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PROCESS FOR THE PRODUCTION OF GAS, OIL, AND OTHER PRODUCTS

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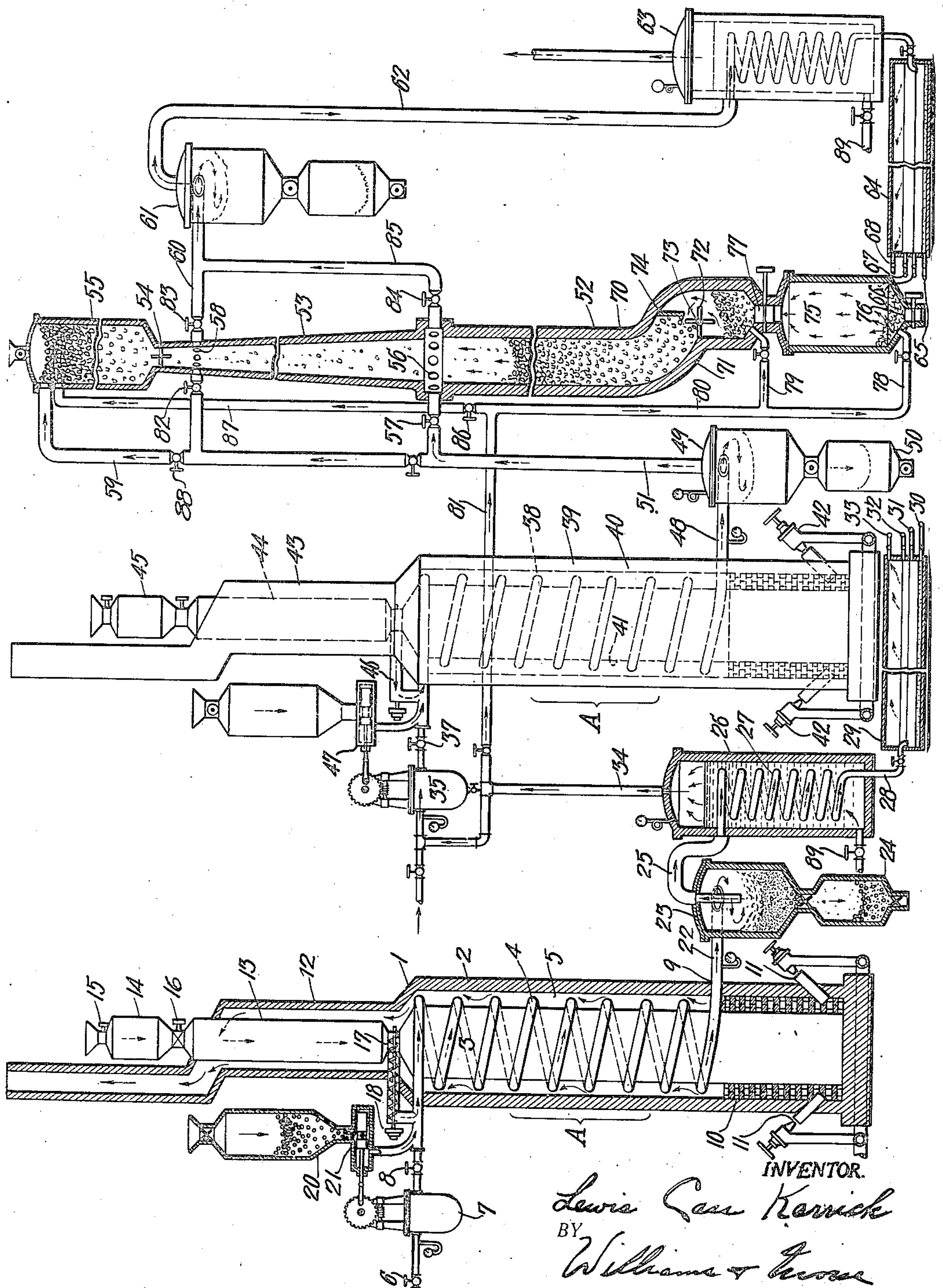

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## PROCESS FOR THE PRODUCTION OF GAS, OIL, AND OTHER PRODUCTS

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3 Claims. (Cl. 202—15)

