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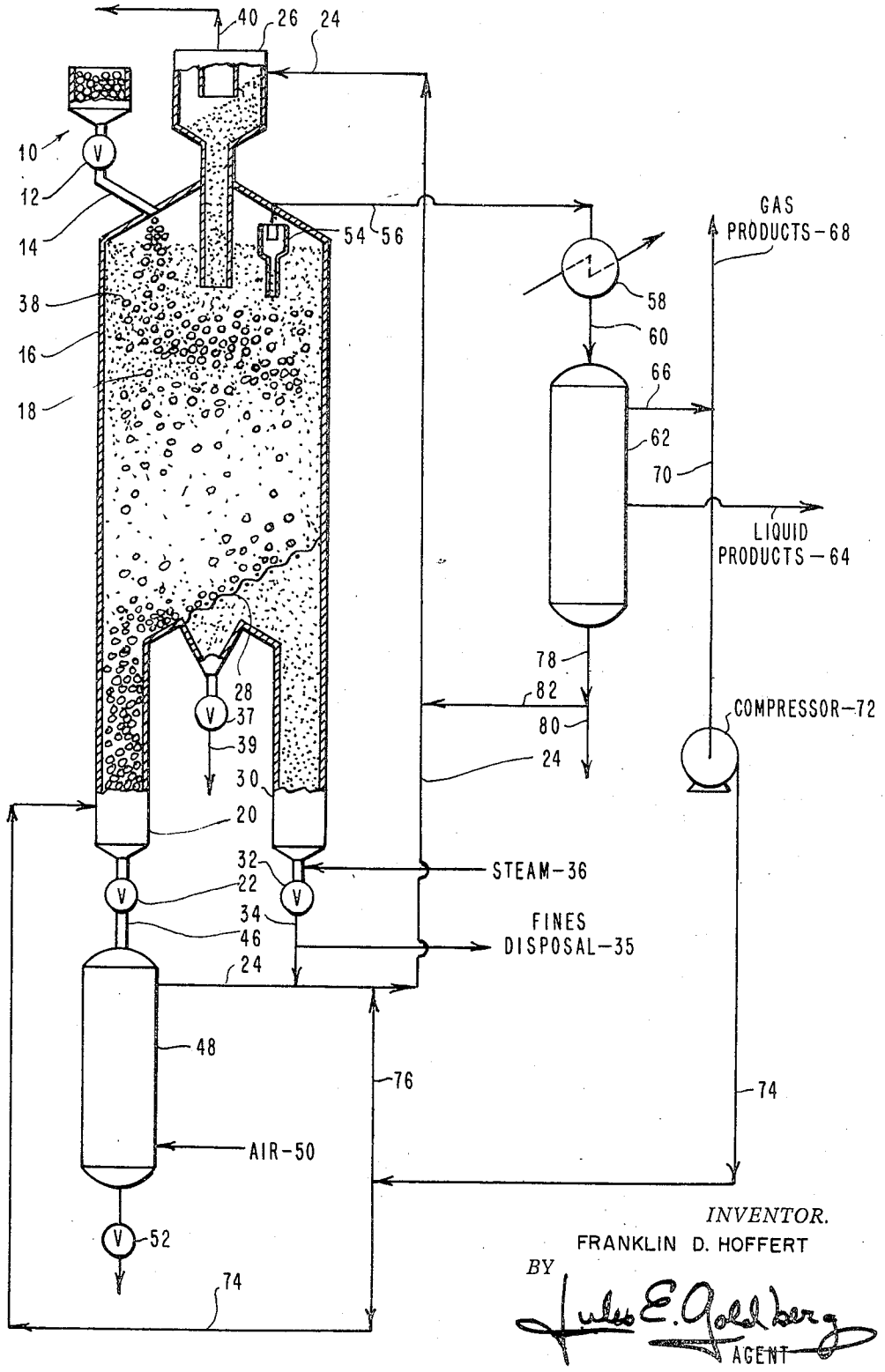

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PRODUCTION OF HYDROCARBONS FROM SHALE

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ABSTRACT OF THE DISCLOSURE

Lump shale is passed downwardly through a contacting zone concurrently with super-heated shale fines, whereby the hydrocarbons are distilled from the shale. The fines travel at a rate greater than that of the moving bed, such that a fluidized bed of fines is superimposed above the lump shale which serves to crack the distilled hydrocarbons. The products are removed from the upper portion of the contact zone and the distilled lump shale and shale fines are removed separately from the lower portion of the contact zone.

BACKGROUND OF THE INVENTION

This invention pertains to the field of production of hydrocarbon materials from shale. More particularly, it pertains to a process for the combined thermal distillation and cracking of hydrocarbons from shale.

