

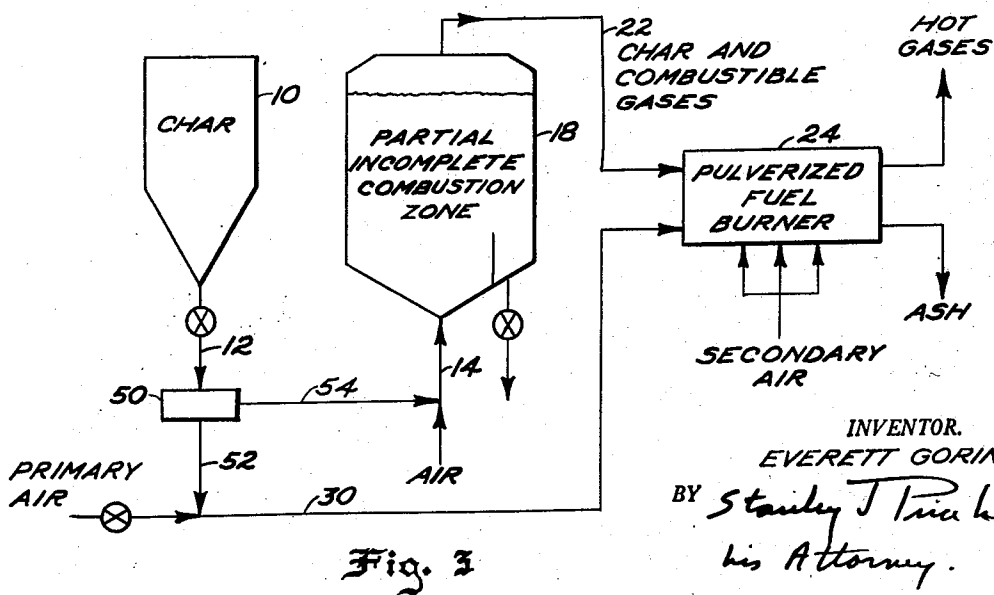
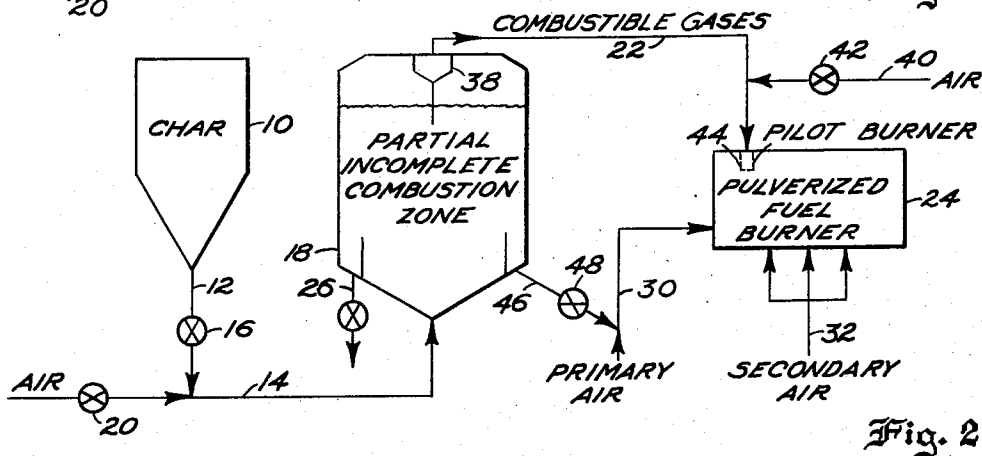
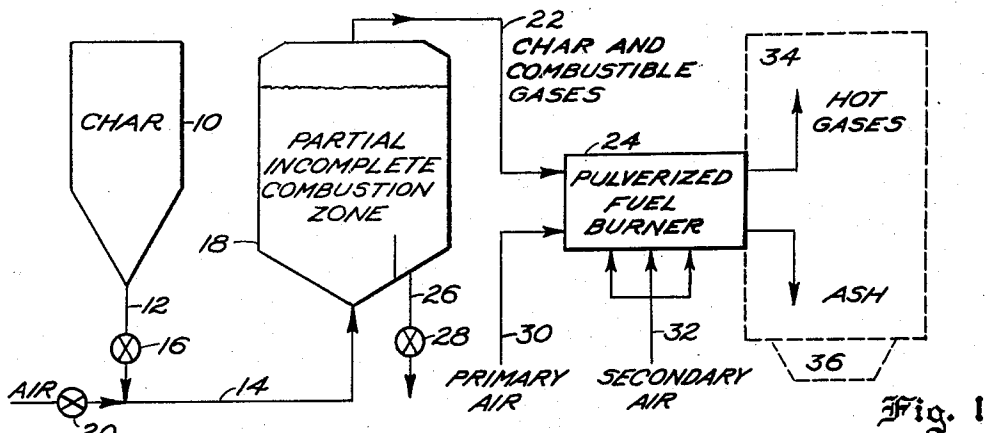
Sept. 15, 1959

