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PLANT AND PROCESS FOR PRODUCTION OF LOW
TEMPERATURE PUMPABLE OIL FROM OIL
SHALES AND THE LIKE

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2 Sheets-Sheet 1

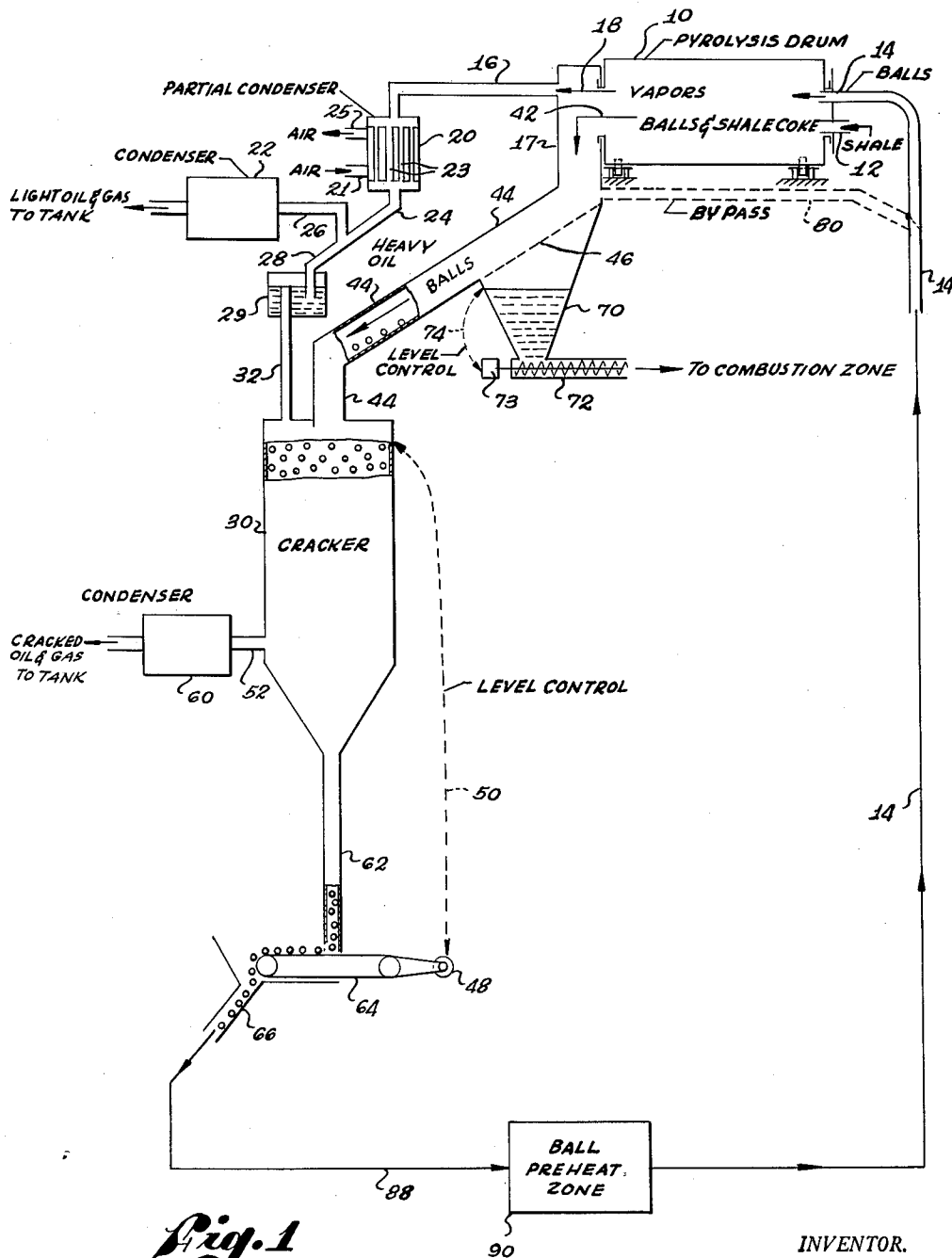
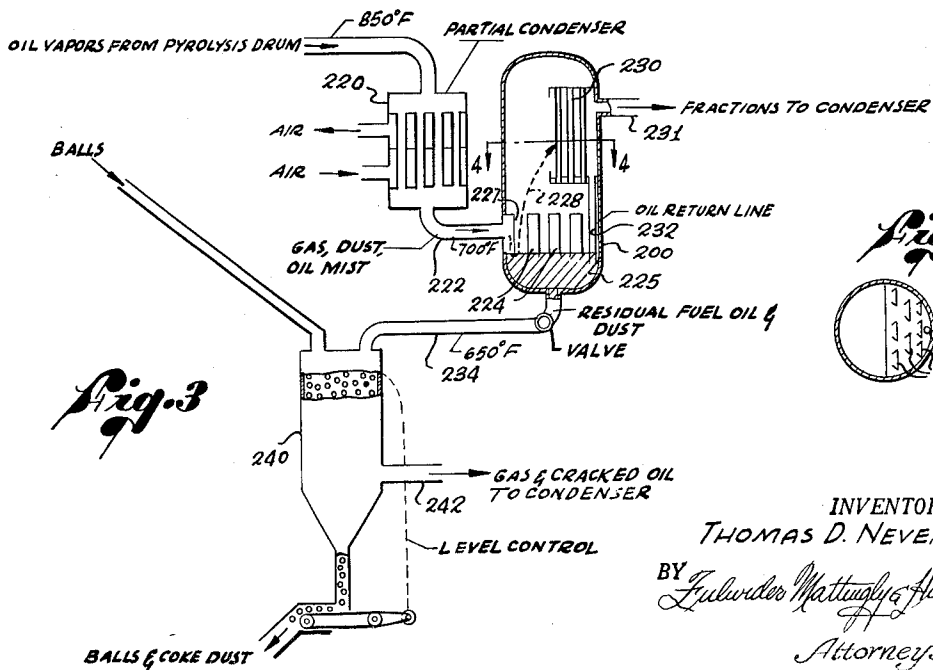