Numerous processes are now known for the recovery of hydrocarbon values from oil shale by thermal distillation or grinding techniques. While these processes have undergone intensive development, the exploitation of shale and the development of a shale oil industry has been limited by a number of factors and circumstances. Particularly, most of the systems now known, have relatively low thermal efficiencies and low heat transfer rates between the shale being treated and the heat source. Thus, these processes require oversize equipment which result in high capital costs.

Additional problems arise from the location of available shale. For instance, because the shale deposits are usually remote from population centers, excessive transportation costs of the products to the consumption centers are prevalent. Additionally, the cost of mining shale varies considerably from location to location, and, thus, cause difficulty in marketing.

The material derived from the shale presents problems in itself, since shale oil is not salable as such, but must be further cracked, processed and desulfurized into useful hydrocarbon materials. This required downstream treatment thereby increases the cost of the final products obtained from the shale.

Generally, the processes now used for recovery of hydrocarbons from shale involve the heating of either lump or pulverized shale to volatilize the hydrocarbons contained therein.

A fluidized bed process system overcomes a number of the objectionable features listed above. However, there are two marked disadvantages of the fluidized bed with respect to excessive grinding costs in reducing the lump shale to a fluidizable powder and the fact that the powdered shale residue presents a difficult disposal problem. Also, many lump shales when subjected to volatilization conditions, partially decompose to produce fine powders. Thus, whether a moving bed of lump shale or a fluidized bed is used, fines formation is inevitable along with the inherent problems caused by such fines.

SUMMARY OF THE INVENTION

I have discovered a method by which shale in lump form may be subjected to retort or distillation conditions

and wherein the volatile products from said retorting step, may be cracked to more desirable products within the same zone in which the retorting takes place. Additionally, I have found a method by which the shale fines produced from the retorting operation may be used as the heat transfer medium for both the distillation or volatilization step and the cracking step.

My invention comprises passing lump shale downwardly through a contact zone containing a fluidized bed of hot shale fines. The temperature and inventory of the fluidized bed is maintained by introducing superheated fines at the top of the bed and removing cooler fines at the bottom. Thus, there is an overall downward flow of fines in the bed resulting in a temperature gradient vertically through the bed, the highest temperature being at the top and the coolest temperature being at the bottom.

As the lump shale travels downwardly through the bed, it is finally heated hot enough whereby the hydrocarbons contained therein begin to retort or distill out of the shale. Generally, the retorting doesn't begin until the lump shale is in the lower portion of the contact zone as it takes a finite time to heat it up to the required retorting temperature.

The vaporized materials travel upwardly into the upper superheated portion of the fluidized bed. The temperature in this upper portion is sufficiently high to result in substantial cracking of the distilled material into lower boiling and more valuable products which are removed from the upper part of the contact zone and cooled and fractionated in the usual manner. Thus, the bed is separated by function into two zones, a lower retorting zone where the lump shale is at its highest temperature and the fines are at their lowest temperature, and an upper cracking zone where the shale is at its lowest temperature and the fines are at their highest temperature. The bed of fines is normally fluidized by an external inert gas, however, the distilled vapors may be used to aid in the fluidization. Additionally, other vaporous materials added to the contact zone for reasons hereafter described, may also be utilized to aid fluidization.

Thus, as described, my invention allows one to successfully and effectively remove the distillable hydrocarbon-containing materials from shale without having to grind the shale to a fine powder. Additionally, my invention makes use of the fines which inevitably result even from a relatively crude grinding step to provide heat, not only for the distillation or retorting of the volatile constituents from the shale, but also for the subsequent thermal cracking of the distilled materials. The distilled lump shale is removed at the bottom of the contact zone and the fines are removed separately from the lump shale and may be re-heated and re-circulated to the upper portion of the zone.

DESCRIPTION OF THE DRAWING

The drawing is a schematic drawing of a shale processing system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The nature of my invention is more specifically illustrated in the drawing and is described as follows: Granulated or lump shale having a nominal diameter size between about ½ to about 4 inches is introduced from hopper **10** through valve **12** and line **14** into the contact zone **16** which contains a fluidized bed of hot shale fines. The lump shale moves downwardly through the bed wherein it is heated by the fluid bed to distill the hydrocarbons therefrom and exits through stripper leg **20**. Exit valve **22** controls the overall rate of flow of the lump shale through the zone. The hot distilled lump shale enters cooling chamber **48** through line **46** where it is cooled by the passage of air therethrough. The cooled dis-

tilled shale is then removed from the system through valve **52**.

