

[54] **RECIRCULATING DRYER SYSTEM**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. Nos. 25,974, April 6, 1970, Pat. No. 3,598,067, and Ser. No. 56,447, July 20, 1970, and Ser. No. 87,806, Nov. 9, 1970.

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[51] Int. Cl. **F23g 7/00**

[58] Field of Search **110/8 A, 8 R, 15, 18 R**

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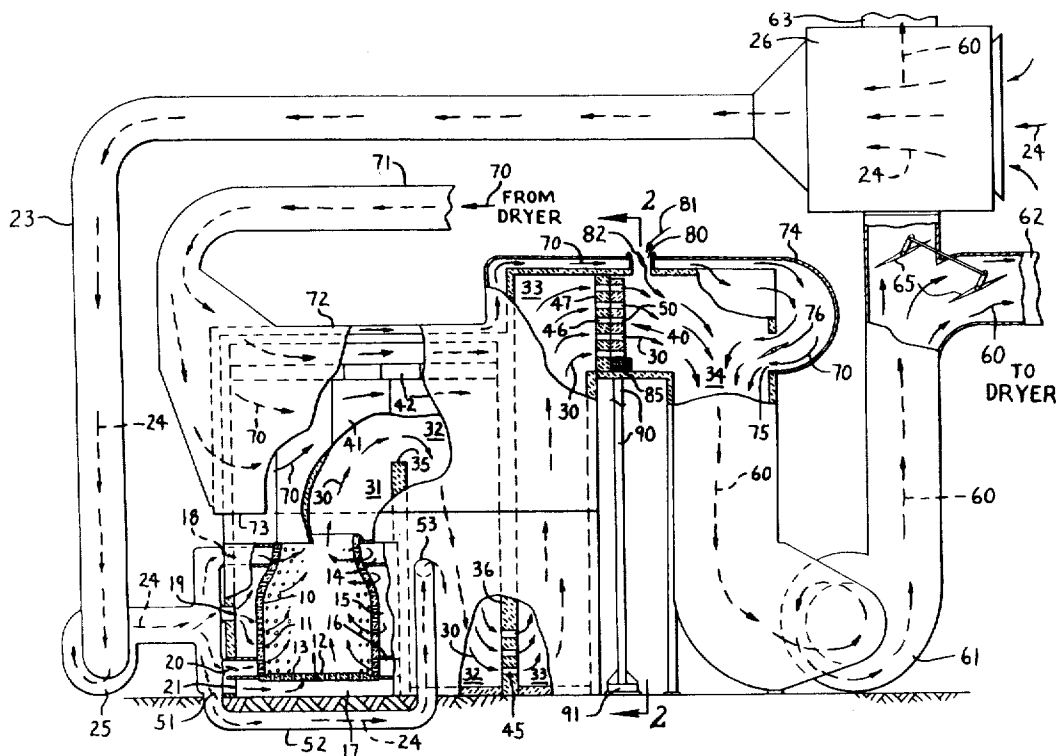
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[57]

ABSTRACT

Combustion gases from a waste wood fired furnace are circulated through a wood veneer dryer or lumber dry kiln and returned to a mixing chamber for exposure to the hot gases leaving the furnace, causing incineration of volatile hydrocarbons and wood fiber picked up by the gas stream in its passage over the veneer or lumber. The only exhaust from the system is located between the outlet from the high temperature mixing chamber and the gas inlet to the dryer. This arrangement insures the incineration of all combustibles before they are vented to atmosphere or returned to the dryer so that no pollutants are discharged into the atmosphere and no potentially explosive substances are passed into the dryer.