This invention relates to processes for the production of gas, tar-oils, coke, and other products from coal and other carbonaceous material and is herein illustrated as applied in a plant for obtaining these products from coal. The solid raw material is reduced to a granular or pulverized condition, such as will permit it to be conveyed through a heated tube by a current of steam or other gas or vapor acting as a carrier for the material and as an atmosphere surrounding it while subjected to heat, suitable for yielding the desired products. The process may be used in treating the fine coal composing parts of shipments received at power plants, the coarser sizes or dust being subjected to other treatments or gasification which inventions form divisions of the present application. This development provides for economical use of steam as the principal heat-transferring agent and permits the grades of coal as received to be subjected to the type of treatment for which they are best adapted.

To carry out economically the features of this process, the fine coal may be treated with superheated steam to yield tar-oils, resins, waxes, gas and fine low-temperature coke. The condensation of these products and the steam gives a large supply of heat which may be utilized for the production of a further supply of steam at a lower pressure. This further supply of steam may be superheated in the form of the invention herein disclosed in distilling a further amount of coal or it may be disposed of advantageously in the other processes.

According to this invention I overcome the operating difficulties of other processes in obtaining rapid distillation of coals. The difficulties are due principally to the fusing properties of the coals and their poor heat conductivity and I overcome these controlling factors to such an extent that coals can be distilled very quickly to any degree of devolatilization regardless of their fusing properties or conductivity of heat, or the grade of coal and amount of mineral matter therein. The present invention provides for the successful use of culm or slack coal as well as for many other types of carbonaceous materials even sawdust being utilizable.

In the form of the invention herein illustrated the finely divided carbonaceous material, such as coal which has preferably been preheated, is introduced into an externally heated pipe carrying a stream of steam. When the carbonaceous material is of the fusing type, air also may be introduced advantageously, or the coal dust may be subjected to a pre-treatment with air or combustion gases in the same type of apparatus. To distill the tar-oils and obtain only part of the total possible gas, from the coal, the stream of steam and air, if added, is heated to a temperature well within the temperature range of low temperature carbonization which will prevent excessive cracking of the tar-oils. Too high a temperature must not be used because the coke formed in the process will react with the steam to form water gas and the tar-oils will be decomposed largely into gases and heavy tars of poor quality. I have used temperatures from 700° F. to 1200° F. satisfactorily.

The finely divided carbonaceous material presents an immense amount of surface to react with the steam and to take up the heat thereof, making it possible to obtain substantially complete gasification of the carbonaceous materials present with great rapidity. Coal carried in steam of high velocity, say 100 to 600 feet per second, in a one-inch pipe 100 feet long has been found sufficiently reactive under the above conditions to complete the gas-forming reactions. Under the conditions described below the turbulent flow of the steam and its contact with the heat-transmitting walls of the apparatus have accomplished very efficient transfer of heat from the combustion gases surrounding the pipe to the rapidly moving steam and to the fine carbonaceous material inside the pipe. Under these conditions the reaction appears to be practically a surface one between the steam and the carbonaceous material. It also appears that either the reaction is almost instantaneous by which the particles are consumed, or, there is rapid disintegration of the carbonaceous particles by the wear to which they are subjected in the pipe and the carbon dust is then reacted upon more efficaciously because of the much greater reacting surface provided.

I have used one form of this process for distilling finely divided coal at low temperatures for the production of coal gas, and obtained a large yield of rich gas and tar oils and a low-temperature coke dust which was easily ignitible and suited for power plant use. In carrying out the process, the preheated coal was placed in a pressure chamber or magazine, hereinafter described, and then was fed by a suitable screw device into the upper end of a one-inch pipe coiled around a vertical axis and carrying steam. The steam carried the coal down through the coil and hot combustion gases surrounding the coil, heated the stream of steam and coal so as to distill the combustible volatiles from the coal. To effect this result the temperature within the pipe was kept above 700° F. and below 1200° F. The products passed out of the lower, hottest part of the coil and entered a hot walled or heat-insulated cyclone dust collector which precipitated most of the coke and ash and permitted the volatile products to pass on to the condenser.

Clogging of the pipes by any adhering coal was found to be entirely prevented by dropping pieces of iron such as small metal punchings into the pipe ahead of the coal injector. These effectively removed any adhering coal and also prevented scale from forming. The pieces of iron were easily separated from the volatilized coke residues and could be returned by mechanical devices for reuse.

