Feb. 10, 1948. P. H. JONES 2,435,746

STAGE EDUCTION OF OIL SHALE

Filed Nov. 13, 1943

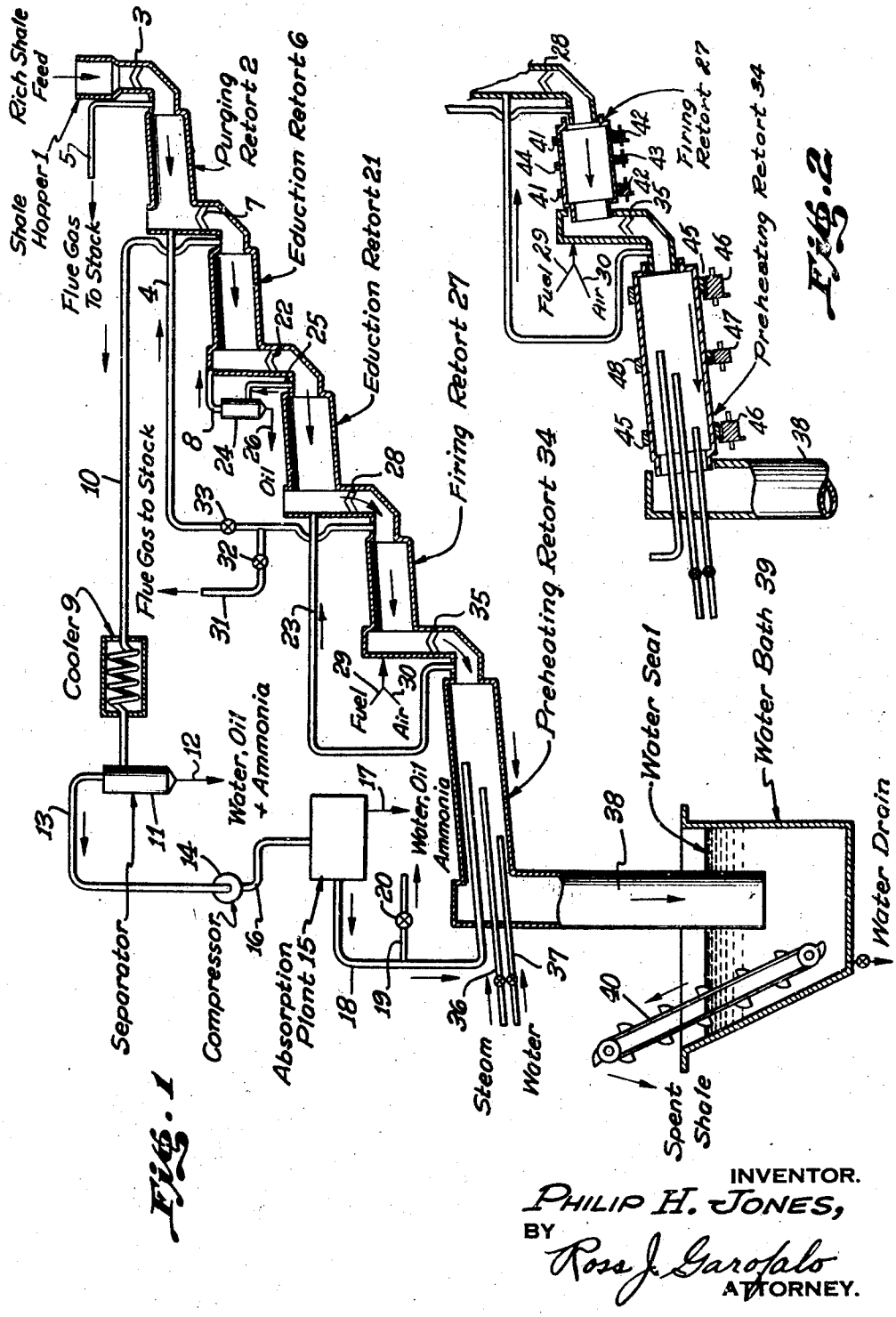


FIG. 1

FIG. 2

INVENTOR.
PHILIP H. JONES,
BY
Rose J. Garofalo
ATTORNEY.

Patented Feb. 10, 1948 2,435,746

UNITED STATES PATENT OFFICE

2,435,746

STAGE EDUCTION OF OIL SHALE

Philip H. Jones, Redondo Beach, Calif., assignor to Union Oil Company of California, Los Angeles, Calif., a corporation of California

Application November 13, 1943, Serial No. 510,249

8 Claims. (Cl. 202—16)

1

The present invention relates to the recovery of oil from shales and the like. The invention is particularly directed to an improved process in which oil shales are rapidly educted and the oil removed immediately upon formation with a minimum of destructive cracking.

