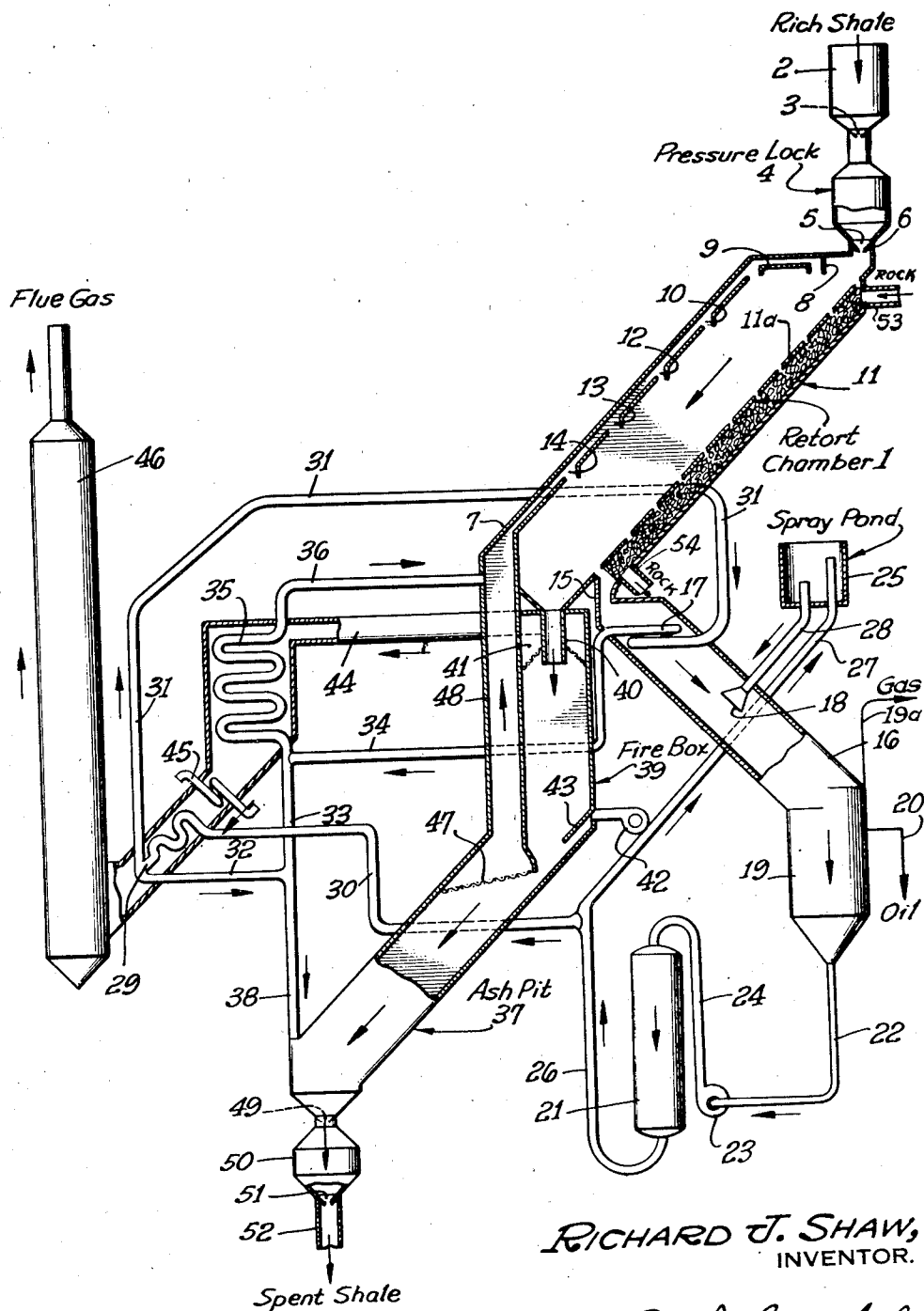


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METHOD AND APPARATUS FOR EDUCTING OIL FROM
OIL SHALE BY USE OF SUPERHEATED STEAM
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METHOD AND APPARATUS FOR EDUCTING OIL FROM OIL SHALE BY USE OF SUPER-HEATED STEAM

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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 educted by means of superheated steam and the oil removed immediately upon formation with a minimum of destructive pyrolysis.

