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RECOVERY OF OIL FROM OIL SHALE

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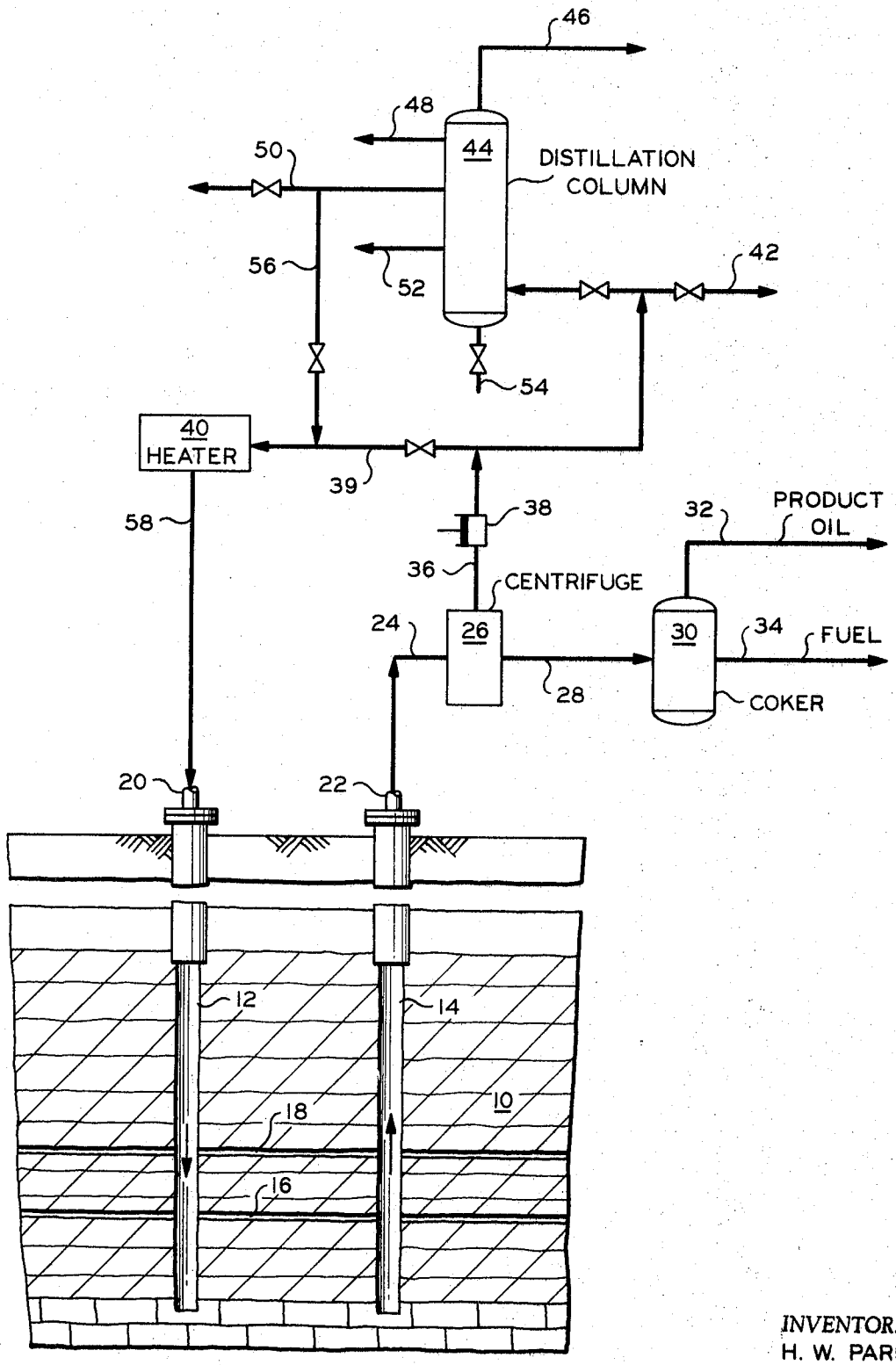

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RECOVERY OF OIL FROM OIL SHALE

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ABSTRACT OF THE DISCLOSURE

Shale oil is produced from oil shale in situ by injecting hot hydrocarbon oil, such as gas oil from crude or from oil shale, or shale oil per se, at a temperature in the range of about 550 to 800° F. thru a fractured section of the shale between wells penetrating said section to heat the shale, cause disintegration thereof, produce shale oil and a resulting suspension of mineral matter from the shale in the resulting oils, and produce the suspension thru one of the wells. Kerogen and bitumen of the shale are dissolved in the hot injected oil, forming a mixed oil from which the solids are separated and coked to produce additional shale oil.