Fig. 1

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PLANT AND PROCESS FOR PRODUCTION OF LOW TEMPERATURE PUMPABLE OIL FROM OIL SHALE AND THE LIKE**Thomas D. Nevens, Denver, Colo., assignor, by mesne assignments, to The Oil Shale Corporation, Beverly Hills, Calif., a corporation of Nevada****Filed Dec. 1, 1958, Ser. No. 777,354****16 Claims. (Cl. 208—11)**

This invention relates generally to a plant and process for the production of oil from solid substances leaving a carbonaceous residue, such as oil shale, tar-sand, peat, etc., and more specifically relates to a plant and process for the production of shale oil and the like having a low pour point and reduced viscosity. The term "carbonaceous residue" denotes a residue which includes fixed combustible carbon.

Inasmuch as the large deposits of solid materials, such as oil shale, are found some distance from refinery centers, it has been considered desirable to thermally crack all the oil pyrolyzed from the solid materials in such a manner as to reduce its viscosity and/or pour point prior to its introduction into a pipe line for ease in transportation. Such a thermal cracking is sometimes referred to as visbreaking, or if the cracking is prolonged, as coking.

While the pour point of an oil is not the most accurate measure of its pumpability, the pour point test does give a fair indication, and generally speaking the lower the pour point, the better the pumpability at the lower temperatures. One plant and method wherein combined pyrolysis and cracking is advantageously employed is disclosed in the co-pending United States application of William J. Culbertson, Jr., Serial Number 736,497, entitled "Method and Apparatus for Producing Oil." Combined pyrolysis and cracking processes, especially those disclosed in the above-identified co-pending application, are extremely advantageous in achieving a lowering of the pour point of the oil product and in producing a greater number of valuable end chemicals and intermediates. It has been found, however, that a relatively high amount of valuable oil is lost in the form of non-condensable gases.

In view of the foregoing facts, it is a major object of the present invention to provide a plant and process for the production of oil having a low pour point and reduced viscosity, from solid materials such as oil shale and the like wherein the amount of valuable oil lost in the form of non-condensable gases is substantially reduced.

Another object of the present invention is to provide a plant and process for the production of oil from solid materials of the class described wherein the cracking of the effluent oil vapors and gases produced during pyrolysis is conducted so that those constituents in the oil vapors and gases, the cracking of which contribute most to the lowering of the pour point lowering of the pour point, are cracked within a certain desired temperature range, and those constituents in the oils and gases, the cracking of which do not contribute appreciably to the lowering of the pour point, are not cracked. The resultant composite oil produced is of greater yield and has a lower pour point and viscosity than in prior art processes.

Yet a further object of the present invention is to provide a process for the production of oil from oil shale and the like wherein a condensation only of part of the pyrolyzed oil vapors and gases occurs, prior to the cracking thereof, thereby resulting in a substantial reduction in total water consumption and smaller capital investment as well as resulting in the production of a composite oil product having a lower pour point and viscosity than in prior art processes.