13 Claims, 5 Drawing Figures



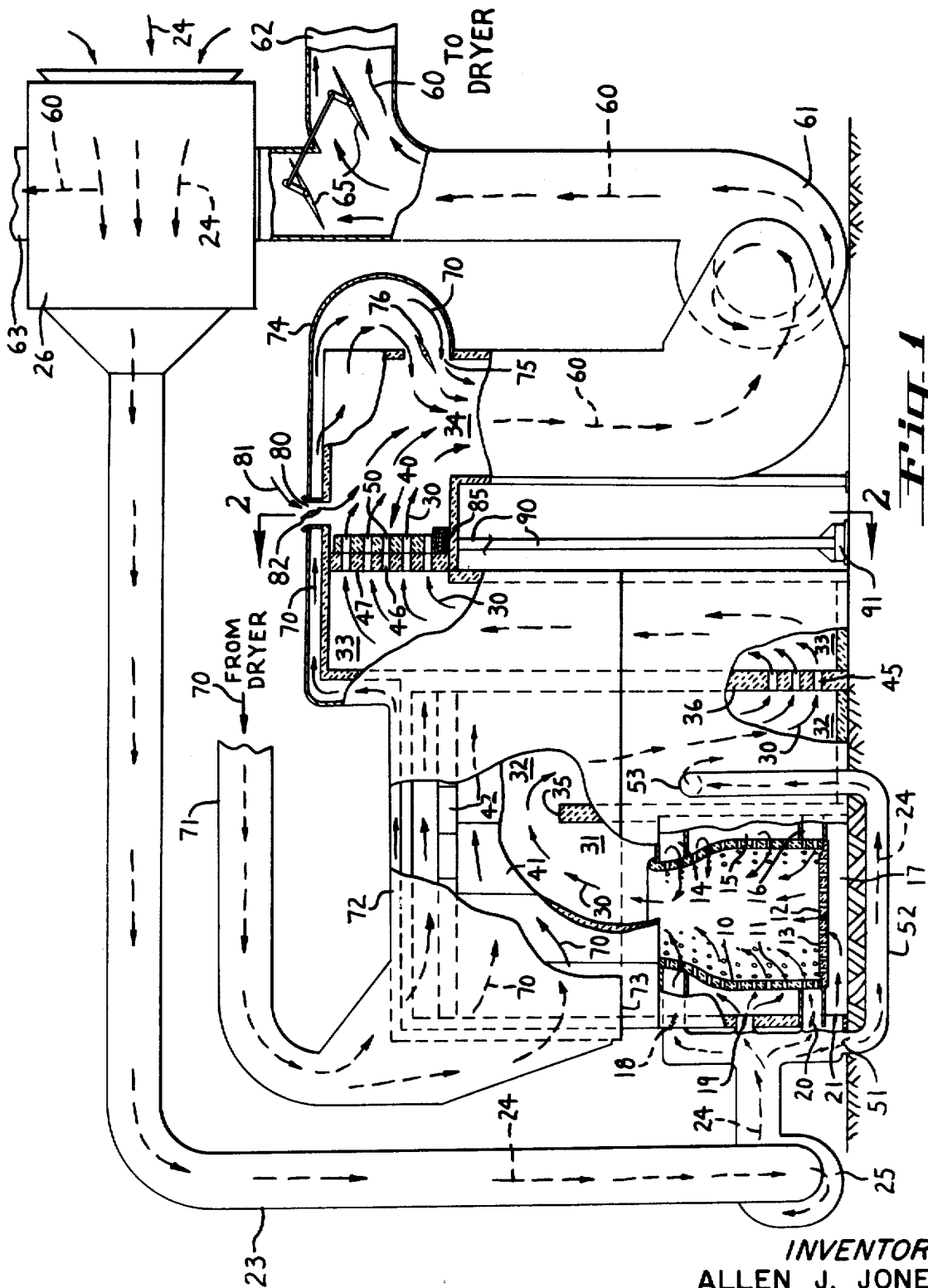
