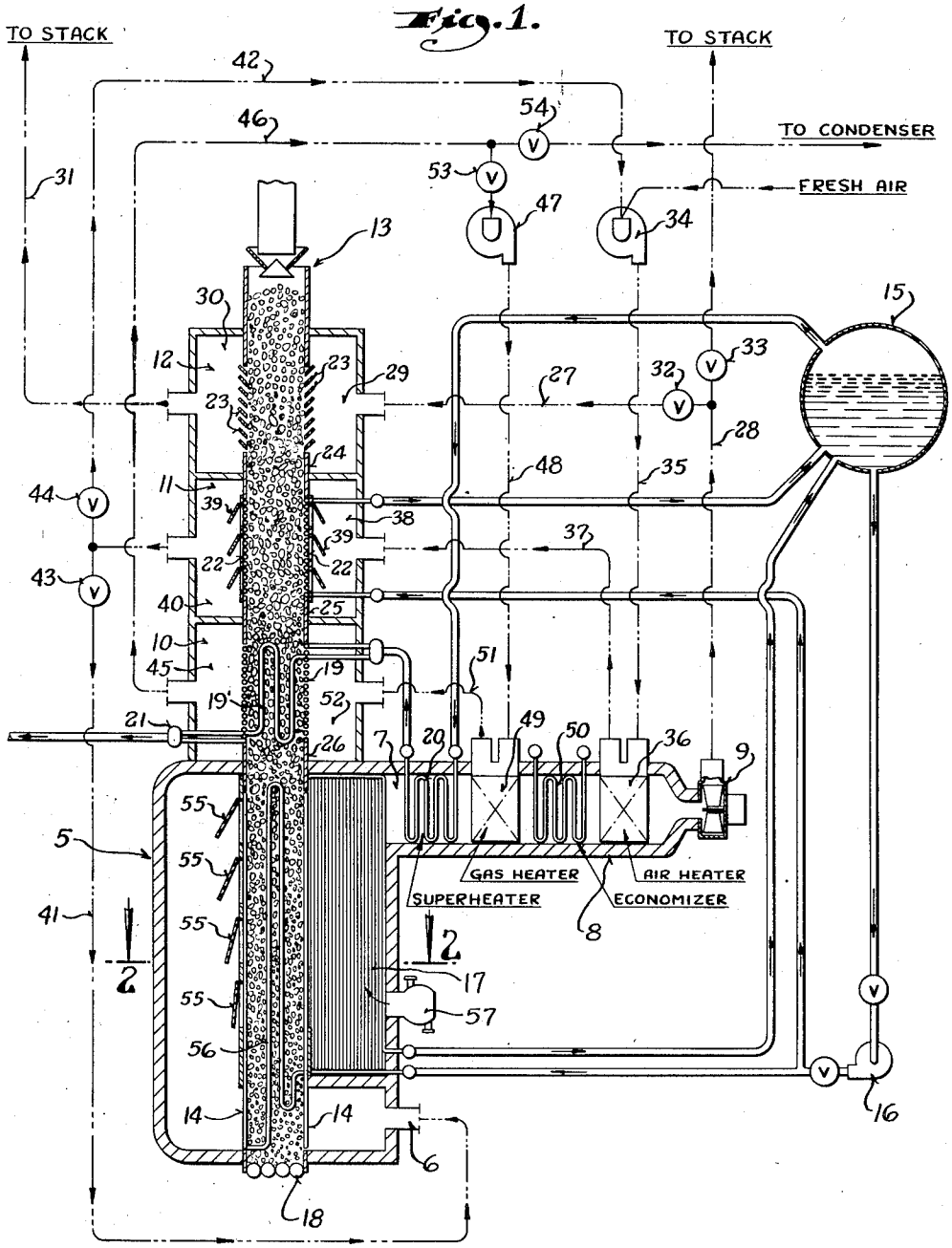
Dec. 28, 1954 D. DALIN 2,698,283

METHOD AND APPARATUS FOR THE DESTRUCTIVE DISTILLATION OF OIL SHALE

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Fig. 1.



Inventor
David Dalin
by Ira Milton Jones
Attorney

Dec. 28, 1954 D. DALIN 2,698,283

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Fig. 2.

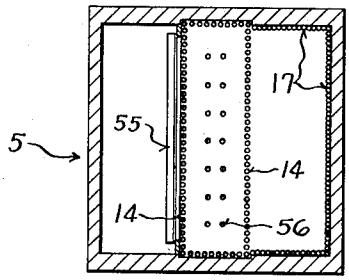


Fig. 3.