E. GORIN
COMBUSTION OF FINELY DIVIDED LOW VOLATILE
CARBONACEOUS SOLID FUELS

2,903,980

Filed Jan. 16, 1956

2 Sheets-Sheet 1



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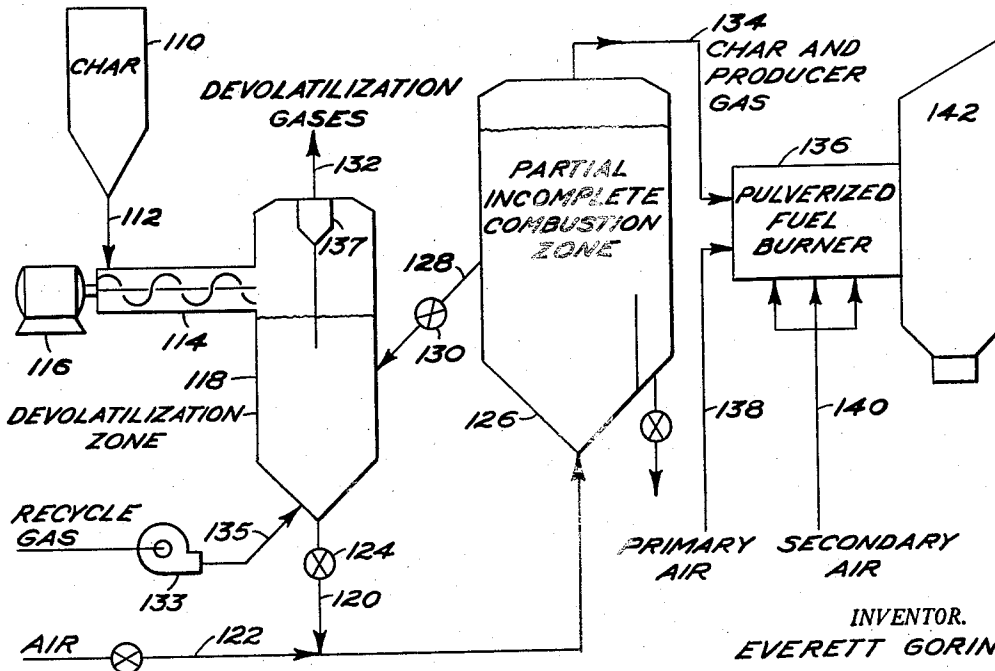
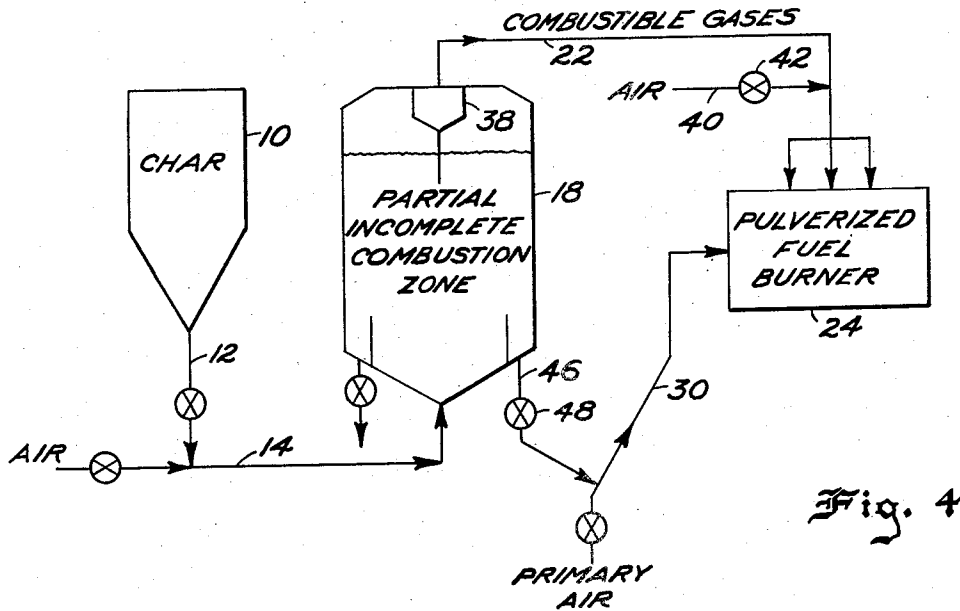
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COMBUSTION OF FINELY DIVIDED LOW VOLATILE CARBONEOUS SOLID FUELS

