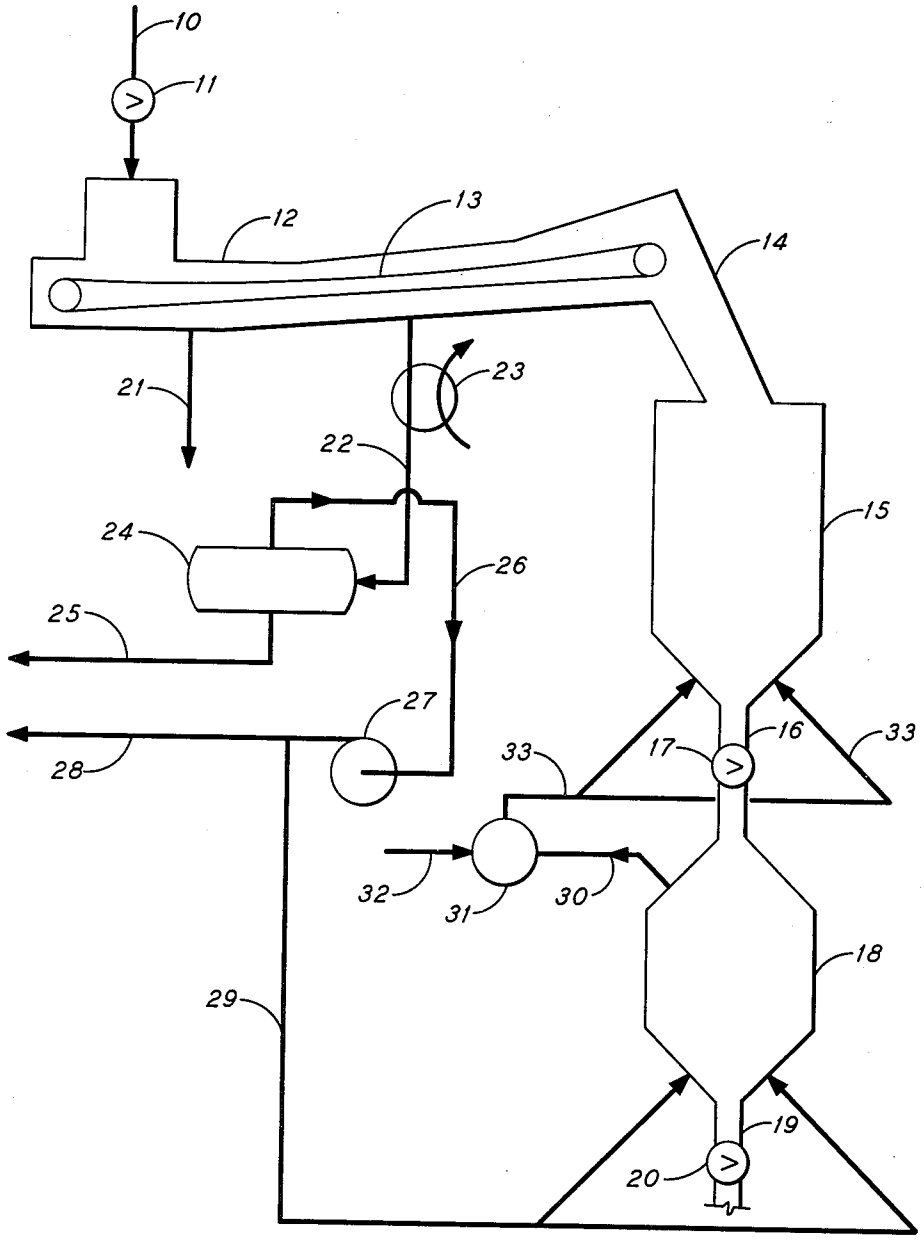
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SHALE RETORTING PROCESS

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SHALE RETORTING PROCESS

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This invention relates to an improved process for retorting oil shale and bituminous solids of similar character in order to recover valuable liquid and gaseous hydrocarbon products.

In the process of this invention, shale is retorted by contacting it countercurrently with hot fixed gases produced from shale. All of the heat required to effect the conversion of the kerogenic constituents of the shale to liquid and gaseous hydrocarbons is supplied as sensible heat of the fixed gases. The gases are heated by contacting the gases countercurrently with spent shale as it comes from the retort and then burning a portion of them in a combustion zone prior to their introduction into the retort.

The process of this invention will be described in detail with reference to the appended drawing, in which fixed gases recovered from the shale are contacted with spent shale as it comes from the retort, partially burned to further increase their temperature, and then introduced into the retort to effect a transfer of their sensible heat to the fresh shale and effect a conversion of its kerogenic constituents.

