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PROCESS OF DESTRUCTIVELY DISTILLING SOLID CARBONACEOUS MATERIAL

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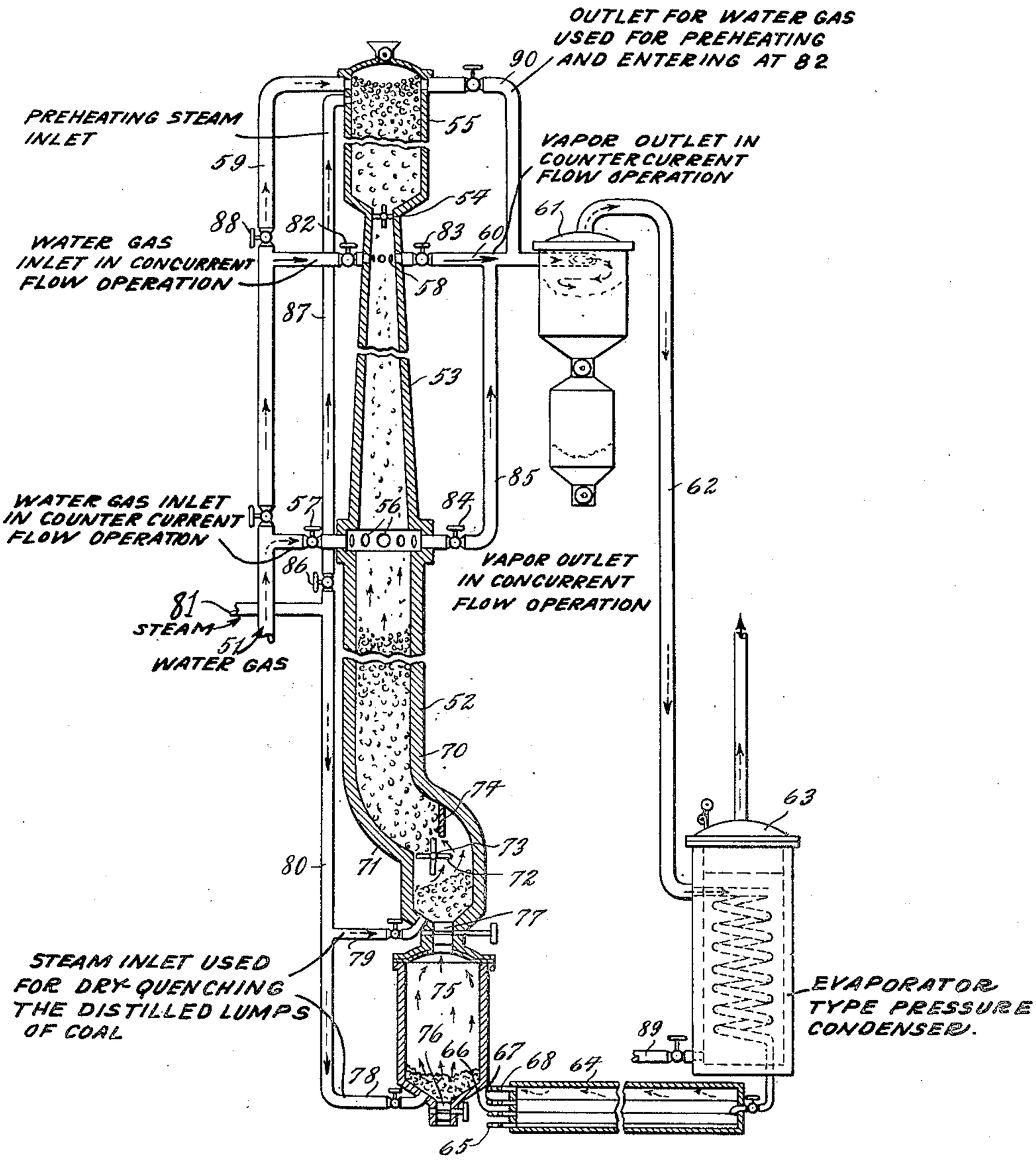

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PROCESS OF DESTRUCTIVELY DISTILLING SOLID CARBONACEOUS MATERIAL

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9 Claims. (Cl. 202—15)

This invention relates to the destructive distillation of coal and other solid carbonaceous materials for separating their solid, liquid and gaseous decomposition products according to a new process whereby the quality and yield of these products is controlled in accordance with the raw materials that are treated also to produce products of such kinds and amounts as may be most profitable or in greatest demand. While my process is most useful for treating coals, it is also applicable to oil shales and other materials. This application is a division in part of my application Serial No. 144,947 filed October 29, 1926.

