

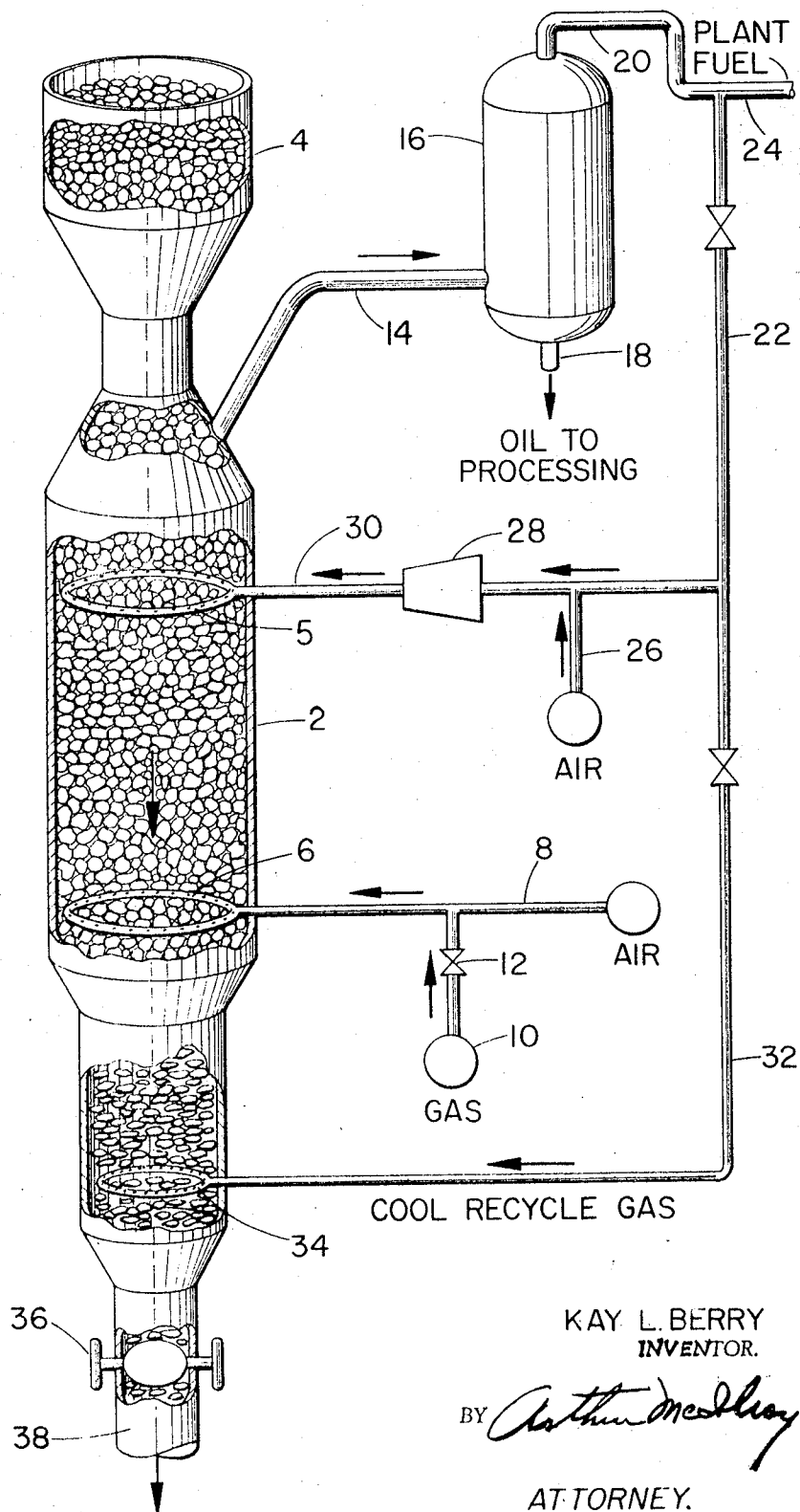
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OIL SHALE RETORTING METHOD

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OIL SHALE RETORTING METHOD

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ABSTRACT OF THE DISCLOSURE

A portion of the heat for retorting oil shale is supplied by injecting externally-generated hot flue gas at about 800° to 1200° F.; the remainder of the retorting heat is supplied by combustion in the spent shale bed. The purpose is to minimize overheating the shale, which causes carbonate decomposition and excessive cracking. In the proposed method a portion of the shale is retorted before heat from the combustion zone reaches it.

The present invention relates to a novel method for the recovery of hydrocarbon oils from mineral solids. More particularly, it is concerned with a relatively low temperature retorting step to effect substantially complete recovery of useful products from the organic portion of mineral solids such as oil shale, lignite, and the like, without causing an unusual amount of inorganic mineral decomposition and excessive cracking of product vapors.