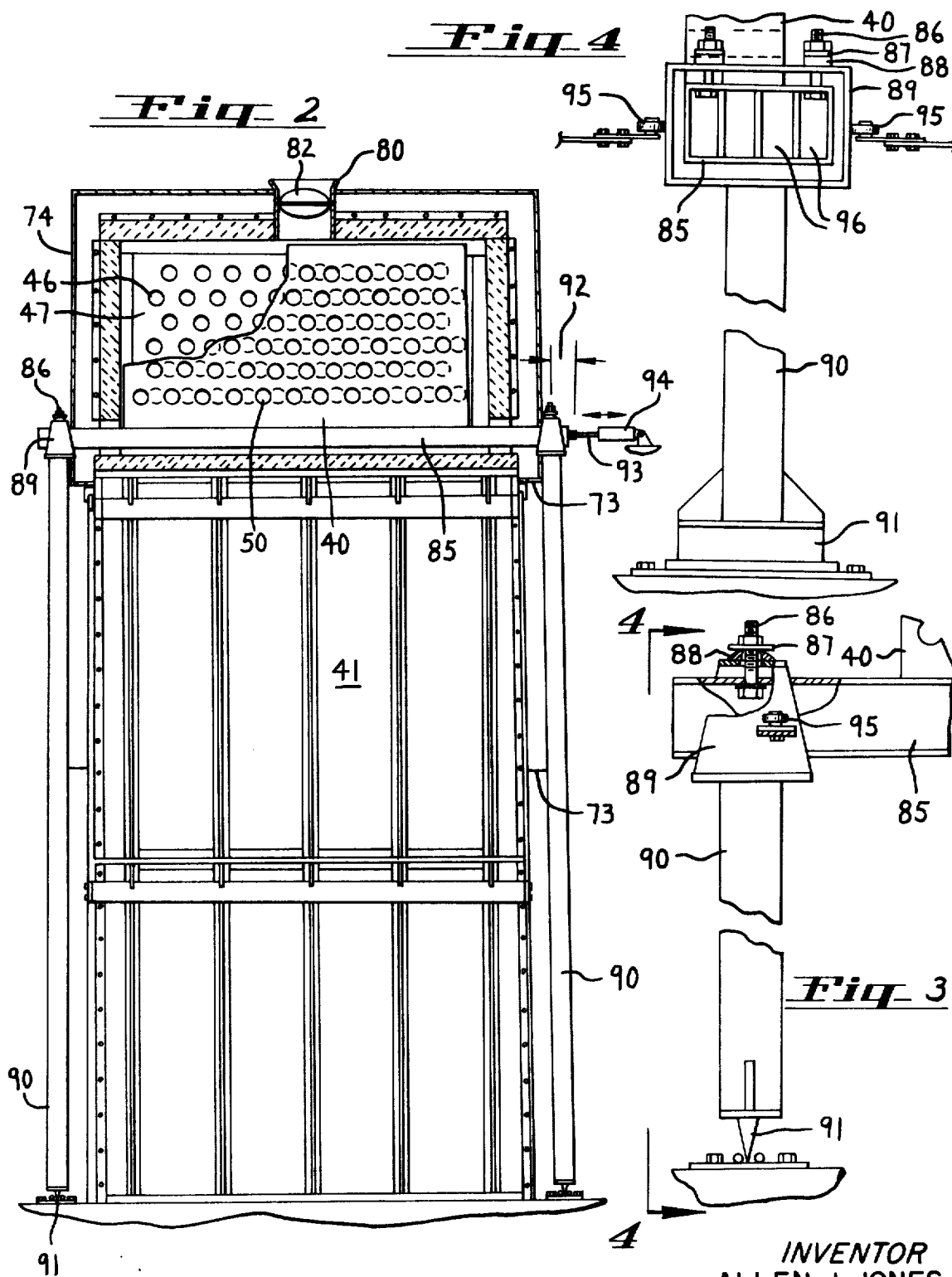


