June 7, 1966 O. WOLF ET AL 3,254,976

METHOD OF AND DEVICE FOR DEGASIFYING FUEL DUST, ESPECIALLY COAL DUST

Filed Nov. 26, 1962 2 Sheets-Sheet 1

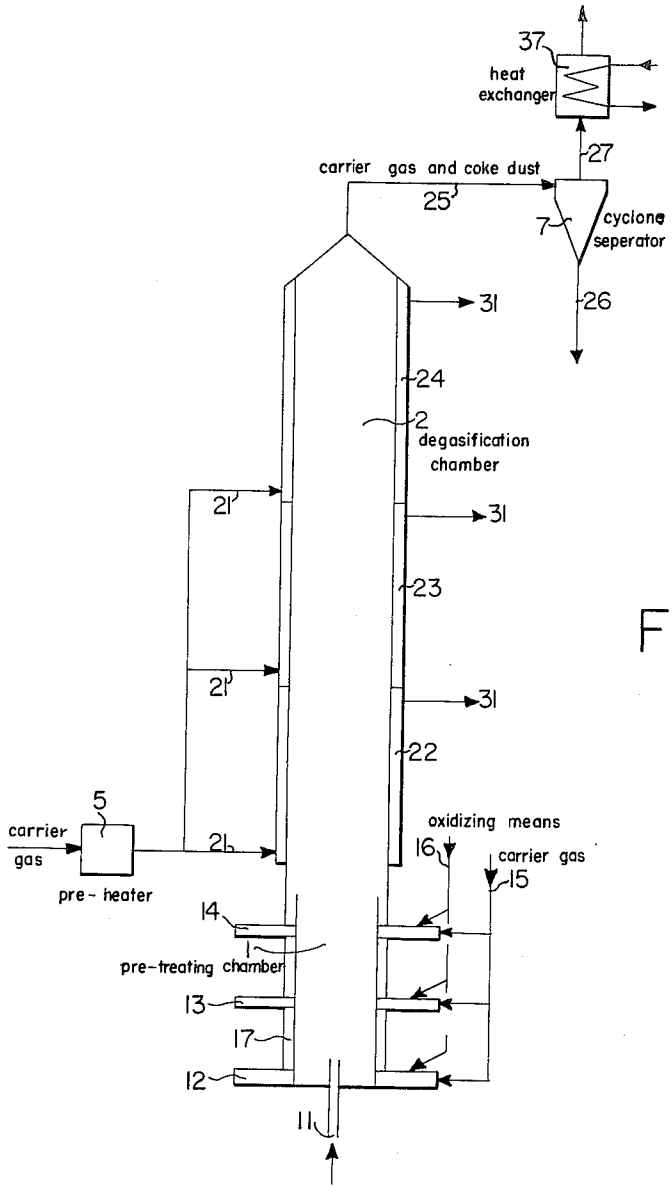

FIG-1

INVENTORS
OTTO WOLF
BY ERNST SCHUSTER

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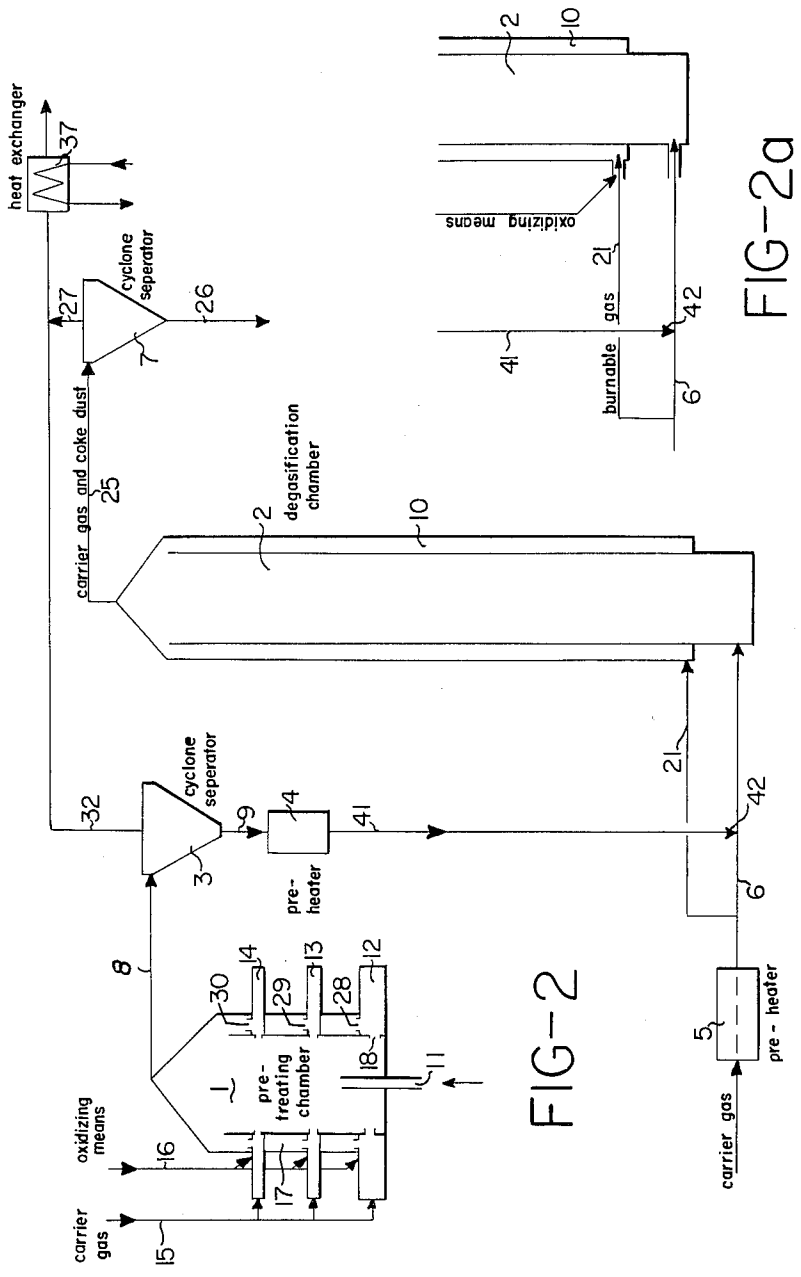

FIG-2

FIG-2a

INVENTORS
OTTO WOLF
ERNST SCHUSTER

BY

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METHOD OF AND DEVICE FOR DEGASIFYING FUEL DUST, ESPECIALLY COAL DUST

Otto Wolf and Ernst Schuster, Gummersbach, Germany, assignors to L. & C. Steinmuller, G.m.b.H., Gummersbach, Germany

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6 Claims. (Cl. 48—63)

The present invention relates to a method of and device for degasifying fuel dust, especially to the coking of coal dust, and is a continuation-in-part application of our copending application Ser. No. 837,650, filed September 2, 1959, now abandoned.

With the general method of this type, the coal dust to be treated is conveyed through a treatment chamber by a carrying gas and thereby heated to a temperature high enough to initiate and perform the degasification of the fuel dust. When carrying out this method, difficulties are encountered due primarily to the fact that the finely ground fuel particles, when reaching coking temperature, stick together and also to the wall of the respective chamber. Efforts directed to a solution of this sticking problem have improved the situation but have not resulted in a final all around satisfactory solution.

It has been suggested to mix the coal particles to be treated with coke particles and that in proportion of 5:50, preferably 15:30. Experience has shown that the sticking of the coal particles is impeded by the said effected mixture but not entirely prevented.

It has also been suggested to carry out the degasification in two stages while pre-treating the fuel particles in the presence of oxygen and so performing a surface oxidation in a first stage whereas the degasification proper was effected in a second stage. When carrying out this pre-treating, care had to be taken that the oxidation remained limited. It had to be carried out only to such an extent that sticking would just be prevented.

It is an object of the present invention further to improve the above-mentioned methods and device for carrying out the same.

It is another object of this invention to improve the regulation of the heat supply in such a manner that a surface oxidation of the fuel particles takes place only to a depth that caking and sticking will be safely prevented.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 diagrammatically illustrates an apparatus employed in practicing the present invention said apparatus comprising a pre-treatment chamber and a degasification chamber.

