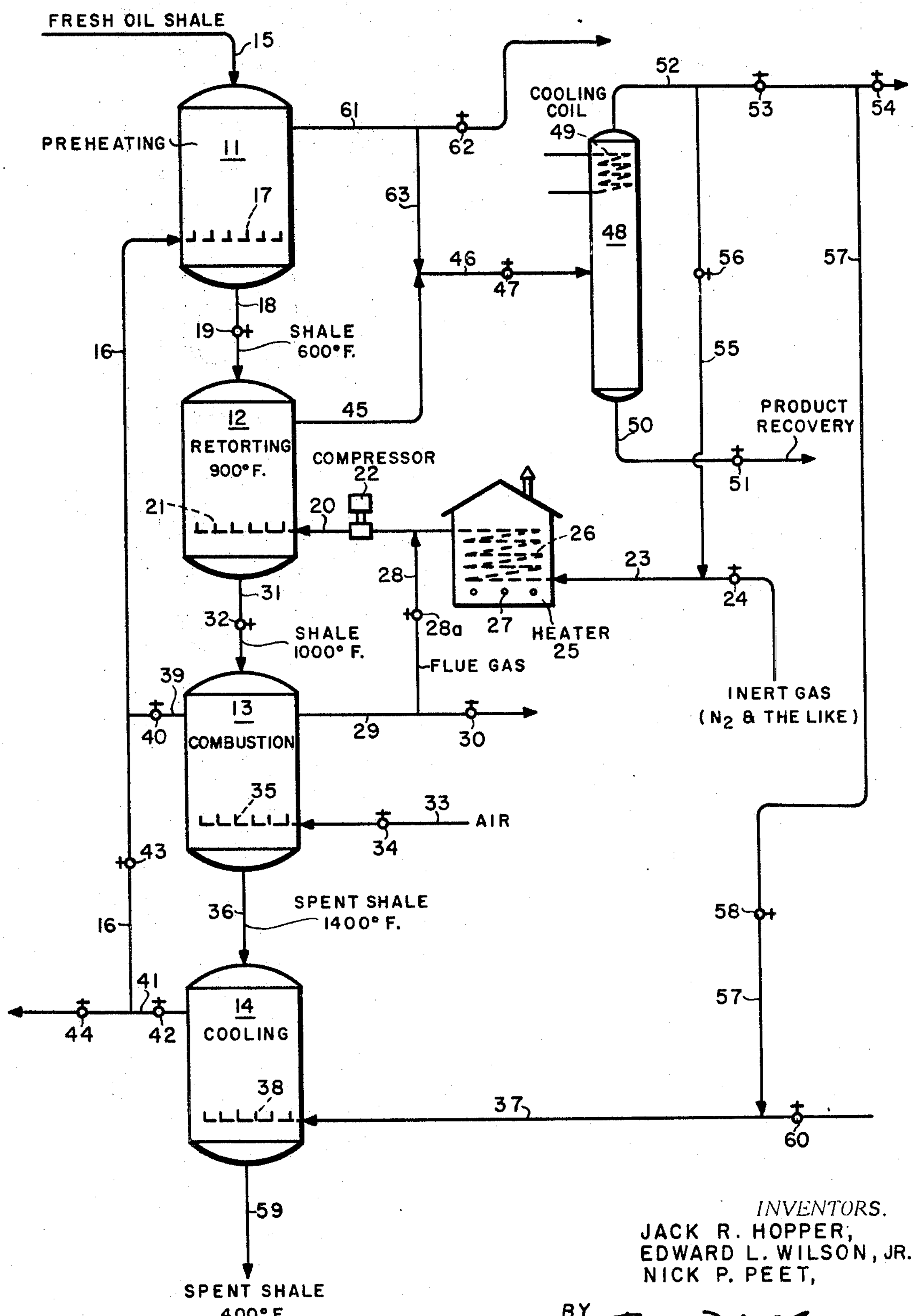
March 30, 1971 J. R. HOPPER ET AL 3,573,194

RETORTING OF OIL SHALE

Filed March 26, 1969



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United States Patent Office

3,573,194

Patented Mar. 30, 1971

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3,573,194

RETORTING OF OIL SHALE

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Filed Mar. 26, 1969, Ser. No. 810,577
Int. Cl. C10b *53/06*
U.S. Cl. 208—11 11 Claims

ABSTRACT OF THE DISCLOSURE

Shale oil of improved quality is recovered from oil shale retorted in a plural stage retorting system at an elevated temperature in the presence of an inert gas under an elevated pressure.