I have found that the heating of coal produces products that differ with the rate of heating, the maximum temperature attained by the decomposition products and the nature of the gases and vapors surrounding the coal during the heating. In my process I provide means for controlling all three variables according to the desired results and also according to the nature of the coal used.

According to my process dust-free coal or other carbonaceous material, preferably of uniform sizes of lumps, is subjected to conditions of low-temperature carbonization which may be varied wherein all particles of the materials may be caused to increase in temperature either at a constant rate or at an increasing or decreasing rate, depending upon the characteristics of the coal and the markets for the products.

I have found that the rate at which the temperature of the coal in lumps of substantially uniform sizes is caused to rise affects greatly the yield and character of the coke, tar-oils and gases and that a slow rate of temperature rise produces a dense coke, a rich gas and high quality tar-oils from common types of coals. A rapid rate of temperature rise produces coke of lower density, more tar-oils and gases but of poorer quality. Furthermore, the yield and character of the resulting gaseous and liquid products is also affected by the conditions of time and temperature under which the vapors are held in the retort and by the type of gases with which they are contacted.

For heating the coal I use hot gases such as water gas, or superheated steam or a mixture of such in contact with the coal moving downwardly in a retort. Also, I have found that a mixture of the above gases and air will reduce the tendency of lumps to cohere.

In carrying out the invention I provide for either up or down flow of the heating fluid, countercurrent or parallel to the movement in the retort and control the character of the products obtained. I also provide for varying the ratio of superheated steam to gas, the ratio of the weight of the heating fluid to coal and the temperature at which the heating fluid is supplied.

When the coal is to be heated most suddenly I use parallel flow of heating fluid and coal. This is especially useful in producing quickly a layer of coke over the outside of the lump before the inside becomes greatly heated, thereby preventing complete fusion of some types of coals or breakage of others which would occur if not so prevented and interfere with their proper subsequent heating and distillation.

A minimum of steam or carbon dioxide is preferable when heating a fusing coal by concurrent movement therewith so as not to consume the outer shell of coke by reaction to producer gas or water gas. When the coal is of non-fusing type a maximum of steam is preferable so as to make water gas from both coke and tar-oils, if a high gas yield is wanted.

Steam is introduced into the coke hopper at the bottom for quenching the coke and regaining part of its heat. Even with parallel-flow heating the coke may be cooled by steam rising countercurrent through it, to conserve its sensible heat and to utilize it higher up in the retort for distillation purposes.

I have operated the process at pressures above atmospheric and have thereby been able to use the latent heats of the vapors to generate a further supply of steam.

Referring to the drawing, the pipe 51 is supplied with hot gases such as water gas, with or without superheated steam, as a heating fluid for the retort shown diagrammatically at 53 where the coal is carbonized or other material subjected to a heating process. The retort may be thirty or more feet high and steam may be fed to it from the pipe 81. The properly sized coal free from fines, is fed into the tapered upper part of the retort 53 by a valved opening 54. To enable the coal to be preheated, it comes from a valve-closed bin 55 provided with heating means described below. For heating the coal in the retort by the heating fluid from the main 51 two procedures have been found useful.

According to one procedure the descending coal is heated by a countercurrent upflow of steam and gas. The principal heat may be supplied by the hot gases coming from the main 51. To effect this an annular manifold 56 sur-

rounds the retort 52 and through this the hot fluid gas and vapors coming from the main 51 are led by a valved connection 57.