Briefly, the process of my invention is carried out by injecting a stream of gaseous combustion products, or the equivalent thereof, at a temperature of from about 800° to about 1100° F. at a level in the upper half of a vertical retort. Additional heat is supplied to the bed as needed by burning at a lower level in the bed and in a deficiency of oxygen a portion of the carbon residue on the shale after the latter has passed through the primary retorting zone in the upper half of the retort. Some heat at this level is also supplied by burning of flue gas introduced below the burning zone and used to absorb heat from the spent shale before the latter is discharged from the retort. Since a deficiency of air or oxygen is employed, less heat is generated by combustion in the bed. Under these conditions the combustion zone temperature is lowered to the desired range of 800° to 1100° F., resulting in little or no decomposition of inorganic materials present in the shale.

According to the present state of the art, in the processing of shale in a vertical retort, heat is supplied to the system by a burner, or a series of burners, located near the mid point of the retort. Once combustion of the oil shale at this level of the downwardly moving bed has been initiated, the heat can be maintained merely by the introduction of air. The heat thus generated liberates kerogen in vapor from from the shale particles and this vapor rises through the bed of cooler shale countercurrently to the flow of the latter and after transferring the major portion of the heat therein in the cooler oil shale, the resulting product stream is withdrawn at a point near the top of the bed and the shale oil separated from the uncondensed portion of the withdrawn stream. In effecting such a retorting process, temperatures of the order of 2000° F. and higher are produced in and near the burning or combustion zone. Bringing raw shale into a portion of the retort at these temperature levels in disadvantageous for at least two reasons. First, much of the kerogen vapors liberated from the shale are severely cracked, forming excessive amounts of carbon and lower molecular weight hydrocarbons, thus reducing materially the ultimate yield of shale oil. It is estimated that the oil lost as the result of this excessive cracking may amount to as much as 15

to 25 percent of the recoverable oil in the shale. The second disadvantage of generating such high temperatures in vertical retorting of oil shale is that the decomposition of carbonates and other inorganic materials in the shale is very substantial. In fact, it has been established that the carbonate decomposition in such operations may range from about 20 to 60 percent of the total carbonate fraction present. Since this decomposition of the carbonate into carbon dioxide and the corresponding metal oxide involves an endothermic reaction, a very substantial amount of the heat supplied the system is required for a useless purpose. This in turn necessitates more air to sustain the process, resulting in higher operating costs. In addition to the above disadvantages, it should be pointed out that with temperatures of 2000° F. and above, spread over a substantial portion of the vertical bed, there is a tendency for excessive clinker formation to occur in the retort.

Accordingly, it is an object of my invention to provide a method for the retorting of oil shale which presents or minimizes the overheating of oil shale above practical retorting temperatures. It is a further object of my invention to provide a method for retorting oil shale in which the amount of recoverable shale oil lost to cracking, as occurs in conventional retorting methods, is reduced to from about zero to not more than 10 percent of the recoverable oil. It is still another object of my invention to provide a method for reducing the inorganic mineral decomposition in the retorting of oil shale to not more than about 0 to about 10 percent of the total carbonates present. It is a further object of my invention to supply spaced, dual-heating zones in a vertical downwardly moving bed of raw oil shale wherein the upper one of said zones is maintained at a temperature of from about 800° to about 1100° F. and the lower of said zones is fueled partially by the carbon residue on the spent shale after the latter has passed through the upper zone and partly by fuel gas from the retorting step.

The process of my invention is further illustrated by reference to the accompanying drawing in which a vertical retort 2 is filled with crushed raw oil shale continuously introduced through hopper 4. The process is initiated by first introducing a hot gaseous stream at a temperature of from about 800° to about 1100° F. into the retort via distributor 5 under conditions such that the major portion of the kerogen and/or hydrocarbons is removed from the shale particles, leaving primarily a carbon residue thereon. This hot gaseous stream may, if desired, be derived by burning a portion of the fuel gas recovered from the retorting operation, as will be explained in greater detail below. The spent shale containing this residue is then passed into the combustion zone adjacent spray burner 6 where combustion of said residue in a deficiency of oxygen is accomplished by the introduction of air into the system via line 8. The heat thus generated in large part passes up the bed and assists in the liberation of additional valuable products from the partially retorted crushed raw shale that has passed on downwardly from distributor 5.

Alternately, the retorting process may be initiated by supplying an air-gas mixture to operate burner 6 via lines 8 and 10, respectively, and igniting said mixture to effect combustion of the oil shale in the vicinity of burner 6. Once combustion is established, valve 12 is closed and the burning operation is sustained by the continued introduction of air through line 8. Retorting in the upper portion of the bed may then proceed as described above.

After the process has lined out, burner 6 is likewise preferably operated at a temperature in a range of from about 800° to 1100° F. At this temperature level, the retorting step is substantially completed with only a portion of the residual carbon on the shale approaching burn-

er 6 generally being consumed. Thus, after the initial retorting step occurring in the vicinity of distributor 5, the carbon residue on the shale amounts to about 3 percent. At burner 6 from about 5 to about 25 percent of the residual carbon is burned by combustion with air introduced through line 8. Some of the heat is also generated by combustion in said zone of the cooled recycled gas introduced into the retort at distributor 34. At all times, however, a deficiency of air is maintained in the system so that the temperature both at burner 6 and distributor 5 does not appreciably exceed 1100° F.