The latent heat released by condensing the volatiles from the above process is shown in the present disclosure as conserved or re-used in producing a second supply of steam which is used for the complete gasification of carbonaceous particles so that the products of this second steam treatment may be used for distilling coarse coal. The new steam from the first unit may, of course, be used in a second similar unit for distilling coal.

One of the economies resulting from the present invention is obtained by operating the above described carbonization and gasification process under suitable pressure so that the volatiles produced, together with any undecomposed steam, and oil vapors may be made to give up their sensible and latent heats to produce fresh steam at a lower pressure to be used in a succeeding unit operating at a lower pressure.

The accompanying drawing which is an elevation with parts in vertical section shows diagrammatically an apparatus for carrying out the process.

In the form of the invention here shown steam is used for distillation of coal in one retort, shown as a coil, the resulting vapors and gases are cooled in a heat exchange device and the fresh steam at lower pressure thus obtained is used with further additional heat to completely gasify other coal or coke in a similar retort. The hot gaseous products from this second lot of coal are shown as heating a retort through which sized coal is fed to produce low-temperature coke, a rich gas, and to obtain the condensible volatiles from it.

The coiled pipe device for gasification was found to work satisfactorily with one inch pipe of uniform diameter, so that the speed of the steam, owing to its increased volume on high temperatures, is increased as it flows through the pipe. Using dry steam at about 25 pounds pressure at a temperature of about 265° F. the volume would be double in rising to 1000° F. and treble in rising to 1700° F. The apparatus was found to work satisfactorily under these and other conditions.

The pulverized fuel gasifier furnace 1 shown, consists of a heat-insulated outer wall 2, inside of which is a cylindrical center wall or core 3 having a pipe coil 4 supported in the annular space 5 between the wall and the core.

Steam from a boiler or other source such as an evaporator enters the system 6 and passes through the steam trap 7 and valve 8 where the steam is throttled down to any desired pressure before passing into the coil 4. The steam passes down through the coil 4 to an exit 9 moving countercurrent to the combustion gases which ascend rapidly in the annular space 5. The required heat is supplied by the combustion of gases in the annular checkerwork 10, the gas and air being introduced by burners 11 at the bottom of the gasifier 1. The combustion gases pass out of the furnace 1 through the stack 12 which also serves as a drier and preheater for the pulverized material such as coal which is to be distilled. The pulverized material is charged into the feed bin 13 in the center of the stack 12 through the magazine 14 which with its top and bottom valves 15 and 16 serves as a lock or means of keeping the bin full at all times while preventing steam from flowing up through the bin 13. The bottom of the feed bin contains a power driven screw-feed 17 having a speed regulating device 18 by which the dry and preheated material can be charged continuously at any rate in the steam line 19 entering the top of the gasifier 1. Pieces of iron which are used to scour the inside walls of the coil 4 may be fed at intervals into the steam line 19 from the valve-closed hopper 20 by means of a suitable feeding device such as a power driven crank and slide valve 21 which contains an aperture to receive one device or more at a stroke.

The exit gases carrying whatever there is of ash and the coke pass through the exit 9 and through the conduit 22 to the dust collector 23, which may be a suitable type of cyclone dust collector and is preferably well protected by heat insulation so that there is no separation of condensible vapors here. The solids may be withdrawn from the collector into a double-valved bottom bin 24 without material loss of gas or pressure.

The cleaned gases and vapors pass on through a conduit 25 to a coil or other cooling element 26 forming part of a heat exchange device which also serves as an evaporator. The pressure and therefore the temperature of the vapors in the conduit 25 will be so high that the water in the device 26 yields the steam used in a second coal heating device while the condenser vapors of water and tar, oils, resins, and so forth, together with uncondensed gases flow out of the coil 27 by a main 28 into a separator 29 without material reduction in pressure.

In this it is found that four products separate when a coal such as Utah coal is used. The heaviest of these products is a layer of resins carrying wax, which is a sticky viscous mixture when cold, and which can be drawn off by a bottom valve 30. Above this lies a much deeper layer of water carrying principally ammonia and some tar acids which can be drawn off by a valve 31. Above the water floats a layer of oil and wax which when cold is of the consistency of cup grease and can be drawn off by a valve 32. Above the oil layer is a space which is occupied by the uncondensible gases carrying some light oil which may be removed in a scrubber and which can be drawn off through a valve 33.

