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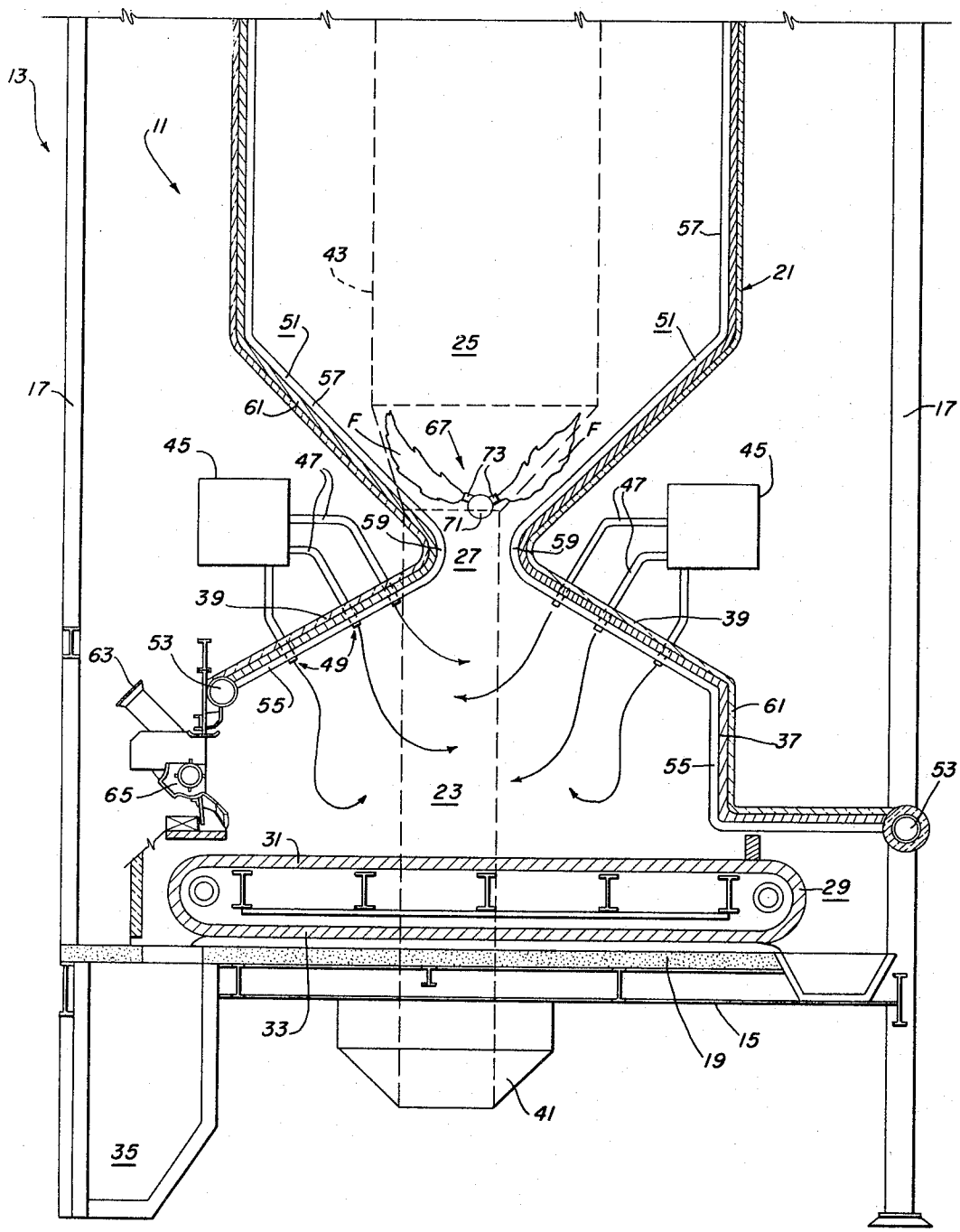

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BOILER APPARATUS FOR COMPLETE COMBUSTION OF FUEL

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This invention relates to water-tube boilers and particularly to steam-generating boilers utilizing wood or vegetable waste material as the primary source of fuel; the invention is particularly suitable for effecting combustion of moisture-laden materials such as wood bark waste material of pulp and paper mills.