The fluidized bed is maintained by introducing superheated shale fines to the chamber through line **24** and gas-solids separator **26**. The rate of passage of the fines through the chamber is a function of the heat transfer requirements of the system. The exiting fines are separated from the larger lumps of shale by screen **28**. The fines enter stripper leg **30**, are steam stripped using steam through line **36** to remove any adhering shale distillate oil and are then removed from the system through valve **32** and line **34**. Fines disposal may take place either through valve **37** and line **39** or through line **35**.

The bulk of the fines is introduced to line **24** where it is mixed with hot air from cooling zone **48**. The air and fines with some residual oils adhering thereon, are passed upwardly through line **24** which constitutes a combustion zone, wherein the residual oils are burned in order to achieve super-heating of the fines. The super-heated fines are then recycled through line **24** into separator **26**. The combustion or flue gas is separated from the fines in separator **26** and exits through line **40**.

Normally, the fines even after the steam stripping have residual shale oil and carbonaceous material adhering thereto and such material provides the heat of combustion which is used to superheat the fines in line **24**. Additionally, however, it is possible to introduce other combustible materials into the combustion zone, in order to supplement and/or take the place of the oils normally adhering to the fines. Thus, both gaseous and liquid residual products obtained from fractionation of the oil eventually obtained from the shale, may be introduced with the fines as described hereafter. Alternately, carbonaceous material derived from external sources may be utilized for combustion.

The superheated fines entering the top of the contact zone through separator **26** provide the heat for the distillation of the hydrocarbon materials from the shale. It has been found that such fines have highly efficient heat transfer characteristics and, thus, provide a superior means for providing or transferring the heat source for the shale oil distillation.

The fines in bed **38** at the top of the contact zone are at a relatively high temperature. Thus, there is sufficient heat provided for the required cracking process. It is also noted, however, that a thermal gradient exists vertically through the reaction zone, since at the top of the zone, the lump shale is at its lowest temperature and the fines are at their highest temperature. As the lump shale progresses downwardly through the zone, it becomes hotter as it picks up heat from the fines. The fines thus become cooler. At a relatively low point in the contact zone, the lump shale is at its highest temperature and the fines are then relatively cool. The differential, however, at this low point between the lump shale and the fines is small, whereas, at the top of the reaction zone, the differential was quite high. Thus, the distillation of the hydrocarbons from the shale takes place at the lower portion of the contact zone, since it is at this point that the lump shale is the hottest.

The vapors then proceed upwardly through the lower portion of the bed, which constitutes the distillation zone and into the upper portion of the fluidized bed which constitutes the cracking zone. The vaporized hydrocarbons then exit the contact zone **16** through separator **54** wherein any fines contained therein are returned to the fluidized bed. The fines-free vapors removed from the separator **54** through line **56** are cooled in cooler **58** and enter fractionator **62** through line **60**.

Fractionator **62**, represents any known type of fractionation systems which are normally used in the separation of multi-boiling component mixtures. It may consist of either a single unit or units in combination including both atmospheric and sub-atmospheric thermal distillations.

From the fractionator **62**, the various products or product fractions of the shale oil are removed. The liquid products are removed through line **64** and the gaseous products are removed through line **66** and fed to distribution through line **68**. A portion of the gaseous products may be taken through line **70**, compressed by compressor **72** and fed through line **74** into the stripper leg **20**. This relatively high velocity compressed hydrocarbon gas serves a two-fold purpose. First, it removes the fines from the lump shale in and entering stripper leg **20** and assures that the distilled lump shale entering valve **22** is essentially dust-free. Second, the gas serves as a fluidizing means for the fines bed **38**.

If desired, a portion of the compressed hydrocarbon gases in line **74** may be removed through line **76** and mixed with hot air from lump shale cooler **48** in line **24** to provide additional combustible material. Generally, however, it is preferred to utilize selective combustion of the coke or residual carbonaceous material which remains in the shale fines. This material ususally has a relatively low hydrogen content.

A unique aspect of the instant invention, embodied in the fluid bed seal in the dip leg of separator **26**, serves to prevent combustion gases from entering the distillation or cracking zone. As shown, the dip leg extends below the top surface or interface of the fluidized bed. A controlled differential pressure exists between the gases in the contact area and those leaving separator **26** through line **40**, the pressure generally being lower in the separator such that the level of the fluidized bed in the dip leg of separator **26** is higher than in the contact zone. This additional depth of the bed, combined with the relatively small diameter of the dip leg compared to the reaction zone and the downward flow of solids being concentrated by the separator, acts to prevent the gases in the contact zone from escaping through the dip leg and, conversely, to seal the combustion gases in the separator from the contact zone.