This invention relates to a process for producing oil and oil shale from a subterranean deposit of oil shale.

There are vast deposits of oil shale in the Rocky Mountain region of the United States and elsewhere, much of which contain more than twenty gallons of shale oil per ton of shale. Because of the solid nature of the kerogen in the shale and the impervious nature of the oil shale, production by conventional oil-producing methods is not feasible. Mining of the shale and transportation of the mined and crushed shale to above-ground retorting plants comprises one method of recovering shale oil from the shale but is too expensive to compete with petroleum oils produced in conventional manner. Various methods for producing shale oil from oil shale in situ have been devised but such methods have not been competitive with methods of producing liquid oil from ordinary oil reservoirs.

The present invention is concerned with a method or process for producing shale oil, both in situ and aboveground, from a subterranean shale deposit which avoids mining and crushing of the oil shale.

Accordingly, it is an object of the invention to provide an improved method or process for producing shale oil from a subterranean oil shale deposit. Another object is to provide a process for producing shale oil from a subterranean oil shale deposit which avoids the necessity of mining and crushing the shale. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises providing an injection well and a production well penetrating a fractured section of a subterranean oil shale deposit, passing thru the fractured shale section from the injection well to the production well a hot hydrocarbon oil containing a major portion boiling above about 500° F. heated to a temperature in the range of about 550 to 800° F. at a sufficient pressure to maintain the oil in liquid phase, continuing the injection of the hot oil thru the injection well and producing the oil thru the production well so as to disintegrate the contacted shale, extract shale oil from the disintegrated shale, form a suspension of the mineral matter of the shale in the resulting mixture of oils, and flow the resulting suspension thru the production well to aboveground level where most of the oil is separated from the suspension as recovered shale oil product. The remaining solids are subjected to fluid bed coking in conventional manner to recover additional shale oil therefrom. The remaining coke and mineral matter provides a solid fuel for any desired use.

The process of the invention is applicable to any oil shale which contains or assays at least twenty gallons of shale oil per ton of shale. It has been found that kerogen and soluble bitumen, the first product of kerogen pyrolysis, are soluble in heavy oils, particularly oils boiling above about 500° F. and up to 800 or 900° F., such as gas oil. It is preferred to utilize the shale oil produced in the process or a gas oil fraction thereof, however, crude oil or the gas oil fraction thereof obtained from a liquid oil deposit is operable in the process.

By flowing the hot oil thru the fractured section of oil shale from the injection well to the production well at the required elevated temperature, the oil shale is heated substantially to the temperature of the injected oil so that after a couple of hours of heating at this temperature the shale disintegrates, the kerogen and soluble bitumen therein going into solution in the injected oil and leaving a suspension of the mineral matter of the oil shale dispersed in the oil mixture. In this manner, the disintegrated and dispersed mineral matter containing additional shale oil is transported to ground level in the produced oil. In the operation, the heated oil-soaked particles are swept away, exposing new oil shale to the heating and contacting, contacting, and soaking process with continuous wearing away of the oil shale, production of shale oil therefrom, and transporting of the oil-soaked mineral matter to ground level for further production.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing which is a flow scheme thru a pair of wells penetrating a fractured oil stratum and thru an arrangement of the equipment aboveground for separating and producing oil.

Referring to the drawing, an oil shale **10** is penetrated by an injection well **12** and a production well **14**. A lower section of the oil shale is fractured as at **16** and **18**, providing communication between wells **12** and **14** thru the oil stratum. While only two wells are shown, well **12** may represent a line of wells parallel with a line of wells **14**, each of wells **12** being used as an injection well while each of wells **14** serves as a production well. Another arrangement comprises a ring of wells around a central well, injection being effected thru the central well and production thru the ring wells or vice versa. One or more fractures are produced by conventional means as by hydraulic fracturing, by an explosion downhole, or by an underground nuclear explosion within the shale formation.

