

March 17, 1970

T. C. LYONS

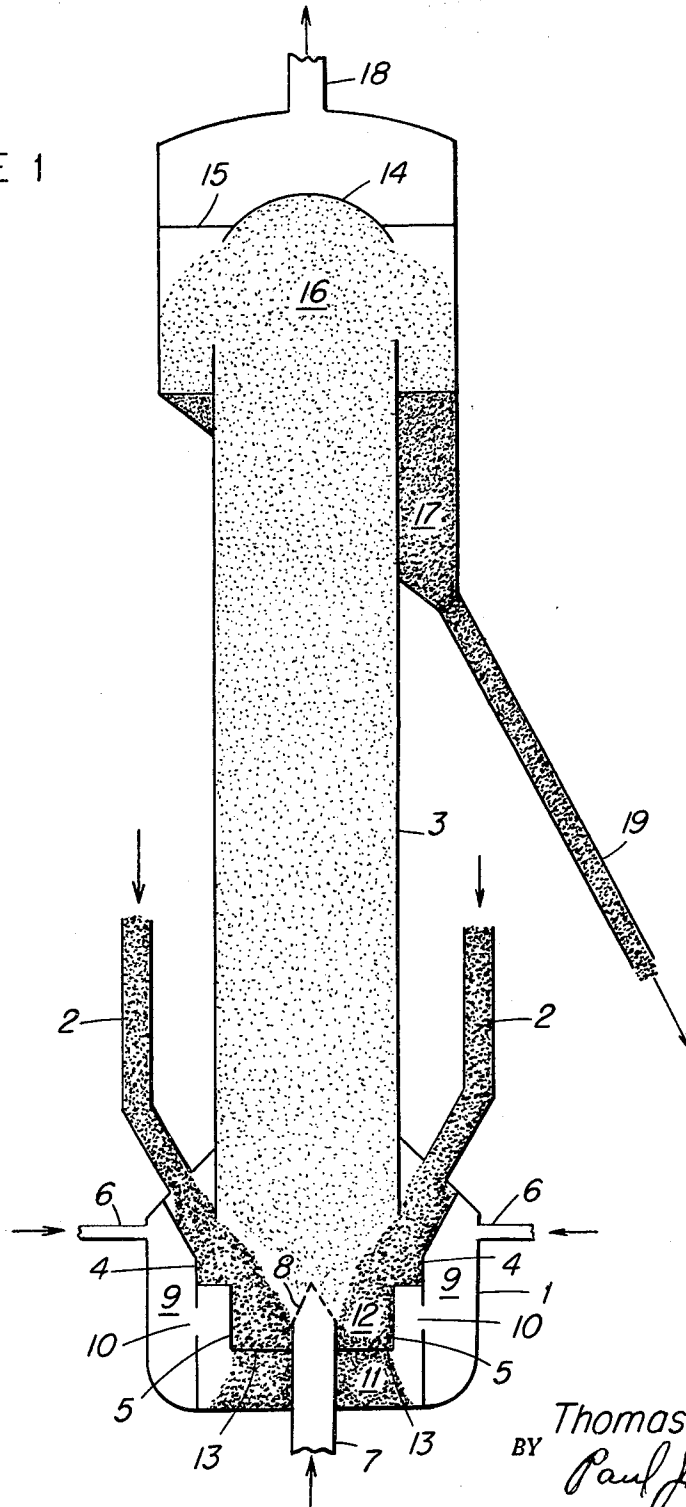
3,501,394

GAS LIFT RETORTING PROCESS FOR OBTAINING OIL FROM FINE
PARTICLES CONTAINING HYDROCARBONACEOUS MATERIAL

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2 Sheets-Sheet 1

FIGURE 1



INVENTOR.
Thomas C. Lyons
BY *Paul J. Cook*
Attorney

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T. C. LYONS

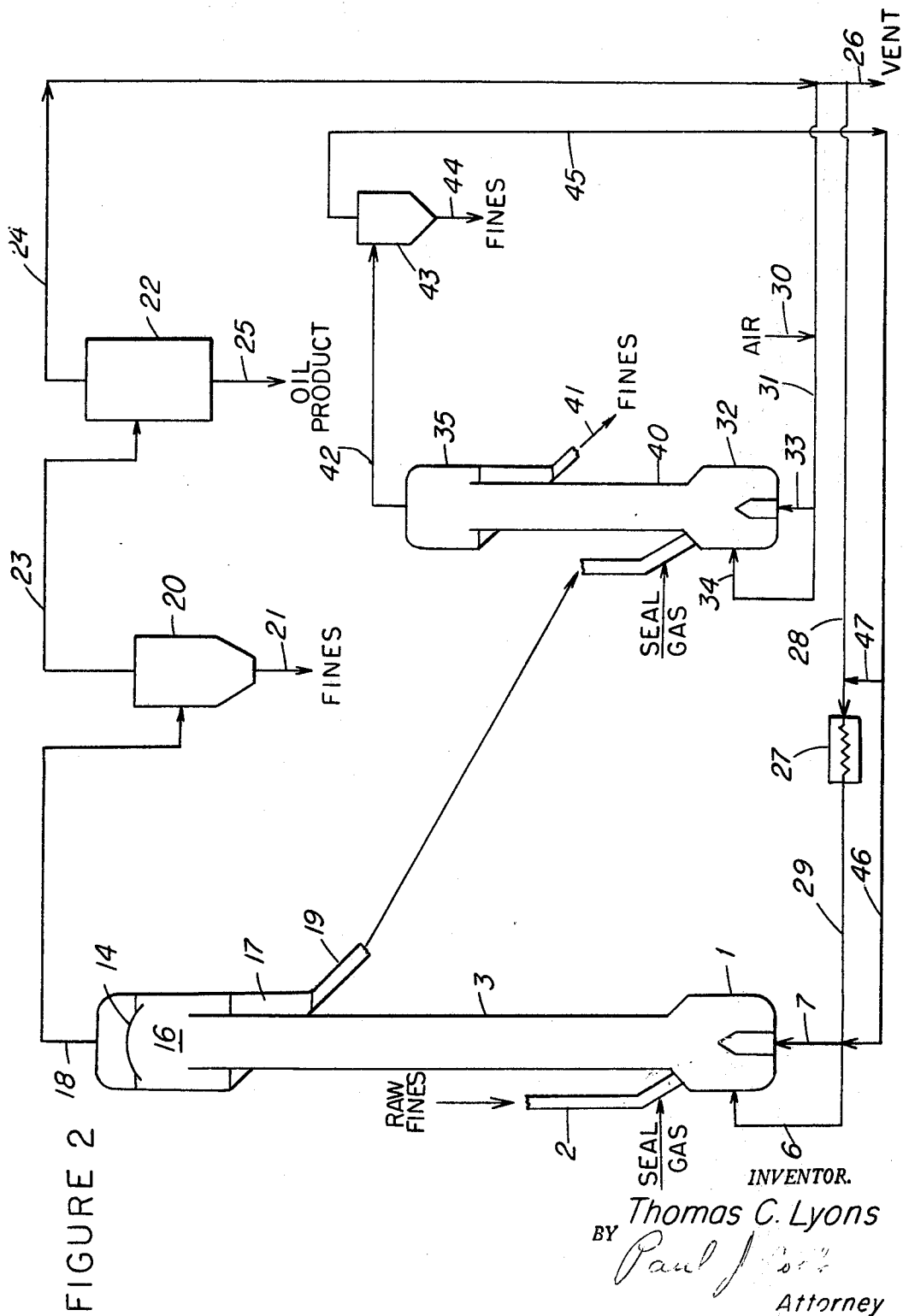
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GAS LIFT RETORTING PROCESS FOR OBTAINING OIL FROM FINE PARTICLES CONTAINING HYDROCARBONACEOUS MATERIAL

Thomas C. Lyons, Rifle, Colo., assignor to Mobil Oil Corporation, a corporation of New York
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4 Claims

ABSTRACT OF THE DISCLOSURE

A process for retorting fine particulate solids such as shale or Athabasca tar sands containing hydrocarbonaceous material to recover oil. The fine solids are mixed with a hot non-combustion supporting lift gas in a lift pot and the resultant mixture is passed upwardly through a riser as a dilute phase. Contact time and temperature in the riser are regulated to effect thermal decomposition of the hydrocarbonaceous material to oil vapor which is subsequently recovered. Spent fines can be burned in a separate combustion zone and at least a portion of the hot gas therefrom is recycled to the lift pot.