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Application January 16, 1956, Serial No. 559,222

7 Claims. (Cl. 110-23)

This invention relates to a new and useful method of burning finely divided low volatile carbonaceous solid fuels and more particularly the finely divided non-agglomerating char product obtained from low temperature carbonization of carbonaceous solid fuels such as coal and lignite. The present invention also can be applied to the combustion of anthracite coal, petroleum coke, metallurgical coke and similar low volatile carbonaceous solid fuels.

In low temperature carbonization of bituminous coal approximately 65 to 70% of the product is a solid carbonaceous substance called char. In general, the char contains from about 10 to about 20% volatile matter and has a heating value of about 12,500 B.t.u. per pound. The volatile matter can be evolved as gases from char on exposure to elevated temperatures, and principally comprises H_2 , CH_4 and CO . As used in this specification the term char not only designates the carbonaceous solid product obtained in low temperature carbonization, but also includes any low volatile non-agglomerating carbonaceous solid fuel.

One of the desired uses of char is as a substitute for high volatile carbonaceous fuels in existing boilers having pulverized fuel burners. The pulverized fuel burners designed to burn high volatile carbonaceous fuels depend on the burning of the volatile matter at the particle surface to raise the particle temperature. In a pulverized fuel burner a stream of finely divided carbonaceous solids mixed with primary air enters the burner through a nozzle under pressure. The mixture is ignited as it leaves the nozzle and secondary air enters the burner at a point beyond the nozzle to promote substantially complete combustion of the solids in the combustion zone. One of the requirements of a pulverized fuel burner is that the carbonaceous solids be finely divided, e.g. having a size consist wherein 100% of the solids will pass through a 100 mesh Tyler standard screen sieve and 50% of the solids will remain on a 200 mesh Tyler standard screen sieve.

It has been found that carbonaceous solids having a low volatile matter content present difficulty in maintenance of combustion temperatures in a pulverized fuel burner. This difficulty in maintaining combustion temperatures is due to the absence of the evolved volatile matter adjacent the burner nozzle to maintain the combustion temperature within the required zone to aid in burning the carbonaceous solid fuel. Several methods have been suggested to compensate for the absence of volatile matter in carbonaceous solids having a low volatile matter content to permit their use in a pulverized fuel burner. One of the methods suggested is the use of an auxiliary fuel as an ignition accelerator. This auxiliary fuel which may be gaseous, liquid or solid, is premixed with either the primary air or the low volatile carbonaceous solids prior to their entry into the burner nozzle. Another suggested method of burning low volatile carbonaceous solids in a pulverized fuel burner

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is to position a pilot flame adjacent the nozzle of the pulverized fuel burner. Auxiliary fuel is used to maintain the pilot flame which aids in maintaining the temperature of the low volatile carbonaceous solids sufficiently high to promote complete combustion in the combustion zone. Both of the above named methods of burning carbonaceous solids having a low volatile matter content require a source of auxiliary fuel which requires additional facilities and decreases the overall economic advantages prospectively obtainable in burning carbonaceous solids having a low volatile matter content.

