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APPARATUS FOR GASIFICATION OF SOLID MATERIALS

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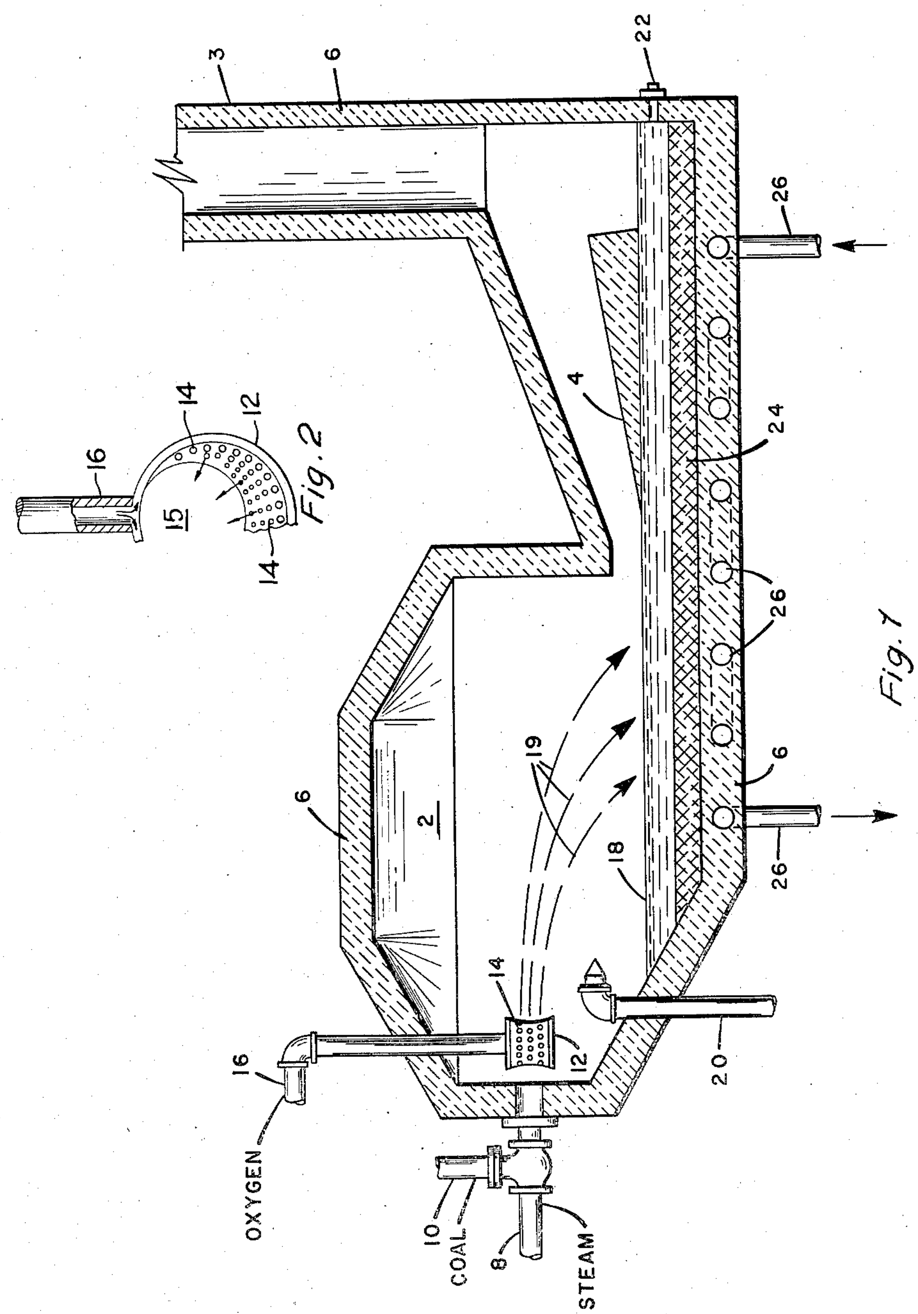

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APPARATUS FOR GASIFICATION OF SOLID MATERIALS

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Original application Dec. 30, 1950, Ser. No. 203,574, now Patent No. 2,770,536, dated Nov. 13, 1956. Divided and this application June 15, 1955, Ser. No. 515,627

2 Claims. (Cl. 48—63)

The present invention relates to an apparatus for the gasification of solid carbonaceous materials, such as bituminous coal, lignite coal, coke, etc., to produce fuel gas and synthesis gas (CO and H_2). More particularly, it pertains to an apparatus for the production of gases of the aforesaid type in a manner such that maximum conversion of carbon into CO is achieved, while at the same time simplifying the procedure of removing the resulting ash from the gas generator.