The steam generated in the heat exchange device 26 from the latent and sensible heats of condensed vapors, gases and water may be used for distilling a further quantity of coal in a second unit similar to the one already described

The invention may also be used for the carbonization of lump coal by the sensible heat of hot gaseous products obtained from the treatment of finely divided coal in one of the units mentioned above. I thus apply the invention by the gasification of coal with the utilization of the sensible heat of the vapors and gases thus produced for the low temperature carbonization of a second quantity of coal which is preferably lump coal, thus providing for the complete utilization of all forms of the coal received by an ordinary commercial plant.

For this purpose the steam generated in the heat exchange device 26 is carried by a valved heat-insulated main 34 through a steam trap 35 and past a valve 37 to gasifying coil 38 into which pulverized coal is introduced as into the coil 4. The coil 38 like the coil 4 lies in an annular space 39 between the heat-insulating outer wall 40 and the core 41. The coil 38 like the coil 4 is heated by burners 42 at the bottom so as to heat the lower part of the coil to the highest temperature while the products of combustion rise around the upper part of the coil and pass off through a stack 43 which, like the stack 12, surrounds a feed bin 44 fed by a magazine 45 similar to the magazine 14. There may also be provided a variable coal feeding device 46, and a variable feeding device 47 for feeding pieces of iron or other solid materials for maintaining the coil 38 free from carbon and scale on its inner surface.

The exit end 48 of the coil passes into a cyclone heat-insulated dust collector 49, similar to the dust collector 23, which removes the hot solids from the gas and vapor stream. There is provided a double-valved bottom bin 50 for removing the solids collected in the dust collector 49.

The heat insulated outlet pipe 51 of the dust collector 49 conducts the still very hot products of gasification into a retort diagrammatically shown at 52 where the gases are used to carbonize coal or other material. The retort may be thirty or more feet high and steam may be fed to it from a number of coils 38. The properly sized coal preferably free from fines, is fed into the tapered upper part 53 of the retort 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 such gases as come from the main 51 two procedures have been found useful. According to one procedure the descending coal is heated by a counter-current up-flow 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 surrounds the retort 52 at the large bottom end of its tapered portion 53 and through this the hot fluid gas and vapors coming from the main 51 are led by a valved connection 57.

The entering gases will be about 1200° F. to 1850° F. and will 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 condensible light hydrocarbons. 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 and the bin 55 is being recharged. The coal may be preheated by passing part of the highly heated gases from the main 51 through a valved insulated pipe 59 into the bin 55. The gases pass 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 which may be like the device 26. Here the latent and sensible heat of condensible materials are recovered and the four products, resin, water, oil and gas, are separated in a separator 64 like the separator 29 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 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 residues or coke drop into a bottom bin 75 and rest on the closed bottom valve 76 thereof. A valve 77 between the bin 75 and 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 gas, water or steam which may be provided by introducing the necessary gas, vapor, water or steam through valved pipes 78 and 79 which are connected by a main 80 to a suitable source of steam 81. The steam or other material introduced at 78 and 79 may be laden with admixed solutions of light-giving salts 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 or 77 superheats the steam or vapors so that they aid in heating the charge in the retort thus recovering a very large proportion of the heat usually lost in carbonizing processes.

The second procedure which has been found useful for heating the charge in the upper part 53 of the retort, is to close the valved connection 57 and open a valve 82 at the upper manifold 58 thus admitting steam 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 steam and vapors from the main 51 enter the top of the retort and flow down with the charge of coal to the manifold 56 and then pass off to the branch 85 in the dust collector 61. It is found that rather more oil is obtained from a charge heated according to the latter method than is obtained when the charge and the retort is heated by a counter-current flow of steam and vapor.

In order to preheat the charge in the bin 55 steam may be drawn either from a steam main 81 or from the steam and vapor main 51. There is provided in the main 80 leading from the main 81 a valve 86 which may be open 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 arise from the upper part of the retort 53.