In accordance with my invention the necessity of an auxiliary fuel is eliminated and it is now possible to burn low volatile carbonaceous solids in a pulverized fuel burner designed to burn high volatile carbonaceous solids. As herein disclosed, at least a portion of the char is introduced into a partial incomplete combustion zone where it is maintained under fluidized solids contacting conditions by means of air passing upwardly therethrough. The air reacts exothermically and incompletely with a portion of the char to elevate the temperature of the char within the partial incomplete combustion zone. The exothermic reaction within the partial incomplete combustion zone is the incomplete combustion of a small amount of the char therein. The heated char particles evolve all or substantially all their volatile matter. The air and char react incompletely under controlled conditions to generate a combustible gas commonly termed "producer gas" which comprises approximately 30% CO , 60% N_2 and 10% H_2 . The gaseous volatile matter and producer gas combine to form a complex combustible gas mixture which is withdrawn from the partial incomplete combustion zone. The resulting reacted char is conveyed to the pulverized fuel burner at the temperature of the partial incomplete combustion zone which also assists in the burning of the char.

By employing the fluidized solids contacting principle for the partial incomplete combustion stage in my present invention, it is possible to expose the incoming char to elevated, devolatilization temperatures quickly since the fluidized bed provides a heat reservoir of sufficient capacity to dampen out temperature variations which would deleteriously interfere with the combustion process in the subsequent pulverized fuel burner.

The stream of combustible gas withdrawn from the partial incomplete combustion zone may be combined with the preheated char to serve as an ignition accelerator for the char in the pulverized fuel burner. The stream of combustible gas alternatively may be mixed with air and be used as an auxiliary fuel in the pilot burner. In this instance the preheated char is mixed with primary combustion air and conveyed directly to the pulverized fuel burner nozzle.

In the event it is desired to recover the volatile matter contained in the char for other uses, the char may be preheated in a devolatilization zone to a temperature sufficiently high to effect the desired devolatilization. The source of heat for this devolatilization step preferably is the preheated char from the partial incomplete combustion zone. Devolatilized char may be treated thereafter in the partial incomplete combustion zone with the air to generate "producer gas" which may be used as the auxiliary fuel in lieu of the combined complex combustible gas heretofore described.

Accordingly the primary object of this invention is to provide a method of efficiently burning the finely divided carbonaceous solids having a relatively low volatile matter content.

Another object of this invention is to provide a method of preheating the carbonaceous solids prior to combustion.

Another object of this invention is to provide a method

of producing auxiliary gaseous fuel through devolatilization of carbonaceous solids having a low volatile matter content.

Other and further objects and advantages will become apparent from the following specification, drawings and claims.

In the drawings:

Figure 1 is a semi-diagrammatic view of a system suitable for carrying out my invention.

Figure 2 is a diagrammatic view of another embodiment of my invention wherein autogenous combustible gas is mixed with a stream of air to serve as an auxiliary fuel for a pilot burner.

Figure 3 illustrates another embodiment of my invention wherein a portion of carbonaceous solids is treated in a partial incomplete combustion zone and conveyed therefrom to a combustion zone.

Figure 4 illustrates another embodiment of my invention wherein autogenous combustible gas from a partial incomplete combustion zone is mixed with air to serve as an auxiliary fuel and source of secondary air.

Figure 5 illustrates a further embodiment of my invention where volatile matter is removed from low volatile carbonaceous solids prior to a partial incomplete combustion preceding their combustion.

In the drawings like reference characters indicate like parts throughout.

Embodiment I

The embodiment shown in Figure 1 illustrates a method for preheating char and introducing heated char in a dilute phase suspension of producer gas and devolatilization gases into a pulverized fuel burner.

Finely divided char is stored in a char storage vessel 10 and conveyed through a conduit 12 to a conduit 14. A valve 16 is positioned in the conduit 12 to control the rate of flow of char from the storage vessel 10 through the conduit 12. Air is pumped through the conduit 14 to a partial incomplete combustion vessel 18. A valve 20 controls the flow rate of air through the conduit 14. The air passing through conduit 14 conveys the char from conduit 12 into a partial incomplete combustion vessel 18. The partial incomplete combustion vessel 18 is constructed to maintain a bed of char under fluidized solids contacting conditions by means of the reactant gas passing upwardly therethrough. The partial incomplete combustion vessel 18 is maintained at a combustion temperature to permit exothermic reaction between char and air therein. This exothermic reaction heats and devolatilizes the char in the partial incomplete combustion vessel 18. During the exothermic reaction "producer gas" is generated within the vessel 18. The "producer gas" and devolatilization gases combine to form a complex combustible gas.