BACKGROUND OF THE INVENTION

Field of the invention

To satisfactorily retort oil shale, it is necessary that it be broken up to a relatively small particle size to effect desirable heat transfer and to obtain a satisfactory shale oil yield. At the present time, gas combustion retorting is the most commonly known method for retorting particulate shale. Gas combustion retorting is usually carried out in a shaft furnace type of retort wherein particulate shale is passed downwardly as a compact bed, countercurrent to upwardly moving hot gas. The particulate raw shale is mechanically crushed prior to being introduced into the retort. When shale is mechanically crushed, there results a wide variance in shale particle size with a large quantity of fines being formed. For example, when it is desired to obtain shale particles having maximum size less than 4 inches, by present crushing methods, the quantity of fines will vary from a minimum of about 8 percent to about 30 percent by weight. Because a large amount of fines are produced while crushing raw shale, there is a strong incentive to retort the fines to recover the oil therefrom.

Description of prior art

In presently employed retorting processes, it is generally undesirable to include shale fines in the raw shale feed. In a gas combustion retorting process wherein a shaft furnace type of retort is employed, the oil vapors condense on and entrain the fines in the cooler upper levels of the bed, and when refluxed, to the lower hot portion of the bed, will coke thereon. This results in an oil yield loss. In addition, the amount of fines and coke gradually builds up in the bed and clinkers form. This results in restricted movement and eventual stoppage of shale particles through the retort. It has been found that the spent shale from these furnaces, even when operated with a fines-free raw shale charge, contains fines concentration greater than about 15 to 20 percent. These fines are formed during the retorting process and are caused by weakening of the shale structure.

It has been proposed to retort raw shale fines in a zone wherein a dense fluidized bed of fines is maintained. Raw shale fines are introduced into the bed and mixed therewith while a heat carrying gas is introduced below

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the dense fluidized bed. The gas is introduced at a velocity and in sufficient amounts to maintain the dense bed in a fluidized condition. The hydrocarbonaceous material in the raw shale is thermally converted to oil vapor. The oil vapor is removed as a mixture with fines from the conversion zone. The fines and oil vapor are then separated into separate streams with the oil vapors being condensed and recovered.

Unfortunately, process disadvantages are inherent when employing a dense fluid bed system for retorting vain fines.

In a dense fluidized bed it is difficult to control time. This is because in a dense fluidized bed, shale fines of varying degrees of thermal conversion are in random motion within the bed. Under these conditions, a relatively large volume of the conversion zone is occupied by spent shale fines. This effects an undesirable reduction of effective reactor capacity and reduces the efficiency of the overall process. When operating with a dense fluidized bed, a relatively large portion of the shale fines can be removed from the reactor when only partially thermally converted to produce oil vapor. In this manner, oil yield can be greatly reduced. When a relatively large portion of the fines in the reactor are spent, a loss in process thermal efficiency occurs since heat is wasted in heating the spent fines.

SUMMARY OF THE INVENTION

Accordingly, by the process of this invention, raw fines are directed to a lift pot located at the bottom of a riser reactor. In the lift pot, the raw fines are contacted with hot non-combustion supporting gas to lift the fines into the riser reactor. The fines are passed upwardly through the riser as a dilute phase and the hydrocarbonaceous material therein is thermally decomposed to form oil vapors. The fines and vapors exit from the top of the riser reactor into a separation zone. In the separation zone, spent fines are separated from the vapors. The spent fines are withdrawn from the separation zone. The vapors can contain some entrained spent fines, and if so, the vapors are directed to a second separation zone to effect relatively complete removal of spent fines from the vapor. The fines-free vapors are directed to a condensation zone to separate oil from lower boiling gaseous components. The gaseous components or a portion thereof from the condensation zone are heated and then recycled to the lift pot to lift raw fines into the riser reactor as described above.

The term "fines" as used herein is meant to include solids containing hydrocarbonaceous material, such as shale, or agglomerates containing hydrocarbonaceous material, such as Athabasca tar sands, of a size less than about 1/4 inch. In the process of this invention, the average fines size employed is usually in the range of from about 20 mesh to about 1/8 inch. The term "raw fines" as used herein refers to unretorted fines which contain hydrocarbonaceous material capable of producing oil vapors by thermal decomposition.