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In the United States, the major source of oil shale lies in Colorado. Further, the oil shale deposits are usually always found in areas where water is scarce. Hence, in conducting condensing, cracking, or other refining operations at the point where the oil shale is pyrolyzed, reduction in the amounts of water required for refining is of real importance. A further object of the present invention, therefore, is to provide a plant and process for the production of oil from oil shale and the like, which incorporates both pyrolysis and refining steps for the purpose of reducing the pumpability of the resulting oil with minimum loss of non-condensables, wherein the amount of water required for the refining steps is considerably reduced.

These, and other objects, of the present invention will become clearly understood by referring to the following description and to the accompanying drawings in which:

FIGURE 1 is a diagrammatic elevational view of one preferred embodiment of the invention showing the essential parts of the pyrolysis and refining phases of the plant;

FIGURE 2 is a diagrammatic elevational view of a modified form of the invention incorporating a high temperature cracking step;

FIGURE 3 is a diagrammatic elevational view of a modified form of apparatus which can be employed with either the FIGURE 1, FIGURE 2, or other embodiments of the invention to be described; and

FIGURE 4 is a cross-sectional view of FIGURE 3 along the line 4—4.

In general, the process, and plant therefor, includes operations which remove the lighter fractions of the oil vapors and gases resulting from the pyrolysis (e.g., gas, gas oil, gasoline, and kerosene) prior to the usual cracking step since these fractions contribute relatively little to the reduction in both pour point and viscosity of the resulting oil, but when cracked, do give rise to a relatively large loss of oil in the form of non-condensable gases. On the other hand, the products of the cracking of the heavier oil fraction resulting from the pyrolysis, do contribute considerably to the reduction in viscosity and pour point of the resulting oil product but do not produce relatively large amounts of non-condensable gas.

More specifically, my process comprises the steps of pyrolyzing oil shale or the like to produce effluent oil vapors and gases, cooling the effluent to a predetermined temperature to thereby condense the heavier fractions contained therein but not the lighter fractions, thermally cracking the heavier fractions within a certain predetermined range of temperature, and condensing the uncracked lighter fractions as well as the cracked heavier fractions to thereby produce a composite oil product. The composite oil product has a pour point and viscosity comparable to, or slightly less than, that of shale oil produced after pyrolysis and cracking of all the effluent oil vapors and gases from the pyrolysis, but the loss of oil is substantially less than in prior art processes for a given pour point.

Referring now to FIGURE 1, a solid material, such as oil shale and generally spherical solid heat-carrying bodies enter the pyrolysis zone or rotatable drum 10 via lines 12 and 14, respectively. The oil shale usually enters the drum 10 at a low temperature, e.g., 50° F., although, in some cases, it is desirable to preheat the oil shale to a temperature of 300° to as high as 600° F. The heat-carrying bodies or balls are made of a hard-heat-resistant material such as alumina, or other ceramic material, or steel and preferably have a diameter somewhat larger than the average mesh size of the incoming fresh or preheated oil shale. For example, the ball diam-

eter usually lies within a range of $\frac{1}{2}$ to 1 inch, whereas the average oil shale mesh size ranges between $\frac{1}{4}$ to $\frac{1}{2}$ inch.

The heat-carrying bodies or balls preferably enter the drum 10 at a temperature lying within the range of 1000–1400° F., and are preferably intermixed in parallel flow, with the oil shale. Counter-flow of balls and oil shale is also employed, although parallel flow is presently preferred. The ratio of the balls to oil shale generally ranges between 1:1 and 3:1 depending upon the nature of the oil shale being processed, the type of heat-carrying bodies being employed, and the rate of heat transfer sought. It should be noted that while other modes of heating and pyrolyzing the oil shale can be employed, e.g. fluidized bed processes employing heated gases, the preferred method and means for pyrolyzation (and also for cracking) utilizes the generally spherical solid heat-carrying bodies, above-described. The advantages of such method and means are several and are gone into, in detail, in copending application S.N. 702,150, now U.S. Patent No. 2,984,602, entitled "Method and Apparatus for Stripping Oil From Oil Shale," filed December 11, 1957.