FIG. 2 illustrates a modified form of an apparatus according to the invention which differs from that of FIG. 1 primarily in that the carrier gas and the preoxidized particles are separated from each other after leaving the pre-treating chamber.

FIG. 2*a* shows a portion of an apparatus similar to that of FIG. 2 but differing therefrom in that the jacket of the degasification chamber communicates with a source of oxidizing means.

General arrangement

According to the present invention, the surface oxidation of the fuel particles is obtained by adding oxidizing means such as air, oxygen enriched air or pure oxygen to the carrier gas and initiating a partial reaction of the carrier gas with the oxidizing means. This method can easily be carried out and it can easily be controlled. To this end, it is merely necessary to vary the quantity of the

added oxidizing means and to so change the reaction temperature so as to adjust the device for the most favorable conditions concerning the course of the reaction.

With certain kinds of coal, the mixture of carrying gas, gas driven out of the coal particles and pre-treated coal particles may be led directly to the degasification chamber, where the said mixture is heated up to the degasification temperature, for instance by adding heat from outside, and the degasification of the coal particles completed. In that case, no change of the carrying gas takes place.

However, the amount of coal dust that can be carried in the carrier gas in the pre-treatment chamber being limited in most cases, the heat values of the gas mixture will not reach the value that could be reached by a degasification alone. Therefore, according to a further development of the present invention, it is suggested to carry out the pre-treating of the fuel dust—namely, the elimination of the caking ability thereof—and the post-degasification of the thus pre-treated fuel dust, in separate devices.

The oxygen supply during pre-oxidation is so controlled that only a surface oxidation of the fine dust particles will take place, but under no circumstances a complete combustion.

Generally, the pre-treatment of the fuel particles is, in conformity with the present invention, effected in a separate pre-treating chamber from which the carrier gas with the fuel dust is conveyed to the degasification chamber proper. However, the pre-treatment of the fuel particles may also be effected in the carbon mill or in the pipe directly behind said mill. By thus splitting up the method and carrying out the same in two separate apparatuses, it has been made possible to carry out the pre-treatment of the fuel as well as the post-degasification at the respective most favorable temperatures and speed ratios and, furthermore, during the degasification to effect the charging of the carrier gas independently of the pre-treating chamber.

If the method is carried out by means of an ordinary carrier gas, which, for instance may be a municipal gas, produced by a municipal gas-producing plant for lighting and heating purposes and, the hydrogen content of which is so high and the methane content of which is so low that the lower heat value is considerably less than 4000 kilocalories/Nm.^{3} (normal cubic meters), a reduction of the amount of inert ingredients therein such as nitrogen, can be obtained by adding oxygen or using oxygen enriched air, or pure oxygen instead of air. By the term "lower heat value" is meant the heat value remaining after deducting the calories represented by the latent heat of the water-steam complex, i.e., those calories which become free during the condensation of the water-steam complex, and are included in the upper heat value of the gas mixture.

In conformity with a further development of the invention, the partial reaction in the carrier gas which is necessary to eliminate the caking or sticking ability, is carried out primarily with the hydrogen of the gas, which hydrogen as the part having the lowest heating value will least affect the heating value of the gas mixture. The combustion products of hydrogen (substantially steam) produced thereby may be withdrawn later during the cooling of the gas so that the contents in inert gases of the withdrawn gas can again be reduced so that the heat value will be increased.

The gas that is obtained as the end result of the present process is a gas mixture which may be composed primarily of CO, CH_4, H_2, CO_2, and N_2. Of these gases, carbon dioxide and nitrogen are inert gases, and the proportion of these in the gas mixture must be kept as low as possible, as has heretofore been pointed out. The heat value of the residual gas mixture is ascertained from the heat values of the combustible ingredients, such as CO, CH_4,

and H_2, and from the proportion thereof in the gas mixture. Inasmuch, as of the last three mentioned, hydrogen has the lowest heat value

$$\frac{\text{2570 kcal./cubic meter}}{\text{3050 (CO) and 8550 } (CH_4)}$$

a relative lowering of the hydrogen content will have the least effect upon the heat value of the resultant gas mixture or produced gas.

