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KARL-HEINZ KÜPPERS

2,861,526

FUEL BURNING APPARATUS

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2 Sheets-Sheet 1

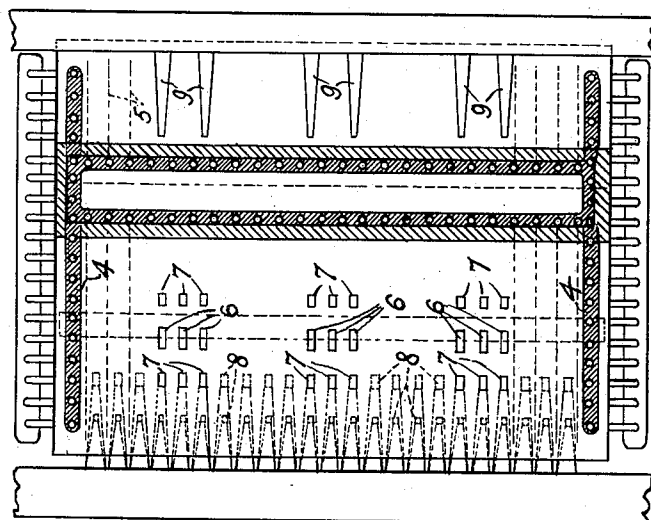


FIG. 2

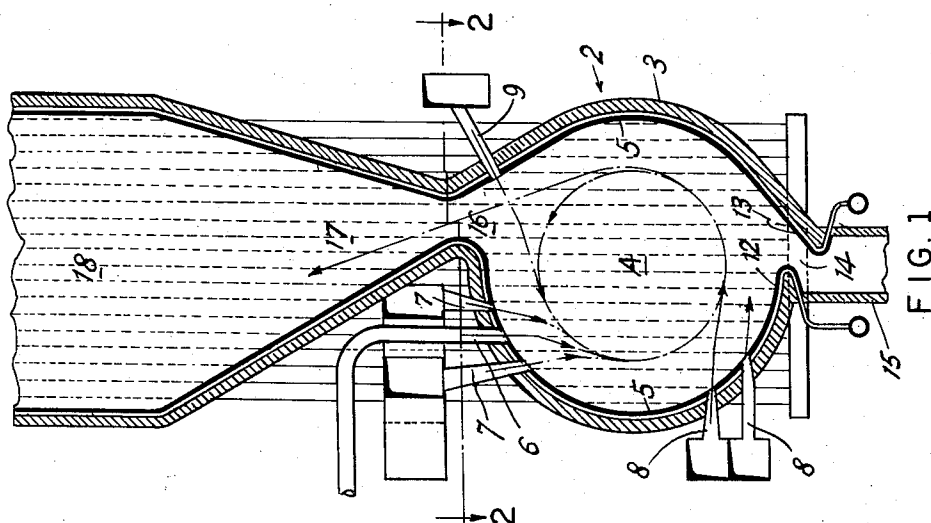


FIG. 1

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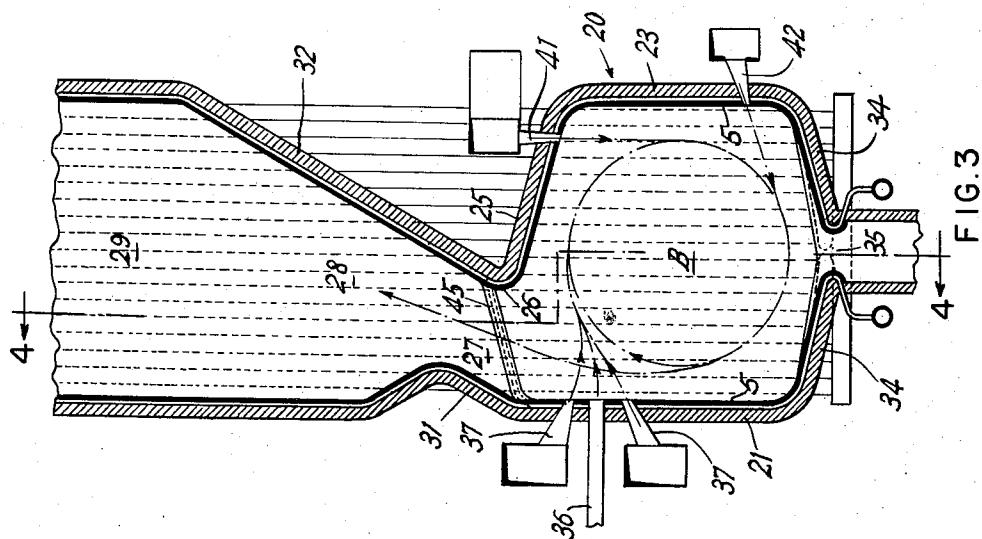