Fig. 1

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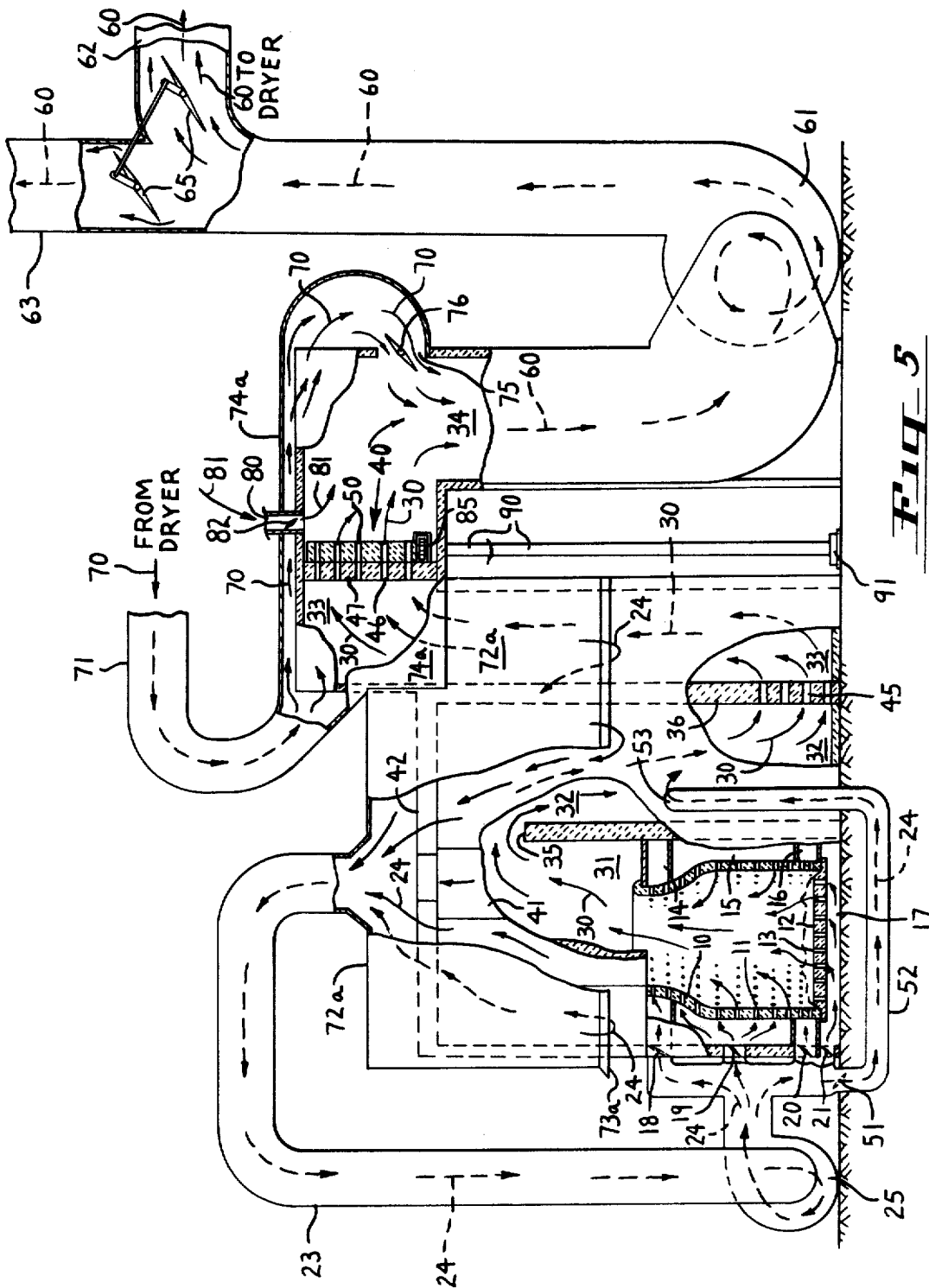


FIG. 5

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RECIRCULATING DRYER SYSTEM

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of my prior copending applications, Ser. No. 25,974 filed Apr. 6, 1970, on DAMPER FOR HIGH TEMPERATURE OR CORROSIVE GASES, now U.S. Pat. No. 3,598,067 issued Aug. 10, 1971; Ser. No. 56,447 filed July 20, 1970, on HANGING WALLS FOR FURNACE, and Ser. No. 87,806 filed Nov. 9, 1970, on ROLL OUT FURNACE GRATE.

BACKGROUND OF THE INVENTION

This invention relates to a recirculating dryer system, particularly for wood veneer dryers and lumber dry kilns.

