the destructive effect of a higher distillation temperature than necessary.

A still further object of the invention is to provide distillation zones which may be entirely encompassed or surrounded by the heating medium and are so constructed and operated that coke is substantially prevented from forming therein.

The improved continuously distilling retort comprises a plurality of longitudinal trough-like closed chambers in which there are rotating shafts having screw conveying means to move the material therethrough from one chamber to the next. All of the trough-like distillation chambers are normally positioned in one horizontal plane in a furnace-like setting or housing, such that hot gases from burners or other suitable heat supplying means may be brought into contact with the chambers which are suspended therein. Crushed oil shale or other solid hydrocarbonaceous material is charged to one end of the plu-

2

ality of chambers by automatic conveyor means, while at the other end of the unit, spent or ash-like material is removed from the unit. In the final distillation chamber, at the discharge end of the retort, rake-like teeth operate to screen out the large lumps or pieces of uncompletely distilled solid material and pass them to a crusher where they are reduced in size and then passed to a recycling conveyor which returns them to one of the intermediate distillation chambers. An outlet for distillation products is provided at each of the independent distillation zones or chambers in order that the distillation products may be withdrawn and passed to suitable condensation and separation equipment.

The recycling feature, whereby the partially spent material is separated out and returned to the distillation chambers, is of particular advantage for efficiently removing all vaporous and volatile matter from the material being charged. Also in the improved retort, burners for heating the distillation zones are distributed across the entire floor of the furnace-like housing and are controllably operated or fired such that the distillation zones may be made successively hotter from the first to the last or final distillation zone. Thus, the volatile material is obtained in varying temperature ranges from the unit with the vapors being individually removed from each of the independent distillation chambers without being subjected to higher distillation temperature than necessary. However, if it is so desired, the outlets or vapor lines may be grouped such that the first two or three zones discharge to one condensing coil, the next two or three discharge to a second condensing coil, etc. It may thus be seen that the vapors from this retort may be obtained in a controlled manner and will be in an uncontaminated form, also, that the improved retort is constructed and arranged to allow for very flexible operation, permitting highly efficient distillation of solid carbonaceous materials.

Further advantages in the retort and in the method of operation will be apparent upon reference to the accompanying drawings and the following description thereof.

Figure 1 is a cross-sectional elevational view through a simplified form of the improved retort, while Figure 2 shows a different cross-sectional elevational view through the retort as indicated by the line 2—2 Figure 1 of the drawing.

Figures 3 and 4 show sectional views of a portion of the final distillation chamber and serve to illustrate the method of removing the pieces of only partially spent solid material and trans-

3

ferring them through a crusher to a recycling conveyor.

Figure 5 is a sectional and side elevational view at the end of the final distillation zone, as indicated by line 5—5 in Figure 3 of the drawing, indicating the relationship of the crusher rollers and inclined conveyor suitable for recycling the incompletely distilled lumps of solid material to an intermediate distillation chamber.

Figure 6 of the drawing is a sectional view at the end of the recycle conveyor system, at the point where the crushed and returned large lumps or particles re-enter the distillation chambers, as indicated by line 6—6 in Figure 1 of the drawing.

Figure 7 shows diagrammatically the flow of the solid material through the improved distillation retort.

Referring now to Figures 1 and 2 of the drawing, the furnace-like housing 1 serves to enclose and separate a plurality of closed distillation chambers 2, which are positioned substantially horizontally across the furnace and are separated one from another sufficiently to allow free circulation of hot flue gases around each of them. Each of the distillation chambers 2 have rounded trough-like bottoms which accommodate rotating screw conveyor shafts 3 and 4, which in turn have paddle type conveyor blades 5 mounted thereon operating to continuously mix and propel forward the crushed shale or other solid material. It should be noted that the blades 5 are mounted on the shafts 3 to move material in one direction and on shaft 4 to move the material in the opposite direction. Thus, the solid material is moved back and forth in each chamber and serially through each of the plurality chambers. The short conduit section 6 provided with means for taking up expansion serves to connect adjacent distillation chambers 2 and to permit the transfer of solids from one to the other. A dividing plate 7 in the center of each of the chambers, prevents the oppositely moving beds of the material from being mixed in any one chamber, however, at one end of each of the chambers, the plate 7 is notched, so that the kicker plates 8 on the shafts 3 will transfer the material from one trough to the other. Kicker plates 8 are also placed on the shafts 4, at the opposite ends of the chambers, so that the material will be transferred through the short conduit 6 to the next adjacent distillation chamber.

