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METHOD OF AND APPARATUS FOR BURNING PULVERIZED FUEL

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2 Sheets-Sheet 1

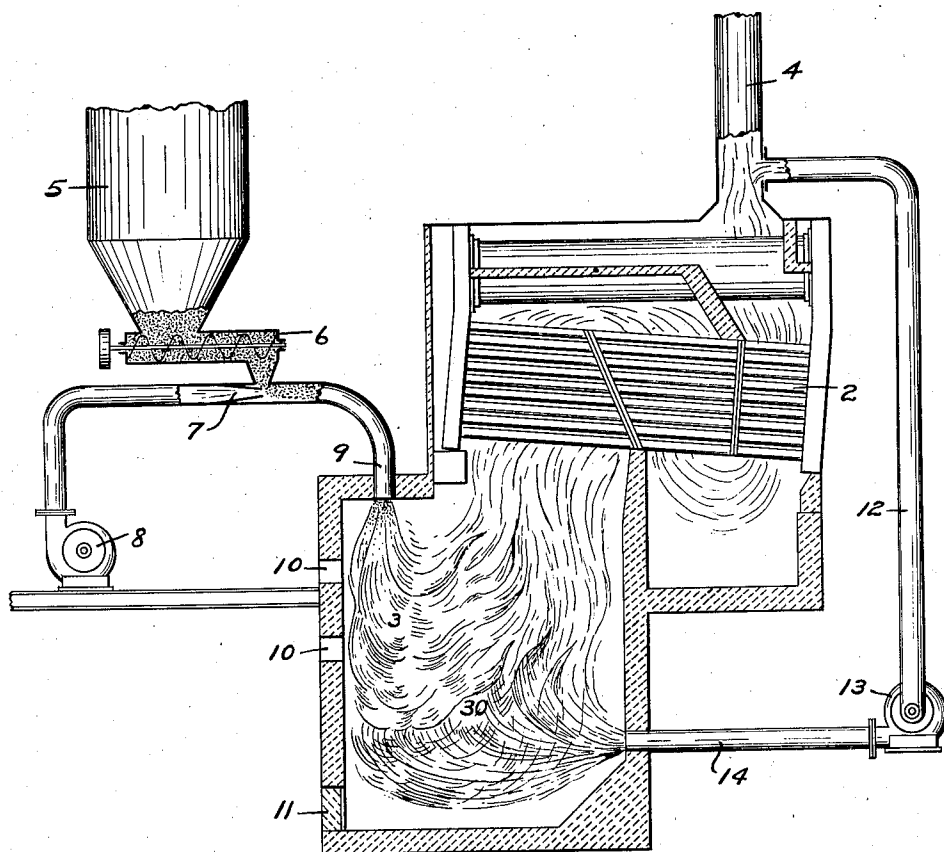


Fig. 1

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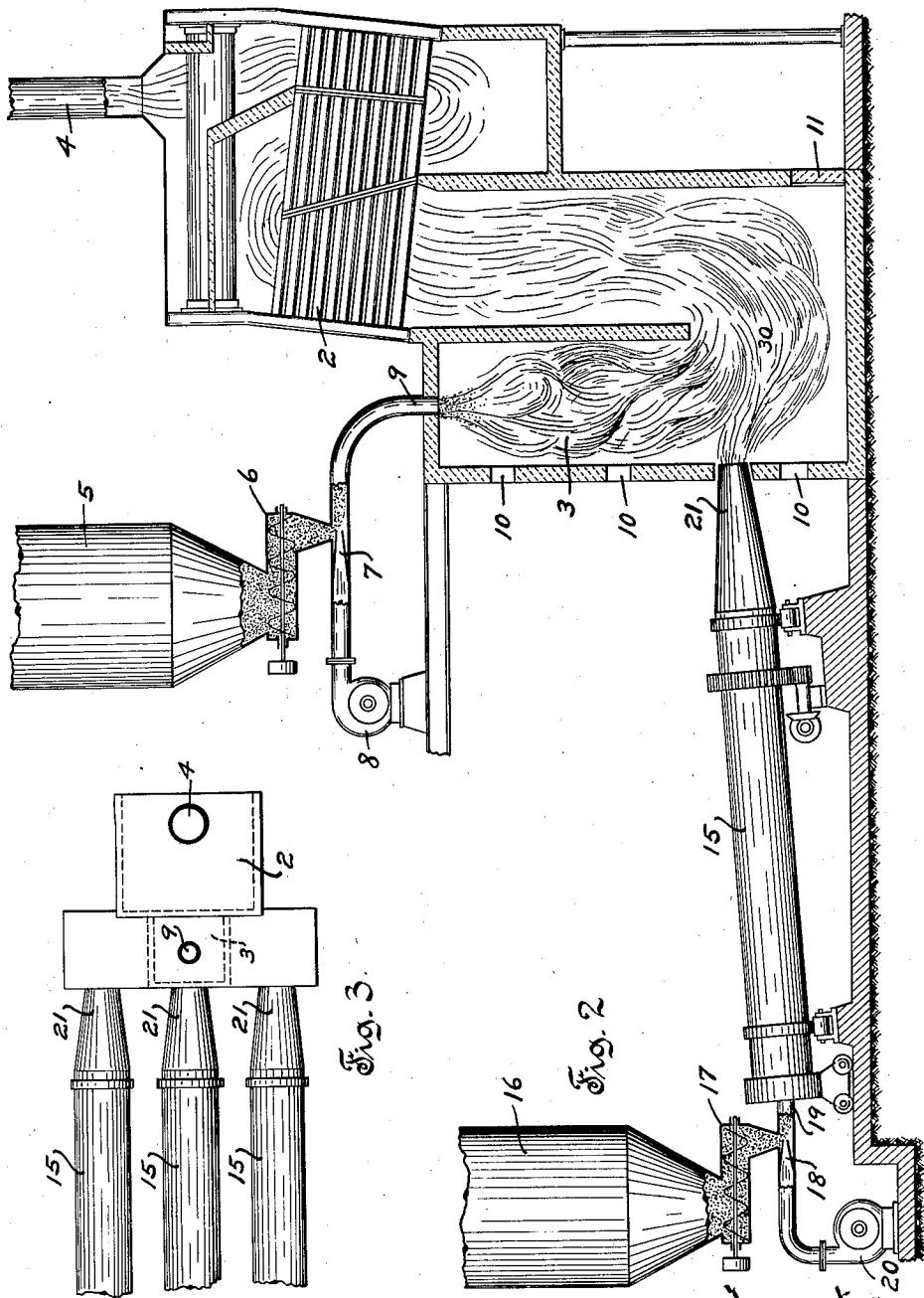
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METHOD OF AND APPARATUS FOR BURNING PULVERIZED FUEL.

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This invention relates in general to improvements in the art of converting heat energy and relates more specifically to an improved method of and apparatus for preventing the formation of slag coatings on adjacent structure, during combustion of pulverized fuels.

An object of the invention is to provide an improved method of converting heat energy. Another object is to provide a method of preventing accumulation of solidified slag during combustion of fuels. A further object is to provide a simple and efficient process of utilizing pulverulent material such as powdered coal, for the purpose of heating an energy absorber such as a boiler. Still another object is to provide simple and efficient apparatus for burning pulverulent fuel and for preventing accumulation of slag during combustion of the material. An additional object is to provide apparatus wherein the heat of combustion resulting from the burning of fuel, may be utilized with maximum efficiency.

It has recently been found commercially practical to utilize powdered coal for the purpose of heating steam generators and similar heat absorbers. The utilization of coal in pulverulent condition has a number of advantages over the prior method of using mine run or coarse crushed coal. The pulverization of the coal facilitates handling thereof and also permits more efficient and complete