It is common practice in the art to recover oils from solid oil-bearing or producing materials, particularly to recover shale oil from oil shales. The recovery of the oil from the oil-bearing or producing material may be accomplished by heating or roasting the oil-bearing or producing material at high temperatures sufficient to educt the oil and separate it from the mineral matter. These processes have not been entirely satisfactory because the shale gas produced in the above-mentioned processes usually contacts flue gases and thereby become contaminated by the same, with a resulting loss of valuable hydrocarbon liquid and gases. Other processes subject the educted oil to long periods of exposure to high temperatures. As a result of this relatively long time of contact an undesirably large amount of the hydrocarbon is converted to non-condensable gases and carbon or carbonaceous solids. There are still other processes which educt shale oil from oil shale by means of external heat alone, in a suitable apparatus, or by external heat in conjunction with a limited amount of steam.

The above-mentioned methods have proved themselves of somewhat limited value in many respects because the oil educted is usually of low specific gravity, containing a reduced percentage of lubricating stock and waxes and an excessive amount of unsaturates. Another disadvantage in the above-mentioned processes is the excessive production of undesirable constituents, such as carbon monoxide and hydrocarbon gases.

I have discovered a process by which oil and hydrocarbon vapors may be readily and efficiently recovered at relatively low temperatures from oil-bearing solid substances by means of the sensible heat of hot flue gas and hot lean shale gas which are products of this eduction process, in conjunction with superheated steam. The oil educted from oil shale by the application of my invention contains a greater percentage of lubricants and waxes, and is more saturated, i. e. better hydrogenated, than oil educted by the aforementioned processes used in the prior art. The practice of my invention is continuous in nature with countercurrent eduction and a resulting uniformity in treatment. Therefore, my process overcomes previous inherent difficulties present in processes employed for the removal and recovery of oils

2

from shales and the like, and permits a maximum recovery of the oils with a minimum amount of cracking, and avoids the commingling of shale gas with flue gas.

The process of my invention may be readily understood by reference to the attached drawings. In the drawings Figure 1 represents a schematic arrangement of apparatus in which the invention may be carried out and Figure 2 shows in more detail the preferred form of retorts to be employed which retorts may be conventional rotary retorts as illustrated in this figure.

Rich oil shale from crushers is introduced into rich shale hopper 1 by means of an elevator conveyor or the like. The crushed rich oil shale from shale hopper 1 is passed into rotary purging retort 2 through lock type valve 3 which may be a rotary valve, a pair of slide valves or any conventional system of valves that will permit the passage of solids and yet prevent the passage of countercurrent gases. The crushed rich oil shale in purging retort 2 is purged of air, dried and pre-heated slightly by means of hot spent flue gas introduced therein by means of line 4. The introduced hot spent flue gas is removed from retort 2 by means of line 5 and disposed of as desired. The warm shale in purging retort 2 is passed into primary rotary eduction retort 6 through lock type valves 7, wherein the first or low temperature stage of eduction of oil takes place. The shale introduced into primary eduction retort 6 passes down through the retort countercurrent to hot lean shale gas and superheated steam introduced by means of line 8. The heat supplied by these gases starts and maintains partial eduction. The rich shale gas and steam from educting retort 6 is introduced into cooler 9 by means of line 10 wherein useful heat may be recovered, if desired, or where water cooling alone may be used. The cooled rich gas and water is then passed into separator 11 by means of line 10, wherein water, oil and ammonia are condensed out of the said gases and removed therefrom by means of line 12 to be handled as desired. The separated gases in separator 11 are removed therefrom by means of line 13 and compressed by means of compressor 14. The compressed gases are then introduced into absorption plant 15 by means of line 16, wherein additional oil, water and ammonia are recovered and which is removed by means of line 17 and handled in any desired manner. The lean gas in absorption plant 15 is removed from said absorption plant by means of line 18 and divided into two

parts, one part being removed from line 18 by means of line 19 and valve 20 to be used as fuel or otherwise disposed of as desired. The other part of the gas is recycled as described later.