FIG. 3

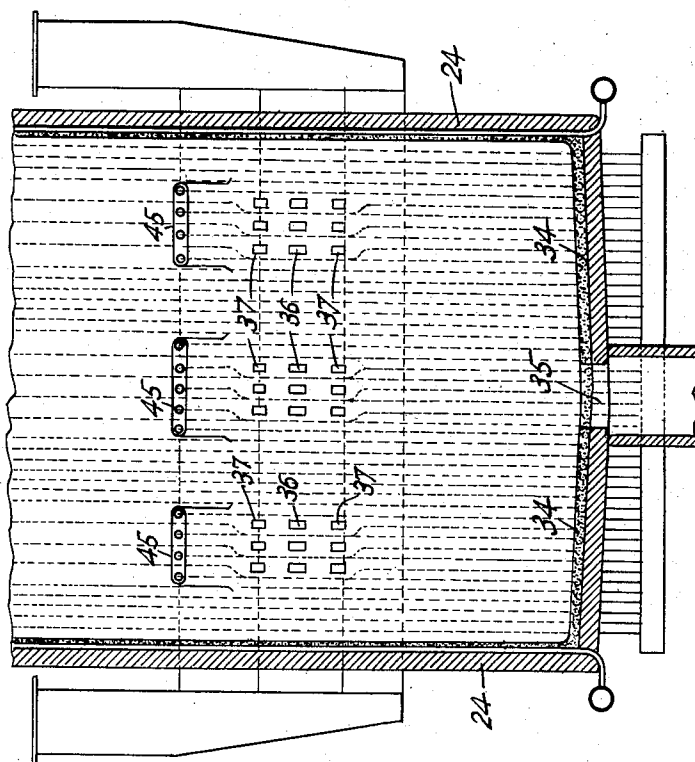


FIG. 4

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FUEL BURNING APPARATUS

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9 Claims. (Cl. 110—28)

The present invention relates to an improved method of and means for burning ash containing solid fuels and more particularly to the construction and operation of a fuel burning furnace adapted for use as the firing means of an associated vapor generating unit. The furnace provides a combustion chamber within which pulverized fuel and air are caused to follow a curvilinear path of generally U-shaped formation throughout the width of the chamber, in contact with the walls of the chamber, with provision for effecting recirculation of fuel and air within the return bend portion of the path. Combustion of the fuel is effected under conditions which result in furnace chamber temperatures above the ash fusing temperature whereby the residual ash is rendered available for removal from the furnace as molten slag. As the combustion proceeds, the slag is discharged from the chamber in liquid form in a downward direction while the hot gaseous products of combustion are discharged from the chamber in an upward direction. The discharging gases are caused to pass through a narrow opening which extends substantially throughout the width of the chamber and then, substantially without change in direction, are caused to flow through a transition passage of progressively increasing cross section directly into the radiant heat absorption chamber of the associated unit.

In pulverized fuel-fired furnaces heretofore known, provision has been made for causing the burning fuel to follow a generally U-shaped path through the combustion space. With such furnaces, the combustion chamber has been arranged either to open directly into the radiation space of an associated vapor generator, or else there has been provided a slag screen formed of tubes between which the gases would reverse their direction of flow before continuing into the radiation space. However, in the operation of such furnaces, the U-shaped flame of the burning fuel-air stream remains slightly spaced from the furnace boundaries because it seeks to enter the combustion chamber outlet over the shortest path. According to the present invention, this is prevented in that the combustion chamber gas outlet is formed as a narrow slot which extends substantially throughout the total width of the combustion chamber. The provision of an outlet of such form and dimensions results in a higher pressure drop into the succeeding radiation chamber than is customary and causes the stream of flaming gases to spread throughout the interior combustion chamber space and thus fill the total cross sectional area of the gas outlet slot. In order to regain the energy expended in effecting a restriction of the discharging gas stream, the body of gases is conducted without substantial change in direction through a widening transition passage into a radiation space. Thus, with a furnace incorporating these features, the combustion chamber may be made as large as may be desired and further a plurality of combustion chambers may be arranged to discharge into a common radiation chamber.