BACKGROUND OF THE INVENTION

(1) Field of the invention

The present invention is directed to retorting of oil shale. More particularly, the invention is concerned with retorting of oil shale at elevated pressures in the presence of an inert gas. In its more specific aspects, the invention is concerned with inert gas pressure retorting of crushed oil shale at elevated temperature to obtain shale oil of improved product quality.

(2) Description of the prior art

It is known to retort oil shale under pressure where the whole system is pressurized. It is also known to retort oil shale under pressure in the presence of hydrogen. Heretofore, noncondensable gas has been used in low presssure retorting of oil shale. Retorting of oil shale in the presence of hydrogen improves the product quality of shale oil. However, it has not been known heretofore that retorting of oil shale under pressure with an inert gas would also improve the product quality comparable to that obtained with hydrogen which at least partially hydrogenated the shale oil. The use of an inert gas at elevated temperature is unobvious and allows the obtaining of marked advantages. Also, the pressurization of the retort only in a plural stage system is advantageous in that the other stages may be operated at low pressures and still obtain the benefit of high pressure. Prior art considered with respect to this invention include the following listed U.S. patents: U.S. 1,734,970, U.S. 1,941,809, U.S. 2,452,634, U.S. 2,601,257, U.S. 2,665,238, U.S. 2,812,288, U.S. 2,-911,349, U.S. 2,991,164, U.S. 3,117,072, U.S. 3,118,746, U.S. 3,361,644, U.S. 3,384,569.

SUMMARY OF THE INVENTION

The present invention is directed to retorting of oil shale. More particularly, the invention is concerned with retorting of crushed oil shale at elevated temperatures and pressures. In its more specific aspects, the invention is concerned with retorting of crushed oil shale at an elevated pressure in the presence of an inert gas wherein the retorting zone of a plural stage retorting system is maintained at an elevated pressure while the other zones are maintained at substantially lower pressure to obtain improved quality of the oil shale.

VARIABLES OF THE INVENTION

In the practice of the present invention, temperatures in the preheating zone may range from about 400° F. to about 800° F. with a suitable temperature being about 600° F. A hot gas at about 1000° F. may serve to preheat the fresh oil shale which may be introduced at a temperature of about 80° F.

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Temperatures in the retorting zone may range from about 600° F. to about 1000° F. with a temperature suitably about 900° F. Inert gas may be introduced into the retorting zone. The amount of the inert gas introduced into the retorting zone may range from about 5,000 to about 15,000 cu. ft. per ton of raw oil shale with about 10,000 cu. ft. of inert content gas per ton of raw oil shale being satisfactory. The inert gas may be preheated to temperatures up to 1200° F.

In the burning zone, the temperature may range from about 1000° F. to about 1400° F. and suitably air at about 80° F. in an amount of about 3,000 to about 6,000 cu. ft. per ton of raw oil shale may be introduced. About 4,000 cu. ft. of air per ton of raw oil shale may be used. The air may be at about 80° F. Other free oxygen-containing gases having a greater content of free oxygen than air may be used.

Temperatures in the cooling zone may range from about 1400° F. to about 200° F. with an inert gas being introduced thereinto for cooling purposes. Thus, the spent shale may enter the cooling zone at 1400° F. and may leave the cooling zone at 400° F. with about 12,000 to about 20,000 cu. ft. of the gas per ton of raw oil shale being used. About 18,000 cu. ft. of the inert gas per ton of raw oil shale may be satisfactory.

The pressure on the retorting zone is suitably maintained by injection of an inert gas which is preferably nitrogen, but may be a mixture of inert gases containing nitrogen and carbon dioxide. Such mixtures may be obtained in the process by burning of residual carbonaceous material remaining on the oil shale after retorting and provide heat for the retorting operation. Other gases which may be used include the inert normally gaseous hydrocarbons such as methane, ethane, propane, mixtures thereof, argon, krypton, neon, and the like.

The pressure on the retorting zone is suitably in excess of 250 p.s.i.g. and may be within the range of 250 p.s.i.g. to about 2500 p.s.i.g. Below 250 p.s.i.g. the effect of pressure with an inert gas is not significant. Above 2500 p.s.i.g. pressure, the added benefits accruing to higher pressures than 2500, are marginal and are offset by the added operating problems and costs required. Hence, the range of about 250 to about 2500 p.s.i.g. is considered to be necessary and important in the practice of the present invention. The pressure in the other zones of the retorting system may be substantially below that of the retorting zone and allows use of less expensive equipment. It is not necessary to use high pressure except in the retorting zone because pressure has no effect except in the retorting zone. Pressures in the other zones may range from 0 p.s.i.g. to 100 p.s.i.g.

DESCRIPTION OF THE DRAWING WITH REFERENCE TO THE PREFERRED EMBODIMENTS

Referring now to the drawing wherein a plural stage retorting system of crushed oil shale is described; numeral **11** designates a preheating zone, numeral **12** is a retorting zone, numeral **13** is a combustion zone, and numeral **14** is a cooling zone. Fresh oil shale having a Fischer Assay within the range from 15 to 70 gal./ton is fed into zone **11** by line **15** wherein the crushed shale is preheated by contact with gas introduced by line **16** connection into a distributing means **17**. The crushed oil shale flows countercurrently to the gas introduced by line **16** and is discharged by zone **11** by line **18** through a suitable control means **19** which may be a locked hopper-Star feeder system into retorting zone **12** which may be maintained at a temperature of about 600° F. to 900° F. Zones **11**, **13** and **14** are suitably maintained at a range of about 0 p.s.i.g. to 100 p.s.i.g. wherein zone **12** is maintained at a higher pressure in excess of 250 p.s.i.g. which may range from 250 p.s.i.g. to about 2500 p.s.i.g.

In zone 12 the preheated crushed shale is retorted in the presence of inert gas introduced under pressure by line 20 into a distributing means 21. Line 20 contains a compressor 22 by way of which the pressure of inert gas is raised to a pressure within the range given. The inert gas may be introduced by way of line 23 controlled by valve 24 from a source outside the system and thence into a furnace or heater 25 containing heat coils 26 and burners 27 and thence into line 20. The inert gas may be obtained from line 28 which connects into combustion zone 13. Line 28 connects to line 29 containing a valve 30 by way of which excess flue gas may be discharged. The flue gas may be a mixture of nitrogen and carbon dioxide resulting from burning residual carbonaceous material on the oil shale introduced into zone 13 by line 31 controlled by control means such as valve 32 for reduction of pressure; the heat retorted oil shale being contacted with a free oxygen-containing gas such as air introduced by line 33 controlled by valve 34 into distribution means 35. The combustion operation in zone 13 produces the flue gas which is withdrawn by line 29 and may be discharged at least in part by opening valve 30 or recycled by line 28 to line 20 by opening or throttling valve 28*a*.

The burned oil shale substantially free of carbonaceous material is then discharged by line 36 into cooling zone 14 where it is contacted with inert gas at a lower temperature introduced by line 37 through distribution means 38 from a source which will be described further.

A portion of the gas from zone 13 or 14 may be introduced into preheating zone 11 by withdrawing a portion of the flue gas from zone 13 by line 39 controlled by valve 40 which connects into line 16 or by withdrawing a portion of the gas from zone 14 by way of line 41 controlled by valve 42. The gas from zone 14 may be discharged from the system by closing valve 43 and opening valve 44 in line 41.

The product from retorting zone 12 is withdrawn by line 45 and introduced by line 46 controlled by valve 47 which reduces the pressure of same into a drum 48 equipped with a cooling means 49 in the upper portion thereof. By virtue of the reduction of pressure and the cooling means 49, the temperature of the product is reduced which allows a separation to be made between the shale oil which is recovered from zone 48 by line 50 controlled by valve 51 for further processing and the inert gas and noncondensables which are withdrawn by line 52. A portion of the inert gas and noncondensables may be discharged from the system by line 52 on opening valves 53 and 54. Preferably, however, the inert gas is recycled to line 23 by branch line 55 controlled by valve 56 connecting to line 23 for heating or recompressing of same.

A portion of the inert gas is suitably recycled by line 57 controlled by valve 58 to line 37 for introduction into cooling zone 14 where it serves to cool the retorted spent shale which is discharged from the system by line 59. When the inert gas is not introduced by line 57, valve 58 would be closed and valve 60 in line 37 opened allowing gas from an extraneous source to be used.

The gas from the preheating zone 11 is withdrawn by line 61 and may be discharged from the system by opening valve 62. Preferably, however, since this gas may contain valuable hydrocarbons, valve 62 remains closed and the gas in line 61 discharges by line 63 into line 46 and thence into zone 48.

