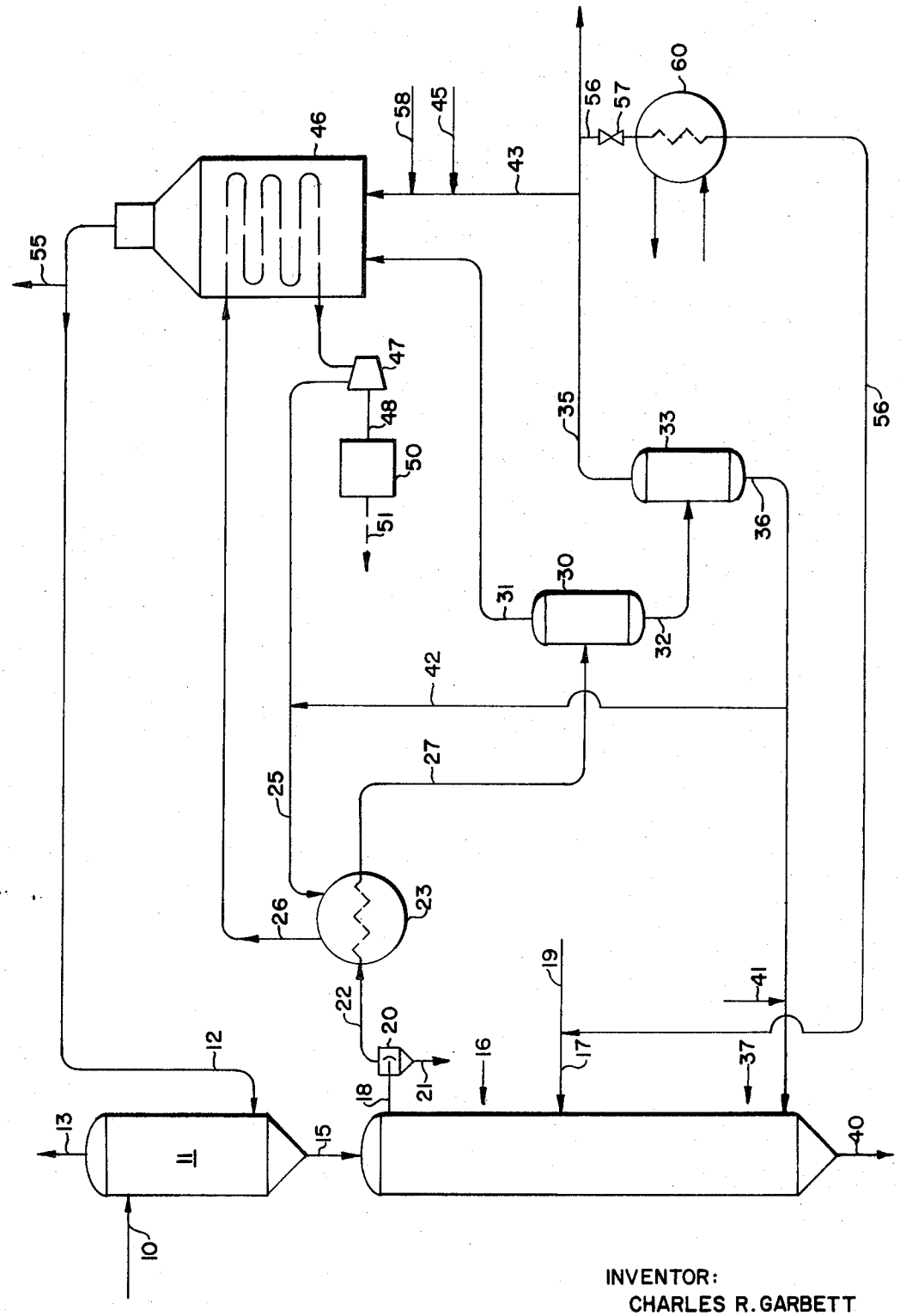
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PROCESS FOR RETORTING OIL-BEARING SHALE