combustion of the fuel. The prohibitory high cost of the better grades of coal and the inability in many cases to obtain a continuous and sufficient supply of such coal for fuel purposes, has in many instances made it necessary to utilize cheaper grades of fuel. Such use of the cheaper grades of fuel is found practicable when the coal is reduced to a powder and is injected into the combustion chamber in this pulverulent condition by means of a jet of air, it having been found possible by this manner of handling, to utilize low grade fuels which under ordinary circumstances could not be used for heating purposes. When using the coal in pulverulent condition; it has been found that if the gases of combustion are not diluted in some manner, the combustion is so violent as to create temperatures above the slagging temperature of the ingredients, especially of the silica, iron oxide and alumina, contained in the material.

With the production of such high temperatures, slag is usually deposited at the bottom of the combustion chamber and is also deposited as a coating upon the heat transferring portions of the heat absorber, thus producing an insulating coating which prevents efficient transfer of the heat.

In order to prevent such objectionable accumulations of slag, it has heretofore been proposed to mix the hot gases of combustion leaving the combustion chamber, with relatively cold air introduced directly from the atmosphere. While this method has eliminated the accumulations of slag, it is objectionable in that the cold air thus introduced in relatively large quantities, must absorb sufficient heat from the gases of combustion resulting from the burning of the fuel, to raise the temperature a considerable amount, thereby wasting considerable heat which might otherwise be available in the heat absorber.

