

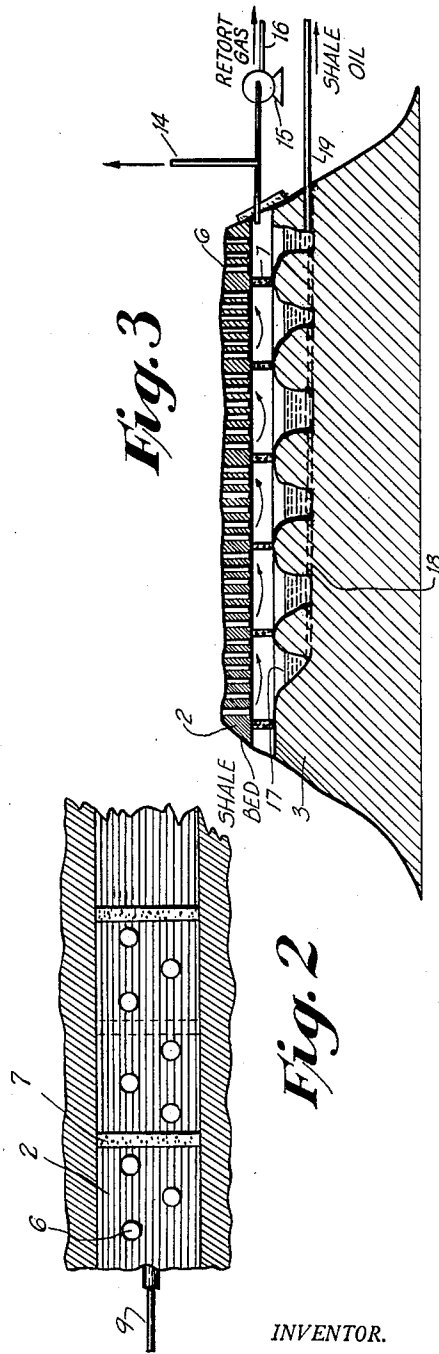
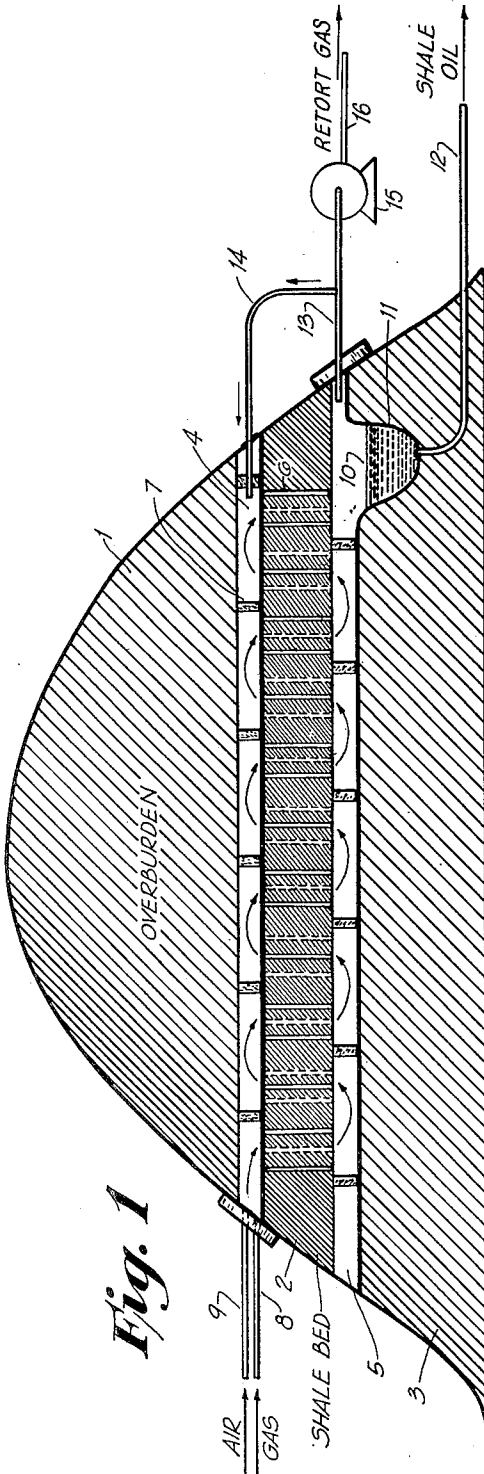
March 3, 1953

