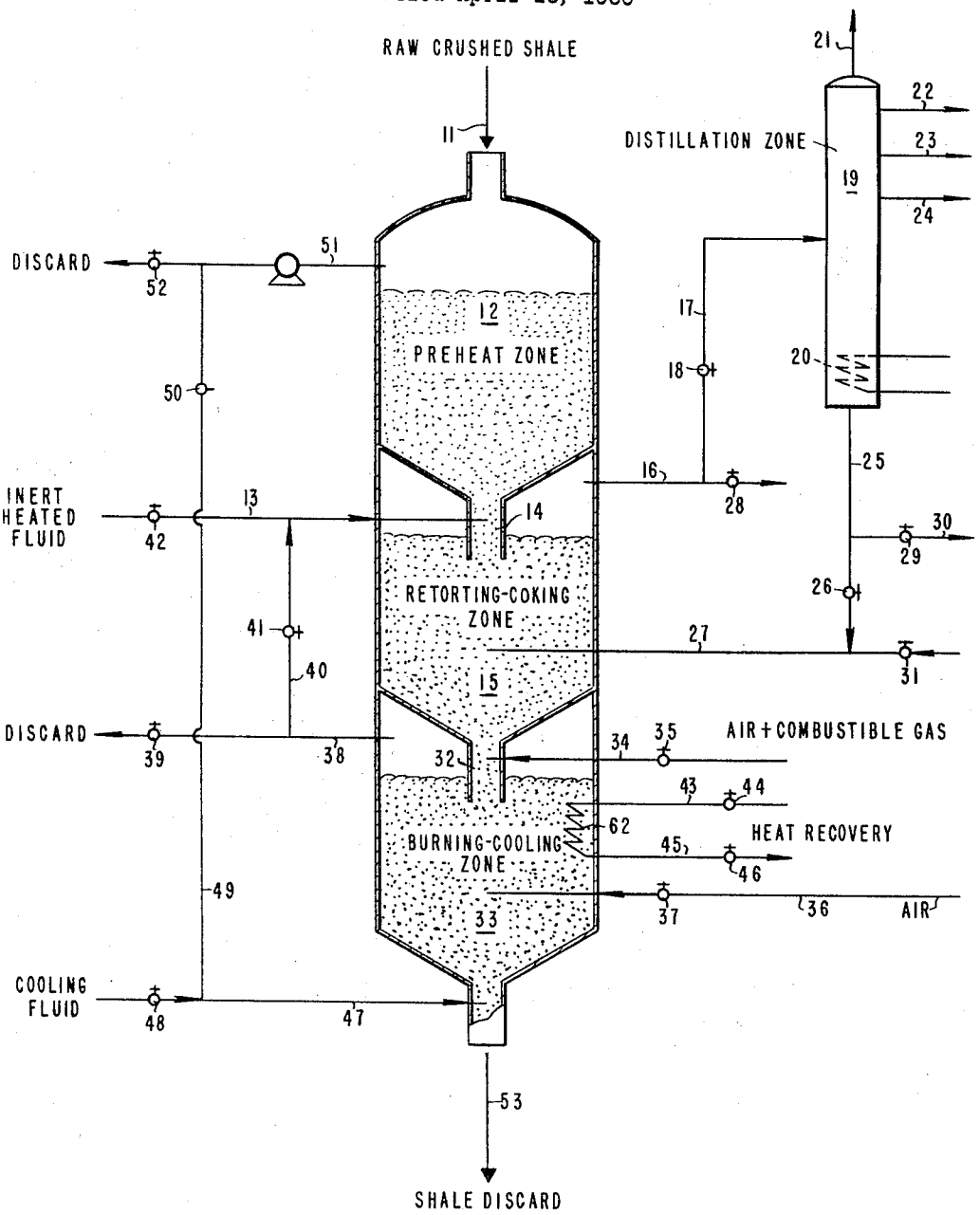
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RETORTING OF OIL SHALE

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RETORTING OF OIL SHALE

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ABSTRACT OF THE DISCLOSURE

Independent control of the retorting of crushed oil shale is provided in a unitary operation by flowing the crushed shale downwardly through preheating, retorting and combustion-cooling zones with vaporous product being removed separately and fractionated. Shale oil bottoms are introduced into the retorting zone and inert heated gas is used to preheat the oil shale with the inert gas being recycled to the burning-cooling zone to cool the discarded shale. Air and combustible gas are introduced into the retorting zone while air may be introduced into the burning-cooling zone.