The bottoms products from fractionator **62** are removed through line **78** and may be sent to further downstream processing through line **80**. If desired, however, a portion of the bottoms material may be introduced to the combustion zone in line **24** through line **82**. The combustion of this bottoms material may then be used to incrementally supply the heat for the fines.

Generally, the conditions under which the process of the instant invention are carried out, would be a distillation zone temperature from about 800 to about 1000° F. and a system pressure from about atmospheric to about 100 p.s.i.g. The example below gives specific process conditions which have been used in applying the instant invention to the production of oil from African and Australian shales.

Example

Shale contact time in retort	20 min.
Distillation temperature	950° F.
Cracking temperature	1050° F.
Lump shale feed rate	2400 lbs./hr./sq. ft. of retort.
Air circulation	16,400 s.c.f.h./sq. ft. of retort.
Fines circulation rate (300° F. AT).	20,600 lbs./hr./sq. ft. of retort.
Heat release in retort	51,000 B.t.u./cu. ft./hr.
Volatile matter in feed	40%.
Total oil product	2 bbl./ton of feed shale.

Generally, my invention comprises a process for the distilling of lump shale by passing it through a fluidized bed of superheated shale fines, both the lump shale and the superheated fines passing downwardly through a contact zone. The distillate vapors from the lower portion of the fluidized bed are cracked in the contact zone by passing them through the upper portion of the fluidized bed. The cracking effect can be varied, simply by regulating the

height of the fluidized fines bed. Also, the heat of both cracking and distillation may be provided by the selective combustion of the carbonaceous material retained in the shale fines and, if desired, the gaseous or liquid bottoms products obtained from subsequent fractionation of the shale distillate and cracked hydrocarbons.

Although the above example and discussion discloses a preferred mode of embodiment of my invention, it is recognized that from such disclosure, many modifications will be obvious to those skilled in the art and it is understood, therefore, that my invention is not limited to only those specific steps, methods or combination or sequence of method steps described, but covers all equivalent steps or methods that may fall within the scope of the appended claims.

I claim:

1. A process for the production of hydrocarbons from oil shale which comprises:

(a) passing lump shale downwardly through a contact zone containing a fluidized bed of hot shale fines, the bed being fluidized by the passage of gas upwardly therethrough;

(b) adding hot shale fines at the top of the bed and withdrawing cooler shale fines from the bottom of the bed, the rate of addition and withdrawal being the same; whereby the hydrocarbons are thermally distilled from the lump shale in the lower portion of the zone, and the distilled vapors pass upwardly through the fluidized bed and are cracked into lower boiling hydrocarbons in the upper portion of the zone;

(c) removing the cracked hydrocarbons from the upper portion of the contact zone and removing the hot lump shale separately from the shale fines, from the bottom of the contact zone.

2. The process as claimed in claim **1** wherein a portion of the withdrawn shale fines are reheated and recirculated to the system.

3. The process as claimed in claim **2** wherein the fines are reheated by contact with hot gases in a combustion zone.

4. The process as claimed in claim **3** wherein the fines are reheated by air oxidation of residual shale oil contained therein.

5. The process as claimed in claim **4** wherein the air used to oxidize the residual oil is preheated by contacting it with the hot lump shale after its removal from the contact zone whereby the lump shale is cooled.

6. The process as claimed in claim **4** wherein the cracked hydrocarbons are fractionated into gaseous, liquid and heavy bottoms products and wherein a portion of the gaseous products are introduced to the air for combustion in the combustion zone.

7. The process as claimed in claim **4** wherein the cracked hydrocarbons are fractionated into gaseous, liquid and heavy bottoms products and wherein a portion of the heavy bottoms products are introduced to the air for combustion in the combustion zone.

8. The process as claimed in claim **4** wherein the cracked hydrocarbons are fractionated into gaseous, liquid and heavy bottoms products and wherein a portion of the gaseous products are compressed and used to fluidize the bed of fines.

9. The process as claimed in any one of claims **1, 2, 3, 4, 5, 6, 7** or **8** wherein the hydrocarbons are distilled from the lump shale at temperatures within the range from about 800 to about 1000° F. and wherein the distilled hydrocarbons are cracked at a temperature within the range from about 1000 to about 1400° F. and wherein the system pressure is within the range from about atmospheric to about 100 p.s.i.g.

10. The process as claimed in any one of claims **1, 2, 3, 4, 5, 6, 7** or **8** wherein the distillation temperature is about 950° F., the cracking temperature is about 1050° F., the lump shale feed rate is about 2400 lbs./hr./sq. ft. of reactor, the air circulation rate is about 16,400 s.c.f.h./sq. ft. of reactor and the fines circulation rate is about 20,600 lbs./hr./sq. ft. of reactor.

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