The evaporators 26 and 63 are provided with valved cold water inlets 89 at their bottoms. The oils condensed by the cold water are easily separated into portions which contain a large proportion of various products. The amount and character of these products varies with the material treated. To obtain the above described separation without any separate operations for separating the materials the separators may consist of long, narrow, closed chambers in which the condensed material moves toward the outlet very slowly, with the result that stratification is effected as the streams approach the decanting valves. The gases leaving the separators are usually scrubbed to remove uncondensed light oils and ammonia.

It will be seen that the apparatus shown is one in which successive gasifiers work efficiently at successively lower pressures, thus one utilizes the latent heat and the sensible heat of steam, gases and superheated vapors from the preceding one, generating from 50% to 75% by weight as much steam as the weight of material so condensed. It has been found that when complete gasification temperatures are used very little coke collects in the dust collectors 23 and 49. For the convenience of operating the apparatus, steam gages are placed on each evaporator and at the outlet to each coil.

In one low pressure test run substantially saturated steam was used at a pressure approximating six pounds per square inch and into this was fed coal, all passing 16-mesh and averaging rather smaller than 40-mesh at the rate of about a half pound of coal per pound of steam, the steam flowing at the rate of about .85 pounds per minute. The coil of one-inch pipe about 100 feet long was heated at the lower end by gases having a temperature of approximately 1830° F. and the steam as it passed through the coil increased in temperature from the admission end where it was 230° F. to about 1600° F. Gas was produced in excess of the capacity of the meter to measure and substantially all the coal was gasified.

It was found that powdered low temperature coke from Utah coal instead of coal, gave a flow of gas which could be controlled instantly by varying the temperature or flow of steam or amount of coke dust supplied, so that the process was well adapted to produce gas for a rapidly varying demand. The ash did not clinker and the small amount of coal too coarse to completely gasify was swept out of the coil by steam. In other runs saturated steam was successfully used at ten and at twenty-five pounds pressure delivering about 1.5 pounds and 2.5 pounds of steam per minute respectively. Varying amounts of coal and coke were used.

Where substantial steam pressures are used they accelerate the water-gas reaction and also permit steam to be regenerated from the heat evolved in the condensation of undecomposed steam and from the vapors from one charge as well as from the sensible heat of the gases formed, and thereby another charge may be distilled by the fresh steam. The gas formed is rich in ammonia since the best conditions exist for the conversion of nitrogen compounds of the coal into ammonia.

When steam was used at 25 pounds pressure and the flow was 2.5 pounds per minute, the steam at the exit end of the coil was 1300° F. and the combustion gases were 1750° F. When delivering 1.5 pounds of steam per minute and the combustion gases in contact with the heated coil were at 1750° F. the steam reached the exit end at 1480° F. and when the combustion gases were at 2000° F. the steam issued at 1800° F.

What is claimed is:

1. The process which consists in carrying finely divided solid carbonizable material admixed with coke in a high speed stream of heated steam to separate the volatile part of said carbonaceous material from the solids, condensing the steam and the condensible volatiles, generating new steam from the latent heat of the condensing materials, and treating solid carbonizable material with the new steam.

2. The process which consists in introducing finely divided solid carbonizable material into a stream of steam, superheating the steam to a temperature in excess of 700° F., carrying the steam and gas produced into heat exchange relationship with a body of water to produce new steam at a lower pressure and then conducting the same from the place of production as a stream of steam, introducing finely divided solid carbonizable material into the stream of new steam, heating the stream with the finely divided carbonizable material contained therein to produce gas, carrying the hot gas produced through a retort to carbonize other solid carbonizable material, and separating the gas produced from the other products.

3. The process which consists in introducing finely divided solid carbonizable material into a stream of steam, superheating the steam to a temperature in excess of 700° F., carrying the steam and gas produced into heat exchange relationship with a body of water to produce new steam at a lower pressure and then conducting the same from the place of production as a stream of steam, introducing finely divided solid carbonizable material into the stream of new steam, heating the stream with the finely divided carbonizable material contained therein to produce gas, carrying the steam and the gas produced through a charge of coarse coal in a retort to carbonize the coal, separating the gas produced from the coke and other products, and effecting absorption of heat from the coke by fluid to be passed into said exchange relation to the coarse coal.

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