The present invention is directed to retorting oil shale. More particularly, the invention is concerned with retorting of crushed oil shale. In its more specific aspects, the invention is concerned with the retorting of oil shale in which the crushed oil shale flows serially through a plurality of zones such as three treating zones.

The present invention may be briefly described as a process for retorting oil shale in which crushed oil shale flows serially through a plurality of zones including a preheating zone, a retorting-coking zone and a burning-cooling zone. The crushed oil shale is preheated in a first zone by contact with an inert heating fluid and the preheated, crushed oil shale is then subjected to retorting-coking conditions in a second zone in contact with a carbonaceous oil. Shale oil is recovered from the second zone, and the oil shale from the second zone is then subjected to a burning-cooling operation in a third zone from which the spent oil shale is discarded.

A free oxygen-containing gas is introduced into at least one of the second and third zones and heat is recovered from the third zone. Thus, shale oil is recovered as a vapor from the process, undesirable reactions are eliminated, and control of each zone is obtained.

The free oxygen-containing gas, such as air, may be introduced into either the second or third zones or both the second and third zones. When the free oxygen-containing gas is introduced into the second zone, a combustible gas may be introduced therewith. This combustible gas suitably may be gas derived in the operation, or it may be a gas from an extraneous source. For example, the combustible gas may be natural gas or the components thereof. A gas having a B.t.u. value within the range from about 100 to about 1000 B.t.u.'s may be employed.

The carbonaceous oil introduced into the second zone is suitably a shale oil residue obtained by distillation of the shale oil in the process. This residue may be a heavy oil boiling within the range above about 950°–1000° F. While it is preferred that the carbonaceous oil be a shale oil residue, it is within the purview and contemplation of this invention that the carbonaceous oil may be derived from a source outside the system. For example, the carbonaceous oil may be an oil such as high boiling residue (950° F. plus) from catalytic cracking operations and the like. Suitably, the carbonaceous oil is a shale oil fraction such as a heavy residual shale oil from which the lighter fractions boiling above 1050° F. have been removed.

A fluid introduced into the third zone as a cooling zone is suitably withdrawn from the first zone, but a cooling fluid from an extraneous source may be employed. For example, a gaseous fluid such as cooled flue gas and the like may be employed.

The inert heated fluid used to preheat the crushed oil shale is suitably withdrawn from the third zone and introduced into the first zone. However, the inert heated fluid may be obtained from outside the system and may be a heated flue gas such as a flue gas derived from combustion of combustible products. For example, the flue gas may be obtained by burning unwanted fractions of the shale oil.

The present invention will be further illustrated by reference to the drawing in which the single figure is a flow diagram of a preferred mode and embodiment. Referring now to the drawing, numeral **11** designates a charge line or conduit by way of which raw crushed oil shale having particle sizes within the range from about one-fourth to about three inches is introduced into the system from a source not shown. The raw crushed shale may suitably be a Colorado shale or oil sale from other western states, but may be an oil shale from any source. The raw crushed shale is introduced into a first zone **12** (which may be termed a preheating zone) in which a bed of the raw crushed shale is formed, with the raw crushed shale being preheated by an inert heated fluid introduced into zone **12** by line **13** from a source which will be described further. The raw crushed shale in zone **12** is preheated to incipient reaction temperature of about 500°–800° F. and then discharges by conduit **14** into a second zone **15**, which is termed a retorting-coking zone. In the retorting-coking zone where temperatures within the range of about 700°–2000° F. are obtained, a retorting and coking reaction takes place, and shale oil products are formed which are withdrawn by line **16**. The shale oil products are discharged from line **16** by line **17**, controlled by valve **18**, into a distillation zone **19**, which may be a plurality of fractional distillation towers, but only one tower is shown for convenience. Distillation zone **19** is provided with heating means illustrated by steam coil **20**, but which may be other heating means, such as an external reboiler. Distillation zone **19** is provided with suitable internal liquid-vapor contacting means, such as bell cap plates and the like. Fractionation of shale oil into component parts is allowed with vaporous and gaseous products being removed by line **21** and liquid fractions by lines **22**, **23** and **24**. Heavy residual fractions boiling above about 1050° F. are discharged by line **25**. The fractions removed by lines **21**, **22**, **23** and **24** may be subjected to suitable treatment to make a commercial, salable product for use as desired. The heavy residual shale oil in line **25** may suitably be discharged by opening valve **26** into line **27** for introduction into retorting-coking zone **15**.