Crushed shale is charged to the top of the distillation retort by the elevator type of conveyor 9 and is then carried by way of a helicoid conveyor 10 in duct 11 to a short transfer duct 12 which in turn connects with the first distillation chamber 2 of the row within the housing. The crushed material is then conveyed serially through each of the chambers by means of the continuously revolving paddle type conveyors within each of the distillation zones. The chambers 2 may be suspended from the housing 1 by hangers 13 or supported in some other suitable manner. The shafts 3 and 4 are positioned and supported by suitable bearings 14 which are placed at each end of the chambers and at the driven end, the end of the shafts project through the wall of the housing 1 in order to connect with a common transfer drive-shaft 15. A worm gear 16 is mounted on the end of each of the conveyor shafts 3 and 4 while a series of worm sections 17 are mounted on the drive-shaft 15 to mesh with the gears 16 such that each of the paddle conveyors and shafts 3 and 4 will be simultaneously rotated.

In the retort shown, heat for contacting dis-

4

tillation chambers and driving off the vaporous and volatile materials from the solid charge, is supplied by a plurality of burners 18 which are mounted below a firing floor 19, in the lower portion of the furnace-like structure. Each of the burners 18 is connected to suitable pipes 20 which are in turn connected to suitable fuel supply lines 21. Control valves 22 are placed in the fuel supply lines 21 in order to provide means for controlling the fuel supply to burners 18 and thereby in turn control the amount of heat to each of the distillation chambers 2. The hot flue gases flow upwardly to the upper portion of the housing passing around each of the suspending distillation chambers and are then discharged through a stack or outlet 31.

In the final distillation chamber 2a, a special shaft 4a is provided with a helicoid conveying blade 24 and tooth-like projections or rakes 25 which are suitable for removing lumps or pieces of solid material from the residual coarse and fine material, such that they may be crushed and recycled to one of the intermediate distillation chambers 2. In Figure 3 of the drawing, the partial plan view serves to show how the solid material is passed from paddle conveyor 3 in one trough to the conveyor blade 24 in the second trough. The rakes 25 will screen out and push the coarse material through the connecting duct or passageway 26 to crusher housing 34 having rollers 35 and then to a recycled conveying tube 27 in which there is a helicoid conveyor 28. Figure 4 of the drawing shows an elevational cross-sectional view through this same portion of the unit as indicated by line 4—4 in Figure 3.

Referring again to Figure 1 of the drawing it may be seen that the conveyor tube 27 slopes upwardly, extending to a point above the transversely positioned conveyor tube 11 wherein by means of the helicoid conveyor 10 the crushed coarse material is carried to the short transfer duct 29 which is in communication with one of the intermediate distillation zones 2. The partition plate 30 in the tube 11 prevents the recycled material from continuing forward and mixing with the fresh crushed solid material entering by way of the charge conveyor 9. The fine spent or ash-like material in the final distillation chamber 2a is conveyed forward by the helicoid conveyor 4a to the end of the chamber where it is discharged through an outlet duct 32. One end of the shaft 10 extends through the wall of the housing 1, and is provided with a gear or pulley 33 such that the shaft may be continuously rotated. Any suitable type of engine or motor and drive equipment (not shown) may be used to operate the drive shaft 15, the crusher rolls 35, the inclined helicoid conveyor 28, and the conveyor shaft 10.

Referring now to Figure 5 of the drawing, it may be still further noted how large particles or lumps from distillation chamber 2a may be selectively discharged therefrom by means of the rakes 25. The lumps separated by the rakes 25 are passed through an opening in the wall of the chamber 2a and then over plate 26 to the crusher rollers 35 from which the smaller crushed particles pass into the inclined helicoid conveyor 28. The conveyor 28 is in turn housed within a closed inclined duct 27 which slopes upwardly to a point above the recycle portion of duct 11 and connects therewith to return crushed solid material to an intermediate distillation zone.

Figure 6 shows the short duct 29 connecting the bottom of the duct 11 to the top of one of

5

the distillation chambers 2 and the closing-off plate 30 which terminates the recycle section of helicoid conveyor 10 within the duct 11. Plate 30 blocks the entire passageway and forces the recycled solid material to drop down into the inlet end of one of the intermediate distillation units, whereby the material is admixed with the incompletely distilled charge stream of solid material and is passed serially through the remaining distillation chambers of the retort.