In order to eliminate undesirable accumulations of slag due to the creation of high temperatures in the combustion chamber without entailing the loss of heat as in the prior method, the present invention contemplates a method of introducing relatively hot gases which are mixed with the gases of combustion to reduce their temperatures prior to delivery to the heat absorber. In this manner, the temperature of the gases of combustion may be readily reduced to a point below the slagging temperature of the fuel ingredients before these gases are brought in contact with the surfaces of the heat absorber, thereby preventing formation of slag in the combustion chamber and eliminating the prior objectionable formation of heat insulating coatings upon the heat transferring surfaces of the heat absorber. With the present invention, cooling gases having relatively high temperature are employed in order to prevent slagging, these gases being derived from some source of prior combustion and thus permitting utilization of heat which is ordinarily wasted. These and other objects and advantages of the invention will be apparent from the following description.

A clear conception of the several steps of the method forming the subject of the present invention and of several embodiments of apparatus for exploiting the same, may be had by referring to the drawings accompanying and forming a part of this specification in

which like reference characters designate the same or similar parts in the several views.

Fig. 1 is a diagrammatic central vertical section through a steam generating installation especially adapted to utilize powdered coal as fuel.

Fig. 2 is a diagrammatic part sectional view through a combined powdered coal steam generating plant and rotary kiln installation.

Fig. 3 is a fragmentary top view, drawn to a reduced scale, of the combined installation disclosed in Fig. 2.

Referring specifically to Fig. 1, the heating plant therein shown comprises in general a fire-proof housing forming a combustion chamber 3 and a mixing chamber 30 in direct communication therewith; a heat absorbing device or steam boiler 2 located in proximity to the chambers 3, 30, apparatus for delivering pulverulent fuel and air to the combustion chamber, and a stack 4 for delivering gases of combustion from the boiler. The combustion chamber 3 is provided with suitable air inlet openings 10 and a fuel inlet conduit or pipe 9 preferably directed downwardly into the chamber 3. The lower portion of the mixing chamber 30 is provided with a cleanout 11 for permitting removal of small quantities of materials which may accumulate during operation of the apparatus. The heat absorbing device or boiler 2 is preferably located above and to one side of the combustion chamber 3 and has a series of heat transferring tubes and baffles which compel the hot gases delivered to the boiler from the combustion and mixing chambers 3, 30, to follow a circuitous path through the boiler. The gases leaving the spaces adjoining the tubes of the boiler 2, are delivered upwardly to the stack 4. A return pipe 12 communicating with the stack 4 leads to the inlet opening of a blower 13 which delivers its discharge through a return injection pipe 14 into the lower portion of the mixing chamber 30. The fuel feeding apparatus which delivers a combustible mixture of air and pulverulent material to the combustion chamber 3 through the inlet pipe 9, comprises a fuel supply bin or hopper 5 having its lower end communicating with a feeder 6, and an air blower 8 having its discharge communicating with a nozzle 7 which is adapted to deliver a jet of air at high velocity past the discharge opening of the fuel feeder 6 and into the fuel inlet pipe 9.

Referring specifically to Figs. 2 and 3, the heating plant therein shown is generally similar to that disclosed in Fig. 1, comprising a fire-proof housing forming a combustion chamber 3 and a mixing chamber 30 in direct communication therewith, a heat absorbing device or steam boiler 2 located in proximity to the mixing chamber 30, and a stack 4 for delivering gases of combustion from the boiler. The combustion chamber 3 is pro-