Under some conditions, it may be desirable not to distill the shale oil prior to treatment. In those cases, valve **18** in line **17** would be closed and valve **28** in line **16** would be open. Similarly, when it is desired not to introduce the shale oil residue into zone **15**, valve **29** in branch line **30** may be opened and valve **26** closed allowing the shale oil residue to be discharged from the system for further use as may be desired. Under these circumstances, a heavy oil may be introduced from an extraneous source by opening valve **31** in line **27**.

The retorted and coked oil shale from zone **15** discharges by conduit **32** into a third zone **33**, which is designated as a burning-cooling zone. It is noted that air may be introduced into the retorting-coking zone **15** by line **34**, controlled by valve **35**. In some instances, it may be desirable to introduce a combustible gas, such as natural gas or its fractions or gas derived from the shale

oil along with the air introduced by line **34**. In this event, about 10% to 100% by volume of combustible gas would be introduced by line **34**. This gas may suitably have a B.t.u. value within the range from about 100 to about 1000 B.t.u.'s. Likewise, in the burning-cooling zone **33** air may be introduced by line **36** controlled by valve **37**. Thus, air may be introduced either by line **34** or by line **36**, or by both lines **34** and **36**. A clean-up burning and cooling operation takes place in zone **33**, and a hot gas is withdrawn from zone **33** by line **38** and may be discharged by opening valve **39**. Preferably, however, valve **39** is closed and the heated inert gas is introduced by line **40**, controlled by valve **41**, into line **13** to serve as the preheating gas in zone **12**. It is to be understood, of course, that inert heated fluid, such as flue gas, may be introduced into zone **12** from an extraneous source by opening valve **42** in line **13**.

The oil shale in zone **33** is cooled by a combination of a heat recovery means **62**, which may be a heat transfer means provided with line **43** controlled by valve **44** and line **45** controlled by valve **46**. Suitably, the gas introduced into zone **12** may be circulated through the heat recovery means **62**, or other gases may be circulated for recovery of heat.

The oil shale in zone **33** is cooled by introducing a cooling fluid by way of line **47**. This cooling fluid may be obtained from an extraneous source by opening valve **48** and suitably may be a gas such as cooled flue gas. Preferably, the cooling fluid is obtained from zone **12** by branch line **49**, controlled by valve **50**, which connects to line **51** by way of which gas is discharged from zone **12**. When gas discharged from zone **12** is used to cool zone **33**, valve **52** in line **51** will be controlled so as to discharge excess gases produced by combustion reactions in zone **33**.

The spent shale is discarded to a spoils dump by way of line or conduit **53**. The following Table I illustrates rates, temperatures, pressures, and other operating conditions in conjunction with the several locations in the drawing.

ing zone or by suitable fluid derived outside the system. The shale is preheated to incipient reaction temperatures of about 500° to about 800° F. and is then discharged into the retorting-coking zone with cooled preheating fluid being discharged from the system or recycled to the cooling zone to cool the spent shale.

Air or other oxygen-bearing material is introduced into the retorting-coking zone, thereby burning sufficient coke, gas or other combustible material to provide heat liberation necessary to heat the shale to reaction temperature and to provide for heat of reaction and vaporization of the oil. Combustible gas derived from shale oil processing or any other manner may be introduced into the retorting-coking zone for the combustion operation. Shale oil residue or other material suitable for coking may be introduced into the retorting-coking zone to provide heat and for conversion into more suitable products. Thus, in accordance with the present invention, low value materials introduced as carbonaceous oils into the retorting-coking zones are upgraded to desirable fractions. Air or other oxygen-bearing material is introduced into the burning zone to provide complete oxidation of coke residue which remains on the oil shale. The hot spent shale is then cooled by suitable cooling fluid either recycled from the preheating zone or this cooling fluid may be other material derived outside the system. The hot gases resulting from the shale cooling and burning operations are used as a preheating gas in the first zone.