Veneer dryers operate at a relatively high temperature, causing a distillation of various volatile hydrocarbons from the wood. Some of these hydrocarbons are non-condensable in the sense that they remain in a vapor or gaseous state when cooled down to outside temperature and are invisible when discharged from the veneer dryer. A major portion of the hydrocarbons extracted along with the moisture in the wood, however, are condensable at outside temperatures and create a plume of blue haze above the exhaust stacks. This haze is referred to as veneer dryer emission and constitutes an objectionable pollutant in the atmosphere. The haze consists mainly of coalesced liquid droplets and also includes a small amount of particulates in the form of wood fiber.

Conventional veneer dryers are heated by steam coils or direct fired gas burners. The veneer is carried through the dryer in a plurality of vertically spaced layers, each referred to as a line or deck. In each deck the veneer travels between pairs of upper and lower driven rollers. The heated air is caused to flow in contact with the surfaces of the veneers between the decks. The moisture laden air is discharged to atmosphere through exhaust stacks which may number from one to as many as seventeen, depending on the type of dryer. As the veneer passes through the dryer, the heated air is circulated and recirculated through the dryer by large fans with a portion of the circulated air being vented through the exhaust stacks.

As the green (wet) veneer enters the dryer, it is heated and any surface water is rapidly evaporated. Then, as the veneer is heated further, the water within the sheets begins to move toward the surface. As the water is continuously evaporated from the surface, some of the hydrocarbons which are present in the wood are removed in a process similar to steam distillation. Thus, even though the surface temperature of the veneer may be below the boiling point of the hydrocarbons, they are vaporized from the veneer and released into the air stream. As long as the air is circulating within the dryer at high temperature, the distilled hydrocarbons remain in a gaseous state but, as soon as they are released to the atmosphere, they cool and some of them condense.

In the outside atmosphere, the condensable hydrocarbons form very fine droplets of sub-micron size. The temperature of the air leaving the stack is in the range between 225° to 325° F. or higher. The condensable hydrocarbons condense slightly below 300° F. and coalesce into a viscous, sticky liquid. The fine droplets of this liquid form the blue haze visible emission which is found objectionable.

Also, the non-visible hydrocarbons are photo-chemically reactive and are capable of later producing smog-like conditions. The total emissions of many veneer dryers already exceed allowable amounts permitted in certain smog-prone regions of the United States. Heretofore, no practical way has been found to eliminate this source of pollution.

The elimination of such pollution has presented a serious problem in the industry because the character of the pollutants is not fully understood and because of the cost of installing and operating auxiliary equipment to eliminate the pollutants, particularly in dryers having a plurality of exhaust stacks. It is necessary to significantly reduce or eliminate the pollution in an efficient manner and at low cost because pollu-

tion control equipment does nothing to enhance the value of the product of the dryer. The criteria for conformity to pollution regulations generally relate to the opacity of the emissions and the acceptable limits of hydrocarbons discharged into the atmosphere.

Another problem in the forest products industries, which may also be characterized as a pollution problem, is the disposal of enormous quantities of and waste products such as plywood trim, knots, bark, sawdust and sander dust. Although these various materials are combustible, it has been extremely difficult for the industry to conform to air quality standards governing stack emissions from bark and wood combustion systems.

Objects of the invention are, therefore, to provide a substantially pollution-free dryer system for wood veneer, lumber and other materials, to provide an improved recirculating dryer system, to provide a veneer dryer in which volatile hydrocarbons and wood fiber entrained in the air stream are incinerated, and to provide a furnace for such a dryer system capable of utilizing various forms of waste wood products.

SUMMARY OF THE INVENTION

In the present dryer system the source of heat is a specially constructed furnace for utilizing the various wood waste materials mentioned hereinabove. A preheated forced draft source of primary air permits the use of damp or even wet fuel. The combustion gases are drawn through a mixing chamber by a fan which then circulates the hot gases through the dryer. No gas, water vapor or emissions are discharged directly from the dryer; they are returned to the mixing chamber where the hydrocarbons and wood fiber picked up from the veneer are incinerated in the hot combustion gases leaving the furnace.