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PROCESS FOR RETORTING OIL-BEARING SHALE

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ABSTRACT OF THE DISCLOSURE

A process for retorting oil-bearing shale including passing shale through a pre-heating zone and a retoring zone. Pre-heated shale is introduced into the retorting zone where it is contacted countercurrently with a hot gas stream which releases an oil vapor product at high temperature from the shale. The oil vapor product is rapidly quenched by heat exchange with water and the resultant heated water is passed to a steam generating plant wherein a fuel fired furnace is employed to produce high temperature steam. The steam is employed to generate electric power and in expanding steam through power recovery means, it is cooled enough to be useful to quench the oil vapor product. The exhaust gas from the fuel fired furnace is passed to the pre-heating zone to pre-heat the shale.

BACKGROUND

Oil is usually removed from oil-bearing shale by retorting, a thermal process that vaporizes volatile oil and thermally decomposes other forms of hydrocarbon to form a vapor product and a heavy residual material. Burning of the residual material provides a hot gas stream for effecting thermal decomposition and vaporizing while it beneficially employs the residual material that is not vaporizable. The thermally decomposed hydrocarbon from the retorting process is highly unsaturated and very reactive and it is capable of polymerization and condensation reactions at high temperature which result in the production of more residual material and lower yields of usable hydrocarbons from the process.

In the usual shale retoring processes the heat energy of the vapor products is saved by using them to pre-heat the incoming shale. Although this processing scheme has the advantage of recovering heat from the product, reducing the heat load in processing shale and quenching the hot product so that condensation reactions are stopped, the cool incoming shale condenses vapors and coalesces droplets of the hydrocarbon product which results in carrying the product back toward or into the retorting zone. As a result, the higher boiling material in the vapor products from the retorting zone are subjected to repeated heating, vaporization, and condensation before finally escaping from the processing equipment, and these repeated high temperature treatments cause the hot unstable material to polymerize to residual materials with a consequent loss of yield.

THE INVENTION

This invention provides a process for retorting shale which is thermally economical, but one that does not produce loss of yield due to repeated vaporization of product. In accordance with this invention preheated oil-bearing shale is retorted in a retorting zone that is separate from the pre-heating zone, and the vapor oil product from the retorting zone is immediately removed from the zone and quenched by heat exchange with water to a temperature at which it is stable. Since the product is immediately removed from the high-temperature zone and quenched, the undesirable polymerization and condensation reactions are stopped and a maximum yield of desirable produce is obtained. The use of the term *water* with regard to various streams is intended to include steam, and is not limited to liquid phase water.

The thermal economy of the process of this invention is maintained by further heating the water employed to quench the vapor product from the retorting zone in a fuel fired furnace to produce high temperature steam that is suitable for generating electric power. This steam is expanded through power generating equipment such as a turbine which reduces its temperature so that it may be employed again as a heat exchange medium for quenching vapors from the retorting zone. The fuel fired furnace, which may burn a portion of the shale-oil product as fuel, produces a hot flue gas in addition to high temperature steam, and this flue gas is composed of neutral material with regard to oil-bearing shale. In accordance with this invention, the hot flue gas from the fuel burning furnace is passed into contact with shale in a pre-heating zone whereby the shale is pre-heated before it enters the retorting zone.

It can be seen that the process of the present invention recovers substantially all of the thermal energy that would normally be lost from the process in a manner that does not adversely affect the product from the process. The hydrocarbon recovered from the oil-bearing shale is cooled by the quench water, the quench water circulates in a closed cycle between the quenching zone, the furnace, and the power generating equipment, and the flue gas generated from the furnace is cooled subsantially to ambient temperature by pre-heating the shale before it enters the retorting zone.

