

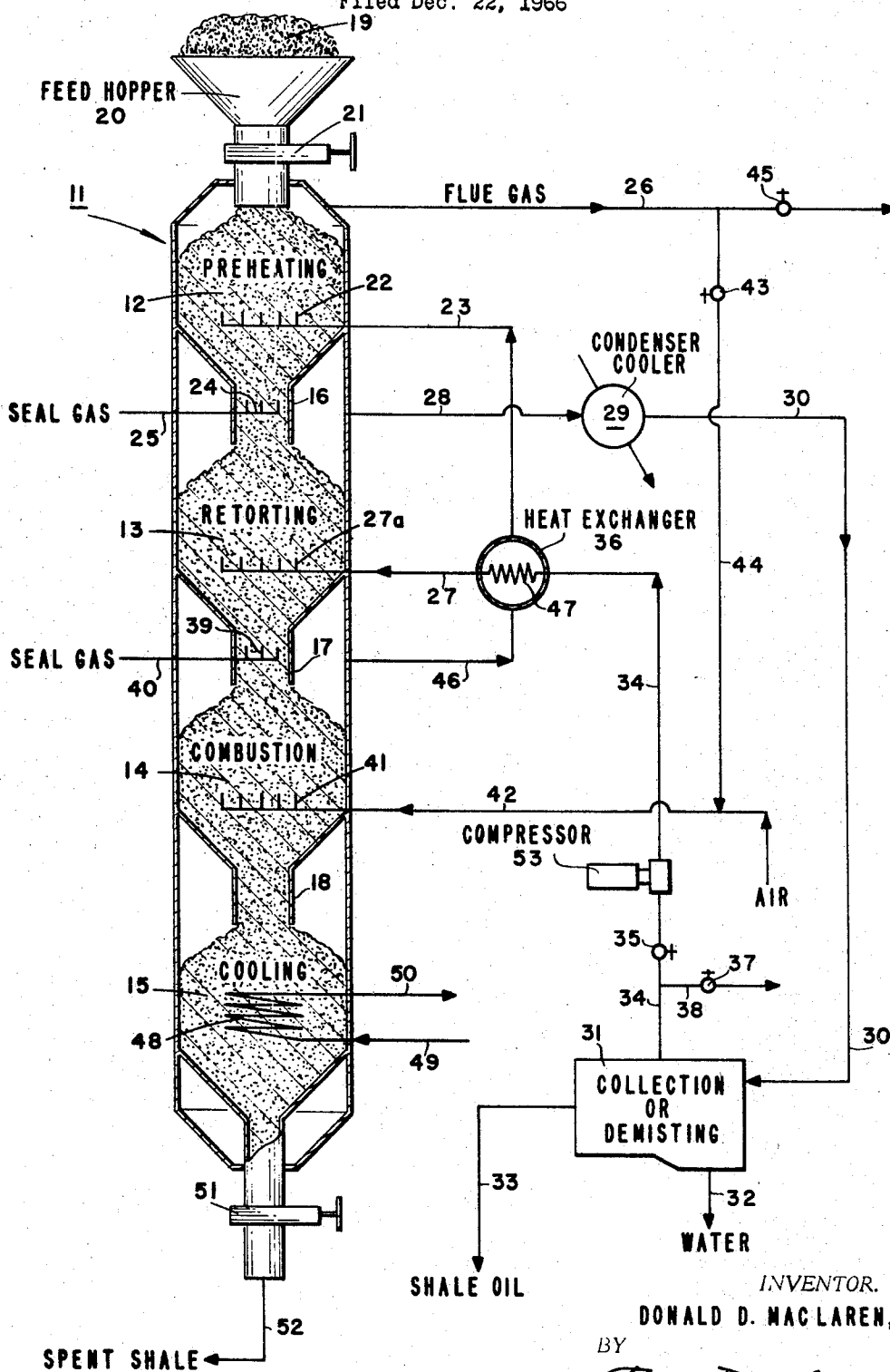
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RETORTING OF OIL SHALE

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1

2

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RETORTING OF OIL SHALE

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ABSTRACT OF THE DISCLOSURE

Oil shale is retorted serially downwardly through a preheating zone, a retorting zone, and a combustion zone. Flue gas generated from burning carbonaceous material on the spent oil shale is withdrawn from the combustion zone and introduced into said preheating zone. The sensible heat of the flue gas is further utilized to raise the temperature of product gas which is introduced into the retorting zone as the source of retorting heat, condensibles having been previously removed from the product gas.

The present invention is directed to the retorting of oil shale at atmospheric or super-atmospheric pressure. More particularly, the invention is concerned with the retorting of oil shale in a system employing a plurality of serially interconnected zones. In its more specific aspects the invention is concerned with retorting oil shale in which the oil shale flows downwardly through a preheating zone, a retorting zone, a combustion zone, and in which gaseous material flows countercurrent to the downwardly flowing oil shale.