The entering heating fluid is supplied at a proper temperature to distill off the volatiles in the coal with great rapidity, while the steam reacts to a considerable extent with the resulting coke and by increasing the rate of flow of the coal so that it carries volatile oil ingredients into steam hot enough to crack them, the steam reacts with the carbon particles released by the cracking and forms water gas and gaseous and condensable hydrocarbons. I have used the heating fluid at temperatures from 1200° F. to 1850° F. The volatile products and gases pass upwardly through the coal and pass out of a manifold 58 below the opening 54.

Preferably there is a column of coal between the manifold 58 and the opening 54 high enough to provide a continuous supply of coal to the distilling zone while the valve 54 is closed when the bin 55 is being recharged. The coal may be preheated by passing part of the heating fluid from the main 51 through a valved insulated pipe 59 into the bin 55. The heating fluid passes down through the material in the bin 55 and out of the system at the manifold 58 thereby drying and preheating the coal and simultaneously serving the valuable functions of preventing tar and oil vapors from the distilling coal from entering the bin 55 and condensing there. The gases and vapors leaving by the manifold 58 enter a heat insulated and valved main 60 which conveys them to a heat insulated cyclone dust collector 61 where the dust is removed. From this a heat insulated main 62 carries the vapors and gases almost at issuing temperature to an evaporator or heat exchange device 63. Here the sensible heat and the latent heat of condensable materials are recovered and four products, resin, water, oil and gas are separated in a separator 64 and removed as desired by valves 65, 66, 67 and 68.

In addition to the heat provided at the manifold 56 the contents of the retort are further heated by steam rising from the solid residues or from the coke formed. The lower part 70 of the retort may be cylindrical or straight instead of tapering. It may terminate in one of the customary forms having an elbow 71 forming a nearly horizontal support for the load of the charge in the retort. The feed of the contents past the elbow 71 may be controlled by arms 72, fast on a rotatable shaft 73 which may be rotated by any suitable means, and extend toward pivoted hanging arms 74 which detain the upper part of the charge at the nearly horizontal section 71. After passing the elbow or horizontal portion 71 the residue or coke drops into a bottom bin 75 and rests on the closed bottom valve 76 thereof. A valve 77 between the bin 75 and the lower part of the retort may be closed when it is desired to remove the contents of the bin 75 which requires the opening of the valve 76. The residues of coke lying upon the valves 76 and 77 can be used to heat steam introduced through valved connections 78 and 79 from the main 81. This steam may be laden with admixed solutions of salts capable of rendering the product useful for illuminating purposes or odoriferous materials, thus enabling any desired properties to be given to the coke discharged. The heat of the coke or residues lying upon the valves 76 and 77 superheats the steam so that it aids in heating the charge in the retort, thus recovering a very large proportion of the heat usually lost in carbonizing processes. The final temperature of the discharged coke is controlled by the amount of free moisture carried by the steam.

The procedure which has been found most useful for heating a charge of fusing coal in the upper part of the retort 53, is to close the valved connection 57 and open a valve 82 at the upper manifold 58, thus admitting the heating fluid from the main 51 to the upper manifold. The valve 83 in the main 60 is also closed, and a valve 84 in a branch 85 of the main 60 and extending to the lower manifold 56 is also opened with the result that heating fluid from the main 51 enters the top of the retort and flows down with the charge of coal to the manifold 56 and then passes off to the branch 85 in the dust collector 61.

It is found that rather more oil may be obtained from a charge if heated at low temperatures according to the latter method than is obtained when the charge in the retort is heated by a countercurrent flow to the same temperature.

In order to pre-heat the charge in the bin 55 while distilling by counter flow either steam may be drawn from the steam main 81, or hot fluid, steam and gas from the main 51. There is provided in the main 80 leading from the main 81 a valve 86 which may be opened to allow steam to flow up an extension 87 into the bin 55. As an alternative method of heating the bin 55 the valve 88 of the extension 59 of the main 51 may be opened. Either of these methods of heating the bin 55 serves to keep vapors and steam from condensing in the bin 55 as they rise from the upper part of the retort 53.

When distilling by parallel flow, preheating of the coal is accomplished by passing part of the hot fluids that enter through the manifold 58 upwardly through the bin 55 thence out through the valved line 90 to the main 60, the valve in this line 90 being left open during this time.

