Dec. 16, 1930. C. DAVIES, JR 1,784,985

APPARATUS FOR GASIFYING COAL AND THE LIKE

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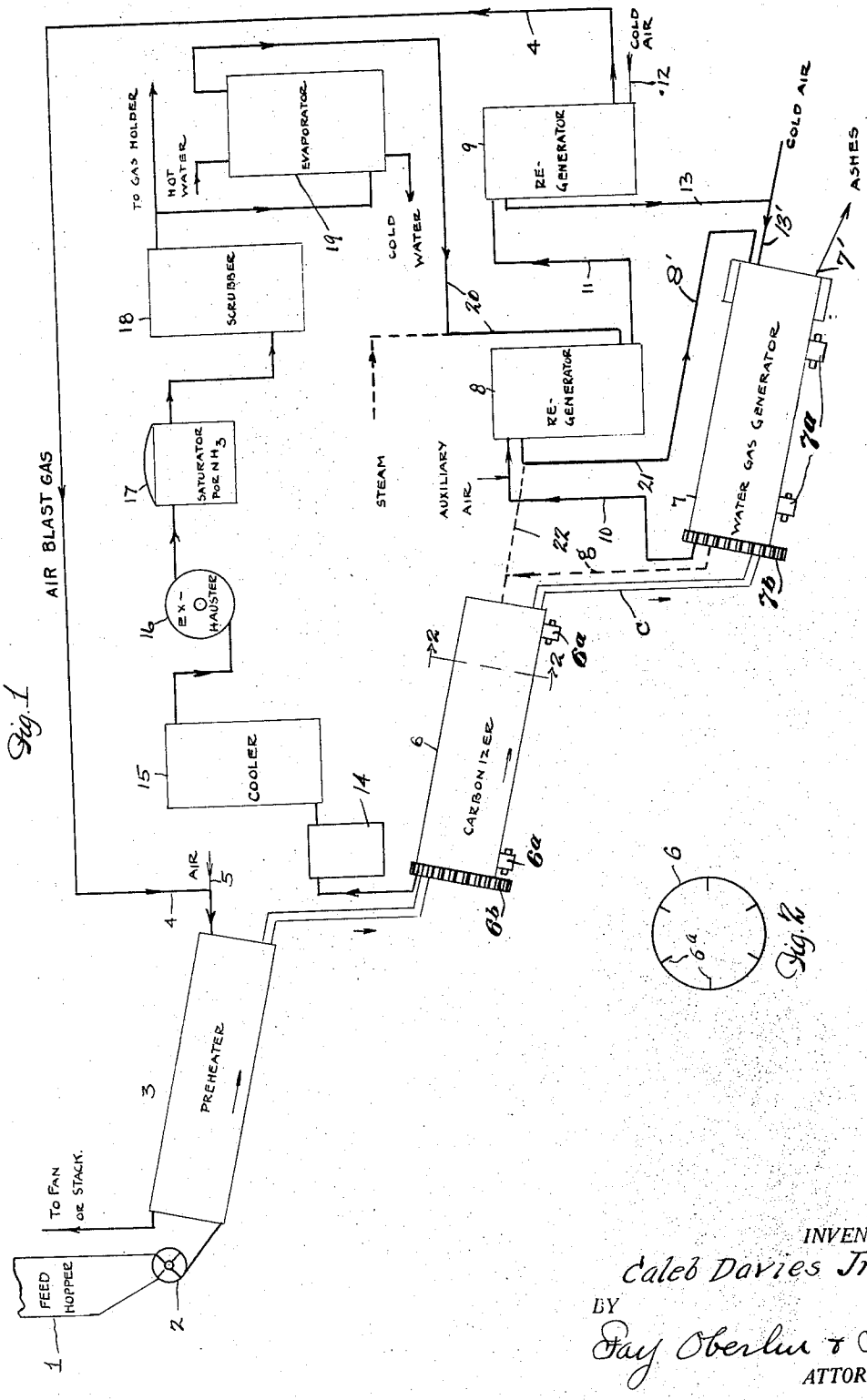


Fig. 1

Fig. 2

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APPARATUS FOR GASIFYING COAL AND THE LIKE

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My improved apparatus has as its general object the complete gasification of bituminous coal, or other suitable fuel such as wood or bituminous shale, including fuel of unfavorable size or poor coking qualities, with large yield of gas low in inert constituents. At the same time I obtain high thermal efficiency due to provision for utilizing low temperature heat; as well as low operating cost, due to continuous operation, if desired. Incidental and yet important objects attained are high yield of tar and ammonia which constitute valuable by-products in any gasifying or carbonizing process of the character in hand. The individual steps of the method and parts of the apparatus may of course be variously combined or in certain cases employed independently in the treatment of fuel for the purpose of converting the same into gaseous form.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means and steps hereinafter fully described and particularly pointed out in the claims, the annexed drawing and the following description setting forth in detail certain means and one mode of carrying out the invention, such disclosed means and mode constituting, however, but one of various ways in which the principle of the invention may be used.