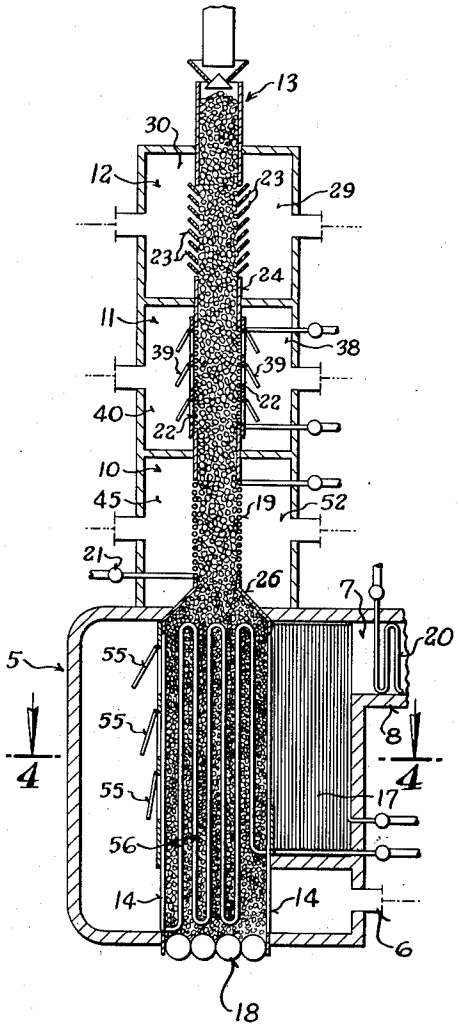
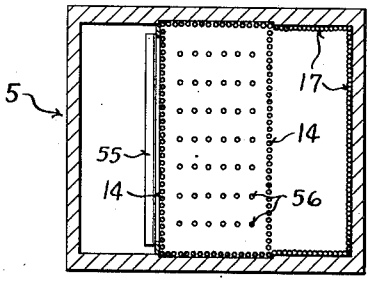


Fig. 4.



Inventor
David Dalin
By Bradshaw Jones
Attorneys

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METHOD AND APPARATUS FOR THE DESTRUCTIVE DISTILLATION OF OIL SHALE

David Dalin, Stenkullen, Ronninge, Sweden, assignor to A/B Svenska Maskinverken, Sodertalje, Sweden, a corporation of Sweden

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5 Claims. (Cl. 202—6)

This invention relates to the art of distilling volatiles from oil-bearing shale and other solid carbonaceous material and has as its purpose to provide an improved method and apparatus therefor.

Many schemes have been proposed in the past for degassing oil shale and the like and while these various past attempts have met with some measure of success, invariably there was always some objection to the method or the apparatus employed which kept it from being economically sound.

At the outset, any method for the distillation of oil shale and similar carbonaceous material to be at all commercially practicable requires that it be capable of processing huge quantities of material per unit of time. This, of course, means a continuous process.

Another serious consideration is that the residue coke left after the volatiles are driven from the material must be disposed of and preferably its combustible fraction should be burnt to provide the heat needed in the process.

The present invention fully satisfies these basic requirements and, as will appear, provides a method and apparatus wherein huge quantities of carbonaceous material may be processed per unit of time and wherein combustible fraction of the residue coke is not only burned, but in the burning thereof steam for power production is derived.

In keeping with its general objective of providing a commercially practicable and economically sound method and apparatus for the distillation of oil shale and the like the invention has an another of its purposes or objects the preheating of the carbonaceous material as it is fed into the distillation zone by the preheated combustion air, the preheating of the combustion air being effected by indirect heat exchange with the flue gases leaving the combustion zone.

Another object of this invention is to utilize the heat contained in the flue gases for driving the volatiles from the carbonaceous material as it moves through a distillation zone, and to this end the invention provides for recirculation of the distillation gases sequentially in indirect heat exchange relation with the hot flue gases and then through the carbonaceous material in the distillation zone.

Again, with a view toward effecting maximum economy the invention has as another of its objects the preliminary heating of the raw carbonaceous material directly before it is fed into the preheating zone by passing the spent, though still hot, flue gases or a part thereof through the raw carbonaceous material before these flue gases move out to the stack.