In this embodiment both the preheated char and combustible gas are withdrawn from the partial incomplete combustion vessel 18 through a conduit 22 which is connected to the inlet side of a pulverized fuel burner 24. The partial incomplete combustion vessel 18 is also provided with a conduit 26 to remove non-combustible impurities which may collect therein. A valve 28 in the conduit 26 controls the discharge through the conduit 26.

Primary combustion air enters the inlet side of the burner 24 through a conduit 30 at a predetermined rate and secondary combustion air enters the side wall of the burner 24 through a conduit 32 to supply additional air required for complete combustion. The burner 24 extends into a combustion zone of a furnace 34 which is diagrammatically shown. The pulverized fuel burner 24 may be of any conventional type and may have any conventional position relative to the combustion zone within the furnace 34. The mixture of char and combustible gas leaves the nozzle of the pulverized fuel burner 24 under pressure. The mixture is ignited adjacent the burner nozzle. Secondary air entering through the conduit 32 supplies additional air to maintain combustion of

the mixture beyond the burner nozzle. The hot gases from the combustion of the char and combustible gas pass upwardly over conventional heat exchange facilities. The ash or non-combustible matter is removed from the furnace 34 through an outlet 36. In this embodiment the combustible gas withdrawn from the partial incomplete combustion zone 18 acts as a carrier gas for the preheated char and additionally aids in the combustion of the preheated char in the pulverized fuel burner 24. Thus in this embodiment char is completely consumed in the burning operation and substantially complete carbon utilization may be obtained from a carbonaceous solid having low volatile matter content in a pulverized fuel burner.

Embodiment II

The embodiment shown in Figure 2 illustrates a method for preheating char and concurrently preparing a complex combustible gas mixture comprising producer gas and devolatilization gases which are introduced separately into a pulverized fuel burner for the preheated char. The primary air supply is employed as a carrier gas to convey the preheated char in a dilute phase suspension into the pulverized fuel burner. The complex combustible gas enters the pulverized fuel burner adjacent the char entry point to serve as an ignition accelerator for the char.

The char is conveyed to the partial incomplete combustion vessel 18 in a manner similar to that shown in Figure 1. The combustible gas is withdrawn from the partial incomplete combustion vessel 18 through an overhead conduit 22. Within the partial incomplete combustion vessel 18, cyclone separator 38 is provided to prevent the passage of char into the conduit 22. A conduit 40 is connected to the conduit 22 and air is conveyed there-through. A valve 42 in the conduit 40 controls the amount of air that is mixed with the combustible gas in conduit 22 so that a flame supporting mixture is obtained. The combustible gas-air mixture enters a pilot burner 44 positioned adjacent the inlet nozzle of the pulverized fuel burner 24. The preheated char leaves the partial incomplete combustion vessel 18 through a conduit 46 which is interconnected with the primary air conduit 30. A solids flow regulator such as a star feeder 48 is positioned in the conduit 46 to regulate the withdrawal of the preheated char from the partial incomplete combustion vessel 18 without loss of fluidizing pressure therein. The preheated char which enters the conduit 30 is mixed with and conveyed to the pulverized fuel burner 24 by the primary air stream. Secondary air enters the burner side wall through the conduit 32 to aid in combustion of the char therein. Thus in this embodiment the combustible gas generated in the partial incomplete combustion vessel 18 serves as an auxiliary fuel to be used in the pilot burner to assist in maintaining the combustion temperature of the char within the burner 24 and combustion zone.

Embodiment III

The embodiment of Figure 3 illustrates a method for applying the principle of this invention to only a portion of the char supply to the pulverized fuel burner according to the embodiment of Figure 1. This embodiment provides increased control over the combustion process of the pulverized fuel burner.