Although gas generators for the production of fuel and synthesis gases have been employed for a number of years, the problems of ash removal and economical utilization of the carbon to be converted have, to a large extent, exerted rather extreme limitations on the design of commercial gas generators. The gas producer, Lurgi, Winkler, and other bed-type generators provide means for withdrawing the ash in the form of a solid. Other generators, such as the Thyssen-Galocsy and Leuna gas generators, provide for removal of the ash in the form of molten slag. When a carbonaceous material, such as coal, is to be gasified in a fluidized bed-type generator as employed in the Koppers design, the ash can be removed either as a solid or as a molten slag.

Gasification of carbonaceous materials by any of the above-mentioned methods presents some rather serious difficulties; this is especially true with the fluidized type generators where the solid ash is so finely divided that it gives rise to complicated dust removal problems. Also, where the operation is effected at high temperatures, fine particles of slag coming in contact with the refractory of the combustion chamber roof and walls cause deterioration thereof. One of the chief reasons for the existence of these problems in the case of currently designed generators resides in the fact that the coal or other solid carbonaceous raw material employed is ground to an extremely fine particle size so that complete combustion can be obtained in the spray-type burners now utilized. The ash particles resulting from this combustion are likewise very fine and, thus, become quite a problem to collect and separate from the generated gas.

I have now devised a method and apparatus by which valuable gaseous products, such as fuel gas and hydrocarbon synthesis gas, can be produced readily and economically without the accompanying disadvantages of prior methods. In accordance with my invention, a solid carbonaceous fuel is broken into particles or small lumps ranging in size from about 3 to about 100 mesh, after which the resulting comminuted fuel is mixed with a suitable driving gas such as, for example, steam or oxygen, and introduced into the combustion zone of a gas generator. Air may be injected along with the steam instead of oxygen; however, regardless of its manner of introduction, sufficient oxygen should be present in the combustion zone to insure satisfactory burning of the fuel particles at the temperature levels employed. Selection of fuel particles, having the average particle size given above, results in the effective reduction of ash fines since, by using initially the relatively large fuel particles, the latter are only partially burned on exposure to the combustion zone and by gravity are removed therefrom together with slag impurities. Under the combustion conditions employed, the ash melts forming a fluid slag on the floor of the generator. In accordance with this method of effecting combustion of the fuel particles, I am able to control residence time and, in turn, the extent of combustion of said particles in the combustion zone. Thus, for any given fuel, I can readily determine the conditions under which combustion should be carried out in order to effect only a partial burning of the particles and to allow the latter to retain sufficient mass to be carried out of the zone of combustion. The path or trajectory taken by the fuel particles is, of course, a function of their density and the pressure exerted by the driving gas employed. For a fuel of given density, the required force supplied by the driving gas to project particles of such fuel out of the combustion zone after only a partial burning thereof has occurred can be readily determined by simple experiment. The partially burned fuel particles are carried on the surface of this slag and react with primary products of combustion from the combustion zone to obtain further gasification of this carbonaceous material on the surface of the slag and shift the CO_2 and water to CO and H_2. Conversion of this partially burned carbon by CO_2 and water to CO and H_2 may be accomplished in a number of ways. Generally, however, I prefer to allow the ash formed by this partial combustion or burning operation to be converted into a slag of suitable viscosity, and thereafter impinge the gaseous products from the primary combustion zone onto the mixture of slag and solid fuel particles. In this manner, the carbonaceous fuel on the surface of the slag is converted into valuable gaseous products while the ash formed during this reaction as well as any ash from the primary combustion zone is taken up by the molten slag, thereby effecting separation of this undesirable material (ash) from the product gases. In instances where the lumps or particles of partially burned carbonaceous fuel are intimately mixed with the slag, further reaction of such carbon with primary combustion zone gases can be effected by blowing the latter through said mixture in accordance with the general Bessemer converter technique. However, I ordinarily prefer to convert the carbon in mixtures of this type by flowing the latter onto an inclined surface in a thin, extended film, and thereafter pass the primary combustion gases over it. Alternatively, I may withdraw the slag, allow it to solidify, crush it, and thereafter mix it with fresh solid fuel particles comprising the feed to the gas generator. By this means, the unburned carbon in the solid slag may be converted to useful products.