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2,630,306

SUBTERRANEAN RETORTING OF SHALES

Filed Jan. 3, 1952



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2,630,306

SUBTERRANEAN RETORTING OF SHALES

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Application January 3, 1952, Serial No. 264,761

6 Claims. (Cl. 262—1)

1

This invention relates to a process for recovering valuable hydrocarbons from hydrocarbonaceous and/or carbonaceous materials such as shales, coals, and the like by treating deposits thereof underground. More particularly, the present invention is concerned with an improved method for subterranean retorting of oil shale to yield shale oil.

It is common practice in the art to recover oils from solid oil-bearing or oil-producing materials and particularly to recover shale oil from oil shales. As is well recognized, ordinary oil shale does not contain oil as such but a solid, bitumen type material known as "kerogen" which, when heated, breaks down into gases, petroleum-like liquids, and carbon.

The recovery of oil from oil shale has heretofore been accomplished by heating the shale at elevated temperatures sufficient to educt the oil and separate it from residual mineral matter. However, commercial shale retorting operations previously employed have generally been cumbersome and expensive, involving large equipment and operating costs per unit of shale throughput. Important factors contributing to these economic burdens have been poor heat recovery in the retorting system and the expense, equipment, and time consumed in mining and crushing the shale, and in subsequently recovering the products of retortation. A major object of this invention, accordingly, is the provision of a process in which oil shale and the like may be efficiently retorted without incurring the large expenditure for equipment and maintenance required by the prior art methods. A further object is to provide a method for retorting oil shale wherein the operation is conducted in an efficient manner underground and the shale is retorted in place. A still further object is the provision of an inexpensive process for retorting oil shale affording convenient means for subsequent recovery of the liquid shale oil.

The above and other objects which will be apparent to those skilled in the art are accomplished in accordance with the present invention.

The large deposits of oil shales in the western part of the United States, particularly in Colorado, Utah, and Wyoming, contain contiguous strata of oil shales ranging from a few feet up to 100 feet in thickness. The instant process takes advantage of these natural features of the shale deposits, namely, the strata formation, structure, and thickness of the shale deposit, to afford a resultant economy in commercial retorting of the shales and handling of the products of retortation.

2

Operation of the process described herein comprises driving horizontal tunnels immediately above and below the oil-bearing shale strata and drilling a plurality of holes vertically through the separating layer of shale to connect the horizontal tunnels. A plurality of blocks or baffles are positioned at predetermined intervals in each of the horizontal tunnels to provide alternate zones of up and down flow through a series of the vertically drilled holes interconnecting the horizontal tunnels. Retorting takes place in the shale bed by ignition of the shale in the first series of vertical holes piercing the shale bed. Upon initiation of combustion in this first series, a combustion supporting gas such as air, or a mixture of air and recycle gas, is blown into and through the first series of vertical holes. The heat thereby generated is sufficient to initiate retorting in the subsequent zones and the retorting proceeds successively through each zone with the released oil vapors diffusing out into the gas stream. The resulting gaseous stream of retortation products flows alternately up and down through each series of vertical holes piercing the shale bed. Shale oil is condensed in the colder zones downstream and drains into the lower of the horizontal tunnels from which it may be removed by suitable conduits. While the downstream shale is preheated with the hot vaporous products of retortation being emitted from previously ignited zones, the upstream or spent shale is cooled as a result of heat exchange with incoming air or other combustion supporting gas, thereby imparting a high thermal efficiency to the over-all process.

The invention may be more readily understood by reference to the attached drawing wherein:

Figure 1 represents a vertical section through a high mesa containing strata of oil shale,

Figure 2 is a plan view in part of the system shown in Figure 1, taken along the elevation of the ceiling of tunnel 4 hereinafter described,

Figure 3 is similar to Figure 1 but depicts an alternate arrangement for withdrawal of the released shale oil.

Referring more particularly to the drawing and specifically to Figure 1 thereof, 1 is the rock overburden lying on top of the strata of oil shale to be worked, 2 is a series of strata of oil shale representing the shale bed to be worked, and 3 is the country rock lying below the main body of shale oil strata. In accordance with the invention, a horizontal tunnel 4 is driven immediately above the shale strata to be worked. Likewise, a horizontal tunnel 5 is driven immediately below the shale strata. A plurality of vertical holes 6 are

3

drilled or otherwise formed between the two horizontal tunnels. A plurality of baffles 7 are inserted at predetermined positions in each of the horizontal tunnels 4 and 5 in such a manner as to provide alternate zones of upward and downward flow through the vertical holes in the shale bed.

The shale in the first of such created zones is ignited by the introduction of hot combustion gases into the formation through conduit 8. After ignition of the shale is started, air or other combustion supporting gas is forced through conduit 9. The gases and vaporous products of retortation thereafter alternately flow upward and downward through the vertical holes in each zone of the shale bed, successively retorting the shale in each of the zones. The shale oil so released undergoes condensation in the cooler downstream zones and ultimately is collected as a pool 10 in the last of the retorting zones. The condensed oil is suitably collected in a depression or hole 11 formed in the underlying country rock from which it may be withdrawn through conduit 12. The remaining retort gas containing combustion gas and the non-condensable portion of the retortation products is withdrawn from the lower horizontal tunnel 5 through conduit 13. If desired, a stream of this cool retort gas may be recycled through conduit 14, passing through the upper horizontal tunnel 4 and entering the last of the retortation zones wherein it serves to cool the products of retortation formed in such zone and in previous zones, thereby aiding in condensation of the vaporous shale oil. Likewise, a cool stream of inert gas may be introduced into the last of the retortation zones to facilitate condensation. The retort gas not recycled is withdrawn by pump 15 and led through conduit 16. If desired, the retort gas passing through conduit 16 may be recycled through conduit 8, the combustible portion thereof serving as a source of heat for further retortation of the shale.

While a series of three vertical holes in each zone have been shown, it will be realized that any convenient number of such holes may be drilled vertically through the shale bed. As a practical matter, the number of such drilled holes will depend upon the extent and richness of the shale deposit being worked. In the case of the richer deposits, generally it is preferable to drill a greater number of holes, whereas in the case of the relatively poorer deposits, a lesser number of holes will usually be sufficient to exhaust the volatile content of the shale bed being worked. The holes are usually so spaced that substantially all of the combustible components present in the shale bed will be removed during the retorting process. As a general matter, it will usually be expedient to drill the holes in staggered relationship such as shown in Figure 2 of the drawing. It will be noted from such figure illustrating zones having three holes drilled therethrough that the holes are suitably so staggered that the centers thereof if joined would form an equilateral triangle. As will further be noted from Figure 2, the holes in alternate zones are alternately spaced so that if the centers of the holes in each zone were joined, the resulting triangles would alternately point downward and upward throughout the series of retorting zones.

An alternate arrangement for collecting the released shale oil is shown in Figure 3. In this embodiment of the process, condensed shale oil is collected in the bottom of each of the retorting zones in a series of holes 17 drilled in the coun-

4

try rock underlying the shale strata. These holes are connected by a common conduit 18 bored through the country rock. Condensed shale oil formed in each of the retorting zones collects in each of the holes 17 and passes through conduit 18 and then outwardly through conduit 19 to suitable storage facilities.

The horizontal tunnels immediately overlying and underlying the shale strata to be worked may be of any desired width, ordinarily depending upon the size and richness of the shale deposit. As a general matter, the tunnels will usually be 100 or more feet long. The time required to complete retorting from the first to the last of the retortation zones will depend on the length of the particular shale strata being worked. As a general rule, for a stratum of approximately 100 feet in length, approximately one week would be required.