In waste fuel boilers, problems are encountered in exhausting carbon particles into the atmosphere with the exhaust stack gases. Dwell time within present type furnaces is too short to provide complete combustion of the carbon cinders, and concentration of flame or heat is not adequate to promote complete burning of the fuel. Present-day designs generally consist of a rectangular furnace chamber with bark or waste fuel introduced by either mechanical spreaders or by air flow conveyance into the furnace. Some waste fuel boilers utilize a so-called arch or nose baffle high in the furnace to slow down the passage of gases through the boiler. The bark fuel is generally burned on a traveling grate or partly in suspension above the grate through employment of tangential air nozzles. A problem encountered in such furnaces is that the high moisture bearing waste fuel does not remain in the combustion zone of the furnace for sufficient length of time to drive out the moisture in the fuel and for the flames to consume all the carbon. The unburned carbon particles are conveyed with the exhaust gases through the smoke stack and into the atmosphere thereby creating air pollution problems. To reduce atmosphere pollution, the general practice is to install some form of collector to collect or re-circulate the carbon particles through the furnace. In order to absorb as much heat from the fuel as possible, prior furnace constructions utilized baffle means to cause the exhaust gases to pass several times past the water-tubes; such furnace constructions generally present cleaning problems, and it is necessary to clean the furnace frequency for it to perform efficiently.

The general object of the present invention is to provide apparatus in a water-tube type boiler for obtaining complete combustion of the fuel, thereby to provide means for more efficient operation of the boiler and to reduce air pollution from unburned exhaust particles.

A further object is to provide a boiler having a lower combustion chamber and an upper combustion chamber and a substantially short, narrow passageway interconnecting the lower and upper chambers and such boiler means in which substantially 50% of the steam-making capacity from waste fuels is in the lower chamber and substantially 50% of the steam-making capacity from waste fuels is in the upper chamber.

A further object is to provide in the boiler apparatus, means for retarding the passage of combustion gases without utilizing baffles or other such means, thereby providing a boiler of clear air passage design and a boiler requiring minimum soot-cleaning maintenance.

A further object is to provide in the boiler apparatus of the present invention, means for retarding the passage of combustion gases and allowing more dwell time for the complete combustion of the wood waste fuel.

A further object is to provide in said lower combustion chamber of the boiler apparatus, an upward flow of primary air and a downward flow of secondary air for causing turbulent air conditions in said lower chamber and for effecting complete fuel combustion.

A further object is to provide water-bearing steam-making tube means arranged respectively along the inward side of the wall means defining the upper and lower combustion chambers and the throat passageway.

A further object is to provide such steam-making tubes in the lower chamber for absorbing radiant heat generated by the waste fuel material.

A further object in the apparatus of the present invention is to provide auxiliary combustion means including fuel burner means arranged directly above the throat passageway and such combustion means for further completing combustion of the waste fuel material.

The means by which the foregoing and other objects of the present invention are accomplished and the manner of their accomplishment will be readily understood with reference to the accompanying drawing which illustrates somewhat schematically the boiler apparatus of the present invention.

In the drawing the boiler apparatus is indicated generally by numeral **11** and comprises the basic structure of a steam-generating plant indicated by numeral **13** and only partially shown.

Steam-generating plant **13** typically includes framework and boiler mounting support structure including horizontal frame members **15**, vertical frame members **17** and floor structure **19**. Also preferably included in steam plant **13**, although not shown, are the usual auxiliary components including boiler water feed and control means, economizer and air heater means, and steam super-heater means.

The base structure of boiler apparatus **11** comprises large upstanding housing means indicated by numeral **21** including lower wall means, upper wall means, and intermediate wall means defining respectively lower combustion chamber **23**, upper combustion chamber **25**, and a short, narrow passageway **27** interconnecting lower and upper chambers **23**, **25**.

Boiler housing means **21** is supported by horizontal and vertical framework members **15**, **17** and floor **19**. An endless chain traveling grate assembly **29** arranged across the bottom of lower combustion chamber **23** receives and supports the wood waste fuel during combustion. Traveling grate **29** is adapted to move in a counterclockwise direction as viewed in the drawing and includes an upper span **31** and a lower span **33**. In operation, ash residue from the burned wood waste fuel is carried horizontally by upper span **31** of grate **29** (to the left as viewed in the drawing) and the ash residue falls into ash trough **35**.

It will be understood that the horizontal area proportions of upstanding boiler housing **21** may be substantially in various shapes; the upper and lower chambers can be round, square or rectangular in horizontal area without departing from the concept of the invention. A basic concept of the invention, however, is the substantially low, broad shape of the lower chamber, the gradual slope of the top wall thereof, and the relatively narrow throat passageway as compared with the broad lower chamber.

The lower wall means defining lower combustion chamber **23** comprises vertically directed side wall means **37** and horizontally directed sloping top wall means **39**.

The interior of lower chamber **23** is such that the interspatial extension between side wall means **37** is substantially greater than the interspatial vertical extension between top wall means **39** and traveling grate **29**. Top wall means **39** converge upwardly and intersect the intermediate wall means defining passageway **27**. Thus, top wall means **39** slope slightly upwardly from side wall means **37** and define respectively angles of less than 40° relative to the horizontal.