The size of the solid fuel particles employed may vary; however, in the majority of instances, I prefer to utilize solid fuels having a particle size of from about 5 to 15 mesh with the major portion of said particles being in the neghborhood of from about 10 to about 12 mesh. Fuel particles of greater or smaller size than those stated may be employed. However, I have found in general that it is undesirable to use fuels having a particle size less than 100 mesh or greater than 3 mesh. Moreover, for satisfactory operation it is generally undesirable to have more than 5 percent of either the 3 mesh or the 100 mesh size fuel particles (10 percent in the aggregate) in the fuel mixtures employed in my invention.

Figure 1 is a sectional elevational view of a form of apparatus which may be employed in carrying out the process of my invention while Figure 2 is a fragmentary view, partly in section, of burner 12 generally shown as a sectional view in Figure 1.

Additional details of the apparatus of my invention are illustrated by the following description of a preferred embodiment thereof as set forth in Figure 1 of the drawings wherein a sectional view of a preferred generator design is shown. As illustrated in the drawing, the gas generator, according to my invention, has a generally horizontally positioned combustion chamber 2, where primary combustion of the solid fuel particles occurs. The walls of the chamber, as well as the floor of the generator, chimney 3 and ramp-like structure 4, are constructed of a suitable refractory material 6. Steam introduced through line 8 is mixed with particles of a solid fuel (10 to 15 mesh) such as, for example, coal, fed through line 10, and projected through burner 12 equipped with jets 14 and supplied with oxygen through line 16. The temperature of the combustion zone may vary from about 2200° F. to about 3500° F., the residence time of the coal and steam mixture in the combustion zone being such that from about 25 to about 50 percent of the original carbon in said coal particles is incompletely burned. The partially burned coal being relatively dense carries the ash out of the combustion zone by gravity onto the floor of the generator where there is ultimately formed a slag bed 18 of molten ash with unburned coal particles floating on the surface thereof. The arcuate path of the partially burned coal particles from the burner to the surface of the molten slag is defined by lines 19. In the event that these coal particles tend to become suspended in the molten slag, further combustion of the coal can be effected, if desired, by introducing additional steam or other suitable gas into chamber 2 through line 20 under relatively high pressure, whereby slag bed 18 is extended into a relatively thin film or sheet along the inclining surface of ramp 4. The pitch of ramp 4 may vary considerably; however, for efficient contact of the combustion gases with the fuel particles, the sloping surface should not appreciably exceed an angle of about 30 degrees. The gases from the primary combustion zone are passed over the aforesaid film and the partially burned fuel particles converted into CO and H_2. Normally, little difficulty is experienced with the coal or other partially burned solid fuel particles sinking into the slag bed owing to the relatively wide difference in density between the latter and the said coal particles. The gases thus produced are free from objectionable quantities of ash and are withdrawn through chimney 3 at a temperature of from about 1800° F. to about 2500° F. and passed through a waste heat boiler capable of supplying all steam requirements of the generator. Thereafter, the gas may be purified in accordance with known procedures after which it is ready for use. As the slag accumulates, it may be drawn off periodically through tap 22. If desired, a layer of chilled solid slag 24 may be provided in order to prevent excessive erosion of the refractory by the action of molten slag thereon. The aforesaid layer of solid slag located adjacent the floor of the combustion zone is formed by rapid withdrawal of heat from molten slag through cooling coils 26. Cooling in this manner may be effected by the use of materials, such as diphenyl, steam, water, etc.

Figure 2 is a more detailed representation of burner 12 showing a fragmentary end view thereof. In this particular burner design oxygen or other suitable combustible gas flows through pipe 16 into a hollow space between the interior and exterior portions of burner 12. Oxygen introduced into the burner in this manner is then conveyed to the open interior portion thereof passing through jets 14 as indicated by the arrows.