The only discharge point in the system is on the pressure side of the fan following the incineration step just described. A portion of the incinerated gas flow leaving the fan is discharged to atmosphere and the rest is circulated through the dryer as above mentioned. The gases circulated through the dryer are partly combustion gases directly from the furnace and partly recirculated and incinerated gases returned from a previous circulation through the dryer.

The invention will be better understood and additional objects and advantages will become apparent from the following description of the preferred embodiments illustrated in the accompanying drawings. Various changes may be made in the details of construction and arrangement of parts and certain features may be used without others. All such modifications within the scope of the appended claims are included in the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view, with parts broken away, showing a first embodiment of recirculating dryer system incorporating the principles of the invention;

FIG. 2 is a view on the line 2—2 in FIG. 1, with parts broken away;

FIG. 3 is an enlarged view of a portion of FIG. 2 with parts broken away;

FIG. 4 is a view on the line 4—4 in FIG. 3; and

FIG. 5 is a view similar to FIG. 1 showing a modification.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, a fuel cell 10 having refractory walls is arranged to receive solid fuel from suitable feed means, not shown. This fuel cell is designed to burn waste wood products such as plywood trim, knots, bark, sawdust and sander dust which may be either wet or dry or mixed wet and dry. In order to burn wet fuel, the wall of the fuel cell is provided with tuyeres 11 and the grate 12 is provided with openings 13 to admit preheated primary air. Grate 12 is preferably a water cooled, roll out grate for convenient cleaning and repair as disclosed in my application Ser. No. 87,806.

In order to control the combustion in the fuel cell, the preheated primary air is supplied to tuyeres 11 and grate openings 13 from a plurality of air pressure chambers 14, 15, 16 and 17 under the control of dampers 18, 19, 20 and 21. This primary air supply indicated by arrows 24 in duct 23 is blown into these chambers by primary air fan 25, the air being heated in a heat exchanger 26 as will presently be explained.

The hot combustion gases 30 generated by the fuel in fuel cell 10 pass through a primary combustion chamber 31, a secondary combustion chamber 32, a tertiary combustion chamber 33 and a mixing and incinerating chamber 34. Chambers 31, 32 and 33 may also be regarded as a single reflex chamber having primary, secondary and tertiary combustion zones therein. Chambers 31 and 32 are separated by a vertical wall 35 and chambers 32 and 33 are separated by a vertical wall 36. Mixing and incinerating chamber 34 is separated from tertiary combustion chamber 33 by a refractory damper 40 which is a modification of the damper shown in my prior application Ser. No. 25,974. The outside walls 41 of combustion chambers 31, 32 and 33 preferably comprise refractory panels as disclosed in my application Ser. No. 56,447. The construction of the roof 42 of chambers 31 and 32 is also illustrated in the last mentioned prior application.

The top of wall 35 is spaced below roof 42, allowing a stream of combustion gases 30 to pass over the top of this wall from primary combustion chamber 31 into the top of secondary combustion chamber 32. These gases pass downward through secondary combustion chamber 32 and flow through openings 45 in a lower portion of wall 36 to enter the bottom of tertiary combustion chamber 33. The combustion gases 30 pass upward through chamber 33 and leave through openings 46 in a refractory panel 47 at the top of chamber 33.

This additional travel through chamber 33 allows time for the efficient combustion of burning cinders which are carried along in the gas stream and may not be completely burned in the primary and secondary combustion chambers. The flow through openings 46 is controlled by movements of the damper 40 which has openings 50 movable into and out of registry with the openings 46.

In order to assist in the thorough combustion of all combustible substances in chambers 32 and 33, the former is supplied with additional preheated primary air 24 controlled by a damper 51 in a duct 52 supplied by primary air fan 25. Duct 52 discharges into secondary combustion chamber 32 at 53.

Mixing and incinerating chamber 34 forms part of an inlet duct conveying a mixed flow of gases 60 to induced draft fan 61. The suction of this fan and the throttling effect of damper 40 produce the lowest pressure in the system in chamber 34 which thus becomes a suction chamber at a pressure below atmospheric pressure.

Duct 62 conveys a major portion of the discharge from fan 61 to the dryer, a minor portion of the fan discharge passing through heat exchanger 26 and being discharged to atmosphere through exhaust stack 63. The ratio of the two flows is controlled by a pair of interconnected dampers 65. The portion of gas stream 60 passing through heat exchanger 26 provides the heat source for preheating the primary combustion air 24. Air 24 and gas stream 60 are conducted through separate passageways in the heat exchanger so that there is no intermixing of gas stream 60 with the incoming air 24.

There are no exhaust stacks in the dryer (not shown). Except for unavoidable leakage, the whole amount of gas stream 60 supplied to the dryer, plus volatile hydrocarbons distilled from the wood and airborne wood fibers released from the wood, are returned from the dryer in a gas stream 70 through return flow conduit 71. This return flow of gases and particulate matter, which is maintained at a temperature above the condensation point of the condensable hydrocarbons distilled from the wood in the dryer, is heated to a higher temperature by passage through a shroud or jacket 72 surrounding the walls 41 and ceiling 42 of the combustion chambers of the furnace.

Either stationary baffles or adjustable damper-type baffles may be provided in jacket 72 for directing the air flow over the walls 41 and ceiling 42 in a uniform flow pattern to avoid hot and cold spots in different areas.

Jacket 72 extends down to a lower end 73 which is closed to confine the flow of gases 70 in heat exchange relation to the walls of the combustion chambers. An extension 74 of the jacket 72 surrounds the upper portion of incinerating chamber 34 and directs the return flow of gases 70 into the incinerating chamber through a port 75 controlled by a damper 76. Thus, hydrocarbons and wood fibers released from the wood in the dryer are incinerated in chamber 34 upon contact with the hot furnace gases 30. Thorough incineration is promoted by an inlet opening 80 which admits a stream of outside air 81 under the control of damper 82.

The adjustment of damper 82 is coordinated with the adjustments of dampers 76 and 65 to control the pressure and temperature in chamber 34 and dryer duct 62. The stream of combustion gases 30 is too hot to be fed directly into the dryer and the air inflow 81 dilutes and cools these gases as well as supplying the oxygen necessary for incineration. Notwithstanding the diluting and cooling effect of air 81, the temperature in chamber 34 remains high enough to perform its incinerating function. The preheating of return gases 70 in jacket 72, 74 reduces the cooling of the incinerating chamber by these gases. Since stack 63 is the only point of discharge for water vapor from the dryer, and carbon dioxide from the furnace and incinerating chamber 34, these components of the gas stream also affect the regulation of the dampers.

A portion of the return flow 70 from the dryer may be diverted into the primary combustion air 24 on the intake side of fan 25, if desired, thereby causing the distilled hydrocarbons from the dryer to pass through the combustion chambers of the furnace.

The construction of damper 40 is illustrated in FIGS. 2 to 4. The movable damper is cast as a perforate block of refractory material which is supported on edge on a horizontal beam 85. Each end of beam 85 is supported by a pair of pivot bolts 86, each having a washer 87 resting on an arcuate bearing plate 88 on a yoke 89. Each yoke 89 is mounted on the upper end of a column 90 having a pivotal knife-edge support 91 at its lower end.

This provides an inverted pendulum support which may be shifted laterally through a small range of movement as indicated at 92 to move the openings 50 in damper 40 into and out of register with the openings 46 in stationary refractory panel 47. Modulating movement is produced by a piston rod 93 in a fluid pressure control cylinder 94. The damper is stabilized in the direction of air flow by pairs of rollers 95 engaging opposite side faces of the yokes 89. The ends of beam 85 extend out of opposite sides of the furnace for the application of air or water cooling means to passageways 96 in the beam.

In lieu of the heat exchanger 26 in FIG. 1, the primary combustion air 24 may be preheated by a modified form of shroud or jacket 72a as shown in FIG. 5. In this arrangement the lower edge 73a of the jacket is open and spaced away from the combustion chamber walls 41 to provide an updraft air intake opening for the primary air 24. The primary air is heated in passing over the hot walls 41 and ceiling 42.