The partially educted shale in rotary eduction retort 6 is passed into rotary eduction retort 21 through lock type valves 22, wherein the final or high temperature stage of eduction takes place. The partially educted shale introduced into rotary eduction retort 21 passes down through the retort countercurrent to hot lean shale gas and superheated steam introduced therein by means of line 23, wherein complete eduction takes place. The partially cooled gases, superheated steam and entrained oil in rotary eduction retort 21 are removed from said retort and introduced into separator 24 by means of line 25. The oil in separator 24 is separated from lean gas and superheated steam and removed therefrom by means of line 26 to be handled in any suitable manner. However, rapid cooling of the oil to prevent cracking is desirable. The hot lean shale gas and superheated steam is introduced into eduction retort 6 by means of line 8 as aforementioned.

The hot lean shale from rotary eduction retort 21 is passed into rotary firing retort 27 through lock type valves 28. The hot lean shale or carbonaceous shale is heated by burning same in the presence of a fuel gas and an excess of air introduced therein by means of lines 29 and 30, respectively. The flue gas produced in firing retort 27 is withdrawn by means of line 4 and divided into two parts, one part is removed from the system by means of line 31 and valve 32 to be disposed of as desired, the remaining part of the flue gas is introduced into rotary purging retort 2 by means of line 4 and valve 33 to act as a purging medium therein as above described.

The hot spent shale in rotary firing retort 27 is then passed into rotary preheating retort 34 through lock type valves 35, wherein the hot spent shale gives up its heat to a countercurrent stream of lean shale gas introduced by means of lines 18 as aforementioned and steam introduced therein by means of line 36. Heat may be added to the lean shale gas prior to its introduction into preheating retort 34 by interchange against the hot rich gas in line 10 or in cooler 9. In some cases it may be desirable to still further preheat the lean shale gas by hot flue gas in a tubular heater. The preheated lean shale gas and steam in rotary preheating retort 34 is introduced into rotary eduction retorts 21 and 6 by means of line 23 as above-described. Preheating retort 34 is also used for the production of process steam. When the hot lean shale introduced into preheating retort 34 has passed part way through said retort and has given up the greater part of its heat to the countercurrent flow of lean shale gas and steam therein introduced, it contacts water introduced therein by means of line 37 and thereby produces steam for above-named process purposes. If sufficient steam is produced by the last named method it will not then be necessary to introduce steam by means of line 36 as above-mentioned. The cooled shale and excess water, if any, in preheating retort 34 is passed out of the system by means of duct 38 and into water bath 39. Additional steam is produced in the water leg from the contact of said spent shale with water contained in the said water bath. If more steam is produced in the water leg and by the injected water as above-mentioned than is required by the process, it may be withdrawn from preheating retort 34 by means of line 36. The spent shale in water bath 39 is removed by means of conveyor 40 and disposed of as desired.

Referring particularly to Figure 2, firing retort 27 is supported by means of tracks 41 on flanged rollers 42 and is rotated by driving gear 43 and ring gear 44. Any conventional source of power (not shown) may be used to operate the driving gear. Preheating retort 34 is similarly supported by tracks 45 on flanged rollers 46 and is rotated by means of driving gear 47 and ring gear 48. The construction, supporting means and driving mechanism of purging retort 2 and eduction retorts 6 and 21 are the same as those illustrated in Figure 2 for firing retort 27.

In the process as illustrated, relatively low temperatures of eduction are maintained so as to produce shale oil with a minimum amount of cracking. As above described, oil is removed by means of separator 24 immediately following eduction in order to avoid an unduly long period of contact between educted oil and the high temperatures existing within eduction retorts so as to avoid above-mentioned cracking. If the above described and illustrated process should fail to reduce cracking to the desired minimum, a suggested modification would be to construct an additional number of eduction retorts similar to those described in above illustration and designated as 6 and 21 with separators attached similar in nature to 24. The application of this modification would allow graduated eduction wherein the easily educted oil fractions would be produced and immediately removed in the first retorts with low eduction temperatures and the difficultly educted oil fractions would be produced in the lower eduction retorts at higher temperatures and then immediately remove and thereby further reduce cracking.

Another modification of the present invention would be to install false bottoms or oil traps at the exit of said eduction retorts and thereby remove the educted oil immediately upon eduction thus still further reducing the possibility of cracking.

Instead of providing a rotary retort for educting the oil from the shale, a stationary retort may be provided with means therein, such as a rotary screw conveyor, to move the shale through the retort.

It is my belief that the oil produced is largely suspended as fine droplets in the high velocity stream of hot gases existing in the eduction retorts, thus its removal in a trap as described would decrease its exposure to high temperatures for an undesirable period of time and subsequent cracking. It is entirely possible that the gas velocities and oil suspension would be such that a single rotary retort for eduction could be used without undue cracking of the oil.