Upon admixture of the balls with oil shale in the rotating drum 10, pyrolysis of the oil shale occurs and the effluent oil vapors and gases leave the drum 10 and enter conduit 16 passing through chamber 17 as indicated by the arrow 18. The effluent oil vapors and gases have a temperature preferably lying between 750° to 950° F. The effluent oil vapors and gases are passed into a fractionator or partial condenser 20 and cooled therein to a temperature lying preferably between 500° F. and 800° F. That fraction of the oil vapors and gases which remains a vapor at 500° F. to 800° F., e.g., gas, gas oil, kerosene, and gasoline, is, of course, not condensed, and is passed into condenser 22 via lines 24 and 25. The condensed heavier fraction, which comprises approximately 10 to 50 percent of the collectible oil product passes along conduits 24 and 28, and thence into a reservoir or tank 29 which serves as a gas seal. The heavier fraction is then fed into the thermal cracker 30 via standpipe 32, and is cracked, as will be described hereafter.

Because the reduction in temperature of the effluent oil vapors and gases entering the partial condenser 20 is approximately only 50° F. to 450° F., the coolant for the condenser is usually ambient air, rather than water, which as mentioned, is extremely scarce in areas where the majority of the oil shale deposits are found. The air enters the condenser 20, via line 21, passes through condenser 20 around a series of tubes 23 in the condenser and exits via line 25.

After pyrolysis, the carbonaceous residue (which in the case of carbonaceous shale residue, is hereinafter, and in the claims, termed shale coke) passes, together with the balls, into the chamber 17, as indicated by the arrow 42. The carbonaceous residue passes downwardly into the inclined passageway 44, and is separated from the larger balls by passing through the openings in the inclined screen 46. In this connection, the carbonaceous residue is considerably reduced in size over the initial oil shale mesh size due to the grinding and crushing action of the hard balls on the oil shale in the pyrolysis drum 10. Separation of carbonaceous residue from the balls is thus readily effected by the screening means 46. It should also be understood that other means of separation of balls from carbonaceous residue can also be employed, such as by magnetic or elutriation means or trommels.

The balls, after being separated from the carbonaceous residue, pass downwardly along the passageway 44 and enter the thermal cracker 30, the ball temperature, after the pyrolysis, lying preferably between 900 and 1100° F. The hot balls within the cracker 30 are maintained at a constant level by suitable conventional level control

means (shown schematically by the numeral 48 and dotted line 50).

The heavier liquid oil fractions enter the cracker 30 from pipe 32 and pass through suitable distribution means, e.g., a sprayer in the cracker (not shown). The heavier oil fraction contacts the hot downwardly moving balls for a predetermined period of time, preferably ranging between one second to two minutes, and a cracking of the heavier oil fractions results. The balls and oils can contact each other in coflow, as shown, or in counterflow, or crossflow, if desired.

The liquid oil fractions contain some dust upon entering the cracker 30, the dust being initially carried with the pyrolyzed oil vapors and gases to the partial condenser 20. Because the balls have deposited thereon a certain amount of coke, the exact amount depending on the conditions under which the cracker is operated, dust adheres to the balls and is carried out with the balls. The dust is removed either during the ball reheating phase of the process, to be described, or is removed during pyrolysis of fresh oil shale in the pyrolysis drum 10.

The cracked oil vapors and gases leave the cracker 30 via the line 52 at a temperature of approximately 825° F. to 1100° F. and are sent to a conventional condenser 60 and cooled therein to a temperature of approximately 100° F., usually by means of water. The uncracked non-condensed oil and vapors, entering condenser 22, are also cooled by water to a temperature of approximately 100° F. The oil condensed in both condensers is then fed to a common tank or reservoir (not shown) to form a composite oil product for transportation by pipeline to market or to further refining steps.

The composite oil product formed by following the above process is advantageous in that, for Colorado oil shale, its pour point generally lies in the neighborhood of 30° to 60° F.; and what is also extremely important, the loss of oil in the process typically amounts to approximately only 5–15% computed on the basis of a 100% oil recovery. In prior processes, wherein cracking of all effluent oil vapors and gases, i.e., both light and heavy ends, occurs, for a given pour point of the resulting shale oil, the loss of oil in the form of non-condensables and coke increases appreciably.

After the balls have passed through the cracker 30, they are returned to the pyrolysis drum 10 for the pyrolysis of additional solid material after being reheated to a temperature of between 1000–1400° F. The preferable method of providing heat for the reheating of the balls is to combust the carbonaceous residue remaining after pyrolysis, and to then transfer the requisite amount of heat from the products of combustion of the carbonaceous residue to the balls.

Thus, the balls pass from the cracker 30, via an outlet conduit 62, an endless conveyor belt 64, and conduit 66 and 88 to a ball heating zone 90 (shown schematically in FIGURE 1) for heating. As mentioned, the balls have coke deposited thereon, and this coke is combusted to furnish additional heat for the heating of the balls.