By the process of the present invention, an effective means is provided for retorting raw fines containing thermally decomposable hydrocarbonaceous material. When retorting raw fines in dilute phase, in accordance with the present invention, the random movement of fines is greatly reduced so that the major movement of fines is in an upward direction. This permits increased control of fines residence time within the riser reactor so that more uniform residence time in the reactor for individual fine particles is attained. In addition, removal of spent fines from the riser reactor promotes process thermal efficiency in that heat is not expended in maintaining spent fines at reaction temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is illustrative of a riser reactor means including a lift pot configuration for carrying out the process of the present invention.

FIGURE 2 is a simplified process flow arrangement for carrying out the process of this invention wherein spent fines are burned to supply hot gaseous products to the riser reactor.

DESCRIPTION OF SPECIFIC EMBODIMENTS

In one embodiment of the present invention, the spent fines recovered from the separation zone located above the riser reactor are burned to obtain the heat needed for retorting. Accordingly, the spent fines obtained from the separation zone above the riser contains some unconverted hydrocarbonaceous material in addition to coke which is formed during the thermal conversion. The spent fines are directed to a combustion zone wherein combustion air is admixed therewith. The gas combustion products are separated from the burned fines and are recycled to the lift pot located below the riser reactor. The recycled gas contains very little or no free oxygen so as to prevent or minimize combustion within the riser reactor.

Conditions in the riser reactor are maintained to obtain the desired heat transfer through the fines and to effect the desired thermal decomposition. For a riser of given diameter and height, the lift gas temperature and volume ratio of gas to fines will vary depending upon the average size of the fines. For larger fines, higher temperatures and/or a higher volume ratio of lift gas to fines are employed. In any event, dilute phase conditions are maintained in the riser. In addition, temperatures and contact times are maintained to effect desired decomposition without overcracking the oil product. For purposes of the present invention, the temperature in the riser is maintained between about 800° F. and about 1300° F., preferably between about 1000° F. and about 1200° F. Contact time of raw fines and hot lift gas in the lift pot and the riser reactor is maintained between about 5 seconds to about 30 seconds, preferably from about 10 seconds to about 15 seconds. In the lift pot, the incoming raw fines and hot lift gas are contacted so as to direct the major force of the resultant mixture upwardly through the riser reactor rather than against the incoming raw fines. This can be conveniently accomplished by a variety of means. For example, baffling arrangements within the lift pot can be employed whereby the major portion of the lift gas is directed away from the raw fines inlet. In addition, a plurality of lift gas inlets to the lift pot can be employed to direct fines to the center portion of the riser inlet and then upwardly therethrough. The use of a plurality of lift gas streams has the advantage of improved gas flow control within the lift pot and riser. Thus, a primary lift gas stream can be injected at a constant rate while the overall gas flow is regulated by adjusting flow rates of the secondary gas stream or streams. The primary gas stream provides the majority of the total lift gas to the lift pot. Upon entering the lift pot, the compact bed of raw fines therein is initially suspended by incoming gas to the lift pot rather than being allowed to exist as a compact bed therein. The initial mixing of fines and gas is turbulent to minimize the possibility of clinkering and excessive coke formation within the lift pot. The suspended fines are further mixed with incoming lift gas and passed upwardly in the riser as a dilute phase. The contact time between lift gas and raw fines in the lift pot is minimized so that the majority of retorting is effected in the riser reactor.

The contact time of fines and hot gas in the riser is conveniently regulated by controlling the pressure differential between the riser inlet and outlet. In the process of the present invention, the pressure at or near the riser outlet is maintained at or about atmospheric pressure. The pressure differential between the riser inlet and out-

let is maintained in the range of from about 1 p.s.i. to about 10 p.s.i., preferably from about 3 p.s.i. to about 5 p.s.i. The desired pressure differential is regulated by regulating the pressure at the riser inlet. For purposes of the present invention, the pressure at the riser inlet is maintained from about 2 p.s.i.g. to about 12 p.s.i.g. and preferably from about 3.5 p.s.i.g. to about 5.5 p.s.i.g.

It is desirable to maintain pressure drop within the above ranges so that the need for undesirably high seal legs can be avoided. Thus, the fines to be converted are directed to the lift pot as a compact bed. Should the pressure in the lift pot be above the desired limit, fines flow thereto will be reduced and the hot lift gas will exit from the lift pot through the compact bed. It is undesirable to contact more than a small amount of hot lift gas with the raw fines in the compact bed since premature retorting results with the attendant possibilities of excessive coke and clinker formation. In the process of this invention, a relatively cold inert seal gas such as steam is employed in the compact bed of raw fines at or near the fines inlet to the lift pot. In this manner, contact is minimized between hot gas and the compact bed of raw fines.