Primary air supply means including conduit **41** provides the main air supply means for the wood waste fuel. The primary air passes through the air heater (not shown), passes downwardly through down draft conduit **43**, horizontally through conduit means **41**, and upwardly through grate **29**.

The secondary air supply passes through main conduit means **45** and through a plurality of branch conduit means **47**. The secondary air preferably passes through the air heater, through conduit means **45**, branch conduits **47** and downwardly into lower chamber **23**. The downwardly directed air outlets **49** of conduit **47** are disposed respectively along the underside of top wall means **39**. Secondary air issuing from outlets **49** provide a plurality of downwardly directed currents of air in the lower chamber (indicated by arrows). The downward secondary currents of air intermix with the upward flow of primary air and cause turbulent air conditions in the lower chamber.

A multiplicity of vertically extending steam-making water tubes **51** are arranged around the interior wall surfaces of housing means **21**. Water tubes **51** are arranged in closely-spaced parallel configuration and extend upwardly respectively from header conduit means **53**. Although only two tubes **51** are illustrated in the drawing, it will be understood that the upwardly extending tubes are preferably arranged substantially around the entire interior periphery of housing means **21**. Each tube **51** preferably includes a lower portion **55**, an upper portion **57** and intermediate portion **59** arranged respectively along the interior wall surfaces of lower chamber **23**, upper chamber **25**, and passageway **27**. Insulating material **61** is provided around the outside of the wall means defining housing **21**.

A pneumatic conveyor conduit **63** and a mechanical spreader mechanism **65** of known construction provide means for conveying and dispensing the wood waste fuel on grate **29**.

Auxiliary combustion means is provided for further completing the combustion of the wood waste fuel and is indicated generally by numeral **67**. The fuel for auxiliary combustion means **67** may be solid, liquid or gas high energy fuel; however, natural gas fuel is preferably used and dispensed through fuel burner **71**. The fuel burner is preferably arranged directly over passageway **27** and in the lower part of upper combustion chamber **25**. Fuel emitting from nozzles **73** burn in flames (indicated F) which preferably sweep upwardly and outwardly along the wall means defining upper chamber **25**.

Although steam-making tubes **51** have been illustrated as being arranged in the upper and lower combustion chambers and in passageway **27**, it will be understood that in certain boiler installations it may be desirable to vary the water tube arrangement. The radiant heat zone of the burning wood waste fuel, however, is substantially in the lower combustion chamber. Therefore, in most boiler installations it is desirable to employ tubes arranged laterally and upwardly in the lower combustion chamber to absorb as much heat from the waste fuel as is feasible.

In operation, the bulk of wood waste fuel burning in the lower chamber is held in a semi-suspended condition over grate **29**. The upwardly moving flow of primary air through the grate and the downward current of secondary air causes considerable turbulence in the lower chamber. The secondary air issuing from outlets **49** substantially retard the passage of gases and cinders through passageway **27**. Unburned carbon particles or cinders passing through passageway **27** enter the auxiliary combustion zone. The flames from the fuel emitting from burner nozzles **73** further complete the oxidation or burning of the waste fuel residue.

The boiler apparatus of the present invention provides means for maximum utilization of heat given off by the wood waste fuel; steam-making tubes arranged in the lower combustion chamber absorb a great amount of the radiant heat given off by the waste material fuel. The downwardly directed currents of secondary air retard the passage of burned gases from the lower combustion chamber and provide more time for effecting complete combustion of the fuel. The auxiliary combustion means arranged in the lower part of the upper combustion chamber substantially complete the burning of unburned carbon particles and further provides additional heat for making steam. The combustion gases passing upwardly through the auxiliary combustion means is substantially free of unburned carbon particles; the furnace construction substantially eliminates the necessity of dust or unburned-carbon-particle arrestors or collectors. Atmospheric pollution is reduced substantially. In summary, the present invention provides a very practical and efficient boiler construction.

Although the present invention has been described with reference to a preferred embodiment, it is not to be so limited since changes and modifications may be made therein which are within the full intended scope of this invention as hereinafter claimed.