One of the most serious drawbacks of the methods proposed by others heretofore for the distillation of volatiles from oil shale and like carbonaceous material resided in their failure to recognize the importance of controlling the temperature of the burning residue coke where combustion thereof was employed to provide the necessary heat source. Oil-bearing shale and similar carbonaceous material has a relatively low sintering temperature and, therefore, unless the temperature of the burning material is controlled and excess heat abstracted therefrom the material quickly sinters which, of course, is highly undesirable. To avoid this objectionable consequence the present invention applies the teachings of the Edling et al. Patent No. 2,504,508 wherein excess heat is abstracted from the burning fuel by circulating a suitable cooling fluid, preferably boiler fluid, in indirect heat exchange relation with the burning fuel.

The problem of too high a temperature is, of course, also encountered in the distillation zone for if the temperature of the material therein is permitted to exceed a predetermined safe maximum, the volatiles driven from the material are carbonized and the distillates begin to crack.

This invention, therefore, has as another of its objects to control the temperature of the material undergoing distillation and accomplishes this purpose by circulating boiler fluid of a temperature correct for distillation in indirect heat exchange relation with the carbonaceous material being degassed.

With the above and other objects in view, which will appear as the description proceeds, this invention resides in the novel method and apparatus hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate two complete examples of the physical embodiment of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a view diagrammatically illustrating one application of this invention and in which the enclosures providing the various zones as well as the upright passageway down which the column of material being treated descends, are shown in section;

Figure 2 is a cross sectional view through Figure 1 on the plane of the line 2—2;

Figure 3 is a view illustrating a slight modification of the apparatus, said view being similar to the main structural portion of Figure 1; and

Figure 4 is a horizontal sectional view through Figure 3 on the plane of the line 4—4.

Referring now particularly to the accompanying drawings, the numeral 5 designates a combustion chamber having an air inlet 6 near its bottom and a flue gas outlet 7 near its top from which a flue gas duct 8 leads to a suction fan 9.

Superimposed upon the combustion zone is a distillation zone 10, a preheating zone 11 and a preliminary heating zone 12. The zones 12 and 11 may be said to provide first and second stages of preheating for the carbonaceous material to be treated which is fed into the top of a vertical retort 13 extending through all of the zones. The retort 13 also preferably extends across the full width of each zone as shown in Figure 2 so as to divide each zone into an inlet and an outlet chamber.

The lower portion of the retort 13 is defined by relatively closely spaced vertical boiler fluid containing tubes 14 which constitute part of the steam generating surfaces of a steam boiler deriving its heat from the combustion of the residue coke. This steam boiler is equipped with a steam drum 15 and is of the forced circulation type, having a force pump 16 which draws water from the steam drum and forces it through the various steam generating tubes, including the tubes 14, and other tubes 17 lining certain of the walls of the combustion chamber.

At its bottom the retort 13 has a grate 18 of any suitable construction to support the column of carbonaceous material and continually discharge the ash from the bottom thereof into an ash pit (not shown).

In the distillation zone 10 the retort 13 for the major portion of its length is defined by horizontal boiler fluid containing tubes 19 and has finger-like ducts or tubes 19' to be embedded into the mass in the retort. Superheated steam flows to the coils 19 and the ducts or tubes 19' from the outlet of a superheater 20 located in the hottest portion of the duct 8 and having its inlet connected with the steam drum in the customary manner. The coils 19 and the tubes 19' empty into a header 21 from which the steam may be led directly to its point of use, or first passed through another superheater (not shown) where its temperature and pressure may be stepped up.

The retort 13 within the preheating zone 11, for the major portion of its length, is likewise defined by horizontal boiler fluid containing tubes 22 but these tubes contain hot water or a steam-water emulsion which is circulated therethrough by the force pump 16.

In the preliminary heating zone 12 the opposite side

walls of the retort 13, i. e. those also defining one side of the inlet and outlet chambers of the zone 12, are perforate and are preferably defined by louvers 23.

Those portions of the retort 13 connecting the adjacent zones are defined by imperforate walls 24, 25 and 26. These imperforate walls facilitate the maintenance of neutral zones in the retort between the adjacent treatment zones by which the gases in one treatment zone are kept from intermingling with those of another. To obtain these neutral zones or "blocks" the pressures within the adjacent treatment zones are so controlled that an area of zero pressure differential is maintained in each neutral zone.

In the practice of the method of this invention the raw oil-bearing shale or other similar carbonaceous material is continuously fed into the top of the upright retort 13 to maintain the height of the column therein. As this raw carbonaceous material descends through the preliminary heating zone 12 it is heated by the passage therethrough of part of the flue gases flowing to the stack. For this purpose a bypass line 27 connects the main stack line 28 with the inlet chamber 29 of the zone 12 and the outlet chamber 30 is connected to the stack through a suitable duct line 31. Valves 32 and 33 in the bypass line 27 and the main line 28 proportion the volume of the flue gases flowing through the zone 12 and thus provide means for controlling the pressure within this treatment zone. Obviously the flue gases entering the zone 12 must pass through the column of carbonaceaus material to leave the zone and flow on to the stack and in so doing effect a preliminary heating of the raw carbonaceous material.