It is common practice in the art to recover oils from solid oil-bearing 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 means of external heat alone, in a suitable apparatus, or by external heat in conjunction with a limited amount of steam. These processes have not been entirely satisfactory because the oil produced is usually of low specific gravity, containing a reduced per cent 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.

Other methods for the recovery of oil from oil-bearing or producing material may be accomplished by roasting in a kiln the oil-bearing or producing material at high temperatures. These processes have not been entirely satisfactory, in that the shale gas and oil produced in the above mentioned processes usually contact flue gases and thereby become contaminated by same, with a resulting loss of valuable hydrocarbon fractions.

In such processes the educted oil is subject to a long period 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.

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 superheated low pressure steam as the only source of eduction heat. The oil educted by superheated steam is of high specific gravity, 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. Furthermore, the gases formed in this process consist almost entirely of carbon dioxide and hydrogen with a relatively small percentage of carbon monoxide and hydrocarbon gases. The process of my invention is continuous in nature with a resulting uniform treatment. Therefore, my process overcomes previous inher-

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ent difficulties present in processes employed for the removal and recovery of oils from shales and the like, and permits a maximum recovery of the oils with a minimum amount of cracking, and avoids commingling of the gas produced from the shale with flue gas.

The process of my invention may be readily understood by reference to the attached schematic drawing illustrating one modification of the same.

Rich shale, i. e., shale containing kerogen, after crushing to desired size is introduced into retort chamber 1 by means of shale hopper 2, gate 3, pressure lock 4, gate 5 and line 6. The above mentioned shale introduced into retort chamber 1 contacts superheated low pressure steam introduced into retort chamber 1 by means of line 7 and openings 8, 9 and 10 which acts as a preheating stage. At this point a small per cent of the oil, i. e., light fractions, will be educted from the rich shale. The shale introduced into retort chamber 1 will cascade down over perforated plate 11a and floor 11 of retort chamber 1, which comprises rocks, bricks or the like. The preheated shale while cascading down over perforated plate 11a and floor 11, will be subjected to total eduction by means of superheated low pressure steam introduced therein by means of line 7 and openings 12, 13 and 14. The gaseous and liquid hydrocarbon products of eduction and suspended shale dust will pass through perforated plate 11a and percolate through rock bed, on floor 11. The above mentioned rock bed will act as a filter and thereby allow the hydrocarbons to pass through same, while the shale dust will be filtered out of said hydrocarbons by means of aforementioned rock bed. The dust-free hydrocarbon fractions will continue their percolating process through said rock bed and into outlet pipe 15. The educted gases and liquids passing through outlet pipe 15 will enter line 16 and therein pass through indirect heat exchanger 17. The eduction products and heating steam from retort chamber 1 will continue its flow through line 16 and enters the spraying zone of spraying nozzle 18, wherein the eduction products and above mentioned heating steam is condensed. The condensed products then enter receiver 19, wherein they form three phases, one a gaseous hydrocarbon phase which is removed by means of line 19a and handled in any desired manner, a liquid hydrocarbon phase and the third an aqueous phase. The hydrocarbons are removed from receiver 19 by means of line 20 to be handled in any desired manner. The aqueous layer in re-