Within the broad framework of the process as described hereinabove, many variations are contemplated. To name a few, it is desirable to remove solid particles from the vapor product from the retorting zone to avoid problems in the liquid phase due to particle accumulations. Since particle removal is a short-time process effected with centrifugal separators and electrostatic precipitators, particles may readily be removed from the vapor phase product prior to quenching without substantial side reactions occuring. Accordingly, it is preferred to remove entrained mineral particles from the vapor phase hydrocarbon stream flowing from the retorting zone before that stream is quenched in that removing entrained solids from a vapor-phase stream can be accomplished more easily and more economically than removing particles from a liquid-phase stream.

To spent shale from the retorting zone leaves the retorting zone at approximately the temperature at which the oil-bearing shale is retorted. To cool this spent shale and to recover heat from it, it is contemplated that water will be introduced into a spent shale cooling zone wherein water will be vaporized while cooling the spent shale. The steam that results from cooling spent shale is preferably introduced into the retorting zone to flow countercurrent to the oil-bearing shale. This steam carries useful heat into the retorting zone and serves to strip hydrocarbon vapors from the shale when they have been vaporized or thermally converted to vapor-phase material. Not only does cooling of spent shale recover process heat and serve to strip product from the retorting zone, but it produces water from which dissolved solids are removed. This water may be used as boiler feed make-up when appropriately treated to remove dissolved gases or inhibit their adverse affects.

The process of the present invention can best be explained with reference to the accompanying drawing which illustrates schematically a process embodying this invention.

In the embodiment shown in the figure, oil-bearing shale is introduced by any conventional means illustrated as line **10** into a preheating zone **11** in which it is preheated by being countercurrently contacted with a rising

stream of flue gas introduced into pre-heating zone **11** through line **12**. The flue gas is a typical flue gas from a fuel-burning furnace, and it contains, among other things, carbon dioxide, water vapor, and nitrogen, all of which are substantially inert at the temperatures involved with respect to the ingredients of oil-bearing shale. After providing heat to the oil-bearing shale, the flue gas is exhausted through line **13** and sent to a stack for disposal. The pre-heated oil-bearing shale passes from the bottom of pre-heating zone **11** through line **15** and into the upper portion of retorting zone **16**.

In retorting zone **16** the oil-bearing shale descends in counter-current contact with a stream of hot gas. The hot gas may be obtained by introducing air or other oxygen-containing gas into the lower portion of retorting zone **16** through line **17**. As the oxygen-containing gas rises, it causes combustion of residual material in the shale thereby producing high temperature gases that rise through zone **16** causing vaporization and thermal decomposition of hydrocarbons contained in the shale. Sufficient oxygen-containing gas may be introduced through line **19** into line **17** to cause substantially complete vaporization and decomposition of those portions of hydrocarbons in the shale that are capable of vaporization and decomposition so that as the shale approaches the introduction point of oxygen-containing gas, it contains lesser amounts of material capable of being vaporized or decomposed than shale higher in the retorting zone **16**. The oxygen-containing gas consumes the refractory carbonaceous portion of the oil-bearing shale so that substantially all of the hydrocarbon material in the shale is used, by being recovered as product or as a process heat source. The hot retorting gas may also be a portion of the product that is supplied to line **17** through line **56**, the source of which will be described later.

As a result of the treatment in the retorting zone, an extremely hot gas stream which contains vaporized hydrocarbon, unstable cracked products, combustion gas or other hot gas, and steam from a source to be described hereinafter, passes through line **18**. This vapor phase stream is immediately subjected to centrifugal separation in separator **20** and if necessary to electrostatic separation to separate entrained particles from the stream, and the resultant substantially particle-free vapor stream passes through line **22** and is immediately quenched in heat exchanger **23**. Heat exchanger **23** is shown as an indirect heat exchanger between the vapors on the tube side and water on the shell side that is introduced through line **25** and removed through line **26**.

The stream emerging from heat exchanger **23** is mixed phase stream of liquid and gas and it passes through line **27** into a phase separator **30**. In phase separator **30** a vapor stream is removed through line **31** and a liquid stream containing hydrocarbon and water is removed through line **32** where it is passed through another phase separator **33**. A liquid hydrocarbon products stream is passed through line **35** and a water stream is removed through line **36** from where it is returned to spent shale cooling zone **37**.