The char leaves the storage vessel 10 through the conduit 12 and enters a flow manifold 50. From the flow manifold 50 the char is directed into one of two conduits 52 and 54. The conduit 52 is interconnected with the primary air conduit 30 and the conduit 54 is interconnected with the air conduit 14. The char conveyed through the conduit 52 enters the conduit 30 and is mixed with the primary air in conduit 30 and conveyed directly to the fuel burner 24. The char entering conduit 54 is conveyed into the partial incomplete combustion zone 18 in a dilute phase suspension in air passing through the

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conduit 14. The char is then subjected to the exothermic reaction with air within the partial incomplete combustion vessel 18 and both the preheated char and combustible gas generated within the partial incomplete combustion vessel 18 are withdrawn therefrom through the conduit 22 and conveyed as a dilute phase suspension directly to the fuel burner 24. The preheated char and combustible gas are mixed with the untreated char and the primary air in the burner 24 where they are burned. Thus in this embodiment of feed rate of preheated and untreated char can be regulated by the flow regulating mechanism 50 to deliver a predetermined amount of preheated char and combustible gas to the pulverized fuel burner 24 to support complete combustion of the untreated char which is conveyed to the pulverized fuel burner 24 with the primary air through the conduit 30.

Embodiment IV

The embodiment of Figure 4 illustrates a method for preheating char for combustion in a pulverized fuel burner and concurrently preparing a combustible gas for use as a secondary source of heat in the pulverized fuel burner. This embodiment is particularly applicable to pulverized fuel burners of the "cyclone" type which require for operation an extremely hot combustion chamber. The char is conveyed to and treated in the partial incomplete combustion vessel 18 in a manner similar to the embodiment shown in Figure 1. A cyclone separator 38 is provided to permit only the solids free combustible gas to be withdrawn through the conduit 22. Preheated char is withdrawn from the vessel 18 through a conduit 46. The combustible gas in conduit 22 is mixed with air which is conveyed through conduit 40. A valve 42 regulates the amount of air mixed with the combustible gas. Combustible gas-air mixture enters the pulverized fuel burner secondary air inlets which are spaced downstream from the burner inlet nozzle. Char which is withdrawn from the partial incomplete combustion vessel 18 through the conduit 46 enters the primary air conduit 30 where the preheated char is mixed with the primary air and conveyed to the pulverized fuel burner inlet nozzle. Thus in this embodiment the preheated char is ignited at the burner nozzle and also exposed to an additional source of heat beyond the burner nozzle by means of the combustible gas mixture flowing through the secondary air inlet. In this manner any char which has not been ignited at the burner nozzle will pass through the heated zone and be ignited at a point beyond the nozzle so that there is complete combustion of all the char entering the pulverized fuel burner 24.

Embodiment V

The embodiment of Figure 5 illustrates a method for burning char which permits a preliminary recovery of the available devolatilization gases which are valuable as a source of hydrogen gas. The devolatilization gases may be separately recovered and used in hydrogenation processes or char desulfurizing process. Necessary auxiliary gaseous fuel for ignition of the low volatile char is obtained as producer gas from partial incomplete combustion of the char with air which concurrently heats the char to render it more readily combustible. In this embodiment, a devolatilization vessel is provided in which the incoming char is heated to a devolatilization temperature by recirculating heated char from the partial incomplete combustion vessel.

As shown in Figure 5 the char is conveyed from a char storage vessel 110 through a conduit 112 to a screw feeder 114 which is driven by a motor 116. The screw feeder 114 conveys the char into a devolatilization vessel 118. The devolatilized char leaves the devolatilization vessel 118 through a conduit 120 which communicates with a devolatilization conduit 122. A valve 124 positioned in the conduit 120 controls the discharge rate of char from the devolatilization vessel 118. Air passing

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through a conduit 122 conveys the char so discharged from the devolatilization vessel to a partial incomplete combustion vessel 126. As in the other embodiments the char within the partial gasification vessel 126 reacts exothermically with the air to generate producer gas and preheat the char.

A portion of the preheated char is withdrawn from the partial incomplete combustion vessel 126 through the conduit 128. A star feeder type valve 130 positioned in the conduit 128 controls the rate of flow of preheated char from the partial incomplete combustion vessel 126 to the devolatilization vessel 118.