vided with suitable air inlet openings 10 and the fuel inlet pipe 9 is preferably directed downwardly through the upper end of the chamber 3. The combustion chamber 3 communicates with the mixing chamber 30 below the end of a baffle wall, the lower portion of the chamber 30 being provided with a cleanout 11 for permitting removal of small quantities of materials which may accumulate below the chambers 3, 30 during operation of the apparatus. The heat absorbing device or boiler 2 is preferably located above the mixing chamber 30 and has a series of heat transferring tubes and baffles which compel the hot gases delivered from the mixing chamber 30 to follow a circuitous path through the boiler. The gases leaving the boiler 2 are delivered upwardly to the stack 4. The fuel feeding apparatus which communicates with the combustion chamber 3 through the inlet pipe 9, comprises a fuel supply bin or hopper 5 having its lower end communicating with the feeder 6, and an air blower 8 having its discharge communicating with a nozzle 7 which is adapted to deliver a jet of air at high velocity through the pipe 9. Leading laterally into the combustion and mixing chambers 3, 30 is a series of conduits 21 communicating with a like series of rotary kilns 15. These kilns 15 are adapted to heat treat materials passed longitudinally therethrough and are provided with fuel feeding apparatus adapted to deliver a mixture of air and pulverized fuel to their lower extremities. Each of the kiln fuel feeding devices comprises a fuel supply bin or hopper 16 having its lower end communicating with a feeder 17, and an air blower 20 having its discharge communicating with a nozzle 18. Each nozzle 18 is adapted to deliver a jet of air at high velocity past the discharge opening of the fuel feeder 17 and into the injection pipe 19 which leads to the lower end of the corresponding kiln 15. Within the kilns 15, the fuel thus injected is ignited and the heat of combustion is utilized to calcine solid material passing longitudinally through the kiln. The hot gases of combustion from the kilns 15 are delivered through the conduits 21 and into the mixing chamber 30, where they are intimately mixed with the relatively hot gases of combustion from chamber 3.

During normal operation of the apparatus disclosed in Fig. 1, the fuel feeder 6 and the air blower 8 are in operation, the blower producing a jet of air at the nozzle 7 which mingles with the powdered coal and forces the combustible mixture of coal and air thus formed, downwardly into the combustion chamber 3 through the inlet pipe 9. In the combustion chamber 3 the combustible mixture thus injected, strikes the incandescent mass of burning mixture previously admitted, and is ignited and burned. The violent burning of the powdered fuel in the combustion

chamber 3 in the presence of air, produces temperatures which are considerably above the slagging temperatures of the ingredients of the coal. The hot gases of combustion delivered from the combustion chamber 3 are drawn laterally and upwardly away from this chamber and toward the boiler 2, by the draft induced in the stack 4. During this lateral and upward progress of the gases of combustion, gases of combustion at approximately the stack temperature, are being injected into the chamber below the combustion chamber 3 through the injection pipe 14. These relatively cool non-combustible gases form a protective film below the combustion chamber 3 and are drawn upwardly into the mixing chamber 30 wherein they intimately mix with the hot gases of combustion leaving the combustion chamber 3 and reduce the temperatures of these gases to a point below the slagging temperatures of the ingredients. The mixed gases thus produced are still of sufficiently high temperature to efficiently perform their heating function in the boiler 2, and are passed through the spaces among the tubes of the boiler 2 wherein their heat is transferred to the absorbing medium located within the tubes. The spent gases of combustion are eventually delivered upwardly from the boiler 2 to the stack 4 wherein a part of the gases are withdrawn and returned to the combustion chamber through the pipes 12, 14 and blower 13, as hereinbefore described. The injection of the non-combustible stack gases into the space below the combustion chamber 3 prevents the formation of slag below the chambers 3, 30 by reducing the temperatures of gases which might otherwise strike the floor of these chambers, below the slagging temperatures of the ingredients thereof. By cooling the gases of combustion delivered to the chamber 30 and by injecting the non-combustible stack gases and mixing them with the gases of combustion prior to application of the heat of combustion to the boiler 2, the formation of slag coatings on the boiler tubes is prevented. As the gases of combustion passing through the stack 4 have relatively high temperature as compared with atmospheric air, the heat absorbed by the cooling gases from the gases of combustion, is considerably less than if atmospheric air were used as a cooling agent, thereby permitting more efficient utilization of the heat of combustion in the boiler 2.

During normal operation of the apparatus disclosed in Figs. 2 and 3, the boiler 2 is being heated solely by the hot gases of combustion delivered from the kilns 15 through the discharge conduits 21. If, however, one or more of these kilns 15 is thrown out of operation, the gases of combustion delivered from the remaining kilns are not sufficient to supply the necessary heat to the boiler 2, whereupon the fuel feeder 6 and the air blower 8 are