The carbonaceous residue, separated from the balls by screen 46, falls into chamber 70. The level in chamber 70 is controlled by level control means 73 and 74. The carbonaceous residue is then conveyed, by conveyor 72, and other means to an appropriate combustion zone, such as a fluidized combustion zone (not shown). The hot products of combustion (which may be both solid entrained particulate products and gaseous products) then impart a substantial portion of their heat to the balls in the ball heating zone 90. The reheated balls, at a temperature of 1000–1400° F., then enter conduit 14 and are sent to the pyrolysis drum 10 for pyrolysis of additional solid material. A specific method and apparatus for reheating the balls by means of shale coke is shown in FIGURE 2 and is preferably employed also in conjunction with the process of FIGURE 1, as will be described.

Mention has previously been made of the fact that the

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solid material entering the pyrolysis drum may either be cold e.g. 50° F. or preheated. If preheated solid material is to be introduced into drum 10, a preferred mode of preheating involves admixing fresh oil shale with hotter balls in either parallel or counterflow, as is disclosed in detail in the above-identified copending United States application of William J. Culbertson, Jr. The hot balls employed for the solid material preheating step are preferably those taken directly from the outlet conduit 66 of the cracker 30. After the solid material preheating, the balls are sent to the ball heating step, just described.

Attention is drawn to the fact that condensation of part of the effluent oil vapors and gases from the pyrolysis zone 10 takes place prior to the cracking of the heavier fraction. While it is possible to first condense all of the effluent oil vapors and gases, and then partially fractionate prior to the cracking of the heavier oil fraction, it will be understood that such a process necessitates an extra condensation step, which in turn, would require additional equipment as well as the use of valuable water.

A specific example of the process with reference to FIGURE 1 is set forth below:

1 ton of 25 gal./ton of Colorado oil shale of approximately a ¼" mesh size enters the drum 10, via line 12, along with 2 tons of ⅝" aluminum oxide-containing ceramic balls, the balls entering the drum 10 via line 14. The oil shale has an average inlet temperature of 50° F. and the balls have an average inlet temperature of 1300° F.

192 pounds of oil vapors and 30 pounds of gases are produced during the pyrolysis, the oil vapors and gases passing via chamber 17, and conduit 16 to a partial condenser 20. The partial condenser 20 cools the oil vapors and gases to 600° F., 60 pounds of oil being condensed and sent to the cracker 30.

These heavier condensed fractions are sent to the cracker 30. They, there, contact balls that have come directly from the pyrolysis drum 10 via line 44, which have a temperature of approximately 1050° F. The period of cracking is approximately 30 seconds, the cracked oil vapors and gases being cooled to 100° F. and being thereby condensed in condenser 60.

The lighter fractions pass from the partial condenser 20 into the condenser 22 and are cooled to approximately 100° F. and thereby condensed. Both the condensed lighter fractions and condensed heavier fractions, when combined total 172 pounds, only 20 pounds or 10% of the maximum oil recovery being lost as non-condensable gases and coke. The pour point of the composite product is 40° F.

Comparing these results with a process wherein all conditions are equivalent to that just described except that all the vapors are cracked, the pour point was 50° F. and the loss of oil was 40 pounds or 20% of the total oil collectible.

The balls from the cracker 30 (now at 1000° F.) were then reheated to a temperature of 1300° F. by directly contacting them with the hot products of combustion of the shale coke. The balls are then sent to the pyrolysis drum to contact fresh incoming oil shale.

Attention is drawn to the fact that the average inlet temperature of the balls entering the cracking zone 30, in the FIGURE 1 embodiment, lies between 900° and 1100° F. It is sometimes desirable to increase the average inlet ball temperature to the cracker 30 so that a high cracking rate is maintained. To this end, a predetermined portion of balls sent from the ball heating zone 90 is by-passed around the pyrolysis drum 10 and enters the lower-temperated ball stream in conduit 44, as is indicated by the conduit 80, shown in dotted line. These by-passed balls may have a temperature as high as 1400° F. upon entering the cracking zone, and can appreciably raise the average inlet temperature of the balls. The amount of total ball-temperature increase that is brought about by the use of the by-pass feature is optimally ap-

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proximately 100 to 150° F. Thus, the temperature range of the balls entering the cracking zone 30 of FIGURE 1 can vary from a low of about 900° F. to a high of about 1250° F. It will be noted that the total ball to shale ratio will increase in proportion to the amount of balls passing through the by-pass conduit 80.

If a thermal cracking of the heavier fractions at still higher temperatures than previously described with reference to FIGURE 1 (with or without ball by-pass) is desired, such a cracking step can be accomplished by referring now to FIGURE 2. The heretofore described advantages of the FIGURE 1 processes with regard to lower pour point and minimal loss of oil are also present in the high temperature cracking process to be described. A preferred method and means of reheating the balls is also shown in FIGURE 2.

In the process embodied in FIGURE 2, the balls leave the pyrolysis drum 110 and are reheated prior to the cracking step, rather than after the cracking step, as in FIGURE 1. Inasmuch as the FIGURE 1 and FIGURE 2 embodiments are quite similar, similar pieces of equipment and conduits, etc., are designated by 100 plus the numeral designation given it in FIGURE 1. Thus, the cracker in FIGURE 1 is designated 30 and in FIGURE 2 the cracker is designated 130.

The balls leaving the pyrolysis drum 110, after giving up some of their heat therein, have a temperature usually ranging between 900° F. and 1100° F. Instead of being sent to the cracker 130 at this temperature, the balls first pass through a ball heating zone 190 and are there reheated, in a manner to be specifically described, to a temperature lying between 1200–1500° F. These hot balls are then conveyed by a moving gate 184 from the heating zone 190 to the cracker 130 via line 186, where the high temperature cracking takes place.

It will be noted that the inlet ball temperature in the cracking zone 30 in the FIGURE 1 embodiment ranges between 900 and 1250° F. depending upon whether ball by-pass is employed or not. Since in the FIGURE 2 embodiment, the ball inlet temperature to the cracking zone 190 ranges from 1200–1500° F., the variation in ball inlet temperature ranges between 900° F. and 1500° F. It will be understood that while the process employed in the FIGURE 2 embodiment is specifically preferred for a high temperature cracking, this embodiment can also be employed for the purpose of low temperature cracking. The balls can thus be heated only to temperatures of 1050° F. if desired.

A specific means of providing heat for reheating the balls is also shown in FIGURE 2. For example, shale coke, the residue produced during pyrolysis of such solid materials as oil shale, is sent from conveyor 172, along line 182, in a stream of entraining air, to a fluidized combustion zone 192. Preheated air enters the zone 192 via line 194, and passes through air distribution plate 196 which imparts to the air passing therethrough a velocity higher than the settling velocity of the shale coke particles to thereby prevent the shale coke particles from settling through openings in the plate.

The shale coke is combusted in the presence of the air, and the hot products of combustion, the gaseous and entrained solids, pass into the ball heating zone 190 via line 197. The hot products of combustion contact the balls in cross flow, and leave the zone 190 via exhaust pipe 198.

Referring now especially to FIGURES 3 and 4, the plant of either FIGURE 1 or FIGURE 2 is advantageously modified by the inclusion of a dust removal and de-mistifying apparatus designated by the numeral 200.

The oil vapors and gas from the pyrolysis drum 10 or 110 (e.g., at a temperature of 850° F.), enter the partial condenser 220, which is similar in construction to the partial condenser 20 or 120 of FIGURES 1 and 2 respectively. The oil vapors and gases usually carry some

dust from the pyrolysis drum. The oil vapors and gases are reduced in temperature (e.g. to 700° F.) in the partial condenser 220 by means of an air coolant, and oil mist, gas and dust pass into the de-mistifier 200 via line 222.

The oil mist, gas and dust enter passages 224 in the de-mistifier 200 initially causing some oil and dust collection. The upper ends of the passages 224 are closed, and the oil mist and dust are forced downwardly into a reservoir of oil, designated by the numeral 225. The oil mist and dust thus agglomerate into larger particles and move upwardly, through pipes 227, as indicated schematically by a dotted line 228, and strike a second set of staggered baffles 230 (best seen in FIGURE 4). This causes the oil mist and dust to be substantially completely "knocked out" of the gas and the lighter fractions proceed to the condenser 22 or 122 via line 231 substantially free of the heavier oils in the form of mist, or any appreciable amount of dust. The residual fuel oil collected from the oil mist returns to the bottom of the de-mistifier 200 via oil return line 232, and along with the dust, is sent to the cracker 240 (which is similar to cracker 30 or 130) along conduit 234 for the cracking thereof, as has been previously described.

The dust removed from the oil vapors and gases in the de-mistifier 200 passes through the cracker 240 with the balls, while the heavier oils fractions are cracked and sent via line 242 to a condenser, such as condenser 60 or 160.