From the foregoing description taken with the drawing representing a preferred mode and embodiment, it will be seen that crushed oil shale may be retorted in a thermal system employing a plurality of stages employing an inert gas under pressure in the retorting zone to obtain a shale oil of improved product quality; the oil recovered by line 50 having high gravity, a low viscosity, a low pour point, and a high hydrogen to carbon ratio.

By virtue of retorting under high pressure with an inert gas substantially improved and useful results are obtained.

EXAMPLES

In order to illustrate the present invention further, comparative runs were made where crushed oil shale having particle diameters within the range from ⅜ to 3 inches and an average Fischer Assay value of 34.4 gal./ton was retorted under the same conditions except in one instance H_2 pressure was used and the other instance N_2 pressure was employed. Runs at 750 and 33 p.s.i.g. were conducted, the results and conditions of which are shown in Table I.

TABLE I

	Run Number JRH			
	8	9	10	11
Retort gas	H_2	N_2	H_2	N_2
Retort pressure, p.s.i.g.	750	750	33	33
Shale lot number	8	8	10	10
Oil inspections:				
Gravity, ° API at 60° F	38.9	36.5	26.2	26.1
Viscosity, cs. at 100° F	1.70	1.73	12.06	10.34
Pour point, ° F	20	20	85	85
Nitrogen, wt. percent	1.40	1.46	1.68	1.60
Hydrogen, wt. percent	12.33	12.17	11.96	11.84
Carbon, wt. percent	81.46	84.75	83.83	82.10

As can be seen from these data, gravity, viscosity and pour point are very similar at the same pressure but significantly different as pressure is changed from 33 to 750 p.s.i.g. Thus, the type of gas had no measurable effect on product quality but an increase in pressure gives a much improved product; i.e., lower density, lower viscosity, lower pour point.

Thus, it will be clear that an unobvious result is obtained since nitrogen retorting at high pressure gave substantially similar results to that obtained with hydrogen. Heretofore, it was thought that a reactive gas at elevated pressure was necessary for such beneficial results. The data in Table I show that beneficial results are obtained with an inert gas.

The reason for such unexpected results is not known, but nevertheless it is quite unexpected to obtain same. Such results are quite useful in that cheap and readily available inert gas may be used in lieu of the expensive and scarce hydrogen and yet obtain quite desirable results.

The nature and objects of the present invention having been completely described and illustrated, and the best mode and embodiment contemplated set forth, what we wish to claim as new and useful and secure by Letters Patent is:

1. In a plural stage thermal operation for recovering shale oil from crushed oil shale in which the crushed shale moves serially downwardly through vertical preheating, retorting, burning, and cooling zones and in which shale oil is formed, the method which comprises:
   - maintaining said retorting zone at a retorting temperature by introducing a heated inert gas thereto under a pressure in excess of 250 p.s.i.g.;
   - recovering from said retorting zone a product containing shale oil and said inert gas;
   - separating inert gas from said recovered product;
   - returning at least a portion of said separated inert gas to said retorting zone after heating and compressing same to said retorting temperature and to said pressure in excess of 250 p.s.i.g.; and
   - the other zones of said plural stage thermal operation being maintained at a pressure substantially below the pressure of said retorting zone.

2. A method in accordance with claim 1 in which the pressure on the retorting zone is within the range from about 250 to about 2500 p.s.i.g.

3. A method in accordance with claim 1 in which the inert gas is nitrogen.

4. A method in accordance with claim 1 in which the inert gas is flue gas.

5. A method in accordance with claim **1** in which the inert gas is a noncondensable hydrocarbon.

6. A method in accordance with claim **1** in which the inert gas is carbon dioxide.

7. A method in accordance with claim **1** in which the retorting temperature is within the range of about 600° F. to about 1000° F.

8. A method in accordance with claim **1** in which:

(a) the pressure on the retorting zone is within the range from about 250 to about 2500 p.s.i.g.;
(b) the inert gas comprises nitrogen; and
(c) the retorting temperature is within the range of about 600° F. to about 1000° F.

9. A method in accordance with claim **8** in which:

(a) the inert gas is flue gas;
(b) the flue gas is obtained from the combustion zone;
(c) the flue gas is compressed to said pressure; and
(d) the product is recovered by reducing its presssure and cooling same.

10. A method in accordance with claim **8** in which

a portion of the separated inert gas is employed in the cooling zone to cool the oil shale from the combustion zone and a portion of the heated inert gas is employed to preheat the crushed oil shale in the preheating zone.

11. A method in accordance with claim **9** in which the separated inert gas is employed to cool the oil shale in the cooling zone.

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U.S. Cl. X.R.

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