In said annexed drawing:

Fig. 1 is a diagrammatic representation, on the order of an elevation, of an apparatus or plant for gasifying fuel in accordance with my present invention; and Fig. 2 is a diagrammatic cross-section of a carbonizer that forms a portion of the apparatus, the plane of the section being indicated by the line 2—2, Fig. 1.

Referring to such illustrative apparatus, it will be understood that specific details thereof may be varied and particularly that the various types of apparatus referred to may be replaced by other equivalent apparatus, it being the system as a whole, or general method of handling the products of the gasifying or carbonizing step, to which attention is primarily directed.

In such illustrative apparatus the coal is fed from a suitable hopper 1 through a feeding device 2 into a drier and preheater 3 where it is brought into contact with hot gases supplied through a duct 4, such gases being conveniently derived from a subsequent stage of the process, as will be presently explained, the temperature of such gases being gauged so as to evaporate any moisture in the coal and heat the same without, however, raising the temperature thereof to a point where any considerable volatilizing of the combustible constituents of the fuel results. Said drier and preheater will preferably be of the rotary cylinder type, as indicated, and the hot gases utilized therein may be flue gases derived from any source, the temperature being controlled by admixing air to the gas stream as by a branch duct 5 connected with said duct 4.

The coal or other fuel after being thus treated in the drier and preheater 3 is transferred to the carbonizer 6 where it is heated and destructively distilled by contact with a current of hot gas. Such gas may be combustible and low in nitrogen, being water gas received direct by a connection g from a water-gas generator 7, to which the residual fuel from carbonizer 6 is transferred; or may be gas circulated or passed through a hot recuperator, regenerator or "hot blast stove" Said carbonizer 6 will preferably be of the rotary cylinder type shown, mounted for instance on rollers $6a$ and having a gear drive $6b$, and will be provided with a brick lining and suitable baffles, preferably in the form of longitudinally extending shelves or troughs 6^a, as indicated in Fig. 2, so as to cause the fuel to keep dropping through the gas stream which flows therethrough in a counter-direction. It will also be understood that said carbonizer may be equipped for surface heating as well as for direct contact heating, if desired.

In water-gas generator 7, to which the residual fuel flows from said carbonizer by a convenient connection c, such fuel is treated intermittently and successively with air and steam introduced through suitable connections, indicated at 13′ and 8′ respectively, the ashes being finally discharged therefrom, as

at 7'. Such a water gas generator is shown as of the rotary cylinder type, mounted for instance on rollers 7a and having a gear drive 7b, but it may be of the stationary, vertical type or of any other standard design, depending upon the physical condition of the residual fuel. For example, in some cases a modified iron cupola may be used, a suitable flux being added to the fuel and the ash being removed as a slag. In actual practice a plurality of such generators will be desirably employed, such generators being arranged in multiple so that one is always blasting and heating a checker-chamber and another will always be producing water gas so as to maintain a continuous supply thereof for the carbonizer 6.

The air and steam for use in the water gas generator may be preheated by recuperators, regenerators or hot blast stoves, and such steam may be mixed with gas from the carbonizing step in the process, or carbon dioxide from various sources may be used with or in place of such steam, all without departing from the principle of my invention.

In the preferred arrangement, however, when a water gas generator 7 is being blown with air, the products of combustion or air blast gases go through regenerators 8 and 9 connected in series by ducts 10 and 11, and thence by way of duct 4 through the drier and preheater 3 from which they are finally discharged to the atmosphere through a stack or by means of an induced draft fan. Ordinarily the heat of the air blast gases is sufficient. If more heat is desired, air can be admitted for combustion in the regenerator chambers. Where more than one water gas generator is provided, there will be a pair of such regenerators in series with each water gas unit and thus a practically continuous stream of waste flue gas rendered available for use in the preheater. The heat stored in regenerators 9 may be recovered by an air current supplied thereto through a duct 12, such air after passing through the chamber being supplied through duct 13 to a water gas generator other than the one by which said chamber is being currently heated.

The distilled vapors and gases leaving the carbonizer 6 are preferably first passed through a dust-collector 14, and then goes to by-product recovery equipment of a suitable and well-known design, such equipment ordinarily including, as shown on the drawing, a tar-extracting cooler 15, an exhauster 16, an ammonium sulphate saturator 17 and one or more light oil scrubbers 18. From the latter the bulk of the gas goes to a gas holder (not shown), but a part of the scrubbed gas from which the by-products have thus been removed is passed through an evaporator 19 which may be a grid-tower or other suitable apparatus where the gas can pick up water vapor from hot water. The hot water after being thus cooled may be employed for cooling the tubes or liquor-cooling pipes of the gas cooling system, in which case it may be heated and returned to the evaporator in close circulation, additional water being added as needed to replace that which has evaporated. The moistened gas from the evaporator with or without additional steam is then passed by way of a duct 20 through the first regenerator 8 in the series previously described, where it is heated, and the resulting hot mixture of combustible gas and steam is then led by duct 21 to the water gas regenerator 7, passing therethrough and through the carbonizer 6, or if desired, such mixture may be diverted in whole or part directly to said carbonizer by way of branch duct 22.