placed in operation. During such operation of the apparatus the blower 8 produces a jet of air at the nozzle 7 which mingles with the powdered coal delivered from the feeder 6 and forces the combustible mixture of coal and air thus formed, downwardly into the combustion chamber 3. In the chamber 3 the combustible mixture is ignited and burned. The violent burning of the powdered fuel in the combustion chamber 3 in the presence of air, produces temperatures which are considerably above the slagging temperatures of the ingredients of the fuel. The hot gases of combustion delivered downwardly from the combustion chamber 3 are diverted laterally and upwardly around the dividing partition, by the draft induced in the stack 4. During this lateral and upward progress of the gases of combustion, other gases of combustion having relatively high temperature as compared with the atmospheric air, are delivered from the remaining kilns 15, being injected below the combustion chamber 3 and into the mixing chamber 30. The kiln gases thus admitted are relatively cool as compared with the gases of combustion generated in the chamber 3, being subsequently drawn through and upwardly from the mixing chamber 30 wherein they intimately mix with the gases of combustion generated in the chamber 3 and reduce the temperature of these latter gases to a point below the slagging temperatures of the ingredients. The mixed gases thus produced are still of sufficiently high temperature to efficiently perform their heating function in the boiler 2, and are passed through the spaces among the tubes of the boiler 2 wherein their heat is transferred to the absorbing medium located within the tubes. The spent gases of combustion from the chamber 3 and the kilns 15 are delivered upwardly from the boiler 2 to the stack 4. The injection of the non-combustible kiln gases in the space below the combustion chamber 3 prevents the accumulation of slag below the chambers 3, 30 by reducing the temperatures of gases which might otherwise strike the floor of these chambers, below the slagging temperatures of the ingredients thereof. By cooling the gases of combustion delivered to the boiler 2 below the slagging temperature of the ingredients thereof, the formation of slag coatings on the boiler tubes is prevented. As the gases of combustion leaving the kilns 15 have relatively high temperature as compared with atmospheric air, the heat absorbed by the cooling gases from the gases of combustion generated in the chamber 3, is considerably less than if atmospheric air were used as a cooling agent thereby permitting more efficient utilization of the heat of combustion in the boiler 2.

It will thus be noted that with the use of either of the installations disclosed, accumulation of solidified slag is positively prevented

regardless of the temperatures produced during combustion of the fuel. While the disclosure has been confined to two specific forms of apparatus for carrying on the present method, it will be obvious that other apparatus may also be utilized to accomplish the desired results. With the use of the present method, the heating apparatus is automatically maintained in clean and efficient condition thereby obtaining maximum efficiency in the application of the heat of combustion.

It should be understood that it is not desired to limit the invention to the exact steps of the process and to the details of construction of the apparatus herein shown and described, for obvious modifications within the scope of the appended claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:—

1. The method of generating and utilizing heat, which consists in injecting ash-containing fuel and air into a combustion chamber, burning the same in suspension, mixing with the hot products of combustion, products of combustion the temperature of which has been lowered by abstraction of heat, and passing the mixture through a heat transfer device.

2. The method of generating and utilizing heat, which consists in injecting ash-containing fuel and air into a combustion chamber, burning the same in suspension, mixing with the hot products of combustion, products of combustion the temperature of which has been lowered by abstraction of heat, and passing the mixture through a steam generator.

3. The method of generating and utilizing heat, which consists in injecting ash-containing fuel and air into a combustion chamber, burning the same in suspension, mixing with the hot products of combustion, products of combustion the temperature of which is below the fusing point of the ash, and passing the mixture through a heat transfer device.

4. The method of generating and utilizing

heat, which consists in injecting ash-containing fuel and air into a combustion chamber, burning the same in suspension, mixing with the hot products of combustion, products of combustion the temperature of which is below the fusing point of the ash, and passing the mixture through a steam generator.

5. The method of generating and utilizing heat, which consists in injecting ash-containing fuel and air into a combustion chamber, burning the same in suspension, mixing with the hot products of combustion other products of combustion the temperature of which has been lowered by passage through a heat transfer device, and passing the mixture through said heat transfer device.

6. The method of generating and utilizing heat, which consists in injecting ash-containing fuel and air into a combustion chamber, burning the same in suspension, mixing with the hot products of combustion other products of combustion the temperature of which has been lowered by passage through a steam generator, and passing the mixture through said steam generator.

7. The method of generating and utilizing heat, which consists in introducing air and ash-containing fuel in a combustion zone, burning the same, subsequently mixing with the hot products of combustion other hot products of combustion the temperature of which has been lowered by passage through a heat transfer device, and passing the mixture through said heat transfer device.

8. The method of generating and utilizing heat, which consists in introducing air and ash-containing fuel in a combustion zone, burning the same, subsequently mixing with the hot products of combustion other hot products of combustion the temperature of which has been lowered by passage through a steam generator, and passing the mixture through said steam generator.

In testimony whereof, the signature of the inventor is affixed hereto.

RAY C. NEWHOUSE.