The process of the present invention may be widely varied. The invention may be adapted for the recovery of oils from any solid substance, but it is particularly directed to the recovery of shale oil from oil shale.

In the practice of my invention as described above, the shale should be crushed. The preferred size should pass a 2 inch mesh sieve and be retained on a ¼ inch mesh sieve. However, either larger or smaller sizes could be used.

The temperatures required for the partial eduction of the shale in first eduction retort may be between that of about 400° F. and 800° F., de-

pending on the type of shale employed and the products desired. The temperatures required for the complete eduction of the partial educted shale in the second eduction retort may be between that of about 800° F. and 1500° F., depending on the type of shale employed and the products desired. However, temperatures outside the ranges specified may be used.

The foregoing description of my invention is not to be taken as limiting my invention but only as illustrative thereof since many variations may be made by those skilled in the art without departing from the scope of the following claims.

I claim:

1. A method for the recovery of shale oil from oil shale which comprises commingling oil shale with hot flue gas to heat said oil shale, removing said flue gas, heating said oil shale with hot lean shale gas and superheated steam to a temperature sufficient to partially educt said oil shale, separating hot rich shale gas and steam from the partially educted oil shale, cooling said hot rich shale gas and steam and separating water and shale oil therefrom, heating the partially educted oil shale with hot lean shale gas and superheated steam to a temperature sufficient to completely educt said partially educted oil shale, separating hot lean shale gas and superheated steam from liquid oil obtained by the complete eduction of said partially educted oil shale, removing said liquid oil, heating the completely educted oil shale by burning, and preheating lean shale gas by means of the sensible heat of spent shale.

2. A method for the recovery of shale oil from oil shale which comprises commingling oil shale with countercurrent hot flue gas to heat said oil shale, removing said flue gas, heating said oil shale with countercurrent hot lean shale gas and superheated steam to a temperature sufficient to partially educt said oil shale, separating hot rich shale gas and steam from the partially educted oil shale, cooling said hot rich shale gas and steam and separating water and shale oil therefrom, heating the partially educted oil shale with countercurrent hot lean shale gas and superheated steam to a temperature sufficient to completely educt said partially educted oil shale, separating hot lean shale gas and superheated steam from liquid oil obtained by the complete eduction of said partially educted oil shale, removing said liquid oil, heating the completely educted oil shale by burning, and preheating recycled lean shale gas from said partial eduction step by means of the sensible heat of spent shale.

3. A method for the recovery of shale oil from crushed oil shale which comprises commingling crushed oil shale with hot flue gas to preheat said crushed oil shale, removing said flue gas, heating the preheated crushed oil shale with hot lean shale gas and superheated steam to a temperature sufficient to partially educt said crushed oil shale, separating hot rich shale gas and steam from the partially educted oil shale, cooling said hot rich shale gas and steam and separating water and shale oil therefrom, heating the partially educted crushed oil shale with hot lean shale gas and superheated steam to a temperature sufficient to completely educt said partially educted crushed oil shale, separating liquid oil from the mixture of shale gas, superheated steam and educted liquid oil and removing said liquid oil, heating the completely educted crushed oil shale by burning, and preheating lean shale gas by means of the sensible heat of the crushed completely educted and burned shale.

4. A method for the recovery of shale oil from crushed oil shale which comprises commingling crushed oil shale with hot flue gas to heat said crushed oil shale, removing said flue gas, heating said crushed oil shale with hot lean shale gas and superheated steam to a temperature sufficient to partially educt said crushed oil shale, separating hot rich shale gas and steam from the partially educted oil shale, cooling said hot rich shale gas and steam and separating water and shale oil therefrom, heating the partially educted crushed oil shale with hot lean shale gas and superheated steam to a temperature sufficient to completely educt said partially educted crushed oil shale, separating liquid oil from the mixture of hot shale gas, superheated steam and liquid oil, said liquid oil being that educted from said partially educted oil shale, heating the crushed completely educted oil shale by burning, preheating lean shale gas by means of the sensible heat of the crushed completely educted and burned spent shale, removing said spent shale and contacting said spent shale with water, thereby producing eduction steam.

5. In an apparatus for educting oil from oil shale, a purging retort, means for introducing oil shale, means for introducing hot spent flue gas into said purging retort, a primary eduction retort, means for transferring hot oil shale from said purging retort into said primary eduction retort, means for introducing hot lean shale gas and superheated steam into said primary eduction retort, means for removing educted oil from said primary eduction retort, a firing retort, means for transferring carbonaceous shale from said primary eduction retort into said firing retort, means for burning said carbonaceous shale in said firing retort, a preheating retort, means for transferring spent shale from said firing retort into said preheating retort, means for introducing steam and lean gas into said preheating retort, means for removing cool spent shale from said preheating retort.