The temperature of retorting generated within the shale bed is generally between about 800 and about 1500° F. For this reason, the baffle 7 used in the formation of the alternate zones of retortation must be composed of a material which is able to withstand such high temperatures. As a practical matter, the baffles are ordinarily composed of rock obtained during the initial drilling and excavation. It will thus be evident that there is very little needed in the way of expensive equipment for carrying out the present process for retortation of shale. The underground or in-place retorting of shale carried out in accordance with the instant process reduces the large mining, crushing, and retorting costs involved in present above ground methods. The instant process also affords a high thermal efficiency since the initial hot vaporous products of retortation passing through subsequent zones serve to preheat such zones and also the spent upstream shale serves to preheat the incoming combustion supporting gas being fed to the down-stream zones. The present process is further advantageous in affording separation of liquid shale oil from the gaseous products of retortation by collecting the shale oil underground in a pool or series of pools from which it may subsequently be withdrawn.

While the process described herein has been directed particularly to the recovery of shale oil from oil shale, the present invention may be adapted for the recovery of oil from any subterranean oil-containing or oil-producing solid substance. Accordingly, it is to be understood that the above description is merely illustrative of preferred embodiments of the invention, of which many variations may be made within the scope of the following claims without departing from the spirit thereof.

I claim:

1. A process for obtaining shale oil from oil shale stratum in its natural position, comprising driving horizontal tunnels immediately above and immediately below said stratum, drilling a plurality of holes vertically through the separating layer of shale to connect said horizontal tunnels, positioning a plurality of baffles at predetermined intervals in each of the horizontal tunnels to provide interconnecting alternate zones of up and down flow through a series of the vertically drilled holes between said horizontal tunnels, initiating combustion of shale in the first of said zones adjacent the exterior of said shale stratum, blowing a combustion supporting gas through said first zone to bring the same to shale retorting temperature, flowing the

5

resulting hot gaseous products of retortation alternately up and down through each series of vertical holes in subsequent zones whereby the shale in each of said zones is initially preheated and ultimately the temperature thereof is raised to such point that retorting of shale proceeds successively through each zone with release of shale oil vapors, condensing the shale oil vapors so released and effecting collection of the resulting liquid shale oil.

2. A process for obtaining shale oil from oil shale stratum in its natural position, comprising driving horizontal tunnels immediately above and immediately below said stratum, drilling a plurality of holes vertically through said separating layer of shale to connect said horizontal tunnels, the number of said vertical holes being such that substantially all of the combustible components present in the shale bed will be removed during retorting thereof, inserting a plurality of baffles at predetermined substantially uniformly spaced intervals in each of the horizontal tunnels in such fashion as to provide interconnecting alternate zones of up and down flow through each series of the vertically drilled holes between said horizontal tunnels, initiating combustion of shale in the first of said zones adjacent the exterior of said shale stratum, forcing a combustion supporting gas under pressure through said first zone to bring the same to shale retorting temperature, flowing the resulting hot gaseous products of retortation alternately up and down through each series of vertical holes in subsequent zones whereby the shale in each of said zones is initially preheated and ultimately the temperature thereof is raised to such point that retorting of shale proceeds successively through each zone with release of shale oil vapors, condensing the shale oil vapors so released in the cooler downstream zones and collecting the resulting liquid shale oil in the form of a pool in the last of the retorting zones.