The present invention may be briefly described as a method of retorting oil shale in which crushed oil shale flows serially downwardly through at least a preheating zone, a retorting zone, and a combustion zone. In the practice of the present invention, each of said zones is isolated from the other zones to prevent upward flow of gas but permitting flow of oil shale downwardly from one zone to the other. Flue gas, at an elevated temperature, is generated by burning carbonaceous material on the oil shale in the presence of an oxygen-containing gas introduced into the combustion zone. Flue gas is withdrawn from the combustion zone and introduced into the preheating zone to preheat raw oil shale introduced into the preheating zone. A flue gas stream is withdrawn from the preheating zone and at least a portion of said flue gas stream is admixed with the oxygen-containing gas introduced into the combustion zone. Vaporous product is withdrawn from the retorting zone and cooled and condensed to separate therefrom a gaseous product, a liquid oil shale product, and water. At least a portion of the separated gaseous product is introduced into the retorting zone after it has been heated to a sufficiently high temperature to supply the heat for retorting the preheated oil shale. The gaseous product is preferably heated to a temperature within the range from about 1200° to about 1700° F. by passage in indirect heat exchange with the flue gas withdrawn from the combustion zone. By virtue of the present invention, the gaseous product is a high B.t.u. gas which is not diluted with flue gas and comprises substantially hydrogen, and normally gaseous hydrocarbons such as methane, ethane, and propane; the yields of shale oil are also increased over that possible heretofore.

In the preheating zone in the present invention, the raw oil shale introduced thereto is essentially at ambient temperature. Ordinarily, a temperature of about 600° F. is reached at the outlet of the preheating zone.

In the retorting zone, the temperature increases from about 600° F. at the inlet to about 1100° F. at the outlet.

In the combustion zone, the temperature of the spent oil shale ranges from about 1100° F. at the inlet to about 1000° F. at the outlet. The temperature of the flame front generated by burning carbon from the spent shale is about 2100° F.

Since the oil shale after combustion is at an elevated temperature, usually a cooling zone will be provided below the combustion zone, and temperatures within the cooling zone may range from about 1000° F. at the inlet to about 200° F. at the outlet to spent shale disposal. If desired, however, the cooling zone may be omitted as such and the burned spent shale may be cooled by exposure to the atmosphere without heat recovery.

The amount of oxygen-containing gas, or air, introduced into the combustion zone may range from about 3000 to about 8000 standard cubic feet/ton of raw oil shale. As an example, the air plus recycle flue gas introduced into the combustion zone may comprise about 22,000 standard cubic feet/ton of raw shale of which about 20% will be air.

The amount of gaseous product introduced into the retorting zone may range from about 15,000 to about 25,000 standard cubic feet/ton of raw oil shale. A suitable amount of gaseous product may be about 22,000 standard cubic feet/ton of raw oil shale. Thus, the amounts of the air plus recycle flue gas mixture, and gaseous products are substantially equal.

The amount of flue gas introduced into the preheating zone may range from about 20,000 to about 25,000 standard cubic feet/ton of raw oil shale; an amount of about 22,000 standard cubic feet of raw oil shale is satisfactory.

In the practice of the present invention, the several zones including the preheating zone, the retorting zone, and the combustion zone are isolated from each other to prevent vapor from the zone below entering the zone above. A sufficient amount of seal gas is employed to displace other gases in the interstices of the oil shale thereby preventing these gases from being carried along with the oil shale such that there is no net flow of seal gas upwardly into the zone above. Seal gas approximately equal in volume to the interstices flows downwardly. The zones may be isolated from each other by providing a restriction between the zones and introducing into the restriction upwardly a seal gas which may be steam or other gas such as, but not limited to, product gas, and the like. Steam is the preferred seal gas, since it does not dilute the product gas since the steam is condensed with the liquid product. Steam simply adds to the water generated by burning carbon from the spent shale. The amount of seal gas introduced into the restriction area may range from about 5 to about 20 standard cubic feet/ton of raw oil shale introduced into the system.

By sealing the zones from each other to prevent commingling of gaseous material in one zone from gaseous material in another zone, it is possible, in accordance with the present invention, to withdraw product vapors substantially uncontaminated with flue gases within the system, and it is possible thereby to recover a recycle gas which comprises about 50 to about 55% hydrogen with the remainder light hydrocarbons such as methane, ethane, and propane, and other gaseous and perhaps normally liquid materials. This enhances the calorific value of the gas and provides a gas having a B.t.u. value within the range from about 500 to about 750 B.t.u.'s/s.c.f. Also, by virtue of the high hydrogen content of the recycle product gas, this gas may be used if desired in hydrogenating the shale oil to remove nitrogen compounds, sulfur, and other deleterious materials therefrom. Also, in accordance with the present invention, by isolating or sealing the zones from each other, the flue gas may be withdrawn from the combustion zone to bypass the re-

torting zone and be introduced into the preheating zone to provide heat for use in preheating the raw oil shale introduced into the system. Also, the recycle product gas introduced into the retorting zone may be suitably heated by passage in indirect heat exchange with the withdrawn flue gas, thus conserving heat and allowing the oil shale to be retorted with a mixture of principally hydrogen and hydrocarbons.