The gas produced by the process is a gas mixture having the composition of elements which are H_2, C_nH_m, CO, CO_2 and N_2, whereby the heat value of the burnable elements varies between 2570 (H_2) and 8550 (CH_4). If the method is carried out by means of an oxidizing carrier gas, e.g., municipal gas, with air as the oxidizing means, the end product will be a gas having such a high content in H_2, N_2 and CO_2 and such a low content in CH_4 that its lower heat value is considerably less than 4000 kcal./Nm^3. The percentages of the inert ingredients can be decreased by employing oxygen enriched air or pure oxygen instead of air. Thus, the quantity of nitrogen employed by the process is less than by employing unenriched air. In conformity with a further development of the invention, the partial reaction in the carrier gas which is necessary to eliminate the caking or sticking ability, is carried out primarily with the hydrogen of the gas, which hydrogen, the part having the lowest heating value, will last harmfully affect the heating value of the gas mixture. The combustion products of hydrogen—mainly steam—produced thereby may be withdrawn later during the cooling of the gas so that the contents in inert gases of the produced gas can again be reduced and the heat value will be increased.

The following table indicates the percentages of the gas elements in relation to the volume of the produced gas and the possibility of increasing the heat value of the produced gas. The end results of four different tests are reflected in the table. A partial combustion of the carrier gas occurs and when, with this partial combustion, of the total volume of the carrier gas burns, as in the two tests of Group A, it is assumed that 10 percent of each individual combustible gas is burned, which means all of the combustible elements of the gas mixture (CO, CH_4, and H_2) burn to the same extent, whereas with the tests of Group B the temperature is kept so low that only the hydrogen ingredients will take part in the combustion. This, however, does not signify that in Group B the totality of hydrogen will burn.

Within these groups, the first column sets forth the results when air is used as the oxidizing means. The first column in the table sets forth the different ingredients of the gas mixture. The symbol H_u means the lower heating value in kilogram calories per cubic meter. The symbol V_g designates the volume of the carrier gas after the partial reaction with the oxygen carries with regard to the volume of the gas mixture prior to the partial reaction which is assumed to equal 1.

Case	A		B	
Reagent	Air	Oxygen	Air	Oxygen
	Composition of the dry gas (percent)			
H_2	44.7	57.55	39.85	51.3
CH_4	22.1	28.34	28.35	36.4
C_nH_m	2.55	3.28	3.25	4.20
CO	3.45	4.37	4.45	5.7
O_2				
CO_2	4.90	6.24	1.67	2.15
N_2	22.3	0.22	22.43	0.25
H_u	3,529	4,534	4,071	5,244
V_g	1.174	0.914	1.016	0.79
Required quantity of air $Nm.^3/Nm.^3$	0.329		0.286	
Required quantity of O_2 $Nm.^3/Nm.^3$		0.069		0.06

With the tests of Group A, all of the individual component gases were employed uniformly for combustion, whereas with Group B, only the hydrogen gas was employed. The end results are particularly well shown by line H_u (lower heating value). Thus, by comparing the heat value (3529) in the "Air" column of Group A with the heat value (4534) in the column entitled "Oxygen," it is evident that by replacing air as a reagent by oxygen, an increase in the heat value of more than 1000 kcal./$m.^3$ was obtained. This result is due, as mentioned above, to the lesser nitrogen content of the gas mixture. Note in this respect the two values for N_2 in the table. On the other hand, if the value H_u in column 2 (3529) is compared with H_u value in column 4 (4071), it will be observed that when limiting the partial combustion to the hydrogen, the heat value of the produced gas mixture will be increased by approximately 550 kcal./$m.^3$. This is due to the fact that the proportion of the gas with the lowest heat value (H_2) in the produced gas has been reduced from 44.7 to 39.85%, whereas with higher heat value (CH_4), C_nH_m and CO have increased. In particular, the proportion of the high value methane (CH_4) increased from 22.1 percent to 28.35 percent.

The so called "latent heat" of the steam produced, i.e., the heat which is set free when the steam is condensed (about 640 kcal.), cannot be utilized inasmuch as the temperature of the burned gas, when leaving the chimney, is still above the condensing temperature.