Shale particles having a size in the range ¼ inch to 2 inches in diameter are passed through line **10** and gas-tight valve **11** into conveyor-condenser **12**. The shale is carried by the conveyor chain **13** into line **14**, through which it passes into retort **15**. Retorted shale is passed from retort **15** through line **16** and gas-tight valve **17** into cooler **18**. Cooled retorted shale is withdrawn from cooler **18** through line **19** and gas-tight valve **20**. Gas and vaporous products from retort **15** pass through line **14** and conveyor-condenser **12** in countercurrent contact with fresh shale en route to retort **15**. Liquid shale oil is withdrawn from conveyor-condenser **12** through line **21**. Shale gas and uncondensed shale vapor is withdrawn from conveyor-condenser **12** at a point intermediate the junction of the conveyor-condenser with lines **21** and **14** through line **22**. These gases and vapors pass through heat exchanger **23** into liquid gas separator **24**. Shale oil is withdrawn from liquid gas separator **24** through line **25**, and fixed shale gases are withdrawn from the separator through line **26** and pass through pump **27**. A portion of the fixed shale gases is withdrawn through line **28** as a net gas product, and the remainder is recycled back to the retorting system through line **29** into cooler **18**, where it countercurrently contacts hot shale from retort **15**. These gases, preheated in cooler **18** by contact with the spent shale, pass through line **30** into combustion chamber **31**. Air is introduced into combustion chamber **31** through line **32** in amount sufficient to raise the temperature of the total gas stream entering the retort **15** to the temperature required for retorting. This may require the combustion of about 10% of the true make gas of the process. The unburned recycle gas and the combustion product are passed from combustion chamber **31** through line **33** into retort **15**, where they countercurrently contact the fresh shale in the retort to effect the conversion of its kerogenic components.

The following table is illustrative of the amounts and temperatures of the process materials involved in typical operation of the process described.

Material	Amount	Temp., °F.
Fresh Shale (½" to 2")	500 lb./hr.	60
Retorted Shale (line 16)	414 lb./hr.	1,000
Cooled Shale (line 19)	414 lb./hr.	250
Shale Oil (lines 21 and 25)	56 lb./hr.	90
Shale Gas (line 28)	35 lb./hr.	175
Recycle Gas (line 29)	240 lb./hr.	175
Air (line 32)	9 lb./hr.	110
Recycle Gas (line 33)	249 lb./hr.	1,050
True Make Gas burned in Combustion Chamber 31.	9 percent	
Flue Gas in Make Gas (line 28)	32 percent	

In the invention described above the combustion of a relatively small proportion of the recycle gas is found to supply sufficient heat to retort the fresh shale. This proportion is ordinarily so small that the net product gas withdrawn from the process through line **28** has a high heat content.

An advantage inherent to the use of a retorting process employing a gas combustion zone separate from the retorting zone is that close control is possible over the temperature of the gas retorting medium, and carbonate decomposition within the retorting zone can thereby be minimized. A further advantage associated with separation of the gas combustion process from the retorting process is the fact that close control over the amount of residual oxygen entering the retort with the hot gas stream may be maintained for the purpose of avoiding an oxidizing atmosphere within the retort which would result in lower yields of liquid products.

In the foregoing specific embodiment of the invention as represented by the appended drawing, it is to be understood that certain modifications in processing techniques and apparatus may be indulged without departing from the basic features of the invention. Thus, the illustrated conveyor condenser **12** may be simplified into a conventional hopper arrangement located directly above line **14**, and shale particles of varying size may be directly fed into the hopper for gravitational loading into the retorting zone. The normally liquid and gaseous products may also be taken from the retorting zone **15** in a conventional manner without affecting the retorting process of the invention. As a conventional modification of the illustrated recovery system, the vaporized products from the retorting zone may be withdrawn from the upper section of the retorting zone and passed into a condensing or mist agglomeration system. The liquid products may be withdrawn from one or more condensers and the product gas accumulated with a distribution into net product gas and recycle gas.

The basic features of the invention involve a recycle of a portion of the product gas which is introduced into countercurrent contact with the spent shale. After preheating by passage through the spent shale, the preheated recycle gas is withdrawn from contact with the shale and passed through a combustion chamber wherein a sufficient portion thereof is burned in contact with controlled introduction of air or oxygen-containing gas to raise the temperature of the recycle gas to the desired retorting temperature and provide the balance of necessary retorting heat, after which it is brought into contact with fresh shale as the retorting heat carrier medium.

This application is a continuation-in-part of application by John W. Scott, Jr., Serial No. 116,260, filed September 17, 1949, now abandoned

Obviously many modifications and variations of the invention as hereinabove set forth may be made without departing from the spirit and scope thereof, and only such

limitations should be imposed as are indicated in the appended claims.

I claim:

1. In a process for retorting shale by countercurrently contacting downwardly moving shale particles with hot gas in a retorting zone to decompose the organic constituents of the shale forming shale oil and shale gas, the improved method which comprises withdrawing vapors comprising normally liquid and normally gaseous products from the upper portion of the retorting zone, cooling the vapors to condense shale oil, withdrawing a minor proportion of the uncondensed gas as a product, reheating the major proportion of the uncondensed gas by contacting it with hot spent shale in a reheating zone, withdrawing reheated gas from the reheating zone and passing it into a combustion zone, introducing into the combustion zone a quantity of a free oxygen-containing gas having an oxygen content stoichiometrically sufficient to cause combustion of only a minor proportion of the reheated gas and burning a minor proportion of the reheated gas sufficient to raise the temperature of the mixture of combustion products and unburned gas to retorting temperature in the combustion zone, and passing the mixture of combustion products and unburned gas from the combustion zone into the retorting zone.

2. Method substantially as described in claim 1, wherein about 10% of the reheated gas is burned in the combustion zone.

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