The various features of novelty which characterize my

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invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is a sectional elevational view of a furnace embodying my invention and arranged as the firing means of a vapor generating unit;

Fig. 2 is a sectional plan view of the furnace shown in Fig. 1, taken along line 2—2;

Fig. 3 is a sectional elevational view of a modified vapor generator furnace; and

Fig. 4 is a sectional elevational view of Fig. 3, taken along line 4—4.

In more detail, as shown in Figs. 1 and 2, a combustion chamber A of substantially circular cross section is provided within a furnace 2 of generally circular cylindrical form about a horizontally extending central axis. The circumferential furnace wall 3 and transverse parallel end walls 4, 4 are formed in known manner with fluid conducting tubes 5 which are extended upwardly along adjoining walls of the associated vapor generating section which is located directly above. The tubes 5 may suitably be provided at the furnace side with studs welded thereto, and with a covering layer of heat refractory material, while at the outer side of the tubes a covering layer of heat insulating material may be provided, together with an air tight sheet metal jacket, the details of which known wall components are not illustrated. A fluent mixture of pulverized coal and air is directed into chamber A through nozzles 6, and secondary air through nozzles 7, all of which enter through wall 3 adjacent the uppermost part of the chamber, and furthermore are pointed in such a direction that they produce within the cylindrical chamber A a rotating flame as diagrammatically indicated. As shown herein, each fuel-air nozzle 6 is positioned between two secondary air nozzles 7 in a common transverse vertical plane, with each fuel air nozzle 6 discharging downwardly and vertically, whereas the secondary air nozzles 7 at opposite sides discharge downwardly in converging relation to nozzle 6. The nozzles 6 and 7 are further arranged in longitudinally spaced groups, as seen in Fig. 2.

Tertiary air is directed into chamber A through nozzles 8 which are distributed throughout the width of the chamber in two horizontal rows adjacent the bottom of the chamber, the nozzles 8 extending horizontally and opening into the chamber at an angle of about 90° to the direction in which the primary air-fuel mixture is admitted through nozzles 6. Other nozzles 9 are positioned in the opposite side wall of chamber A so as to provide quaternary air as may be required, the nozzles 9 opening into the chamber at approximately the same elevation as nozzles 6 and discharging in an inclined downward direction so as to conform to the rotational movement of the flame.

The furnace is dimensioned in such a way that at full load, and at the permissible partial loads, the slag in the combustion space A is liquid. Accordingly, at the lowermost part of chamber A, portions 12, 13 of wall 3 at opposite sides of the chamber are spaced apart so as to provide a slag outlet opening or slot 14 extending longitudinally of the chamber, suitably throughout the width thereof between planar end walls 4, 4. The wall portion 12, including portions of tubes 5, conforms to the circular curvature of the chamber wall 3, whereas the wall portion 13 is extended downwardly in tangential relation to the curved portion of wall 3 so as to be overlapped by

the wall portion 12 in the direction of flame rotation, thereby permitting the molten slag to discharge through the opening 14 while the fine fuel particles remained entrained in the whirling fuel-air mixture. The slag outlet slot 14 opens into a shaft 15 through which the slag is discharged below the level of liquid in a trough, not shown, whereby a gas seal is provided.

At the top of chamber A, toward the side opposite the location of fuel-air nozzles 6, there is formed an upper gas outlet 16 which at this particular location, in relation to nozzles 6, permits a portion of the combustion gases to return into the circuit of the whirling body of fuel and air and thereby contribute to the ignition of the fuel. The gas outlet 16, which extends throughout the width of the chamber, is relatively narrow so as to provide sufficient restriction to the discharge of gases therethrough to cause the combustion gases to continuously fill the total interior chamber space A. The gaseous products of combustion pass upwardly through the outlet slot 16 into a transition passage 17 of progressively increasing cross section parallel to end walls 4, 4 whence the gases are directed into the adjoining radiation space 18 from which the gases are further directed into contact with convection heating surfaces, not shown. The walls 3 and 4 of chamber A, together with the tubes therein, are extended upwardly as indicated to form the corresponding fluid cooled walls of the transition passage 17, and the radiation chamber 18, with tubes of the respective walls having lower ends connected to fluid supply headers as shown.