In spent shale cooling zone **37** water is contacted with hot spent shale from retorting zone **16** and it is vaporized to form steam. The steam passes upwardly through the retorting zone **16** providing heat and a stripping vapor medium which helps separate the hydrocarbon from the shale. The cool spent shale passes from zone **37** through line **40** to be disposed of. Make-up water may be added to the cooling zone through line **41**, and the make-up water employed herein may be any water that is available including saline or brackish water in that it is vaporized in zone **37** and scale-forming materials within the make-up water are deposited on the spent shale and discarded through line **40**. The water vaporized in zone **37** ultimately is recovered as the underflow from separator **33** which may be subjected to appropriate treatment to make it suitable as boiler feed make-up water after which it may be passed into line **25** via line **42**.

The vapor products from the retorting zone which were not condensed in heat exchanger **23** pass through line **31** into furnace **46**. A portion of the hydrocarbon product from the retorting zone also passes from line **35** via line **43** into furnace **46**, and air is supplied through line **45** to furnace **46**. Line **58** may also be provided for an independent fuel supply to furnace **46** for emergencies and start-ups.

A portion of the product from line **35** may be passed through line **56** and valve **57**, through heat exchanger or furnace **58** wherein it is heated to retorting temperature, and then to line **17** from which it passes to retorting zone **16** as the hot gas. When hydrocarbon is used as the hot gas, the product does not contain oxygen compounds or nitrogen and is therefore more stable and purer. However, when oxygen-containing gas is employed as the hot gas, the energy required for retorting is supplied by carbonaceous materials on spent shale. The hot gas may also be a fraction of the total product recovered after fractional distillation of the total product stream in line **35**, and it may include some or all of the lighter materials shown passing through line **31** for fuel.

In furnace **46** the hot water in line **26** is heated to high temperature steam and the steam is expanded through turbine **47** which in turn drives shaft **48** and generator **50** to produce electric power shown schematically being taken off through means **51**. In expanding through the turbine **47** the high temperature steam is cooled and it discharges into line **25** wherein it is condensed by conventional means and pumped to heat exchanger **23**. The flue gases from furnace **46** emerge through the before-mentioned line **12** and are passed into the lower portion of pre-heating zone **11**. Line **55** may be provided to divert some of the flue gas to the atmosphere so that the heat supplied to preheating zone **11** may be controlled.

As stated above, the process illustrated in the drawing is one embodiment of the process of this invention and it is capable of many modifications and alterations within the scope of this invention. The highly schematic drawing does not illustrate pumps, conveyors, valves, heat exchangers, controllers, condensers and other conventional equipment and it is contemplated that such equipment will be supplied where appropriate.

I claim as my invention:

1. A process for retorting oil-bearing shale comprising:

(A) introducing shale into a pre-heating zone wherein it is pre-heated with hot flue gas;

(B) passing pre-heated shale into a separate retorting zone wherein it is countercurrently contacted with hot gas to produce a vapor hydrocarbon stream and spent shale;

(C) quenching the vapor hydrocarbon stream by indirect heat exchange with water to produce a liquid, stabilized hydrocarbon stream and heated water;

(D) passing the heated water into a fuel fired furnace to produce high temperature steam and hot flue gas;

(E) passing the hot flue gas to said pre-heating zone to provide the heat source therein;

(F) expanding said high temperature steam through electric power generating means to produce power and water for quenching said vapor hydrocarbon stream.

2. The process of claim **1** wherein particles are separated from the vapor hydrocarbon before it is quenched.

3. The process of claim **1** wherein spent shale is cooled by vaporizing water, and the resultant water vapors are passed counter-currently through the shale in the retorting zone.

4. The process of claim **1** wherein at least a portion of the stabilized hydrocarbon is employed as fuel in said fuel fired furnace.

5. The process of claim **1** wherein said hot gas is a portion of the product that has been heated.

6. The process of claim 1 wherein said hot gas is air heated by combustion of carbonaceous material on the spent shale.

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