Shale oil vapors rise through the descending bed of shale particles, preheating the latter, and at the same time lowering the temperature of the rising vapors and combustion products. At the top of retort 2 shale oil mist and products of combustion are removed by means of line 14. This product stream is sent through separator 16 where the liquid portion is withdrawn through line 18 and sent to further refining while the uncondensed fraction is taken through line 20 to in-line burner 28. A portion of this gaseous stream is diverted through line 22 and the rest taken from the system via line 24. The gaseous fraction in line 22 contains light hydrocarbons, hydrogen, carbon monoxide, and products of combustion and is mixed with air from line 26 after which the resulting mixture is fed to in-line burner 28. Sufficient air is present in the aforesaid mixture to form a stream of combustion products in line 30, having a temperature of from 800° to 1100° F. These hot gases then flow into the bed of raw shale via suitably shaped distributor 5 which is preferably spaced from about 2 to about 5 feet above burner 6. At this level in the downwardly moving bed the oil shale particles are heated to a temperature within the last-mentioned range, resulting in the release of a substantial portion of the volatile carbon compounds from said particles. At these temperatures, however, essentially none of the carbonates or other inorganic materials present decompose. Cool fuel gas is returned to the system via line 32 and distributor 34 to take up heat from spent shale being removed from the retort through valve 36 and outlet 38.

Once the supply of fuel gas is generated as explained above, the amount of air supplied to the system through line 8 can be reduced to the volume just necessary to maintain the temperature at burner 6 in the range of 800° to 1100° F. The fuel required to produce temperatures in this range is derived partly from residual carbon on the spent shale and partly from the recycled flue gas from distributor 34.

While I have shown the source of flue gas as being derived from the retorting operation itself, the process of my invention is not limited thereto, but on the contrary, any hot gaseous or vaporous stream within the recited temperature range will be satisfactory for this purpose.

Ordinarily it is considered that about 20,000 standard cubic feet of gas, i.e., fuel gas plus air, is required to retort one ton of oil shale. Under retorting conditions the shale moves through the retort at a rate of from about 3 to about 10 feet per hour. This volume of introduced gas may be somewhat less than 20,000 s.c.f. per ton because the heat in the combustion products resulting from burning of the residual carbon on the spent shale supplies an appreciable amount of heat to the downcoming raw shale. An additional heat source is the spent solids coming in contact with cool fuel gas introduced via line 32.

In a typical case, the 20,000 s.c.f. of gas and air may be proportioned as follows: 1,000 s.c.f. of fuel gas in line 22 and 1,000 s.c.f. of air through line 26, 1,000 s.c.f. of air via line 8, and about 17,000 s.c.f. of fuel gas through line 32. In carrying out the method of my in-

vention I contemplate employing generally from about 1,500 to about 2,500 s.c.f. of air per ton of shale processed in order to maintain the temperature within the above-recited range. In most cases, and as indicated above, the total volume of air employed is divided evenly between the supply going to line 30 and that introduced into the system via line 8. This constitutes a substantial savings in air pumping costs over prior art methods which require from about 5,000 to 6,000 s.c.f. per ton of shale.

Although the process of my invention is particularly adapted to the recovery of oil from oil shale, it is to be understood that this procedure is equally applicable to the recovery of oil or similar materials from a wide range of mineral solids and hence, such variations are considered to lie within the scope of my invention.

I claim:

1. In a method for the recovery of valuable products by retorting oil-forming mineral solids wherein said solids flow within an elongated vessel in the form of a downwardly moving bed, the improvement which comprises injecting hot gaseous combustion products in the upper half of said bed, said combustion products having been formed by burning a gaseous fuel with sufficient air to bring the temperature of said combustion products to a level ranging from about 800° F. to about 1100° F. whereby a zone in said upper half of said bed is maintained within the aforesaid range thereby liberating oil-containing vapors from said solids; allowing the resulting solids from said zone, which contain a carbon residue, to flow on down said vessel; establishing a combustion zone in the lower half of said bed and thereafter contacting said resulting solids in said lower half of said bed with air in an amount sufficient to produce a temperature in said combustion zone of from about 800° F. to about 1100° F., continuing this combustion step simultaneously with injection of said combustion products, the total amount of air consumed in the retorting operation ranging from about 1500 to about 2500 s.c.f. per ton of said solids and further said amount of air being substantially evenly divided between the quantity required to form said combustion products and the quantity introduced into said lower half of said bed; and recovering hydrocarbon products from said vapors.

2. The method of claim 1 wherein the recovered vapors are separated into a gas and a liquid fraction, burning a portion of said gas fraction in a deficiency of oxygen and introducing the resulting products of combustion at a temperature of from about 800° to about 1100° F. into said upper portion to supply heat necessary for retorting said solids.

3. The method of claim 2 in which a portion of said gas fraction is used as a partial source of fuel for said combustion zone.

4. The method of claim 2 in which said mineral solids are oil shale.

5. The method of claim 1 wherein a portion of the fuel to the combustion zone is supplied by cool product fuel gas introduced into said bed below said combustion zone in direct heat exchange with spent mineral solids.

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