The present invention will be further illustrated by reference to the drawing in which the sole figure illustrates a best mode and embodiment. Referring now to the drawing, numeral 11 designates a retorting system provided with a preheating zone 12, a retorting zone 13, a combustion zone 14, and a cooling zone 15. The several zones are isolated from each other by restrictions 16, 17, and 18.

The raw oil shale 19, having particle diameters ranging from about ¼ up to about 3 inches, is introduced into the system by means of a lock hopper device 20, provided with a control mechanism 21 for maintenance of the retorting system 11 under pressure, as will be described further. The raw oil shale 19 is introduced into preheating zone 12 where it is contacted with the hot flue gas at a temperature of about 650° F. introduced thereto by a distribution means 22 connected to line 23. The raw oil shale is preheated in zone 12 to a temperature of about 600° F., and thereafter the preheated oil shale flows through distribution means 24 connected to line 25. A flue gas stream is withdrawn from the preheating zone 12 by line 26 to be used in a manner which will be described further.

The preheated oil shale flows downwardly through restriction 16 into retorting zone 13 where it is contacted with the heated gaseous product introduced into zone 13 through distribution means 27a connected to line 27 and introduced from a source which will be described further. The temperature at the bottom of the retorting zone 11 is suitably about 1100° F. and by virtue of contact with the heated gaseous product, the kerogen in the raw oil shale is decomposed to shale oil which is withdrawn as a vaporous product from zone 13 by line 28. The withdrawn vaporous product is cooled and condensed in condenser-cooler 29, and then introduced by line 30 into a collection or demisting drum 31, where a separation is made among the gaseous product, shale oil, and water obtained in the operation. The water may be withdrawn by line 32 and the shale oil may be withdrawn by line 33 for further refining such as by hydrogenation.

The off gas, comprised of gaseous product and recycle product gas, is withdrawn from collection drum 31 by line 34. An amount equal to the gaseous product produced is withdrawn through valve 37 and line 38. The rest is recycled by compressor 53 to heat exchanger 36 where it is preheated before injection through distributor 27a into zone 13.

The retorted oil shale then discharges through restriction 17 into which a seal gas is introduced through distribution means 39 from line 40 which prevents commingling of gaseous material from zone 14 with the product in zone 13, but permits passage downwardly of the retorted oil shale into combustion zone 14. In combustion zone 14, where a maximum temperature of about 2100° F. may prevail, an oxygen-containing gas is introduced therinto through distribution means 41, connected to line 42. Flue gas from line 26 is introduced into line 42 by opening valve 43 in branch line 44 which connects to line 42. Flue gas not introduced into zone 14 is discharged from the system by opening valve 45 in line 26. The flue gas is withdrawn from zone 14 through line 46 which connects to heat exchanger 36, and this withdrawn flue gas at a temperature of about 2100° F. passes in indirect heat exchange with the gaseous product introduced into heat exchanger 36 by line 34 and which passes through coil 47. Passage of the flue gas through heat exchanger 36 cools it to temperatures within the range from about 500° to about 800° F.

In combustion zone 14, the free oxygen-containing gas, such as air, causes combustion of carbonaceous material, such as coke, on the oil shale and generates heat for the retorting operation. The oil shale, after being suitably burned, discharges through restriction 18 into cooling zone 15 which is provided with a cooling coil 48 through which cooling medium is circulated by line 49 and discharged by line 50. The cooled oil shale is then withdrawn through a suitable lock means 51 and withdrawn to a waste pile by line 52 connected to the lock means 51. The spent shale will comprise from about 75% to about 90% by weight of raw oil shale fed into the system.

By virtue of the operation described in the foregoing best mode and embodiment, the gases and products in the system are prevented from commingling with each other and yields are enhanced allowing the production of increased amounts of products and gaseous material of greater utility and increased value than heretofore.

Heretofore, the resulting product gas has been diluted with an excess of combustion product such as nitrogen, carbon monoxide, and carbon dioxide which resulted in a gas having a very B.t.u. content of about 80 B.t.u.'s per standard cubic feet. Furthermore, separating the retorting and combustion zones prevents burning of any of the shale oil product which might be carried into the combustion zone along with the spent shale and burned.