I claim:

1. The process of destructively distilling lumps of solid carbonizable material of substantially uniform sizes which comprises volatilizing the outer surface layers of the lumps without removing an appreciable amount of the volatile constituents from the interior portions of the lumps by means of hot water gases in contact therewith in the presence of steam so as to cause rapid pyrolysis, and then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while effecting further pyrolysis of the interior of the lumps at a slower rate.

2. The process of destructively distilling lumps of solid carbonizable material of substantially uniform sizes which comprises heat treating the lumps at distillation temperatures and devolatilizing the outer surface layers of the lumps rapidly by means of hot water gases in contact therewith in the presence of steam so as to cause rapid pyrolysis, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while continuing the devolatilization, and effecting further pyrolysis of the interior of the lumps at a slower rate until substantially all of the volatile products are removed.

3. The process of destructively distilling lumps of solid carbonizable material of substan-

tially uniform sizes which comprises heat treating the lumps at distillation temperatures and devolatilizing the outer surface layers of the lumps rapidly by means of hot water gases in contact therewith in the presence of steam so as to cause rapid pyrolysis, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while continuing the devolatilization, and effecting further pyrolysis of the interior of the lumps at a slower rate until substantially all of the tar-oils are removed.

4. The process of destructively distilling lumps of solid carbonizable material of substantially uniform sizes which comprises initially heating the lumps rapidly to distillation temperatures and forming some water gas by means of hot water gas and steam in contact therewith while effecting rapid pyrolysis of the surface of the lumps, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation, and controlling the proportion of water gas to steam whereby a variation may be effected.

5. The process of destructively distilling lumps of solid carbonizable material of substantially uniform sizes which comprises initially heating them rapidly at distillation temperatures and forming some water gas by means of hot water gas and steam in contact therewith while effecting rapid pyrolysis of the surface of the lumps, moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and controlling the composition of the water gas whereby a variation may be effected in accordance with the nature of the material being treated.

6. The process of destructively distilling lumps of solid carbonizable material of substantially uniform sizes which comprises initially heating the lumps rapidly at distillation temperatures by means of hot water gases in contact therewith in the presence of steam so as to cause rapid pyrolysis, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while effecting further pyrolysis of the interior of the lumps at a slower rate, and contacting the treated lumps with steam flowing countercurrent.

7. The process of destructively distilling lumps of solid carbonizable material of substantially uniform sizes which comprises initially heating the lumps rapidly at distillation temperatures and at pressures considerably above atmospheric by means of hot water gases in contact therewith in the presence of steam so as to cause rapid pyrolysis, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while effecting further pyrolysis of the interior of the lumps at a slower rate, and contacting the treated lumps with steam flowing countercurrent.

8. The process of destructively distilling under pressure lumps of solid carbonizable material of substantially uniform sizes which comprises initially heating the lumps rapidly at distillation temperatures and at pressures considerably above atmospheric by means of hot water gases in contact therewith in the presence of steam so as to cause rapid pyrolysis, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while effecting further pyrolysis of the interior of the lumps at a slower rate, contacting the treated lumps with steam flowing countercurrent, condensing the volatile products in a water cooled heat exchanger without material reduction in pressure so as to regain their useful heat, forming a further supply of steam at lower pressure, and separating the cooled gas and condensed liquid products under pressure.

9. The process of destructively distilling lumps of solid carbonizable material and collecting separately the coke, tar-oils, fixed gases, and water involved which comprises initially heating the lumps rapidly at distillation temperatures and at pressures considerably above atmospheric by means of hot water gases in contact therewith in the presence of steam, so as to cause rapid pyrolysis, then moving the gases and lumps together in the same direction while maintaining the lumps substantially free from agitation and while effecting further pyrolysis of the interior of the lumps at a slower rate, contacting the treated lumps with steam flowing countercurrent, condensing the volatile products in a heat exchanger without material reduction in pressure, so as to regain their useful heat, forming a further supply of process steam at lower pressure, and separating the cooled gas and condensed liquid products under pressure.

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