It can thus be seen that the de-mistifier 200 and ball cracker 240 both act to prevent dust from moving out with the lighter oil fractions, and cracked heavier fractions, respectively. The need for additional dust-removal equipment such as cyclones, is thus substantially reduced.

It will be seen that the de-mistifier 200, or similar apparatus, will appreciably add to the efficiency of my process where any substantial amount of oil mist is present in the outlet line 222 from the partial condenser 220.

While several embodiments of my invention have been shown and described herein, it will be understood that modifications and changes may be made herein that lie within the ordinary skill of those in the art. For this reason, I do not intend to be bound by the embodiments herein shown and described, but intend to be bound only by the appended claims.

I claim:

1. A process for producing oil from oil shale, leaving a solid combustible carbonaceous residue, which comprises: admixing said oil shale in solid-to-solid milling contact with hot heat-carrying bodies to pyrolyze said oil shale and produce thereby an effluent of oil vapors and gases containing both heavy and light oil fractions, and a solid carbonaceous residue, said heat-carrying bodies being larger than the average size of said solid carbonaceous residue; cooling the effluent oil vapors and gases to a temperature of between about 500 and 800° F. to thereby condense the heavier oil fractions contained therein; thermally cracking the heavier oil fractions by admixture with said hot heat-carrying bodies employed in the pyrolysis, to produce a second stream of effluent oil vapors; condensing both the uncracked lighter fractions and the cracked heavier oil fractions to thereby produce a composite oil product; combusting said solid carbonaceous residue to produce hot products of combustion; and transferring some of the heat in said products of combustion to said oil shale and heavier oil fractions for the pyrolysis and cracking thereof respectively.

2. The process of claim 1 wherein said admixture of oil shale and hot heat-carrying bodies is in parallel flow.

3. The process of claim 1 wherein said admixture of oil shale and hot heat-carrying bodies is in counter-flow.

4. The process of claim 1 wherein said hot heat-carrying bodies are reheated after pyrolyzing said oil shale.

5. The process of claim 1 wherein said hot heat-carrying bodies are reheated after cracking said heavier oil fractions.

6. The process of claim 1 wherein said oil shale is preheated by hotter heat-carrying bodies, said heat-carrying bodies being then reheated, and sent to said pyrolyzing and cracking steps.

7. A process for the production of oil from oil shale which comprises: admixing said oil shale in solid-to-solid milling contact with one to three times its weight of hotter heat-carrying solid bodies, having an initial temperature of 1000° to 1400° F. to thereby pyrolyze said oil shale and produce an effluent of oil vapors and gases at a temperature of 750° to 950° F. and containing heavier and lighter oil fractions, and to produce also shale coke residue, said shale coke residue having an average size substantially smaller than said heat-carrying solid bodies; cooling the effluent to a temperature of about 500° F. to 800° F., to condense a substantial portion of the heavier oil fractions, but not the lighter oil fractions, contained therein; cracking said heavier oil fractions by admixture with heat-carrying solid bodies employed in the pyrolysis, said heat-carrying bodies having an initial temperature of between 900° and 1500° F.; cooling said cracked heavier oil fractions and said lighter fractions to temperatures of about 100° F. to produce a composite oil product; combusting said shale coke to produce hot solid and gaseous products of combustion; reheating said solid heat-carrying bodies by means of said hot solid and gaseous products of combustion; and recycling said reheated solid heat-carrying bodies to said pyrolysis and cracking steps.

8. The process of claim 7 wherein said shale coke is fluidized during its combustion, and said solid products of combustion are entrained in said gaseous products of combustion for reheating said solid heat-carrying bodies.

9. The process of claim 7 wherein dust in said effluent oil vapors and gases is removed therefrom and transferred to said cracking step along with said heavier oils, said dust being removed with said heat-carrying solid bodies from the cracking step.

10. A process for the production of oil from oil shale which comprises: admixing said oil shale in solid-to-solid milling contact with one to three times its weight of hotter heat-carrying solid bodies to thereby pyrolyze said oil shale and produce effluent oil vapors and gases at a temperature of 750° to 950° F., containing heavier and lighter oil fractions, and shale coke residue, said shale coke residue having an average size substantially smaller than said heat-carrying solid bodies; cooling the effluent to condense a substantial portion of the heavier oil fractions, but not the lighter oil fractions contained therein; cracking said heavier oil fractions by admixture with said heat-carrying solid bodies employed in the pyrolysis, said heat-carrying bodies having an initial inlet temperature of between 900° F. and 1250° F.; condensing said cracked heavier oil fractions and said lighter fractions to produce a composite oil product; combusting said shale coke to produce hot solid and gaseous products of combustion; reheating said solid heat-carrying bodies, leaving said cracking step, by means of said hot solid and gaseous products of combustion; and recycling said reheated solid heat-carrying bodies first, to said pyrolysis step and second, to said cracking step.