3. A process for subterranean retorting of oil shale in its natural position, which comprises driving horizontal tunnels immediately above and immediately below strata of oil shale, drilling a plurality of holes vertically through the separating layer of shale to connect said horizontal tunnels, positioning a plurality of baffles at predetermined intervals in each of the horizontal tunnels to provide interconnecting alternate zones of up and down flow through a series of the vertically drilled holes between said horizontal tunnels, initiating combustion of shale in the first of said zones adjacent the exterior of said shale strata, blowing a combustion supporting gaseous mixture of air and recycle gas prepared as hereinafter defined through said first zone to bring the same to shale retorting temperature, flowing the resulting hot gaseous products of retortation alternately up and down through each series of vertical holes in subsequent zones, whereby the shale in each of said zones is initially preheated and ultimately the temperature thereof is raised to such point that retorting of shale proceeds successively through each zone with release of shale oil vapor and retort gas, condensing the shale oil vapor so released, effecting collection of the resulting liquid shale oil, withdrawing a stream of the retort gas and recycling the same for admixture with air to form the aforesaid combustion supporting gas mixture.

4. A process for obtaining shale oil from oil shale stratum in its natural position, comprising

6

driving horizontal tunnels immediately above and immediately below said stratum, drilling a plurality of holes vertically through the separating layer of shale to connect said horizontal tunnels, positioning a plurality of baffles at predetermined intervals in each of the horizontal tunnels in such fashion as to provide interconnecting alternate zones of up and down flow through a series of the vertically drilled holes between said horizontal tunnels, initiating combustion of shale in the first of said zones adjacent the exterior of said shale stratum, blowing a combustion supporting gas through said first zone to bring the same to shale retorting temperature, flowing the resulting hot gaseous products of retortation alternately up and down through each series of vertical holes in subsequent zones, whereby the shale in each of said zones is initially preheated and ultimately the temperature thereof is raised to such point that retorting of shale proceeds successively through each zone with release of shale oil vapors, condensing the shale oil vapors so released, effecting collection of the resulting liquid shale oil in the bottom of the lower horizontal tunnel, withdrawing a stream of non-condensable retort gas from the lower horizontal tunnel and recycling said stream to the upper horizontal tunnel, whereby gaseous retortation products entering the last of said zones are cooled, thereby facilitating condensation of the condensable portion of said retortation products.

5. A process for subterranean retorting of oil shale, which comprises driving horizontal tunnels immediately above and immediately below a natural deposit of oil shale stratum, drilling a plurality of holes in staggered relationship vertically through the separating layer of shale to connect said horizontal tunnels, the number of said vertical holes being such that substantially all of the combustible components present in the shale bed being worked will be removed upon retortation, inserting a plurality of baffles in substantially uniformly spaced predetermined intervals in each of the horizontal tunnels to provide interconnecting alternate zones of up and down flow through a series of the vertically drilled holes between said horizontal walls, initiating combustion of shale in the first of said zones adjacent the exterior of said shale stratum, blowing a combustion supporting gas into said first zone to bring the same to shale retorting temperature, flowing the resulting hot gaseous products of retortation alternately up and down through each series of vertical holes in subsequent zones, whereby the shale in each of said zones is initially preheated and ultimately the temperature thereof is raised to such point that retorting of shale proceeds successively through each zone with release of shale oil vapors, condensing the shale oil vapors so released, effecting collection of the resulting liquid shale oil in a series of pools in the bottom of each of said retorting zones and withdrawing a stream of liquid shale oil from each of said pools.

6. A process for obtaining shale oil from oil shale stratum in its natural position, comprising driving horizontal tunnels immediately above and immediately below said stratum, drilling a plurality of holes vertically through the separating layer of shale to connect said horizontal tunnels, positioning a plurality of baffles at predetermined intervals in each of the horizontal tunnels to provide interconnecting alternate zones of up and down flow through a series of the vertically

drilled holes between said horizontal tunnels, initiating combustion of shale in the first of said zones adjacent the exterior of said shale stratum, blowing a combustion supporting gas through said first zone to bring the same to shale retorting temperature, blowing the resulting hot gaseous products of retortation alternately up and down through each series of vertical holes in subsequent zones, whereby the shale in each of said zones is initially preheated and ultimately the temperature thereof is raised to such point that retorting of shale proceeds successively through each zone with release of shale oil vapors, introducing a cold inert gaseous stream into the last of said zones to facilitate condensation of shale

oil vapors within said zone and effecting collection of liquid shale oil as a pool in the bottom of said zone.

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