A variety of riser reactor shapes can be employed in the process of this invention. Thus, a riser having vertical walls or tapered walls can be employed. A riser which is tapered so that the outlet has a larger diameter than the inlet is a convenient means for reducing the exit velocity of the dilute phase from the riser. This reduced exit velocity assists in separating spent fines which are passed downwardly by gravity from the vaporous material which is passed overhead. In addition, a riser having vertical walls and having an increased inner diameter in the upper portion thereof can be employed.

Referring now to FIGURE 1, raw fines are directed to lift pot 1 as compact beds through conduit 2. This internal portion of lift pot 1 is structured to provide ease in controlling the amount and velocity of the lift gas entering riser reactor 3. Baffles 4 and 5 are provided so as to permit secondary gas entering conduits 6 to contact a relatively large portion of the compact bed surface area located in the bottom portion of the lift pot 1. Primary lift gas is supplied to the interior of the riser 3 through conduit 7. Conduit 7 has a conical top portion 8 provided with perforations. The primary lift gas contacts the raw fines introduced through conduit 2 to provide a dilute phase within riser 3. The secondary lift gas stream 6 provides means for controlling the velocity and the amount of lift gas provided to the riser 3. The secondary lift gas stream 6 is provided with means not shown for controlling the amount of gas supplied to the riser 3. The secondary lift gas is directed to plenum zones 9 and therefrom through openings 10 to contact compact bed of fines in zones 11 and 12. Baffles 5 are held to conduit 7 by ribs 13. The secondary lift gas and primary lift gas are supplied at elevated temperatures within the range described above to effect the thermal decomposition desired. The mixture of gas and fines pass upwardly through the riser 3 as a dilute phase and contact deflector 14 which is held by ribs 15 to the interior walls of the separation zone 16. After contacting the deflector 14, the spent fines from the riser 3 are caused to pass downwardly to a compact bed of fines 17. The lift gas and the vaporized product pass upwardly through and out of the separation zone 16 through conduit 18. From the bottom of separator zone 17, the fines are removed therefrom through conduit 19.

The particular type of deflector employed in the separation zone above the riser is not critical. Any type of deflector which effects adequate separation of vapors from fine particles, can be employed. In addition, it is within the scope of the present invention to employ a riser reactor which is outwardly tapered at the top thereof. This provides for a decrease in the effective velocity of the dilute phase and enhances separation of solid

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fines from vapor. In addition, it is not essential to employ the particular lift means shown in FIGURE 1. Any lift means which will provide for intimate mixture of raw fines and lift gas at the desired conditions of temperature and contact time can be employed. Thus, for example, it is not necessary to employ a secondary lift gas stream since adequate control of the amount of primary gas can be effected.

Referring now to FIGURE 2, raw fines are directed as a compact bed to a lift pot 1 through conduit 2. In lift pot 1, the raw fines are contacted with a secondary gas stream from conduit 7. The fines-gas mixture passes upwardly through riser reactor 3 as a dilute phase in a manner described above for FIGURE 1. In the riser reactor 3, the hydrocarbonaceous portion of the raw fines is thermally decomposed to produce oil vapors. The oil vapors and spent fines exit the riser reactor 3 and contact deflector 14 in the upper portion of separation zone 16. The spent fines are directed downwardly to a compact bed of spent fines located in chamber 17. The bottom portion of chamber 17 slopes down at an angle greater than the angle of repose of the spent fines. Chamber 17 can be provided with stripping means to remove entrained vapors from spent fines. Thus, baffles can be employed or an inert stripping gas can be employed in a manner well known in the art.