It has been found that not very high temperatures are required for the surface oxidation of the fuel particles, especially not for all fuels. Generally, temperatures of about 300° C. are sufficient. These temperatures can be maintained in the pre-treating chamber either by a corresponding control of the partial reaction or by heating the pre-treating chamber from the outside.

If desired, the partial reaction may be aided by adding substances which burn at low temperatures, such as ether, benzine, acetylene, etc. Advantageously, the pre-treating chamber and the degasification chamber are separate from each other. When, however, no change of the carrying gas takes place, there exists also the possibility to combine the chambers and to carry out in one zone of the combined chambers the elimination of the caking or sticking ability, whereas in the other zone the degasification proper is being effected.

The heating from the outside of the degasifying chamber may be effected in various ways, either by flue gases of an adjacent boiler firing system, by just produced generator gas, or also by hydrogen which, if desired, may be heated by partial combustion. In this instance, the produced steam may be conveyed to the degasifying chamber for initiating a water gas reaction whereby a further correction of the heat value will be possible.

Structural arrangement

FIG. 1 illustrates a preferred embodiment of the apparatus employed in the practice of the invention.

FIG. 2 illustrates a modified form of apparatus suitable in practicing the invention.

Referring now to the drawings in detail showing an apparatus for carrying out the method according to the invention, FIG. 1 shows a device employed when the carrier gas and pre-oxidized particles are fed directly into the degasification chamber. With this arrangement, **1** indicates the pretreatment zone or chamber, whereas **2** indicates the degasification zone or chamber. In this instance, the fuel together with a carrier gas, preferably withdrawn from the produced gas, or together with superheated steam, is at **11** blown into the pre-treatment chamber. Additional carrier gas fed through conduit **15** is added through nozzles **12**, **13** and **14**. This additional carrier gas may consist either of the gas obtained in the process itself or may consist of another burnable gas. Oxidizing means, for instance air, or even better, oxygen enriched air or pure oxygen, are fed through conduit **16**

and added to the carrier gas and that at such a quantity that a partial combustion of the carrier gas will take place, which will furnish the heat required for carrying out the superficial oxidation of the fuel particles by the rest of the oxidizing means. The steam, if added, may be in such proportions that primarily the hydrogen content of the carrier gases is burned. The obtained mixture of carrier gas and volatile ingredients of the fuel dust expelled during the pre-treating directly enters the degasification chamber **2**. The degasification chamber **2** is surrounded by a hollow space subdivided into three parts **22, 23** and **24**. It is into these parts that carrier gas is introduced which was previously preheated in chamber **5** to a high temperature. The carrier gas passes through conduits **21** into the chambers **22, 23** and **24**, conveys its heat by heating from the outside to the mixture of gas and fuel particles flowing through the degasification chamber, and at the upper ends leaves the chambers through conduits **31**. The mixture of carrier gas, produced gas and coke dust leaves the degasification chamber **2** by conduit **25** and flows into the separator **7**, where the coke dust is separated from the gas mixture. The remaining gas mixture passes through conduit **27** to the heat exchanger **37** where it is cooled to the desired temperature and conveyed to the consumer. The coke dust withdrawn from the separator **7** may be conveyed to any consumer or may be blown into the combustion chamber of a boiler in hot state.

A modification is illustrated in FIG. 2, wherein a device is employed in which the carrier gas and the pre-oxidized particles are separated from each other after leaving the pre-treating chamber in a cyclone separator from where the pre-treated dust particles are led to the degasification chamber while the carrier gas is led off.

The said apparatus comprises the pre-treating chamber **1** and the degasification chamber **2**. The fuel dust is by means of the carrier gas or by means of steam introduced into pre-treating chamber **1** from below through the intervention of a nozzle **11** so that the fuel dust will pass from the bottom upwardly to the top.