11. The process of claim 10 wherein part of said reheated heat-carrying bodies by-pass said pyrolysis step and are transferred to said cracking step to thereby raise the initial average inlet temperature of said heat-carrying bodies to said cracking step.

12. A process for the production of oil from oil shale which comprises: admixing said oil shale in solid-to-solid milling contact with one to three times its weight of hotter heat-carrying solid bodies, having an initial temperature of 1000° to 1400° F. to thereby pyrolyze said oil shale and produce an effluent of oil vapors and gases at

a temperature of 750° to 950° F., containing lighter and heavier oil fractions, and shale coke residue, said shale coke residue having an average size substantially smaller than said heat-carrying solid bodies; cooling the effluent to condense a substantial portion of the heavier oil fractions, but not the lighter oil fraction, contained therein; cracking said heavier oil fractions by admixture with heat-carrying solid bodies employed in the pyrolysis, said heat-carrying bodies having an initial temperature of between 1050° to 1500° F.; condensing said cracked heavier oil fractions and said lighter fractions to produce a composite oil product; combusting said shale coke to produce hot solid and gaseous products of combustion; reheating said solid heat-carrying bodies, leaving said pyrolysis step, by means of said hot solid and gaseous products of combustion; and recycling said reheated solid heat-carrying bodies first, to said cracking step and second, to said pyrolysis step.

13. A plant for the production of oil from solid materials which, upon heating, leaves a solid carbonaceous residue, comprising: means for heating the solid material to produce an effluent of oil vapors and gases and said solid carbonaceous residue, which includes apparatus for admixing said solid material in solid-to-solid milling contact with hot heat-carrying bodies, said heat-carrying bodies being larger than the average size of said carbonaceous residue; partial condensation means for cooling the effluent oil vapors and gases to condense a substantial portion of the heavier oil fractions, but not the lighter fractions, contained therein; means for cracking said heavier oil fractions which includes apparatus for admixing said heat-carrying bodies with said heavier oil fractions; and means for condensing said cracked heavier oil fractions and said lighter fractions to produce a composite oil product.

14. A plant for producing oil from solid materials from which oil is recoverable upon being heated, which comprises: means for heating said solid material to produce an effluent of oil vapors and gases, and a solid carbonaceous residue which includes apparatus for admixing said solid material in solid-to-solid milling contact with hot heat-carrying bodies, said heat-carrying bodies being larger than the average size of said carbonaceous residue; partial condensation means for cooling the effluent 50 to 450° F. to thereby condense the heavier oil fractions, but not the lighter fractions, contained therein; means for thermally cracking the heavier oil fractions which in-

cludes apparatus for admixing said heat-carrying bodies with said heavier oil fractions; means for condensing both the uncracked lighter fractions and the cracked heavier oil fractions to thereby produce a composite oil product; means for fluidizing said carbonaceous residue; means for combusting said fluidizing residue to produce hot products of combustion; and means for transferring at least part of the heat in said products of combustion to said solid material and heavier oil fractions for the pyrolysis and cracking thereof respectively.

15. The plant of claim 14 wherein a conduit means for said heavy condensed oil, lighter oil fractions, and dust leads from said partial condensing means to a dust-removing and oil-collecting apparatus, another conduit means for collected oil and dust leads from said apparatus to said thermal cracking means, and a third conduit means for said lighter oil fractions leads from said apparatus, to said condensing means.

16. A process for producing oil from solid material which, upon heating, leaves a solid carbonaceous residue, comprising: admixing said solid material in solid-to-solid milling contact with hot heat-carrying bodies to heat said solid material and produce thereby a first effluent of oil vapors and gases containing both heavy and light oil fractions, and a solid carbonaceous residue, said heat-carrying bodies being larger than the average size of said solid carbonaceous residue; substantially cooling the effluent oil vapors and gases to thereby condense the heavier oil fractions contained therein; thermally cracking the heavier oil fractions by admixture with said heat-carrying bodies employed in the pyrolysis, to produce an effluent of cracked heavier oil fractions; and condensing both the uncracked lighter fractions of said first effluent, and the cracked heavier oil fractions to thereby produce a composite oil product.

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