The vaporous material, including oil vapor and lift gas, is removed from separation zone 16 through conduit 18 at a temperature from about 700° F. to about 1000° F. and are directed to cyclone 20. In cyclone 20, vaporous material is separated from any fines carried over from separation zone 16. The fines are removed from cyclone 20 through conduit 21 and are discarded. It is desirable to maintain the vaporous material in cyclone 20 at a high temperature of above about 700° F. This is because partial condensation of oil at a lower temperature will result in oil yield loss caused by absorption thereof by the carried over fines. Vapors from cyclone 20 are directed to a condensation step 22 through conduit 23. In condensation step 22, the vapors are cooled to obtain a liquid oil product and a gas overhead. The condensation step is carried out in a manner to recover the hydrocarbon product boiling in the naphtha boiling range and above. Hydrocarbons boiling below the naphtha boiling range in addition to the lift gas employed in the riser 3 are withdrawn from condensation step 22 through conduit 24. Oil product is withdrawn from condensation step 22 through conduit 25. A portion of the gas from condensation step 22 is vented through conduit 26 while another portion of the gas is employed to support spent fines combustion in a manner described below. The remainder of the gas from a condensation step 22 is directed to heater 27 through conduit 28 to be heated to a temperature which supports conversion. The heated gas is directed from heater 27 through conduits 29, 7 and 6 to lift pot 1.

The gas from condensation step 22 which is used to support spent fines combustion is admixed with air from conduit 30. The resultant mixture of air and gas is directed to lift pot 32 through conduits 31, 33 and 34. The lift gas contacts hot spent fines containing unconverted hydrocarbonaceous material and coke in lift pot 32. The spent fines are obtained from chamber 17 and are directed to lift pot 32 through conduit 19. The ratio of combustion air to recycle gas in lift pot 32 is regulated so that the vaporous combustion products from separation zone 35 are oxygen free. That is, the oxygen entering the lift pot 32 is totally consumed in combustion. In addition, the amount of gas entering lift pot and the presence thereof is regulated so that a dilute phase of fines is maintained in riser 40 without an undesirably high pressure drop across the riser 40. The hot spent fines and gas are passed upwardly as a dilute phase in riser 40 to effect combustion of carbonaceous material in the fines. The fines and vapors are passed upwardly to separation zone 35 wherein

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fines are separated from vapors. The fines are removed from separation zone 35 by being passed downwardly through conduit 41. The vapors from separation zone 35 are passed overhead through conduit 42 to cyclone 43 wherein carried-over fines are separated from vapor. The fines are removed from cyclone 43 through conduit 44. The hot vapors from cyclone 43 are recycled to lift pot 1 through conduits 45, 46, 7 and 6. A portion of the recycled vapor from cyclone 43 can be directed to heater 27 through conduit 47 to provide additional heat of conversion in riser 3. The power for recycling vapors is supplied by means not shown, as for example, compressor means.

It is preferred to supply the majority of the heat required for conversion by burning spent fines. It is within the scope of this invention to employ means for burning spent fines other than the dilute phase combustion means described above. For example, the fines can be burned as a dense fluid bed or as a moving bed. Burning spent fines to obtain hot lift gas reduces outside fuel requirements for heating the lift gas. However, supplying heat by burning spent fines is somewhat limited since care should be taken to avoid the presence of oxygen in the combustion gas. In this manner, combustion of raw fines in the combustion zones is avoided. Thus, provision is made for employing additional gas heating means to assure adequate heat supply to the raw fines conversion zone.

Having fully described the invention, I claim:

1. The process for retorting oil shale and tar sands raw fines containing hydrocarbonaceous material which comprises:

- (a) contacting said raw fines with a heated non-combustion supporting gas as the sole source of reaction heat in a lift pot in a manner to suspend said fines,
- (b) passing said raw fines and gas as a dilute phase mixture upwardly substantially vertically from said lift pot through a riser reactor at a temperature between about 800° F. and about 1300° F. and a contact time between about 5 seconds and about 30 seconds to effect decomposition of hydrocarbonaceous material in said fines to oil vapors,
- (c) separating spent fines from said non-combustion supporting gas and said oil vapors in a separation zone,
- (d) condensing said oil vapors to separate and recover condensable oil from non-condensed vaporous material,
- (e) passing said spent fines to a combustion zone,
- (f) burning said spent fines in said combustion zone to produce a heated non-combustion supporting gas, and
- (g) recycling said heated non-combustion supporting gas from said combustion zone to said lift pot.

2. The process of claim 1 wherein a portion of the non-combustion supporting gas obtained by condensing oil vapors is heated and recycled to contact and suspend raw fines.

3. The process of claim 1 wherein the pressure drop across the riser reactor is maintained between about 3 p.s.i. and about 5 p.s.i.

4. The process of claim 1 wherein spent fines are stripped of oil vapors prior to being burned.

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HERBERT LEVINE, Primary Examiner

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