6. In an apparatus for educting oil from oil shale, a rotary purging retort, means for introducing oil shale, means for introducing hot spent flue gas into said rotary purging retort, a primary rotary eduction retort, means for transferring hot oil shale from said rotary purging retort into said primary rotary eduction retort, means for introducing hot lean shale gas and superheated steam into said primary rotary eduction retort, means for removing educted oil from said primary rotary eduction retort, a rotary firing retort, means for transferring carbonaceous shale from said primary rotary eduction retort into said rotary firing retort, means for burning said carbonaceous shale in said rotary firing retort, a rotary preheating retort, means for transferring spent shale from said rotary firing retort into said rotary preheating retort, means for introducing steam and lean gas into said rotary preheating retort, means for removing cool spent shale from said rotary preheating retort.

7. In an apparatus for educting oil from oil shale, a rotary purging retort, means for introducing oil shale, means for introducing hot spent flue gas into said rotary purging retort, a primary rotary eduction retort, means for transferring hot oil shale from said rotary purging retort into said primary rotary eduction retort, means for introducing hot lean shale gas and super-

heated steam into said primary rotary eduction retort, means for removing educted oil from said primary rotary eduction retort, a secondary rotary eduction retort, means for transferring partially educted oil shale from primary rotary eduction retort into said secondary rotary eduction retort, means for introducing hot lean shale gas and superheated steam into said secondary rotary eduction retort, a rotary firing retort, means for transferring carbonaceous shale from said second rotary eduction retort into said rotary firing retort, means for burning said carbonaceous shale in said rotary firing retort, a rotary preheating retort, means for transferring spent shale from said rotary firing retort into said rotary preheating retort, means for introducing steam and lean gas into said rotary preheating retort, means for removing cool spent shale from said rotary preheating retort.

8. An apparatus for educting oil from oil shale, comprising in combination a rotary purging retort, means for introducing crushed oil shale, means for introducing and passing hot spent flue gas countercurrent to said crushed oil shale introduced into said rotary purging retort, means for removing said hot spent flue gas from said rotary purging retort, a primary rotary eduction retort communicating with said rotary purging retort, means for introducing hot crushed oil shale from said rotary purging retort into said primary rotary eduction retort, means for introducing and passing hot lean shale gas and superheated steam countercurrent to said hot crushed oil shale introduced into said primary rotary eduction retort, means for separating rich shale gas from partially educted oil shale, means for removing said rich shale gas from said primary rotary eduction retort, a secondary rotary eduction retort communicating with said primary rotary eduction retort, means for introducing partially educted oil shale from said primary rotary eduction retort into said secondary rotary eduction retort, means for introducing and passing hot lean shale gas and superheated steam countercurrent to said partially educted oil shale introduced into said secondary rotary eduction

retort, means for separating hot lean shale gas and liquid oil from carbonaceous shale, means for removing said hot lean shale gas and liquid oil from secondary rotary eduction retort, means for separating and removing said liquid oil from said hot lean shale gas, a rotary firing retort communicating with said secondary rotary eduction retort, means for introducing carbonaceous shale from secondary rotary eduction retort into said rotary firing retort, means for burning carbonaceous shale in said rotary firing retort, means for separating hot flue gas and hot spent shale in rotary firing retort, means for removing said flue gas from said rotary firing retort, a rotary preheating retort communicating with said rotary firing retort, means for introducing water, steam and lean gas countercurrent to hot spent shale introduced into rotary preheating retort from said rotary firing retort, a water bath communicating with said rotary preheating retort, means for introducing hot spent shale in said rotary preheating retort into said water bath, means for introducing steam produced in said water bath into said rotary preheating retort.

PHILIP H. JONES.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,943,291	Abbott	Jan. 16, 1934
Re. 16,326	Bacon	Apr. 20, 1926
1,674,420	Trumble	June 19, 1928
1,814,463	Trent	July 14, 1931
1,375,714	McLeod	Apr. 26, 1921
2,140,276	Alther	Dec. 13, 1938
1,824,282	Loughrey	Sept. 22, 1931
1,297,022	Shreves	Mar. 11, 1919

FOREIGN PATENTS

Number	Country	Date
286,404	Great Britain	Mar. 8, 1928
388,853	Great Britain	Mar. 9, 1933