A portion of the gases evolved during devolatilization of the char in the devolatilization vessel 118 is recycled by means of a pump 133 through a conduit 135 into the devolatilization vessel 118. The rate of recycle is controlled to maintain the char within the devolatilization vessel 118 under fluidized solids contacting conditions. The preheated char which enters the devolatilization vessel 118 through the conduit 128 and the untreated char which enters the devolatilization vessel 118 through the screw feeder 114 are thoroughly mixed in the devolatilization vessel so that the temperature of the incoming untreated char is raised to cause devolatilization. Evolved gases are withdrawn from the devolatilization vessel 118 through a conduit 132. A cyclone separator is positioned within the devolatilization vessel 118 to permit only solids-free gaseous product to pass into the conduit 132. The mixture of preheated char from the partial incomplete combustion vessel 126 and the devolatilized char are withdrawn from the devolatilization vessel 118 through the conduit 120 and conveyed to the partial incomplete combustion vessel 126 as stated. The exothermic reaction within the partial incomplete combustion vessel 126 generates producer gas which is withdrawn with a portion of the preheated char through the conduit 134. The preheated char and producer gas mixture are conveyed to the inlet nozzle of a pulverized fuel burner 136. Primary air from conduit 138 is mixed with the char-producer gas mixture and ignited at the nozzle of the pulverized fuel burner 136. Secondary air enters the side wall of the pulverized fuel burner 166 through a conduit 140 and completes combustion of the char-producer gas mixture. Thus in this embodiment not only are the gases of devolatilization separately recovered, but the devolatilized char is subsequently subjected to substantially complete combustion in a pulverized fuel burner.

According to the provisions of the patent statutes, I have explained the principle, preferred construction and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. The method of burning finely divided, low volatile, non-agglomerating carbonaceous solid fuels in a dilute phase pulverized fuel burner which comprises introducing at least a portion of said carbonaceous solid fuels into a partial incomplete combustion zone, maintaining said solid fuels therein under fluidizing conditions at an elevated temperature, passing air upwardly therethrough under fluidizing conditions, subjecting a portion of said solid fuels in said partial incomplete combustion zone to an exothermic thermal treatment in the presence of said air to generate a combustible gas and to provide heat for maintaining said partial incomplete combustion zone at said elevated temperature, recovering therefrom for further treatment a combustible gas and unreacted solid fuels at an elevated temperature, and introducing said combustible gas and said unreacted solid fuels at said elevated temperature into a dilute phase pulverized fuel burner along with air in a manner that said combustible

gas, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said dilute phase pulverized fuel burner for substantially complete burning of said unreacted solid fuels and said combustible gas.

2. The method of burning finely divided, low volatile, non-agglomerating carbonaceous solid fuels in a dilute phase pulverized fuel burner which comprises introducing at least a portion of said carbonaceous solid fuels into a partial incomplete combustion zone, maintaining said solid fuels therein under fluidizing conditions at an elevated temperature, passing air upwardly therethrough under fluidizing conditions, subjecting a portion of said solid fuels in said partial incomplete combustion zone to an exothermic thermal treatment in the presence of said air to generate combustible gases and to provide heat for maintaining said partial incomplete combustion zone at said elevated temperature, recovering therefrom a stream of unreacted solid fuels at said elevated temperature and a stream of combustible gases at said elevated temperature, mixing said stream of unreacted solid fuels with air, introducing said mixture into a dilute phase pulverized fuel burner for burning therein, and introducing said stream of combustible gases into said dilute phase pulverized fuel burner in a manner that said combustible gas, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said dilute phase pulverized fuel burner for substantially complete burning of said unreacted solid fuels and said combustible gas.

3. The method of burning finely divided, low volatile, non-agglomerating carbonaceous solid fuels in a dilute phase pulverized fuel burner which comprises introducing said carbonaceous solid fuels into a partial incomplete combustion zone, maintaining said fuels therein under fluidizing conditions at an elevated temperature, passing air upwardly through said partial incomplete combustion zone under fluidizing conditions, subjecting a portion of said solid fuels in said partial incomplete combustion zone to an exothermic thermal treatment in the presence of said air to generate a combustible gas and to provide heat for maintaining said partial incomplete combustion zone at an elevated temperature, withdrawing from said partial incomplete combustion zone at said elevated temperature a mixture consisting of a combustible gas and unreacted solid fuels, and introducing said mixture into a dilute phase pulverized fuel burner along with air in a manner that said combustible gas, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said dilute phase pulverized fuel burner for substantially complete burning of said unreacted solid fuels and said combustible gas.