Within the preheating zone 11 the carbonaceous material is further heated by the passage therethrough of the air for combustion which has been previously preheated. To this end the combustion air which enters the inlet of a blower 34 is fed through a duct line 35 to an air heater 36 located in the flue gas duct 8 where the air is heated. The air thus heated passes through a duct line 37 to the inlet chamber 38 of the zone 11 from which it flows through the carbonaceous material under the control of dampers 39 into the outlet chamber 40 of the preheating zone.

From this point part of the combustion air is conducted through a line 41 to the combustion air inlet 6 of the combustion zone while the remainder thereof is fed back through a duct line 42 to the inlet of the blower 34 for recirculation. Valves 43 and 44, in the lines 41 and 42 respectively, proportion the amounts of the combustion air fed to the combustion chamber and recirculated through the air heater.

The hot combustion air flowing through the preheating zone 11 coacts with the hot boiler fluid flowing through the tubes 22 to effect the desired preheating of the carbonaceous material.

The carbonaceous material, after being preheated in the manner described, passes through the adjacent neutral zone of the retort and into the distillation zone 10 where the volatile gases are driven off by heat supplied conjointly by the superheated steam flowing through the tubes 19 and 19' and heated distillation gases. To this end the outlet chamber 45 of the distillation zone 10 is connected through a duct line 46 with the inlet of a blower 47 as well as a condenser (not shown) where the gases are condensed and subjected to further treatment.

The blower 47 discharges into a duct line 48 which leads to the inlet of a gas heater 49 located in the flue gas duct 8 preferably directly downstream from the superheater 20 and between it and the usual economizer 50. The outlet of the gas heater is connected through a duct line 51 with the inlet chamber 52 of the distillation zone 10. Valves 53 and 54, located respectively at the inlet of the blower 47 and in the line leading to the condenser, control the proportion of the distillation gases recirculated through the gas heater and thus enable regulation of the pressure within the zone 10.

The temperature of the superheated steam circulating through the coils 19 and the tubes 19' is maintained at the value best suited for distillation of the carbonaceous material and hence its effect is to stabilize the temperature of the carbonaceous material undergoing degassing, abstracting excess heat in the event the distillation gases entering the zone 10 from the heater 49 are too hot and imparting heat if the temperature of these gases is too cool. The desired temperature is thus maintained in the distillation zone.

The degassed residue coke passes through the adjacent neutral zone into the combustion zone where it is burned, the air for combustion being supplied thereto in the manner described and being distributed over the full height of the fuel bed in accordance with the setting of dampers 55.

It is to be noted that the incoming combustion air which enters the combustion zone at its bottom first flows transversely through the extreme lower portion of the retort and then passes transversely across therethrough at different levels in accordance with the setting of the dampers 55. All of the material being burned in the combustion zone is thus fed the proper volume of combustion air and, as will be readily apparent, the total volume of air fed to the combustion chamber may be regulated to produce an optimum rate of combustion.

This latter desirable result is enabled by the fact that the temperature of the burning mass is controlled to preclude sintering thereof and in certain cases the dissociation of mineral CO_2 by the circulation of boiler fluid through the finger-like ducts or tubes 56 imbedded in the burning mass and connected in the steam generating system of the boiler to have boiler fluid continuously circulated therethrough. Thus the boiler fluid circulated through the tubes 56 coacts with the boiler fluid flowing in the tubes 14 to effectively abstract the excess heat from the burning mass and thereby enable rapid combustion of the combustible fraction residue coke without the danger of sintering and in certain cases the dissociation of mineral CO_2.

The heat obtained from the burning of the coke residue is sufficient for ordinary requirements. To take care of abnormal demands upon the boiler, a gas or oil burner 57 mounted in a wall of the combustion chamber, provides a supplemental heat source.

Since the volume of material that can be combusted per unit of time largely determines the capacity of the plant and since the material being handled burns notoriously slow, it may be desirable to increase the cross sectional dimensions of the lower portion of the retort and consequently the overall volume of the material being combusted. This may be done in the manner shown in Figure 3 wherein the sides of the lower retort portion defined by the coils 14 are spaced farther apart and the coils 56 imbedded in the burning mass are increased in number to enable the cooling effect of the boiler fluid flowing therethrough to reach all portions of the burning fuel. Such increase in the horizontal area of the burning fuel bed also has the desirable advantage of enabling reduction in the overall height of the unit.