In the modification illustrated in Figs. 3 and 4, the furnace 20 is formed in general as a hollow right prism of substantially equilateral formation providing a combustion chamber B, the furnace having opposing upright side walls 21, 23 arranged at right angles to upright end walls 24, 24, all of which walls include fluid conducting tubes as indicated. The upper furnace wall 25 is inclined upwardly toward the front wall 21 for a distance greater than one-half of the distance between side walls 21, 23 where it is formed with a rounded arch nose portion 26 which, with the front wall 21, defines a relatively narrow rectangular slot 27 through which gases are discharged from the combustion chamber B into a progressively widening transition passage 28, and thence into a radiation chamber 29 of increased rectangular horizontal cross section. The front wall 21 is formed with a reentrant upper portion 31 arranged parallel to the inclined upper rear wall portion 32. The bottom wall is formed with oppositely inclined floor portions 34, 34 converging downwardly in symmetrical arrangement toward a central area in which a slag outlet 35 is formed, spaced from all lateral walls of the chamber. The primary air-fuel streams are directed horizontally past the gas outlet 27 into an upper portion of chamber B through nozzles 36 which are positioned in front wall 21 subjacent the gas outlet. Secondary air is introduced through nozzles 37 which, in the same wall, are arranged at opposite inclinations to the horizontal, above and below nozzles 36, so as to provide air streams directed in converging relation to the primary air-fuel streams. Tertiary air is introduced downwardly through a row of nozzles 41, adjacent the opposite side wall 23, and quaternary air through a row of nozzles 42, all arranged to discharge in the direction of rotational movement of the fuel-air mixture within the chamber, as in the embodiment hereinbefore described. As a means contributing to the maintenance of such rotational movement, the gas outlet slot 27 is traversed at intervals by bridges or tube panels 45 which are formed by groups of alternate wall cooling tubes 5 of opposing wall portions 21 and 32, with refractory material covering the tubes and filling the spaces therebetween. The bridges 45 are desirably inclined across the slot 27 as indicated in Fig. 3 and furthermore are positioned over the respective groups of fuel and air ports 36 and 37 as shown in Fig. 4.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. Apparatus for burning particle-form solid fuel comprising wall means forming an elongated combustion chamber of generally symmetrical transverse cross-section arranged with its longitudinal axis substantially horizontal, said wall means having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing combustion air and particle-form solid fuel in suspension into said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel.

2. Apparatus for burning particle-form solid fuel comprising wall means forming an elongated combustion chamber of generally symmetrical transverse cross-section arranged with its longitudinal axis substantially horizontal, said wall means having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted with said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing combustion air and particle-form solid fuel in suspension into the upper portion of said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel, said last named means including a series of longitudinally spaced fuel inlets disposed at one side of and adjacent to said gas outlet, and additional air inlets arranged to direct air streams into said combustion chamber tangent to said imaginary cylinder

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at positions downstream from said fuel inlets and in directions promoting the whirling motion of the burning fuel-air mixture.

3. Apparatus for burning particle-form solid fuel comprising wall means forming an elongated combustion chamber of generally symmetrical transverse cross-section arranged with its longitudinal axis substantially horizontal, said wall means having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing combustion air and particle-form solid fuel in suspension into the upper portion of said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel, said last named means including a series of longitudinally spaced fuel inlets disposed at one side of and adjacent to said gas outlet, and additional air inlets arranged to direct air streams into said combustion chamber tangent to said imaginary cylinder at positions downstream from said fuel inlets and in directions promoting the whirling motion of the burning fuel-air mixture.