To further explain the operation of the improved unit with the plurality of separate enclosed distillation chambers 2, it will be assumed that a crushed oil-shale is to be distilled therein. The crushed shale is fed to the elevator conveyor 9 which in turn passes it to the preheating conveyor tube 11 and as it is transferred to the first distillation zone 2, it is heated by the outgoing flue gases within the housing 1. The burners 18 below the first few distillation chambers 2 are maintained at a relatively low heat output so that a mild distillation is effected in the first few zones. However, the burners are controlled so that the distillation zones become increasingly hotter across the width of the retort and the material therein is subjected to relatively high distilling and cracking temperatures in the last few zones. As the material is slowly propelled through each of the zones, the volatile and vaporous matter is driven off and the solids are broken down into an ash-like material by the action of heat, as well as the action of the blades 5. In order to accomplish the efficient removal of all vaporous material and the break-down of all of the solid material, the rakes 25, crusher rolls 35, and recycling conveyors 27 and 11 provide means for returning the large lumps or pieces to an intermediate chamber for further heating and distillation.

The distillation products are withdrawn by way of outlet lines 23 and may be sent separately to condensing and separating equipment (not shown) or, of course, the lines may be combined such that the products of the first two or three zones are commingled, the products of the next two or three commingled, etc. prior to their passage to the separating equipment. It should be noted, that since the distillation chambers 2 are entirely surrounded by hot gases, that there will be very little condensation or coking of carbonaceous materials within the retorts, due to cool surfaces.

With some materials it may be unnecessary to recycle any part of the material and a continuous once-through operation may be employed. The removal of the rake-like teeth 25 on shaft 4a allows the material to be passed directly from the retort without any recycling and thereby affect a "once-through" operation.

The flow diagram of Figure 7 shows by means of the lines and arrows the path of the solid carbonaceous material. The crushed solid material is charged first to a preheating zone in one end of duct 11 and passes therefrom into the first or end distillation chamber of a plurality of distillation zones or chambers 2, all of which are connected in a manner to pass the solid material serially through the plurality of adjacent chambers 2 to the last chamber 2a. At the final distillation chamber 2a, the large particles and lumps are separated and crushed while the fine, primarily ash-like material is discharged from the retort by the helicoid conveyor 24 and duct 32. The separated and crushed material for redistillation passes from the crushing zone to the

6

inclined conveyor 27, which in turn carries the material to the recycle portion of duct 11 in order that it may be returned to one of the intermediate distillation zones.

It is not intended to limit the operation of this retort to oil-shales only, for it is within the scope of this invention to use all types of crushed solid carbonaceous materials. It is also contemplated that various structural and mechanical changes may be made in connection with the construction details, without deviating from the improved arrangement and method of operation which comprises the invention.

I claim as my invention:

1. A method for recovering vaporous and volatile material from crushed hydrocarbonaceous solids which comprises conveying said solids serially through a plurality of distillation zones, passing hot gases in indirect heat exchange relationship with said distillation zones, withdrawing distillation products independently from each of said distillation zones, separating and removing fines from the solid material present in the last of said plurality of distillation zones and recycling the remaining portion of solids to an intermediate distillation zone of said plurality of zones for reheating.

2. A method for recovering vaporous and volatile material from crushed hydrocarbonaceous solids which comprises conveying said solids serially through a plurality of distillation zones, passing hot gases in indirect heat exchange relationship with said distillation zones, controlling distribution of said hot gases to provide an increasing heat intensity from the first charged distillation zone to the final distillation zone, withdrawing distillation products independently from each of said distillation zones, separating and removing fines from the solid material present in the last of said plurality of distillation zones and recycling the remaining portion of solids to an intermediate distillation zone of said plurality of zones for reheating.

3. A method for recovering vaporous and volatile material from crushed hydrocarbonaceous solids which comprises preheating said solids in indirect heat exchange relationship with a hot gaseous medium, passing said preheated solids to a plurality of distillation zones, conveying said solids serially through said distillation zones, passing a hot gaseous medium in indirect heat exchange relationship with said distillation zones, controlling distribution of said hot medium to provide an increasing heat intensity from the first charged distillation zone to the last of said plurality of distillation zones, withdrawing distillation products independently from each of said distillation zones, separating and removing fines from the solid material present in the last of said plurality of distillation zones and recycling the remaining portion of solids to an intermediate distillation zone of said plurality of zones for reheating.