Well **12** is provided with an injection tubing string **20** while well **14** is provided with a production tubing string **22**. A production line **24** connects with tubing **22** and leads into a centrifuge **26** or other separation means for separating most of the produced oil from the particulate solids flowing to the surface. Line **28** connects the centrifuge with a fluid bed coker **30** for delivery of separated solids thereto. Oil produced in the coker is recovered thru line **32** while residual coke and mineral matter are recovered thru line **34** and may be used as fuel for any desired purpose.

Separated oil from centrifuge **26** is passed thru line **36** under the impetus of pump **38** partially to oil heater **40** and partially to production line **42** or to distillation column **44**. Distillation column **44** is a conventional distillation column from which various fractions are recovered in conventional manner such as normal gaseous hydrocarbons thru line **46**, gasoline thru line **48**, gas oil thru line **50**, cycle oil thru line **52**, leaving a residuum or topped crude which is recovered thru line **54**. In a preferred mode of operation, gas oil is passed thru line **56** and line **39** into oil heater **40** for heating to the required temperature of 550 to 800° F. for passing thru line **58** into tubing string **20** and injecting into the oil shale.

Any type of oil heater may be utilized as heater **40** such as a gas-fired indirect heat exchange heater. While a centrifuge is shown as equipment **26**, a filter or any other type of solids-liquid separator may be utilized. Likewise, a fluid bed coker is shown for the separation of oil from the mineral matter recovered from the centrifuge in line **28**, however, the oil may be produced from this material by retorting or any other suitable method.

In operation, hot oil heated to a temperature in the range of 550 to 800° F., and preferably to at least 750° F., is injected from a line **58** thru tubing string **20** into fractures **16** and **18** from which the oil flows into well **14** and is produced thru tubing string **22**. Suitable pressure is maintained on the injected oil to provide liquid phase operation and to force the oil thru the system into centrifuge **26**. After sufficient heating period with oil flowing thru the system, the oil shale surface within the fractures is brought to disintegrating temperatures with kerogen going into solution in the injected oil and disintegration of the mineral matter associated with kerogen. The particulate mineral matter forms a dispersion in the injected and produced oil and the dispersion is flowed thru tubing string **22** and line **24** into the centrifuge **26** for separation into a stream of oil recovered thru line **36** and a thick slurry of mineral matter in oil thru line **28** from which it is passed to fluid bed coker **30**. The coker is operated in conventional manner to produce shale oil thru line **32** and coke and mineral matter thru line **34**.

In preferred operation, the oil recovered in line **36** is passed in part to distillation column **44** from which a gas oil is recovered in line **50**. The required amount of heating oil is passed from line **50** thru line **36** and line **39** into heater **40** where it is heated to 775° F. under a pressure of about 300 p.s.i.g. before being injected as the heating oil into the oil shale.

Another oil that functions efficiently as a heating oil comprises a cycle oil produced from catalytic cracking of heavy oils. Cycle oils have excellent solvent capacity for asphaltic materials which aids in the disintegration of the oil shale.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for producing shale oil from an oil shale assaying at least 20 gallons of oil per ton of shale which comprises the steps of:

(a) providing an injection well and a production well penetrating a fractured section of said oil shale with communication between the wells thru said fractured section;

(b) injecting hot hydrocarbon oil a major portion of which boils above about 500° F. thru said injection well into said fractured section at a temperature in the range of about 550 to 800° F. and sufficient pressure to maintain said oil in liquid phase and producing said oil thru said production well;

(c) continuing the injection of hot oil in accordance with step (b) so as to disintegrate the shale contacted by said oil, form a suspension of the mineral matter of said shale in the resulting mixture of oils, and produce said suspension thru said production well;

(d) separating most of the oil from said suspension; and

(e) recovering shale oil from the recovered oil as product.

2. The process of claim **1** including the step of:

(f) passing a slurry of mineral matter in shale oil recovered in step (d) to a coking step to recover additional shale oil.

3. The process of claim **1** wherein step (d) comprises centrifuging said suspension.

4. The process of claim **1** including the steps of:

(f) heating a portion of the oil recovered in step (d) to a temperature in the range of 750 to 800° F.; and

(g) injecting the resulting hot oil as said oil in step (b).

5. The process of claim **1** wherein said oil injected in step (b) is shale oil.

6. The process of claim **1** wherein said oil injected in step (b) is a gas oil.

7. The process of claim **1** wherein said oil injected in step (b) is a gas oil distilled from the produced shale oil.

8. The process of claim **1** wherein said oil injected in step (b) is a cycle oil obtained from catalytic cracking of a crude oil.

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