The recirculation of gas just referred to tends to carry heat to the carbonizer, to sweep by-products out of the same with minimum secondary decomposition, to complete the reduction of carbon dioxide formed, and if cooling water is used in the evaporator, to avoid excessive net steam consumption when carbonizing in presence of much steam, as is desirable if high ammonia production is to be obtained, as for example, when using Mond gas producers. On the other hand, too much recirculation requires very much by-product apparatus and causes some decrease in thermal efficiency. Moreover, unless regenerator 8 is large and well-heated, a large recirculation would tend to cause too low a temperature and high carbon dioxide content in the gas.

In case the gas may contain considerable nitrogen, the water gas generator 7 may be used as a continuous gas producer, the checker-chambers or regenerators 8 and 9 being omitted. In this case air will be blown directly into the gas generator from connection 13' and the products of incomplete combustion or producer gas will pass therefrom through the carbonizer 6 giving by-product producer gas designed for good yields of both tar and ammonia. Where the operation is thus modified steam may be advantageously introduced with the air, as by passing the latter through the evaporator 19, just as part of the water gas has heretofore been described as being passed, or such steam may be introduced between the generator 7 and the carbonizer 6; also the units 6 and 7 may be combined into one rotary unit of suitable dimensions acting as a by-product gas producer.

Other modifications may be made, such, for example, as the introduction of a waste heat boiler in place of or after regenerator 9 or in place of said regenerator and its companion 8. Again the residual fuel from the carbonizer 6 may be transferred preferably continuously and without cooling, to a suitable boiler stoker or be otherwise disposed of as one of the main products. Where

the carbonizer thus discharges into a boiler stoker, part of the hot products of combustion will preferably be taken off right at the stoker and passed through the carbonizer in order to form by-product producer gas as described above and a part or all of this gas may then be returned for use as auxiliary fuel under the boiler. In case the carbonizer 6 is operated on pulverized fuel suitable provision should, of course, be made to remove most of the dust from the gas at a high temperature before very much of the tar is condensed out. It may be noted in this connection that coal is much more easily pulverized than either coke or the semi-coke of most other low temperature distillation processes.

Due to the manner in which the coal is agitated in the rotary carbonizer 6, the resultant product is coke-like material possessing special characteristics. The process of carbonization is preferably not carried to a point where the volatile elements are completely driven off, and the product retains the form of the original pieces, except that they are more porous and are rounded off and more or less nodular, due to the action of the rotating cylinder in dropping such pieces while in semi-plastic state from shelf to shelf. Such pieces are, however, kept from sticking together by this same action, taken in connection with the application of heat internally of the carbonizer instead of externally as in an ordinary coke oven.

Due to the preheating of the coal in the preheater 3, condensation and redistillation of the higher boiling constituents of the tar are largely avoided in the carbonizer 6. This has a favorable effect on by-product recovery, and also helps to keep the mass of fuel loose and open.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the means and the steps herein disclosed, provided those stated by any one of the following claims or their equivalents be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. Apparatus for complete gasification of solid fuel, comprising a rotary water-gas generator; a carbonizer thereabove connected to receive hot water-gas therefrom and supply carbonized residue thereto, said carbonizer being inclined and having a rotary mounting whereby to continuously lift and drop the fuel through the hot gas stream; a fuel preheater; and a connection between said preheater and said carbonizer.

2. Apparatus for complete gasification of solid fuel, comprising a water-gas generator; a carbonizer; a connection to pass carbonized residue from said carbonizer to said generator; an independent connection to supply water-gas from the generator into contact with fuel in said carbonizer, said carbonizer being inclined and having a rotary mounting whereby to continuously lift and drop the fuel through the hot gas; a fuel preheater; and a connection between said preheater and said carbonizer.

3. Apparatus for complete gasification of solid fuel, comprising a rotary water-gas generator, a carbonizer thereabove; a connection to pass carbonized residue from said carbonizer to said generator; an independent connection to supply water-gas from the generator into contact with fuel in said carbonizer, said carbonizer being inclined and having a rotary mounting whereby to continuously lift and drop the fuel through the hot gas; a fuel preheater; and a connection between said preheater and said carbonizer.

4. Apparatus for complete gasification of solid fuel, comprising a water-gas generator; a regenerator coacting therewith; a carbonizer; a fuel preheater connected with said carbonizer; a connection to pass carbonized residue from said carbonizer to said generator; an independent connection to supply water-gas from the generator into contact with fuel in said carbonizer, said carbonizer being inclined and having a rotary mounting whereby to continuously lift and drop the fuel through the hot gas; and means for heating said preheater independently of the carbonizer, said means including a gas-connection from said regenerator to the preheater.

5. Apparatus for complete gasification of solid fuel, comprising a rotary water-gas generator; a regenerator coacting therewith; a carbonizer; a fuel preheater connected with said carbonizer; a connection to pass carbonized residue from said carbonizer to said generator; an independent connection to supply water-gas from the generator into contact with fuel in said carbonizer, said carbonizer being inclined and having a rotary mounting whereby to continuously lift and drop the fuel through the hot gas; and means for heating said preheater independently of the carbonizer, said means including a gas-connection from said regenerator to the preheater.

Signed by me this 25th day of May, 1922.

CALEB DAVIES, JR.