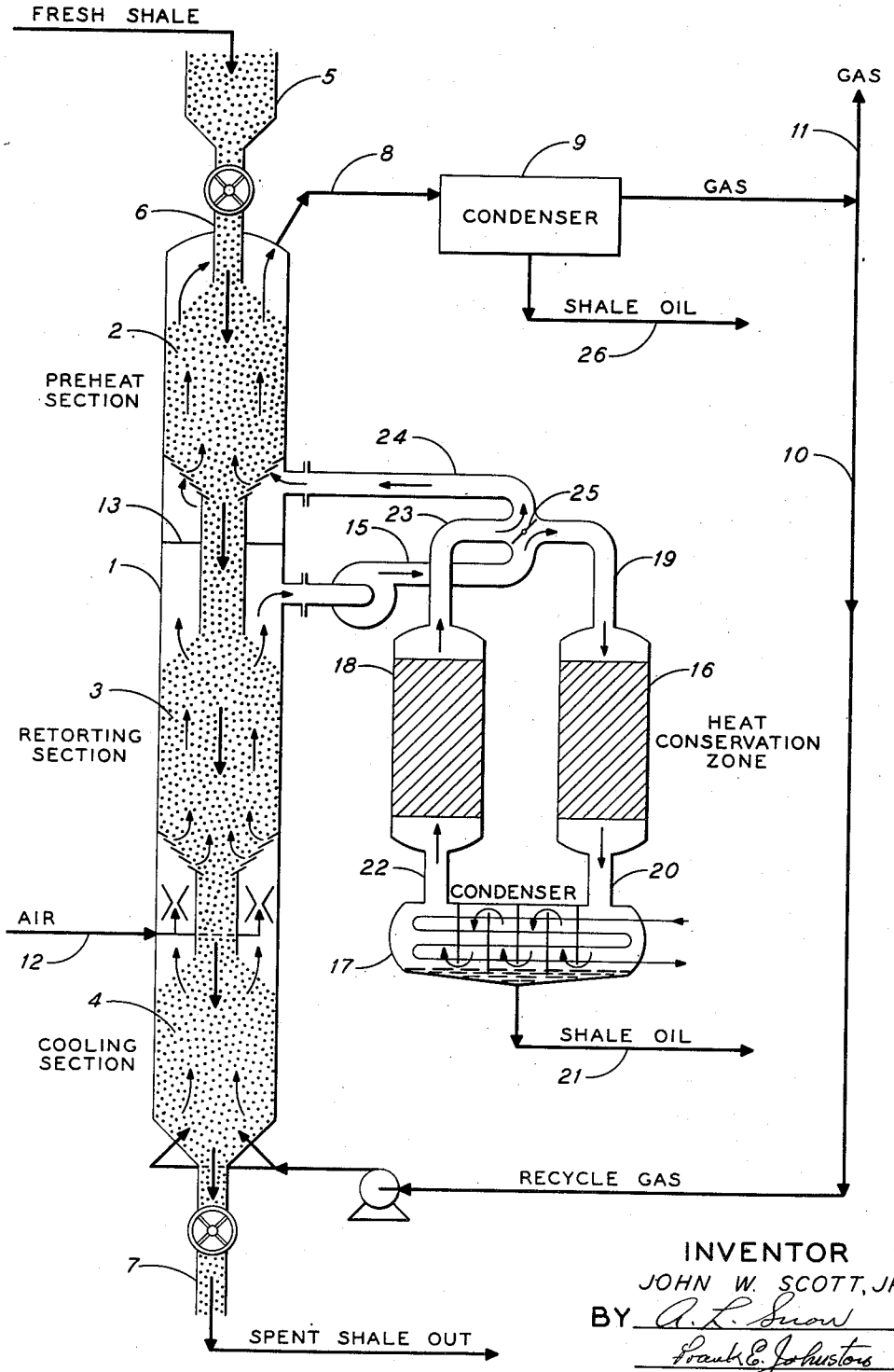
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VERTICAL SHALE RETORTING WITH INTERMEDIATE OIL RECOVERY

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VERTICAL SHALE RETORTING WITH INTERMEDIATE OIL RECOVERY

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

The recovery of hydrocarbon liquids and gases from shale and similar solids by countercurrently contacting the solids and hot gas in a retorting zone to vaporize oil from the solids has previously been described. A particularly efficient process for treating shale in this manner is described in my copending application Serial No. 244,620, filed August 31, 1951. That application describes the recovery of gaseous and liquid hydrocarbons from shale by heating shale in a retorting zone to a temperature sufficient to convert its kerogenic constituents to normally gaseous and normally liquid hydrocarbons by direct countercurrent contact with hot partially burned gases previously recovered from the shale, withdrawing spent shale from the retorting zone to a cooling zone, withdrawing gases and vapors from the retorting zone, and contacting them countercurrently with fresh shale en route to the retorting zone, passing the vapors and gases into a condensing zone, separately withdrawing shale oil and uncondensed shale gases from the condensing zone, passing at least a portion of the shale gases into a cooling zone in direct countercurrent contact with the hot spent shale, withdrawing shale gases from the cooling zone and passing them into a combustion zone, introducing an oxygen-containing gas into the combustion zone to burn a minor proportion of the shale gases sufficient to raise the temperature of the resultant mixture of shale gases and combustion products to a temperature substantially above that at which the conversion of the kerogenic constituents of the shale to gaseous and liquid hydrocarbons occurs, and passing the mixture from the combustion zone into the retorting zone. When this process is practiced on a reasonably large scale, it is found that a substantial proportion of the hydrocarbon material formed in the retorting zone is condensed during its contact with the incoming cold shale and forms a distinct liquid phase which refluxes in the unit. This condition increases the tendency of the shale particles to agglomerate, with the result that clinkering in the retorting zone is aggravated. Further, vaporized normally liquid hydrocarbons in contact with the cold incoming shale condense in the form of a fog, which is not precipitated in the condensation zone, and which emerges therefrom in suspension in the gaseous product. This condition requires either that a substantial loss of liquid product be accepted or that unusually elaborate recovery equipment be provided to capture the suspended oil droplets.

Pursuant to the present invention, continuous processes for recovering oil from oil-bearing solids by passing the solids downwardly through a shale treating zone, countercurrently contacting the solids in the shale treating zone with hot gas to vaporize oil from the solids, recovering oil vapors from the upper portion of the shale treating zone and withdrawing substantially oil-free

solids from the lower portion of the shale treating zone, is markedly improved by withdrawing a substantial proportion of the vapors produced in the shale treating zone from a point in the zone where the temperature of the solids contained therein is at or somewhat above the average dew point of the normally liquid components of the vapors, i. e., ordinarily at about 400 to 800° F., passing the withdrawn vapors through a heat conservation zone comprised of a first mass of inert solid heat exchange material serially connected with an indirect heat exchange zone which is serially connected to a second mass of inert solid heat exchange material, recovering a liquid product from the indirect heat exchange zone, returning a normally gaseous effluent from the second mass of inert solid heat exchange material to the shale treating zone at a point immediately above the point of withdrawal of said vapors from the zone, and periodically reversing the direction of flow of the withdrawn vapors through the heat conservation zone.

The process of the invention will be better understood by reference to the appended drawing which is a diagrammatic illustration of appaartus and process flow suitable for its practice.

Vessel 1 constitutes the shale treating zone. It contains the preheat section 2, a retorting section 3 and a cooling section 4. Cold shale is introduced into the preheat section of the treating zone from hopper 5 through line 6. In preheat section 2 the cold shale is contacted countercurrently with hot gases flowing upwardly through the treating zone. Preheated shale is withdrawn from preheat section 2 usually at a temperature of from 500 to 750° F. and passed into the retorting section of the treating zone. In the retorting section the preheated shale is further heated by countercurrent contact with gas ordinarily at a temperature of from 1100 to 1500° F. produced as described hereinafter. Spent shale is withdrawn from the retorting section and passed into the cooling section of the treating zone where it is countercurrently contacted with cold recycled product gas. Cold spent shale is withdrawn from the cooling section of the treating zone through line 7 at a tempearture usually in the range from 100 to 200° F. Substantially all of the gas produced in the process and a minor proportion of the normally liquid materials produced in the process are withdrawn from the upper portion of the treating zone through line 8 and passed through condenser 9. The normally liquid components of this stream are liquefied in condenser 9 and withdrawn from the condenser as product through line 26. The normally gaseous components of the stream withdrawn from the treating zone through line 8 are passed from condenser 9 through line 10 into the lower portion of cooling section 4 of treating zone 1. A portion of the gas from line 10 is withdrawn through line 11 as product. The recycled gas introduced into cooling section 4 contacts hot spent shale countercurrently, cooling the shale, and being itself heated usually to 700 to 900° F. The heated gas flowing upwardly from cooling section 4 passes into the open annular space between the cooling section and the retorting section of the treating zone. Air is introduced into this annular space through line 12 to burn a portion of the gas flowing upward from the cooling section. The quantity of air introduced through line 12 ordinarily amounts to from about 10 to about 20% of that stoichiometrically required for complete combustion of net make gas. Putting it another way, the amount of air introduced is sufficient to burn from 2 to 12% of the gas entering the annular space from the cooling section. The amount of air is varied ordinarily within these limits, depending upon the composition of the gas flowing upward from the cooling section, but may exceed this if heat requirements are unusually high as when a very wet shale is run, when carbonate de-

composition is encountered, or when the gas yield itself is low. The quantity of air introduced through line **12** is adjusted so that the temperature of the mixture of unburned gas and combustion products produced in the annular space between the cooling section and the retorting section is raised to a temperature sufficiently high that this gaseous mixture can supply all of the heat required to decompose the kerogenic constituents of the shale in the retorting zone. This temperature is usually in the range from 1100 to 1500° F. In the retorting zone the downflowing shale is countercurrently contacted with the hot gas flowing upwardly from the annular space between the cooling section and the retorting section and is so heated that substantially all of the kerogenic constituents of the shale are converted to normally gaseous and normally liquid hydrocarbons. Normally gaseous hydrocarbons and vaporized normally liquid hydrocarbons flow upwardly from the retorting section into the annular space between the retorting section and the preheat section. This annular space is divided into two zones by baffle **13**, which may be either a solid or perforated metal sheet. A substantial proportion or all of the vapors effluent upward from the retorting section are withdrawn from the retorting zone through line **15** and passed into the heat conservation zone. The heat conservation zone contains vessel **16** with inert solid heat exchange material, an indirect heat exchange zone **17**, and vessel **18** packed with inert solid heat exchange material. The stream withdrawn from treating zone **1** through line **15** and which contains normally liquid and normally gaseous hydrocarbons is passed through line **19** into vessel **16**. This stream is cooled by direct heat exchange with the inert solid packing in vessel **16** and is passed from vessel **16** at a temperature from about 200 to 300° F. through line **20** into indirect heat exchange zone **17**. In indirect heat exchange zone **17** the effluent from vessel **16** is further cooled, if desired, to approximately atmospheric temperature, by indirect heat exchange with a cooling medium such as water. If the normally liquid product is unusually viscous the cooling in exchanger **17** may be deliberately limited so that the liquid product is sufficiently hot that it is easily handled as a liquid. A substantial portion of the normally liquid hydrocarbon components of the effluent are condensed in condensation zone **17** and withdrawn therefrom through line **21** as product. Uncondensed gases comprising normally gaseous hydrocarbons are passed from condensation zone **17** through line **22** into vessel **18**. At the startup of the unit, the solid packing in vessel **18** will be cold, but after operation is under way this packing will be hot by reason of its having served to cool the material carried by line **15** in an earlier cycle of operation. Accordingly, in the usual operation of the process, the uncondensed gases passing from indirect heat exchange zone **17** into vessel **18** will be heated by contact with the hot solid packing in vessel **18** and then passed through lines **23** and **24** into the lower portion of preheat section **2** of treating zone **1**. A two-way valve **25** is placed in the junctions of lines **15**, **19**, **23** and **24**. The material withdrawn from treating zone **1** through line **15** is passed through line **19**, vessel **16**, condenser **17**, vessel **18** and line **23**, until the solid packing in vessel **16** has been heated to the point where its capacity to cool the product is exhausted, i. e., the solid packing has attained an average temperature of 500 to 800° F., or the temperature of the effluent product rises to an undesirably high value, for example, to 350° F. or higher. When this condition is reached, valve **25** is turned so that the flow of gas from line **15** through the heat conservation zone is reversed, i. e., the gas passes successively through line **15**, line **23**, vessel **18**, condenser **17**, vessel **16**, line **19**, and line **24**.

By operating in this manner, refluxing of the liquid product in treating zone **1** is prevented and the loss of product due to fogging is very substantially reduced. These results are attained with only very small losses of heat. Most of the heat contained in the product withdrawn from treating zone **1** through line **15** is stored up in the solid packing of vessel **16** during one cycle of operation of the heat conservation section and is returned to the uncondensed gas when the flow through the heat conservation section is reversed in the succeeding cycle of operation. The only net loss of heat sustained is the relatively small amount of heat lost to the cooling water during indirect heat exchange of the partially cooled products with cooling water in condenser **17**.

Those skilled in the art may vary operation of the process of the invention, for example, by the employment of a Ljungstrom type of heat exchanger instead of packed vessels **17** and **18**, by adding heat to line **24** by direct or indirect means if an unusually high preheat load is encountered in a particular application, or by conducting the partial combustion of the gases effluent upwardly from the cooling section of the treating zone in a burner exterior to the treating zone, as shown in my copending application above referred to.

Representative operation of the process of the invention with a Colorado shale is illustrated in the following table, where amounts and temperatures of the process materials and products are shown.

Table

	Amount, lbs./hr.	Temperature, ° F.
Fresh Shale (¼" to 2" size) (line 6)	800	60–70
Cool Spent Shale (line 7)	640	150–250
Shale Oil (line 21)	62	100–300
Shale Oil (line 26)	27	90
Shale Gas (line 10)	440	90
Shale Gas (line 11)	56	90
Shale Gas (line 15)	327	700
Recycle Gas to Cooling Section	384	150
Air (line 12)	14	150

In the preheat section of the treating zone the incoming shale is preheated ordinarily to a temperature from 500 to 700° F. In the retorting zone the preheated shale is further heated to attain a maximum temperature in the range from 900 to 1300° F. in the lower portion of the retorting section. In the cooling section the hot spent shale effluent from the retorting section is cooled from 900 to 1300° F. down to 100 to 200° F.

The heat conservation section is desirably operated so that a minimum amount of heat is lost to the cooling water in the indirect heat exchanger of that zone. No difficulty is encountered in precooling the product stream in either vessel **16** or **18** down to a temperature in the range from 250 to 300° F. so that relatively little heat is lost in heating the water. This heat may, in part, be transferred back to the process by preheating air stream **12** in condenser **17**. This reduces both combustion and cooling water requirements.

I claim:

1. In a continuous process for recovering oil from oil-bearing solids by passing said solids downwardly through a shale treating zone, counter-currently contacting the solids in the shale treating zone with hot gas to vaporize oil from said solids, recovering oil vapors from the upper portion of the shale treating zone and withdrawing substantially oil-free solids from the lower portion of the shale treating zone, the improvement which comprises withdrawing a substantial proportion of the vapors from a point in the shale treating zone where the temperature of the solids contained therein is in the range from about 400 to 800° F., passing the withdrawn vapors through a heat conservation zone comprised of a first mass of inert solid heat exchange material serially connected with an indirect heat exchange zone which is serially connected to a second mass of inert solid heat exchange material, recovering a liquid product from the indirect heat exchange zone, returning the normally gaseous effluent from the second mass of inert solid

heat exchange material to the shale treating zone at a point immediately above the point of withdrawal of said vapors from the zone and periodically reversing the direction of flow of the withdrawn vapors through the heat conservation zone.

2. In a continuous process for recovering oil from oil-bearing solids by passing said solids downwardly through a retorting zone, countercurrently contacting the solids with hot gas in the retorting zone to vaporize oil from said solids, recovering oil vapors from the upper portion of the retorting zone and withdrawing substantially oil-free solids from the lower portion of the retorting zone, the improvement which comprises withdrawing a substantial fraction of the oil vapors from a point in the retorting zone where the temperature of the solids contained therein is in the range about 400 to 800° F., passing the last-mentioned oil vapors through a partial condensation zone comprising a mass of relatively cool inert solid heat exchange material to partially cool said vapors, passing the partially cooled vapors through an indirect heat exchange zone to condense substantially all of the normally liquid components of said vapors therefrom, withdrawing uncondensed gas from the indirect heat exchange zone, passing it through a reheating zone comprised of a relatively hot mass of inert solid heat exchange material, passing the reheated gas into the upper portion of the retorting zone at a point above the point at which said withdrawal of a substantial part of the oil vapors is made, and periodically re-directing the flow of the withdrawn vapors so that each of the two masses of solid heat exchange material alternately functions in the partial condensation zone and in the reheating zone.

3. A process for recovering oil from shale which comprises maintaining a shale treating zone comprising a preheating section, a retorting section and a cooling section,

passing cold shale downwardly and successively through the preheating section, the retorting section and the cooling section of the treating zone, withdrawing cool spent shale from the cooling section of the treating zone, withdrawing substantially all of the normally gaseous products and a portion of the normally liquid products from the upper portion of the preheating section and cooling it to condense normally liquid products therefrom, passing a substantial proportion of the residual uncondensed gas into the lower portion of the cooling section, introducing air into the treating zone at a point intermediate the cooling section and the retorting section in amount sufficient to cause combustion of a minor proportion of the gas enroute from the cooling section to the retorting section and raising its temperature to about 1100 to 1500° F., passing the resultant hot gas through the retorting section, withdrawing a substantial proportion of the vapors effluent from the retorting section of the treating zone and passing them through a heat conservation zone comprised of a first mass of inert solid heat exchange material serially connected with an indirect heat exchange zone which is serially connected to a second mass of inert solid heat exchange material, recovering a liquid product from the indirect heat exchange zone, passing the normally gaseous effluent from the second mass of inert solid heat exchange material into the lower portion of the preheating section of the treating zone and periodically reversing the direction of flow of the withdrawn vapors through the heat conservation zone.

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