A plurality of rows of combustion chambers **12, 13, 14** are distributed over the height of the pre-treating chamber. These combustion chambers **12, 13, 14** are connected on one hand to the feeding line **15** for the carrier gas and on the other hand to the feeding line **16** for the oxodizing means which may consist or air, oxygen enriched air, or pure oxygen. The said combustion chambers extend through the intermediate space **17** between the two walls at different levels and are connected with the interior of the pre-treating chamber **1** by ports **18, 19, 20**. The feed lines leading from the combustion chambers into the pre-treating chamber are, at least as far as the lower combustion chamber **12** is concerned, arranged tangentially with regard to the pre-treating chamber so that a turbulence of the entering carrier gas will be obtained from the bottom in an upward direction. The pre-treating chamber is provided with a double wall or jacket. The combustion chambers **12, 13, 14** have other openings **28, 29, 30** by which they are in connection with the intermediate space **17**, and it is through these openings that a portion of the carrier gas heated by the partial reaction passes into the intermediate space **17** and thus heats the pre-treating chamber from the outside.

It is also possible to carry out the heating by other means as, for instance, by flue gases of an adjacent boiler or by liquid sodium circulation which has been heated by the boiler, or electrically. When flue gases from the boiler are employed for heating purposes, they have to be withdrawn separately from the carrier gas. For that purpose in this case the intermediate space **17** is closed at its upper end so that the heating gases cannot enter the pre-treating chamber.

The carrier gas loaded with the surface oxidized fuel particles passes through conduit **8** into a cyclone separator **3** where gas and fuel particles are separated from each other and are separately passed to their point of employment. The gas leaves the cyclone separator through conduit **32**, and in a heat exchanger **37** gives up its excessive heat to the boiler feed water, steam or combustion air, and after a further fine purification, will be conveyed to the ultimate consumer. The cooling by a heat exchanger **37** is expediently carried out to such an extent that the steam contained in the gas will be condensed and may likewise be separated therefrom. The aged fuel dust leaves the separator through conduit **9** and first passes into a pre-heating apparatus **4** in which it is pre-heated to as high a temperature as possible. Subsequently, it leaves pre-heater **4** through conduit **41** and at **42** is admixed to the incoming carrier gas which has been pre-heated in the pre-heater **5** and is conveyed to the degasification chamber **2** through line **6**.

The carrier gas loaded with aged fuel particles passes through the degasification chamber **2** from the bottom to the top while the complete degasification of the fuel particles is being carried out. Inasmuch as for this degasification, additional heat has to be added, the degasification chamber is provided with a jacket **10**. According to the arrangement shown in FIG. 2, a portion of the carrier gas pre-heated in the pre-heater **5** is passed through a branch conduit **21** to the jacket **10** of the degasification chamber **2** to thereby heat the degasification chamber from the outside thereof. According to the modification shown in FIG. 2*a*, in addition to burnable carrier gas, oxidizing means is fed to jacket **10**. The gas passing through the jacket may combine with the gas which moves upwardly in the interior of the degasification chamber and may be withdrawn together with the latter through conduit **25**. There also exists the possibility to heat the degasification chamber from the outside by means of flue gas from an adjacent boiler or by means of liquid sodium circulation or electrically.

In those cases the jacket **10** dare not be in connection with the degasification chamber **2** at its upper end as illustrated in FIG. 2, but must be closed there.

Inasmuch as the degasfication chamber has to be made relatively high in order to assure a relatively long stay therein of the fuel particles to be degasified, it may be advantageous in some instances to subdivide the jacket and to feed into said jacket fresh heat carriers at different zones of the jacket, as shown in FIG. 1.

If it is necessary to accelerate the degasification or to crack the tar, for which purpose higher temperatures are required than can be obtained by additional heat supply from the outside, corresponding carrier gases, after a partial combustion especially of the hydrogen, may be introduced at any level of the degasification chamber, especially at the end thereof.

Carrier gas and coke dust leave the degasification chamber through conduit **25**. From here they pass into the cyclone separator **7** from where the coke dust is withdrawn through conduit **26**. The obtained coke dust is expediently conveyed directly to the burners of a boiler firing system and is burned below the boiler; the separated gas passes through conduit **27** into conduit **32** and together with the gas withdrawn from the separator **3**, is conveyed to the consumer.

It is, of course, to be understood that the present invention is, by no means, limited to the method and device set forth above but also comprises any modifications within the scope of the appended claims.