I claim:

1. In a steam-generating boiler utilizing wood waste material fuel, the apparatus for obtaining complete combustion of the wood waste fuel comprising lower wall means, upper wall means, and intermediate wall means defining respectively a lower chamber, an upper chamber, and a substantially short, narrow throat passageway interconnecting said lower and said upper chambers; grate structure arranged across the bottom of said lower chamber for receiving said wood waste fuel; said lower wall means including vertically directed side wall means and substantially horizontally directed top wall means defining substantially the side and top bounds of said lower chamber; the interspatial horizontal extension of said lower chamber being substantially greater than the interspatial vertical extension of said lower chamber; primary air supply means including conduit means for directing an upward flow of air through said grate structure and for combustion of said waste fuel material; secondary air supply means including conduit means having a plurality of downwardly directed air outlets disposed respectively along the underside of said top wall means for causing a plurality of downwardly directed currents of air; water-bearing tube means arranged along the underside of said top wall means for absorbing heat from said waste fuel material and for generating steam; and auxiliary combustion means including fuel burner means arranged substantially directly above said throat passageway and disposed in the lower portion of said upper chamber for burning a high-energy fuel other than the wood waste material fuel and for further combustion of said waste fuel material.

2. In a steam generating boiler utilizing wood waste material fuel, the apparatus for obtaining complete combustion of the wood waste fuel comprising lower wall means, upper wall means, and intermediate wall means defining respectively a lower chamber, an upper chamber and a substantially short, narrow throat passageway interconnecting said lower and said upper chambers; means in said lower chamber for receiving the wood waste fuel, said lower wall means including vertically directed side wall means and substantially horizontally directed top wall means defining substantially the side and top bounds of said lower chamber; said top wall means sloping slightly upwardly from said side wall means at an acute angle of substantially less than 40° relative to the horizontal; primary air supply means including conduit means for directing an upward flow of air into said lower chamber and for combustion of said waste fuel material; secondary air supply means including conduit means having a plurality of downwardly directed air outlets disposed substantially along the underside of said top wall for causing a plurality of downwardly directed currents of air; water-bearing tube means disposed along the underside of said top wall

means for absorbing heat from the waste fuel material and for generating steam; and auxiliary combustion means including fuel burner means arranged substantially directly over said throat passageway and in the deep lower portion of said upper chamber for burning a liquid or gaseous fuel and for further completing combustion of said waste fuel material.

3. In a steam generating boiler utilizing wood waste material fuel, the apparatus for obtaining complete combustion of the wood waste fuel comprising lower wall means, upper wall means, and intermediate wall means defining respectively a lower chamber, an upper chamber and a substantially short, narrow throat passageway interconnecting said lower and said upper chambers; means in said lower chamber for receiving the wood waste fuel, said lower wall means including vertically directed side wall means and substantially horizontally directed top wall means defining substantially the side and top bounds of said lower chamber; said top wall means sloping slightly upwardly from said side wall means at an acute angle of substantially less than 40° relative to the horizontal; primary air supply means including conduit means for directing an upward flow of air into said lower chamber and for combustion of said waste fuel material; secondary air supply means including conduit means having a plurality of downwardly directed air outlets disposed substantially along the underside of said top wall for causing a plurality of downwardly directed currents of air; water-bearing tube means disposed along the underside of said top wall means for absorbing heat from the waste fuel material and for generating steam; auxiliary combustion means including fuel burner means arranged substantially directly over said throat passageway and in the deep lower portion of said upper chamber for burning a liquid or gaseous fuel and for further completing combustion of said waste fuel material; and water-bearing tube means arranged in the interior of said intermediate wall means and along the periphery of said throat passageway for additionally absorbing heat from said wood waste fuel material.

4. In a steam generating boiler utilizing wood waste material fuel, the apparatus for obtaining complete combustion of the wood waste fuel comprising lower wall means, upper wall means, and intermediate wall means defining respectively a lower chamber, an upper chamber and a substantially short, narrow throat passageway interconnecting said lower and said upper chambers; means in said lower chamber for receiving the wood waste fuel, said lower wall means including vertically directed side wall means and substantially horizontally directed top wall means defining substantially the side and top bounds of said lower chamber; said top wall means sloping slightly upwardly from said side wall means at an acute angle of substantially less than 40° relative to the horizontal; primary air supply means including conduit means for directing an upward flow of air into said lower chamber and for combustion of said waste fuel material; secondary air supply means including conduit means having a plurality of downwardly directed air outlets disposed substantially along the underside of said top wall for causing a plurality of downwardly directed currents of air; water-bearing tube means disposed along the underside of said top wall means for absorbing heat from the waste fuel material and for generating steam; auxiliary combustion means including fuel burner means arranged substantially directly over said throat passageway and in the deep lower portion of said upper chamber for burning a liquid or gaseous fuel and for further completing combustion of said waste fuel material; and water-bearing tube means arranged in the interior of said upper wall means and along the periphery of said upper chamber for absorbing heat from said waste fuel material and from said auxiliary combustion means.

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