4. The method of burning finely divided, low volatile, non-agglomerating carbonaceous solid fuels in a dilute phase pulverized fuel burner which comprises introducing said carbonaceous solid fuels into a partial incomplete combustion zone, maintaining said solid fuels therein under fluidizing conditions at an elevated temperature, passing air upwardly through said partial incomplete combustion zone under fluidizing conditions, subjecting a portion of said solid fuels in said partial incomplete combustion zone to an exothermic thermal treatment in the presence of said air to generate a combustible gas and provide heat for maintaining said partial incomplete combustion zone at said elevated temperature, recovering a stream of unreacted solid fuels at said elevated temperature from said partial incomplete combustion zone, separately recovering a stream of combustible gas at said elevated temperature from said partial incomplete combustion zone, mixing said combustible gas with air, introducing said stream of unreacted solid fuels at said elevated temperature into a dilute phase pulverized fuel burner, separately introducing said combustible gas-air mixture into said pulverized fuel burner in a manner that said combustible gas-air mixture, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said

dilute phase pulverized fuel burner for substantially complete burning of said unreacted solid fuels.

5. The method burning finely divided, low volatile, non-agglomerating carbonaceous solid fuels in a dilute phase pulverized fuel burner having an inlet nozzle and secondary air inlet which comprises introducing said carbonaceous solid fuels into a partial incomplete combustion zone, maintaining said solid fuels therein under fluidizing conditions at an elevated temperature, passing air upwardly through said partial incomplete combustion zone under fluidizing conditions, subjecting a portion of said solid fuels in said partial incomplete combustion zone to an exothermic thermal treatment in the presence of said air to generate a combustible gas and to provide heat for maintaining said partial incomplete combustion zone at said elevated temperature, recovering a stream of unreacted solid fuels at said elevated temperature from said partial incomplete combustion zone, separately recovering a stream of combustible gas at said elevated temperature from said partial incomplete combustion zone, mixing said combustible gas with air, introducing said stream of unreacted solid fuels at said elevated temperature into said inlet nozzle of said pulverized fuel burner, introducing said combustible gas-air mixture into said secondary air inlet in a manner that said combustible gas-air mixture, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said dilute phase pulverized fuel burner for substantially complete burning of said unreacted solid fuels.

6. The method of devolatilizing and burning finely divided, non-agglomerating carbonaceous solid fuels in a dilute phase pulverized fuel burner which comprises introducing said solid fuels into a devolatilization zone, subjecting said solid fuels to a thermal treatment at an elevated temperature until the volatile matter is evolved from said solid fuels, continuously withdrawing said evolved volatile matter from said devolatilization zone, continuously withdrawing thus devolatilized solid fuels from said devolatilization zone, introducing said devolatilized solid fuels into a partial incomplete combustion zone, subjecting said devolatilized solid fuels to a thermal treatment in the presence of air at an elevated temperature under fluidizing conditions until said air reacts exothermically with a portion of said devolatilized solid fuels to generate producer gas, continuously withdrawing a mixture consisting of producer gas and unreacted devolatilized solid fuels from said partial incomplete combustion zone, introducing said mixture into a dilute phase pulverized fuel burner along with air in a manner that said producer gas, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said dilute phase pulverized fuel burner.

7. The method of burning the finely divided char product recovered from the low temperature carbonization of bituminous coal in a dilute phase pulverized fuel burner which comprises introducing said char into a devolatilization zone, subjecting said char to a thermal treatment therein under fluidizing conditions at an elevated temperature until the volatile matter is evolved from said char, continuously recovering said evolved volatile matter from said devolatilization zone, continuously withdrawing thus devolatilized char from said devolatilization zone, introducing said devolatilized char into a partial incomplete combustion zone, subjecting said devolatilized char to a thermal treatment in the presence of air at an elevated temperature under fluidizing conditions until said air reacts exothermically with a portion of said devolatilized char to generate producer gas, continuously recycling a portion of unreacted devolatilized char from said partial incomplete combustion zone to said devolatilization zone to supply the heat required for thermal treatment of the char in said devolatilization zone, recycling a portion of said evolved volatile matter recovered from said devolatilization zone as a gas to maintain said char within said devolatilization zone under fluidizing conditions, continuously withdrawing a mixture consist-

ing of producer gas and unreacted devolatilized char from said partial incomplete combustion zone, and introducing said mixture into a dilute phase pulverized fuel burner in a manner that said producer gas, as an auxiliary fuel, maintains ignition of said unreacted solid fuels in said dilute phase pulverized fuel burner for substantially complete burning of said unreacted solid fuels.

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