celver 19 will be introduced into treating plant 21 by means of line 22, pump 23 and line 24, wherein the water is acidified very slightly and counter-currently extracted with hot kerosene, or some similar hydrocarbon fraction so as to remove any acidic materials, particularly phenolic materials, such as phenol and its homologues, such as cresol and xylenols and suspended shale oil. The clarified water will be divided, a part going to spray pond 25, by means of lines 26 and 27 and therein cooled. The cooled water is then introduced into spraying zone of spraying nozzle 18 by means of line 28 as aforementioned. The remainder of the clarified water in treating plant 21 is introduced into indirect heat exchanger 29 by means of lines 26 and 30. Only a part of the water introduced into heat exchanger 29 is converted into steam, the remainder of said water, now containing a high concentration of ammonia salt and other acidified nitrogenous compounds, is passed from heat exchanger 29 through line 31, and into heat exchanger 17 wherein a part of the introduced water is converted to steam, with a resulting effect of further concentrating said salts. Heat exchanger 17 is of such a construction that the increased concentration of ammonia salts will not plug the tubes therein. Heat exchanger 17 is provided with an outlet, not shown here, so as to remove the ammonia salt crystals formed therein. The steam formed in heat exchanger 17 is combined with steam from heat exchanger 29 (lines 32 and 33), by means of line 34. The steam produced in heat exchanger 29 as above mentioned is again divided, a part going to indirect superheater 35, by means of lines 32 and 33. The superheated steam in superheater 35 is introduced into retort chamber 1 by means of lines 36 and 7, and openings 8, 9, etc., as described above. The remainder of said steam from heat exchanger 29 is introduced into ash pit 37 by means of lines 32 and 38.

The carbonaceous shale in retort chamber 1 after being educted, as aforementioned, of all liquid products is introduced into fire box 39, by means of throat 40. Throat 40 is so arranged that the shale from retort chamber 1 does not completely fill fire box 39 and thereby leaves a vapor space therein, which is designated as 41. An excess of air is blown into fire box 39 by means of fan 42 and grate 43 thereby contacting the hot carbonaceous shale with the resulting effect of burning said carbonaceous material. The flue gas created by said burning in fire box 39 is passed through a series of indirect heat exchangers by means of vapor space 41 and duct 44. The above mentioned hot flue gas will pass through superheater 35 and thereby produce superheated steam as mentioned above; then through indirect heat exchanger 45 so as to generate steam for power plant or operational purposes; and finally through heat exchanger 29 for the above described purposes. The cooled flue gas is then passed into stack 46 where it is washed with sulfuric acid, or other absorbing agent by any suitable means, so as to produce ammonia salts.

The very hot and completely spent char in fire box 39 is introduced into ash pit 37, wherein the said hot spent char contacts steam introduced by means of line 38 as aforementioned and thereby, exchanges heat with said hot char. The superheated low pressure steam thereby created will rise in said ash pit through screen 47 and duct 48 and combine with the superheated steam from superheater 35, as shown above, and passed

into retort chamber 1, by means of line 7 and openings 8, 9, etc., as shown above. The cooled char in ash pit 37 is removed therefrom, by means of gate 49, pressure lock 50, gate 51 and line 52, to be disposed of as desired.

One modification of the present invention is to construct floor 11 containing above mentioned rocks or bricks in such a manner that fresh rocks may be introduced by means of line 53 and clogged filter bed removed by allowing same to slide downward at the same rate as the shale bed and withdrawn separately from the educted shale by means of line 54. The rocks removed from the above mentioned filter bed may be treated in any suitable manner so as to remove any foreign matter thereon, this will allow the continuous use of same, if suitable rocks are in abundance the cleaning process would then be unnecessary. This modification will enable the operator to clear a clogged filter without interrupting the eduction process.

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 shown above, the starting operation may consist of filling ash pit 37 with barren shale or the like. Fire box 39 is then filled with a mixture of barren shale and coke such as the type recovered from cracking units, at a ratio of around about 5 to 1 respectively. An amount of the above named mixture equal to the capacity of both the ash pit and fire box is introduced into retort 1. The remaining space of retort 1 is filled with charging stock, i. e., rich shale. A fire is started at the bottom of fire box 39, after the fire has been burning for a designated period, a per cent of the barren shale within ash pit 37 is withdrawn by means of lock 50, the flue gas created by above burning will rise and enter duct 44. Water is then introduced into heat exchangers 45 and 29. The steam therein produced is passed through superheater 35 and as soon as enough hot char enters ash pit 37, sufficient steam is diverted into said ash pit and the process continued until shale oil is being educted.