Excess heat over that required for shale preheating is recovered for use in the system by suitable heat exchange means arranged in the burning-cooling zone. Suitably heat may be recovered from the gas discharged from the burning-cooling zone.

The present invention has several marked advantages over the prior art of gas combustion retorting operations. In the present invention, products are taken as vapors and may be condensed directly or being in a heated condition subjected to fractionation for recovery of suitable fractions which may be further processed. Also, the present invention provides flexibility in controlling the quality of oil derived from the retorting of shale by eliminating undesirable cracking reactions and providing a means for converting less desirable fractions to more desirable fractions. Also, in the process independent control of each of the several critical steps of shale preheating, retorting and cooling is obtained in the present invention which was not obtainable heretofore.

The present invention is therefore quite important and useful.

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

1. In a unitary process for continuously retorting oil shale in which crushed oil shale flows serially downwardly

TABLE I.—RATES, TEMPERATURES AND PRESSURES FOR OIL SHALE RETORTING PROCESS

Location	Typical				Range			
	M s.c.f./ton	Pounds/ton	° F.	P.s.i.g.	M s.c.f./ton	Pounds/ton	F°.	P.s.i.g.
Line 51	29		130	5	25–30		100–200	0–50
Valve 52	10		130	5	0–30		100–200	0–50
Valve 50, Line 49	19		130	5	0–30		100–200	0–50
Line 47	19		130	5	15–30		100–200	0–50
Line 40, Valve 41	28		800	5	0–29		700–900	0–50
Valve 42	0				0–29		700–900	0–50
Valve 39	0				0–40		700–900	0–50
Valve 48	0				0–30		100–200	0–50
Line 36, Valve 37	8		150	5	5–15		100–1000	0–50
Line 34, Valve 35	3		150	5	0–5		100–1000	0–50
Line 27, Valve 26		40	750	5		0–100	600–800	0–50
Line 16, Valve 18, Line 17 (or Valve 28)	3.8	515	800	5	3.8–15		600–800	0–50
Line 21	3.5	265	100	0	3.8–15		100–300	0–40
Line 30, Valve 29		20	750	5		0–40	600–800	0–50
Valve 31		0				0–100	600–800	0–50

OTHER OPERATING CONDITIONS

	Typical	Range
Shale rate, pounds/hr./sq. ft.	500	100–800
Depth preheat zone, ft.	4	2–10
Depth retorting zone, ft.	3	1–6
Depth cooling zone, ft.	7	3–15
Heat recovery, M B.t.u./ton	0.45	0.3–0.7

It will be seen from the foregoing description taken with the drawing that a unitary operation is described by way of which numerous advantages are obtained. In short, the invention is quite important, advantageous and useful.

In the practice of the present invention, raw crushed shale is introduced by suitable means into a preheating zone, and the shale flows downwardly continuously by gravity flow and is heated by countercurrent flow of an inert, hot fluid derived from the shale cooling-coke burn-

through a plurality of zones, the method of independently controlling each step of said process which comprises:

preheating said crushed oil shale in a first zone by contact with an inert heated fluid introduced in the bottom of said first zone and withdrawing inert fluid from the top of said zone;

subjecting said preheated crushed oil shale to retorting-coking conditions in a second zone in contact with a carbonaceous oil introduced into said second zone;

recovering vaporous shale oil from said second zone; and

subjecting said oil shale from said second zone to a burning cooling operation in a third zone and withdrawing inert heated fluid from said third zone,

a free oxygen-containing gas and a combustible gas being introduced into said second zone, a free oxygen-containing gas being introduced into said third zone, and heat being recovered from said third zone.

2. A method in accordance with claim 1 in which the inert heated fluid withdrawn from the third zone is introduced into the first zone.

3. A method in accordance with claim 1 in which the carbonaceous oil is a shale oil fraction.

4. A method in accordance with claim 1 in which the inert fluid withdrawn from the first zone is introduced into the third zone as a cooling fluid.

5. A method in accordance with claim 1 in which the carbonaceous oil is obtained as a residue from distillation of the shale oil.

6. A method in accordance with claim 1 in which the inert heated fluid is flue gas.

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