4. A retort for the distillation of solid hydrocarbonaceous material which comprises a furnace-like housing, means for passing hot gases through said housing, a plurality of enclosed distillation chambers positioned adjacent one another in the upper portion of said housing, means for conveying crushed solid material to the first of said plurality of chambers and passing said material serially through each of said chambers, means for separating and removing fines from the solid material present in the last distillation

7

chamber of said plurality of chambers and a recycling conveyor in communication with said last distillation chamber, means for transferring the remaining larger solid particles to said recycling conveyor, said conveyor being constructed and arranged to carry said larger particles to an intermediate distillation chamber.

5. A retort for the distillation of solid hydrocarbonaceous material which comprises a furnace-like housing, means for passing hot gases through said housing, a plurality of enclosed distillation chambers positioned adjacent one another in the upper portion of said housing, means for conveying crushed solid material to the first of said plurality of chambers and passing said material serially through each of said chambers, means for separating and removing fines from the solid material present in the last distillation chamber of said plurality of chambers, crusher rolls and a recycle conveyor in communication with said last distillation chamber, said rolls being positioned between said last chamber and the recycle conveyor, and said recycle conveyor communicating with an intermediate distillation chamber.

6. A retort for the distillation of solid hydrocarbonaceous material which comprises a furnace-like housing, a firing floor in the lower portion of said housing, a plurality of fuel burners spaced across said floor, a plurality of enclosed distillation chambers positioned horizontally and adjacent one another in the upper portion of said housing, means for conveying crushed solid material to the first of said plurality of chambers and passing said material serially through each of said chambers, a recycling conveyor in communication with the last of said plurality of distillation chambers, means for separating large solid particles from fines in the last of said chambers, said separating means being constructed and arranged to transfer said large particles to said recycling conveyor and to discharge fines from said retort, said recycling conveyor communicating with one of the intermediate distillation chambers of said plurality of chambers.

7. A retort for the distillation of solid hydrocarbonaceous material as described in claim 5 further characterized in that said fuel burners within said housing are arranged and mechanically controlled to provide a varying intensity of heat below each distillation chamber.

8. A retort for the distillation of solid hydrocarbonaceous material which comprises a furnace-like housing, a firing floor in the lower portion of said housing, a plurality of fuel burners spaced across said floor, a plurality of elongated and enclosed distillation chambers positioned horizontally and adjacent one another in the upper portion of said housing, a connecting duct between each of said chambers, a preheating tube in said housing having internal conveying means positioned above and transverse to said plurality of chambers, said preheating tube operating to carry solid material from outside said retort to the first of said distillation chambers, conveying and mixing blades in each of said chambers operating to pass said solids serially through each chamber and from one chamber to the next, means for separating and removing fines from the solid material present in the last distillation

8

chamber of said plurality of chambers and a recycling conveyor in communication with said last distillation chamber, means for transferring the remaining larger solid particles to said recycling conveyor, said conveyor being constructed and arranged to carry said larger particles to an intermediate distillation chamber.

9. A retort for the distillation of solid hydrocarbonaceous material which comprises a furnace-like housing, a firing floor in the lower portion of said housing, a plurality of elongated enclosed distillation chambers positioned horizontally and adjacent one another in the upper portion of said housing, an expansible connecting duct between each of said chambers, a preheating tube within said housing having an internal helicoid conveyor blade therein positioned above and transverse to said plurality of chambers, said preheating tube operating to carry solid material from outside said retort to the first of said distillation chambers, two longitudinal trough-like sections formed in the lower portion of each of said distillation chambers, a rotatable shaft having paddle type conveyor blades in each of said trough-like sections, said paddle type conveyors being constructed and arranged to pass said solid material in opposite directions therein and serially from one chamber to the next, projecting ends from each of said rotatable shafts in said distillation chambers, a drive-shaft positioned outside of said housing and mechanically connecting with each of said projecting ends, means for separating and removing fines from the solid material present in the last distillation chamber of said plurality of chambers and a recycling conveyor in communication with said last distillation chamber, means for transferring the remaining larger solid particles to said recycling conveyor, said conveyor being constructed and arranged to carry said larger particles to an intermediate distillation chamber.

10. The retort as defined in claim 8 further characterized in that said means for separating and removing fines from the solid material in said last distillation chamber comprises a rotatable shaft in said last chamber and rake-like members and a helicoid conveyor blade mounted on said shaft.

LYMAN C. HUFF.

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