4. Apparatus for burning particle-form solid fuel comprising wall means forming an elongated combustion chamber of generally symmetrical transverse cross-section arranged with its longitudinal axis substantially horizontal, said wall means having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing combustion air and particle-form solid fuel in suspension into the upper portion of said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel, said last named means including a series of longitudinally spaced fuel inlets disposed at one side of and adjacent to said gas outlet, auxiliary air inlets disposed adjacent said fuel inlets and arranged to

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introduce air into the upper portion of said chamber in the same direction as and in impinging relation with the fuel stream, and additional air inlets arranged to direct air streams into said combustion chamber tangent to said imaginary cylinder at positions downstream from said fuel inlets and in directions promoting the whirling motion of the burning fuel-air mixture.

5. In a fluid heating unit, in combination, wall means defining a vertically elongated furnace having an upper radiant chamber and a lower horizontally elongated combustion chamber of generally symmetrical transverse cross-section about its longitudinal axis, the portion of the wall means defining said combustion chamber having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber dividing said furnace into said combustion and radiant chambers, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing a combustion air and particle-form solid fuel in suspension into said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel.

6. In a fluid heating unit, in combination, wall means defining a vertically elongated furnace having an upper radiant chamber and a lower horizontally elongated combustion chamber of generally symmetrical transverse cross-section about its longitudinal axis, the portion of the wall means defining said combustion chamber having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber dividing said furnace into said combustion and radiant chambers, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing combustion air and particle-form solid fuel in suspension into the upper portion of said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel, said last named means including a series of longitudinally spaced fuel inlets disposed at one side of and adjacent to said gas outlet, and addi-

tional air inlets arranged to direct air streams into said combustion chamber tangent to said imaginary cylinder at positions downstream from said fuel inlets and in directions promoting the whirling motion of the burning fuel-air mixture.

7. In a fluid heating unit having a natural circulation fluid circulation system, in combination, wall means defining a vertically elongated furnace having an upper radiant chamber and a lower horizontally elongated combustion chamber of generally symmetrical transverse cross-section about its longitudinal axis, the portion of the wall means defining said combustion chamber having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, said wall means including fluid heating tubes extending uninterruptedly upwardly to conform to the contour of said combustion chamber and said radiant chamber, means connecting said fluid cooled tubes into said fluid circulation system, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber dividing said furnace into said combustion and radiant chambers, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, and means for introducing combustion air and particle-form solid fuel in suspension into said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel.

8. Apparatus for burning particle-form solid fuel comprising wall means forming an elongated combustion chamber of generally symmetrical transverse cross-section arranged with its longitudinal axis substantially horizontal, said wall means having an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, and means for introducing combustion air and particle-form solid fuel in suspension into the upper portion of said combustion chamber tangentially to an imaginary horizontally disposed cylinder in said combustion chamber and

effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber and the slag outlet thereof to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel, said last named means including a series of longitudinally spaced fuel inlets disposed at one side of and adjacent to said gas outlet, said wall means including lower wall portions terminating downwardly at different elevations at opposite sides of said slag outlet, with the terminal wall portion at the higher elevation being disposed upstream with respect to the movement of the burning fuel-air mixture.

9. Apparatus for burning particle-form solid fuel comprising wall means forming an elongated combustion chamber of generally symmetrical transverse cross-section arranged with its longitudinal axis substantially horizontal, said wall means including an inner exposed refractory surface and fluid heating tubes proportioned for the maintenance of said refractory surface under a normal mean temperature in said combustion chamber above the fuel ash fusion temperature, means forming a longitudinally extending greatly restricted slot-like gas outlet in the upper portion of said combustion chamber, said gas outlet being proportioned so that a predominant portion of the radiant heat energy emitted within said combustion chamber will be absorbed therein and that the pressure drop of the gases flowing through said outlet will be sufficient to assure uniform distribution of the gases along the walls of the combustion chamber, means forming a restricted slag outlet in the lower portion of said combustion chamber for the continuous discharge of molten slag, means for introducing combustion and air particle-form solid fuel in suspension into said combustion chamber tangentially to an imaginary horizontally disposed cylinder disposed in said combustion chamber and effecting a whirling path of fuel-air travel therein along and in sweeping relation with substantially the entire inner surfaces of the walls of said combustion chamber to cause continuous discharge of some of the gases through the gas outlet and recirculation of some of the gases in the whirling path to enhance the ignition of the incoming fuel, and means including portions of said fluid heating tubes and refractory material co-operating to define longitudinally spaced tube panels extending across the narrow part of said gas outlet.

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