It is also advantageous to carry out this invention at elevated pressure. Heretofore, about 15% to 20% of the bottoms fractions of the raw shale oil produced has been coked extraneously from the retorting system to make it easier to hydrogenate the product. In this invention, at a pressure of about 60 to about 120 p.s.i.g., preferably from 75 to 100 p.s.i.g., about 15% of the heaviest portion of the product will condense on the relatively cool shale entering the retorting zone. When this condensed material is carried down to the retorting zone, it will be converted into lighter products and coke by cracking. Additionally, the coking-retorting operation by virtue of isolating the gases, is carried out in a hydrogen-rich atmosphere since the gaseous product introduced into the retorting zone contains about 50% to 55% hydrogen. This coking in the presence of hydrogen in the retorting zone under pressure results in an improved overall product distribution resulting from in situ hydrogenation of the product.

As will be seen from the foregoing description taken with the drawing, the present invention is quite advantageous and useful, and increases the overall product quality and yields. As an example, the yields may be increased from about 5 to about 30% over that possible heretofore, while the nitrogen and sulfur content of the product may be decreased by about 5 to 25% before subsequent hydrogenation.

Furthermore, the B.t.u. value of the gas as has been indicated before is increased from about 80 to about 650 B.t.u.'s/s.c.f., which is quite substantial.

The present invention is, therefore, quite advantageous and useful.

The nature and objects of the present invention having been completely described and illustrated and the best mode contemplated set forth, what I wish to claim as new and useful and secure by Letters Patent is:

1. A method of retorting oil shale whereby yields of shale oil are increased in which crushed oil shale flows serially downwardly through at least a preheating zone, a retorting zone, and a combustion zone which comprises: isolating each of said zones from the other zone to prevent upward flow of gas, but permitting flow of oil shale downwardly from one zone to the other; generating flue gas at an elevated temperature by burning carbonaceous material on the spent oil shale in the presence of an oxygen-containing gas introduced into said combustion zone; withdrawing the flue gas from said combustion zone and introducing it into said preheating zone to pre-heat raw oil shale introduced therinto;

5

withdrawing flue gas from said preheating zone and admixing at least a portion of said flue gas withdrawn from said preheating zone with said oxygen-containing gas introduced into said combustion zone; withdrawing vaporous product from said retorting zone and cooling and condensing it to separate therefrom a gaseous product, a liquid oil shale product, and water; and introducing at least a portion of said gaseous product into said retorting zone after heating same a sufficient amount to provide heat for retorting the preheated oil shale; said gaseous product being heated by passage in indirect heat exchange with said flue gas withdrawn from said combustion zone; whereby the gaseous product comprises substantially hydrogen and normally gaseous hydrocarbons.

2. A method in accordance with claim 1 in which said zones are isolated by injecting a seal gas between said zones.

3. A method in accordance with claim 2 in which the seal gas is gaseous product.

4. A method in accordance with claim 1 in which said gaseous product is heated to a temperature within the range from about 1200° to about 1700° F.

5. A method in accordance with claim 1 in which said flue gas withdrawn from said combustion zone is introduced into said preheating zone at a temperature within the range from about 500° to 800° F.

6. A method in accordance with claim 1 in which a portion of the shale oil formed in the retorting zone is liquefied and coked therein.

7. A method in accordance with claim 6 in which the pressure in at least said retorting zone is within the range from about 60 to about 120 p.s.i.g. to cause liquefaction of about 10% to about 20% of shale oil on the oil shale entering said retorting zone.

8. A method of retorting oil shale whereby yields of shale oil are increased in which crushed oil shale flows serially downwardly through at least a preheating zone, a rotating zone, and a combustion zone which comprises: isolating each of said zones from the other zone to

6

prevent upward flow of gas, but permitting flow of oil shale downwardly from one zone to the other; generating flue gas at an elevated temperature by burning carbonaceous material on the spent oil shale in the presence of an oxygen-containing gas introduced into said combustion zone;

withdrawing the flue gas from said combustion zone and introducing it into said preheating zone to preheat raw oil shale introduced thereinto;

withdrawing flue gas from said preheating zone and admixing at least a portion of said flue gas withdrawn from said preheating zone with said oxygen-containing gas introduced into said combustion zone;

withdrawing vaporous product from said retorting zone and cooling and condensing it to separate therefrom a gaseous product, a liquid oil shale product, and water; and

introducing at least a portion of said gaseous product into said retorting zone after heating same a sufficient amount to provide heat for retorting the preheated oil shale;

said gaseous product being heated by passage in indirect heat exchange with said flue gas withdrawn from said combustion zone;

whereby the gaseous product comprises substantially hydrogen and normally gaseous hydrocarbons, wherein the seal gas is steam.

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