In the performance of this operation the feed stock i. e., rich shale may be between that of a small fragment of about 0.01 inch and that of lumps of about 6 inches. For the preferred operating conditions, sizes between about $\frac{1}{8}$ of an inch and 2 inches are most suitable.

The temperatures required for the proper eduction of shale in retort chamber 1 may be between about 600° F. and 1200° F., depending on the type of shale employed and the products desired. Temperatures between about 700° F. and about 1000° F. are suitable for most operations. The lower temperatures existing in the preheating stage of retort chamber 1 and gradually increasing as the shale reaches the final eduction stage therein.

The contact time required for reasonably complete eduction in retort chamber 1 may be as low as 0.01 second or less, and generally will not exceed 4 hours. Contact time of around about $\frac{1}{2}$ of an hour to 3 hours have proved very successful. The longer times of contact within these ranges being required where the temperatures are in the lower parts of the above ranges and shale fragments are relatively large.

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. An apparatus for educting oil from oil shale comprising a retort provided with means for continuously introducing oil shale, means for introducing superheated steam, means for separating educted oil from carbonaceous shale, means for filtering said educted oil comprising a filter bed within said retort spaced from the oil shale, and means for continuously removing carbonaceous shale; a fire box communicating with said retort, into which fire box carbonaceous shale is continuously received from said retort and in which said carbonaceous shale is burned, said fire box being provided with means for introducing air, means for removing hot flue gases and means for removing hot spent shale; an ash pit communicating with said fire box into which hot spent shale from said fire box is continuously received, said ash pit being provided with means for introducing steam to contact hot spent shale, means for removing superheated steam and passing said superheated steam to said means for introducing said superheated steam into said retort and means for continuously removing cooled spent shale from the base of said ash pit; a superheater provided with means for passing hot flue gases from said fire box in indirect heat exchange with steam, and means for passing said superheated steam to said means for introducing superheated steam into said retort.

2. An apparatus according to claim 1 in which the means for filtering the educted oil consists of a continuously changing filter bed.

3. An apparatus according to claim 1 in which the means for introducing superheated steam into the eduction retort comprises a series of spaced jets.

4. A method for the recovery of shale oil from oil shale which comprises continuously introducing oil shale into an eduction chamber, heating said oil shale with superheated steam to a temperature in the range of about 600° F. to 1200° F., thereby educting shale oil from said oil shale, separating said educted oil from carbonaceous shale and filtering said educted oil through a filter bed contained in said eduction chamber, burning said carbonaceous shale in a separate chamber to produce hot fuel gas and hot spent shale, passing said hot flue gas in indirect heat exchange with

steam thereby partially cooling said flue gas and producing a portion of the superheated steam used in the eduction step, contacting said hot spent shale in a separate chamber with steam to produce the remaining portion of the superheated steam employed in the eduction step and producing the steam supplied to each of the superheating units by contacting said partially cooled flue gases in indirect heat exchange with water.

5. A method for the recovery of shale oil from oil shale which comprises continuously introducing crushed oil shale into an inclined eduction retort, heating said oil shale with superheated steam and thereby effecting eduction of said shale oil at a temperature of about 700° F. to 1000° F., separating said educted oil from carbonaceous shale and passing said educted oil through a continuously changing filter bed, burning said carbonaceous shale in a separate chamber to produce hot flue gas and hot spent shale, passing said hot flue gas in indirect heat exchange with steam thereby partially cooling said flue gas and producing a portion of the superheated steam used in the eduction step, contacting said hot spent shale in a separate chamber with steam to produce the remaining portion of the superheated steam employed in the eduction step and producing the steam supplied to each of the superheating units by contacting said partially cooled flue gases in indirect heat exchange with water.

6. An apparatus according to claim 1 in which the eduction retort is inclined at an angle sufficient to allow shale to cascade therethrough.

7. An apparatus according to claim 1 in which the filter bed consists of rocks.

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