From the foregoing description taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art that this invention provides a practical and economically sound method of distilling the volatiles from oil-bearing shale and similar carbonaceous material and that the invention lends itself to practice by means of relatively simple apparatus.

What I claim as my invention is:

1. Apparatus for distilling oil-bearing shale and similar solid carbonaceous material, comprising: means defining a retort divided vertically into a preliminary heating zone, a preheating zone below the preliminary heating zone, a distillation zone below the preheating zone, and a combustion zone below the distillation zone, said zones being in open communication with one another so that carbonaceous material fed into the top of the retort can pass from each zone directly into the next zone therebelow; a flue gas duct leading from the combustion zone; a primary heat exchanger in the flue gas duct in which heat exchange fluid may be heated by indirect heat exchange with the hot flue gases to a temperature at least as high as that at which distillation of the carbonaceous material takes place; a secondary heat exchanger in the distillation zone connected with said primary heat exchanger to enable heated heat exchange fluid to impart its heat to the carbonaceous material by indirect heat exchange to effect distillation thereof; an air preheater in the flue gas duct downstream from said primary heat exchanger; means for passing preheated air from said air preheater through the carbonaceous material in the preheating zone to preheat the same by direct heat exchange therewith; means for conducting air which has been passed through the carbonaceous material in the pre-

heating zone to the combustion zone to take part in the combustion process; means connecting said flue gas duct, at a location downstream from said air preheater, with said preliminary heating zone, and for passing flue gas across the carbonaceous material in said preliminary heating zone in direct heat exchange relation therewith; and means for regulating the relative pressures of the air and flue gases passing through the carbonaceous material and the distillation gases in the distillation zone to maintain said pressures at values such as to preclude the admixture of flue gases in the preliminary heating zone with distillate products in the distillation zone.

2. The apparatus of claim 1, further characterized by means for recirculating a portion of the air which has been passed through the carbonaceous material in the preheating zone through the air preheater.

3. Apparatus for distilling oil-bearing shale and similar solid carbonaceous material, comprising: means defining a retort divided vertically into a preliminary heating zone, a preheating zone below the preliminary heating zone, a distillation zone below the preheating zone, and a combustion zone below the distillation zone, said zones being in open communication with one another so that carbonaceous material fed into the top of the retort can pass from each zone directly into the next zone therebelow; a flue gas duct leading from the combustion zone; means for effecting indirect heat exchange between flue gases from the combustion zone and carbonaceous material in the distillation zone; an air preheater in the flue gas duct; means for passing preheated air from said air preheater through the carbonaceous material in the preheating zone to preheat the same by direct heat exchange therewith; means for conducting air which has been passed through the carbonaceous material in the preheating zone to the combustion zone to take part in the combustion process; means connecting said flue gas duct, at a location downstream from said air preheater, with said perliminary heating zone, and for passing flue gas across the carbonaceous material in said preliminary heating zone in direct heat exchange relation therewith; and means for regulating the relative pressures of the air and flue gases passing through the carbonaceous material and the distillation gases in the distillation zone to maintain said pressures at values such as to preclude the admixture of flue gases in the preliminary heating zone with distillate products in the distillation zone.

4. The method of distilling oil-bearing shale and similar solid carbonaceous materials which comprises: moving the carbonaceous material in a column through a preliminary heating zone and downward successively through a preheating zone, a distillation zone and a combustion zone where the degassed material is burned; passing flue gases from the combustion zone in heat exchange relation with a heat exchange medium; heating carbonaceous material in the distillation zone to distillation temperatures by passing said material in heat exchange relation with said heat exchange medium; heating combustion air by passing the same in indirect heat exchange relation with the flue gases which have been passed in indirect heat exchange relation with said fluid heat exchange medium; passing the heated combustion air through the column of carbonaceous material in the preheating zone, in direct heat exchange relation therewith; thereafter conducting said air to the combustion zone to maintain combustion; passing flue gases which have heated said combustion air through the column of carbonaceous material in the preliminary heating zone, in direct heat exchange relation therewith; and regulating the relative pressures of the air in the combustion zone, the distillation gases in the distillation zone and the flue gases in the preliminary heating zone to maintain the same at a value which will preclude intermingling of the flue gases in the preliminary heating zone with distillate products in the distillation zone.

5. The method of claim 4 further characterized by the step of recirculating a portion of the combustion air which has been passed through the column of carbonaceous material in the preheating zone in indirect heat exchange relation with flue gases to reheat said air.

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