What we claim is:

1. A device for degasifying fuel dust particles in suspension in a gaseous carrying means which includes: a pre-treatment chamber for oxidizing the surface only of the fuel dust particles suspended in the gaseous carrying means, said pre-treatment chamber being surrounded by a jacket to form a space therebetween, a plurality of rows of combustion chambers distributed over the height of the pre-treatment chamber, said combustion chambers

penetrating said jacket and being connected to a feeding line for burnable gaseous carrying means and to a feeding line for oxidizing means and having outlet ports leading into the pre-treatment chamber and other outlet ports leading into the hollow space between said pre-treatment chamber and said jacket, a degasifying chamber in communication with said pre-treatment chamber for receiving the pre-treated fuel dust particles therefrom, means for conveying gaseous carrying means into said degasifying chamber, and means for maintaining the temperature in the degasifying chamber at a temperature high enough to complete the degasification of the fuel dust particles.

2. In a method of degasifying fuel dust particles in suspension in a streaming gaseous carrying means, the steps of: conveying the fuel dust particles in a gaseous carrying means containing burnable gases comprising hydrogen into a reaction chamber together with a gaseous oxidizing means comprising oxygen, said gaseous oxidizing means being introduced into said reaction chamber at a plurality of points along said reaction chamber, said oxidizing means being added to said gaseous carrying means to such as extent as to produce a partial reaction of said carrying gas with said oxidizing means, igniting said mixture to initiate said reaction, and thereby initiating a surface oxidation of said fuel dust particles by the rest of the oxidizing means thereby eliminating the sticking ability of said fuel dust particles, and thereafter adding heat to said fuel dust particles from outside the reaction chamber to such an extent as to raise the temperature of the fuel dust particles up to the degasifying temperature, and keeping the fuel dust particles at that temperature for a predetermined period of time, thereby completely degasifying said fuel dust particles.

3. A method as claimed in claim 2, which includes the step of adding steam to the oxidizing means in such a ratio that primarily the hydrogen content of said gaseous carrying means is burned to initiate the surface oxidation of the fuel dust particles while the rest of the gas content remains unburned in the gas stream.

4. A device for degasifying fuel dust particles in suspension in a gaseous carrying means which includes: a pretreatment chamber for oxidizing the surface only of the fuel dust particles suspended in the gaseous carrying means, a degasifying chamber communicating with said pre-treatment chamber for receiving the pre-treated fuel dust particles therefrom suspended in a carrier gas, said degasifying chamber being provided with a jacket which at its upper end opens into the degasifying chamber and which is provided at its lower end with connecting means for connection of said jacket with a supply source of heating gases to raise the temperature of said degasifying chamber to the degasifying temperature.

5. A device for degasifying fuel dust particles in suspension in a gaseous carrying means which includes: a pretreatment chamber for oxidizing the surface only of the fuel dust particles suspended in the gaseous carrying means, a degasifying chamber communicating with said pre-treatment chamber for receiving the pre-treated fuel dust particles therefrom, said degasifying chamber being provided with a jacket subdivided into sections along its height, said sections each being provided with connecting means for connection with a supply source for heating means.

6. In a method of degasifying fuel dust particles in suspension in a streaming gaseous carrying means, the steps of: conveying the fuel dust particles in a gaseous carrying means including combustible gases, adding oxidizing means comprising oxygen to said gaseous carrying means in such ratio as to produce a partial reaction of said carrying gas with said oxidizing means, igniting the mixture to initiate said reaction, and thereby initiatng a surface oxidation of said fuel dust particles by the rest of the oxidizing means to eliminate the sticking ability of said fuel dust particles, separating the thus treated fuel dust particles from said mixture of gaseous carrying means and dust particles following said surface oxidation, preheating said treated fuel dust to a higher temperature, blowing the pre-heated fuel together with superheated gaseous carrying means into a degasifying chamber for completely degasifying the fuel dust particles, said degasifying chamber being heated from outside by a partial combustion of burnable gaseous carrying means and thereafter adding said partly burned gaseous carrying means to the mixture of fuel dust particles and gaseous carrying means within the degasifying chamber.

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MORRIS O. WOLK, *Primary Examiner.*