The slot-like inlet opening 73a may be equipped with a series of dampers, referred to as segmental dampers, and stationary baffles may be provided within jacket 72a, to control the pattern of air flow over walls 41 and ceiling 42 so as to prevent hot spots.

In FIG. 5 the jacket 72a is separate and independent from the jacket 74a. Jacket 74a then heats the return gas flow 70 from the dryer by passing this gas flow across the top and around the upper side walls of tertiary combustion chamber 33 and incinerating chamber 34 independently of the jacket 72a.

In this FIG. 5 modification there is somewhat more loss of heat from the system by discharging the stack gases at a higher temperature but there is the advantage of saving the first cost

and maintenance of the rather expensive separate heat exchanger 26 in FIG. 1. In installations where wood waste products may be obtained for fuel at very little cost, the saving in the cost of equipment may outweigh the loss resulting from a lower thermal efficiency.

Having now described my invention and in what manner the same may be used, what I claim as new and desire to protect by Letters Patent is:

1. A recirculating dryer system comprising a furnace having a combustion chamber, a first fan supplying primary air from outside atmosphere to said combustion chamber, a second fan having an inlet duct receiving hot combustion gases from said combustion chamber and having a discharge duct conveying said combustion gases to a dryer, a return duct conveying said combustion gases out of said dryer together with combustible substances from material being dried in said dryer, said return duct discharging into said hot combustion gases on the inlet side of said second fan causing said combustible substances from the material being dried to be incinerated, and an exhaust stack branching from said discharge duct to vent a portion of the gases in said discharge duct to atmosphere.

2. A system as defined in claim 1 including heat exchange means arranged to heat said gases and combustible substances from said return duct before they are discharged into said hot combustion gases.

3. A system as defined in claim 2, said heat exchange means comprising a jacket around at least a portion of said combustion chamber and said inlet duct to said second fan.

4. A system as defined in claim 1 including heat exchange means for heating said primary air.

5. A system as defined in claim 4, said heat exchange means comprising a heat exchanger in said exhaust stack.

6. A system as defined in claim 4, said heat exchange means comprising a jacket around a portion of said combustion chamber.

7. A system as defined in claim 1 including a damper between said combustion chamber and said inlet duct for said second fan, said return duct from the dryer discharging into said inlet duct for said second fan on the downstream side of said damper.

8. A system as defined in claim 1, said combustion chamber

having walls causing said combustion gases to flow first upward, then downward, then again upward, and a refractory damper in elevated position at the top of said last upward flow of the gases.

9. A system as defined in claim 8 including an inverted pendulum support for said damper.

10. A system as defined in claim 9, said support comprising a horizontal beam supporting the damper, and a pair of columns at opposite ends of said beam pivotally supported at their lower ends for horizontal movement of the damper in the vertical plane of said beam and columns.

11. A recirculating dryer system comprising a furnace having a combustion chamber, a first fan supplying primary air from outside atmosphere to said combustion chamber, an outlet for said combustion chamber controlled by a damper, a second fan, an incinerating chamber between said damper and the inlet to said second fan, said second fan drawing combustion gases from said combustion chamber through said damper and incinerating chamber and discharging said gases through a discharge duct to a dryer, a return duct from the dryer conveying said combustion gases out of the dryer together with combustible substances from material being dried in the dryer, said return duct discharging into said incinerating chamber causing said combustible substances to be incinerated, and an exhaust stack venting a portion of the gas flow in said discharge duct to atmosphere.

12. A system as defined in claim 11, said furnace being a cell type furnace with tuyeres in the cell wall and openings in the furnace grate admitting said primary air from said first fan, heat exchange means utilizing heat in said combustion gases to preheat said primary air, and heat exchange means utilizing heat in said combustion gases to heat said return flow of gases from the dryer to said incinerating chamber.

13. A system as defined in claim 12, said combustion chamber being under pressure from said first fan and said incinerating chamber being under suction from said second fan, a duct conveying a portion of said preheated primary air from said first fan to said combustion chamber, and an opening admitting air from the outside atmosphere into said incinerating chamber.

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