The ash content of a solid fuel, such as coal, is generally composed of aluminum oxide, ferrous oxide, calcium oxide and silicon dioxide and is usually high in the basic constituents, thus resulting in relatively viscous slag. The viscosity and melting point of such a slag, however, may be readily reduced by the introduction of additional silicon dioxide. The resulting slag typically contains 40 to 50 percent ferrous oxide, 20 to 25 percent calcium oxide, and 20 to 25 percent silicon dioxide. In general, it may be said that slags melting in the neighborhood of from about 1800° to 2000° F. are satisfactory for use in the process of my invention. Slags other than those specifically mentioned above and having the aforesaid desired properties may be selected from a wide range of such materials employed in the non-ferrous metals art. Slags having the proper density can readily be determined experimentally. Other materials which contribute to the degree of viscosity and melting point of the slag such as, for example, sodium oxide and zinc oxide, may be added if desired. Also, it may generally be found desirable to add these viscosity and melting point depressants to the solid coal particles so that they are injected into the burner along with the coal particles and steam. By this means, the ash and slag-forming constituents are intimately mixed, passed through the hot combustion zone and fall to the floor of the generator at melting temperature.

The quantity of slag required to entrap the ash particles formed by the combustion process may be conveniently controlled by pulverizing previously formed low-melting slag and mixing it with the coal or other solid fuel particles together with other slag-forming constituents, if desired. Normally, the quantity of slag mixed with the solid fuel particles may vary considerably; however, in the majority of instances, from about 10 to about 25 weight percent of slag in the charge will be found adequate. This mixture of slag and fuel particles is blown into the combustion chamber where the comminuted slag contained therein is rapidly melted forming liquid droplets which fall in a shower to effectively trap the ash particles thus formed so that the latter is incorporated into the slag bed.

With regard to the nature of the steam and CO_2 mixtures employed, it may generally be said that the quantity of either of these materials utilized depends on the amount of oxygen present. The ratio of steam and/or CO_2 to oxygen is ordinarily preferably held at from about 1.0 to 3.0 but may, in some instances, be as high as 6.0. In this connection, steam and CO_2 may be considered as equivalents inasmuch as both of these materials give the same yield of H_2 and CO with approximately the same heat effect. It will be found that use of steam and/or CO_2 in the concentrations just specified will result in steam and/or CO_2 ratios to partially burned carbon in the combustion zone of from about 1.0 to about 3.0 mols per mol of carbon.

One of the outstanding features of my invention is the fact that by the utilization thereof I am able to employ any type of solid carbonaceous fuel without encountering the difficulties experienced with prior art procedures when employing coking coals and fuels of relatively low calorific content which, for various reasons, have previously been considered undesirable. A further advantage of my invention lies in the feature of recycling crushed slag to the regenerator since this renders possible a substantial increase in the conversion of carbon over conversions obtainable by prior art procedures. Thus, the initially unburned carbon in the primary slag is partially converted by recycle thereby effecting substantial carbon clean-up by recycle of the crushed slag.

Numerous changes may be made in the form and structure of the apparatus as well as in details of operation described herein without departing from the scope of the present invention.

This application is a division of my copending application, U.S. Serial No. 203,574, filed December 30, 1950, now U.S. 2,770,536.

I claim:

1. In an apparatus for effecting combustion of solid combustible materials to produce both gaseous products of combustion and liquid slag, the combination comprising a combustion chamber having a generally hori-

zontal floor, means for horizontally injecting solid combustible particles into said chamber, a construction in said chamber opposite said injection means through wh ch products of combustion can pass, a passageway communicating with said construction and said chamber leading away therefrom, the floor of said passageway constituting an inclined surface having a grade not exceeding about 30° with respect to the horizontal, means for extending said liquid slag along said inclined surface, and means in said chamber for burning said particles, said burning means being adjacent said injection means.

2. In an apparatus for effecting combustion of solid combustible materials to produce both gaseous products of combustion and liquid slag, the combination comprising a combustion chamber having a generally horizontal floor, means for horizontally injecting said particles into said chamber, means in said chamber for burning said particles, said burning means being adjacent said injection means, a constriction in said chamber opposite said injection means through which products of combustion can pass, a passageway communicating with said constriction and said combustion chamber and leading away therefrom, an inclined surface within said passageway having a grade not more than about 30° with respect to the horizontal, and means for extending said liquid slag along said inclined surface.

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CERTIFICATION OF CORRECTION

Patent No. 2,965,461 December 20, 1960

Scott W. Walker

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, lines 2 and 5, for "construction", each occurrence, read -- constriction --.

Signed and sealed this 20th day of June 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents