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OPEN PASS VAPOR GENERATING AND SUPERHEATING UNIT WITH GAS RECIRCULATION TO OPEN PASS

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Fig. 1.

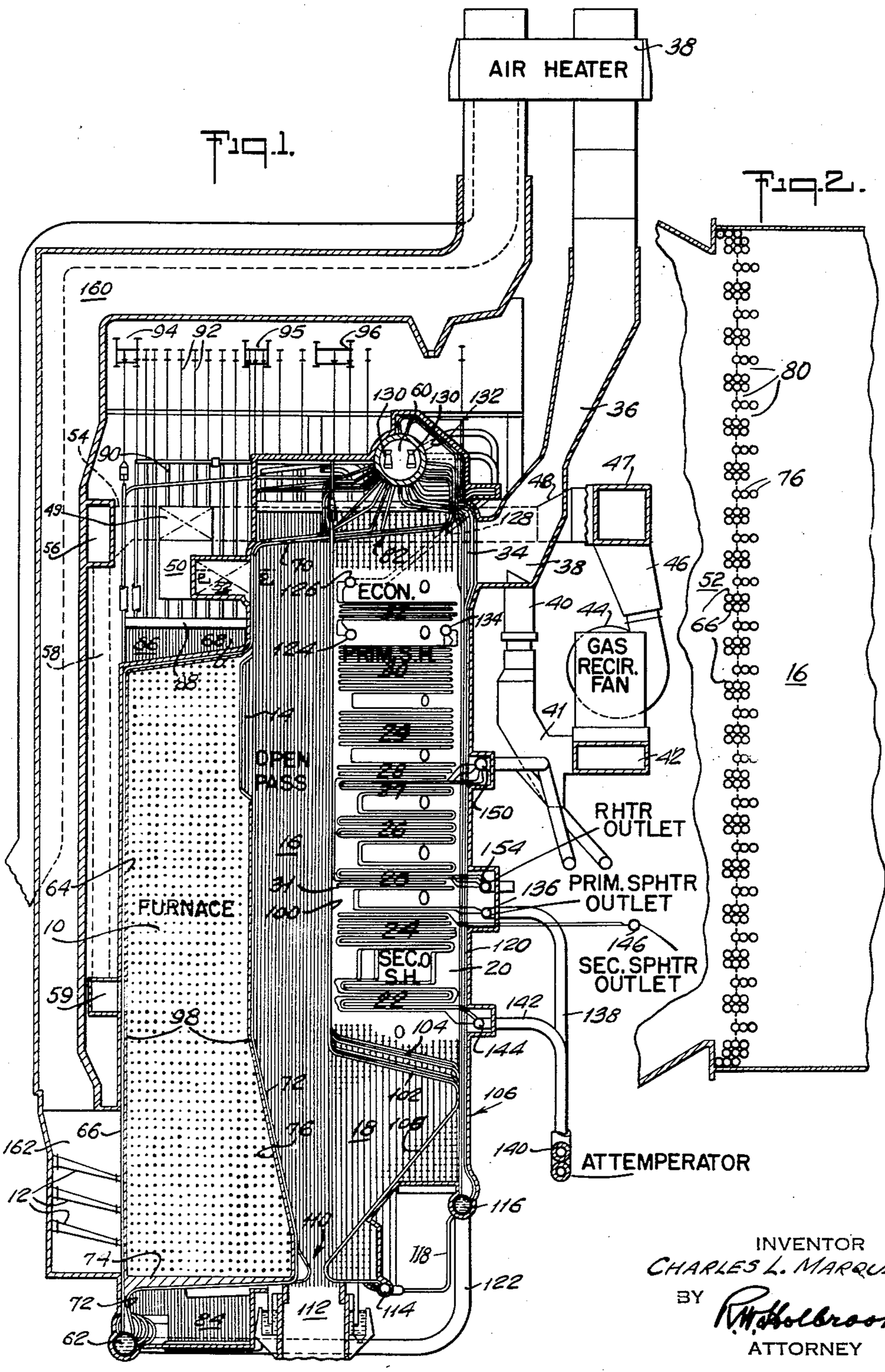

Fig. 2.

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OPEN PASS VAPOR GENERATING AND SUPERHEATING UNIT WITH GAS RECIRCULATION TO OPEN PASS

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6 Claims. (Cl. 122—478)

This invention relates to the generation and superheating of high pressure steam, vapor, or other elastic fluid. It involves a vapor generating and superheating unit having a furnace operating at high temperatures, the utilization of heat transmitted from the combustion elements in the furnace to confined streams of vaporizable liquid, the separation of the generated vapor from the liquid, the superheating of the separated vapor to high temperature, and the control of the superheat temperature by the regulated recirculation of partially cooled gases to an open gas pass (leading from the furnace) in order that a predetermined final high temperature of the vapor may be attained, in the interest of optimum availability and in the interest of high efficiency of the cycle of the power plant of which the illustrative steam generating unit is a part.

The invention is exemplified in an open pass steam generating unit in which pulverized fuel is burned in a furnace under high furnace temperatures above the slagging temperatures are maintained in the interest of optimum combustion and in the interest of optimum transfer of heat by radiation from the combustion products in the furnace to vapor generating tubes defining the walls of the furnace. The illustrative unit involves a convection superheater in which the generated vapor passes through spaced tubes arranged transversely to the path of furnace gases beyond the furnace gas outlet. Between the superheater and the furnace gas outlet there is an open pass, the walls of which include vapor generating tubes absorbing heat from the combustion products and thereby reducing the temperature of those products and changing their state so that a large proportion of the solids suspended in the gases may be removed therefrom before the gases contact the superheater, and so that the suspended particles of incombustible will not contact the superheater tubes in such condition that they will stick to the superheater tubes and accumulate thereon. The illustrative unit also includes the introduction of recirculated gases, taken from a position in the gas flow path beyond the superheater and introduced into the gas flow stream at a point beyond the furnace combustion chamber, and preferably at the inlet of the open pass. The flow of recirculated gases into the open pass is desirably coordinated with the vapor generating load or the rate of firing of the furnace in order that an inherent characteristic of the superheater may be compensated or overcome. This inherent characteristic is such that when the load drops appreciably, the superheater, if set to attain a certain vapor temperature at full load, will not attain any such temperature at low load.

When ash bearing fuel is burned in suspension in the combustion zone the invention involves the passage of the combustion gases from the combustion zone, and into and through an open pass zone in which there is such direct transmittal of radiant heat from the combustion gases and the fused particles of incombustible suspended therein that these gases and the suspended particles are

reduced in temperature to a value at which those particles will not stick to or adhere to the convection elements of the convection superheater which is subject to the gas flow at a position beyond the outlet of the open pass zone. This direct transmittal of radiant heat is effected by heat absorption to confined streams of a vaporizable liquid in the walls of the open pass zone and not at positions such that the gases pass over and around the confined streams. This lowering of the temperature of the gases and their suspended particles in the open pass zone is increased and the total heat absorbed by vapor generation is decreased, in increasing degrees, as the load on the unit decreases toward a low load value. This action is affected by the increasing introduction of recirculated gases into the entry part of the open pass zone as the load decreases. These combined actions not only minimize the adherence of fused particles of incombustible to the convection elements of the superheater zone but they also so compensate for the above indicated inherent tendency of the convection superheater zone as to maintain the final vapor or steam temperature at a predetermined optimum value over the lower part of the load range. This end effect is promoted not only by the consequent decrease in the proportion of the total heat absorbed in vapor generation but also by the concomitant increase in the heat available in the gases for convection superheating. This last result takes place largely because of the increased weight of gases passing through the convection superheater zone, as a result of the introduction of increased amounts of recirculating gases into the open pass zone as the load decreases toward a low load value.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification, but, for a better understanding of the invention, its operating advantages and the specific object attained by its use, reference should be had to the accompanying drawings and description in which there is illustrated a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a sectional elevation of the pertinent open pass vapor generating and superheating unit; and

Fig. 2 is a horizontal section on the line 2—2 of Fig. 1, illustrating on a large scale, the arrangement of the upper parts of some of the vapor generating tubes to provide the ports through which the recycled gases enter the top of the open pass.

The illustrative unit includes a high temperature combustion chamber **10** fired by rows of pulverized fuel burners **12**. The combustion products pass from the furnace through the furnace gas outlet **14** into the upper portion of an open pass **16** in which the gases flow downwardly to a gas turning space **18**. From this space the gases flow upwardly through the gas pass **20** and over the several banks of tubes constituting the convection heating section. The gases first pass over the banks **22** and **24** of serially connected tubes constituting the high temperature, or secondary, superheater. Above the secondary superheater the gases pass over the similar banks of tubes **25—27** constituting a vapor reheater, and beyond the reheater the gases next pass over the banks of tubes **28—30** constituting the primary superheater. Beyond the primary superheater the gases pass over the bank of tubes **32** of the economizer and thence through the gas outlet **34** to the flue **36**, and then through the air heater **38**.

For effecting superheat control throughout a wide load range, recirculated gases are withdrawn from the flue **36** at the position **38**. They pass through the ductwork components **40—42** to the inlet of the gas recirculating fan **44**. From this fan the gases pass through the duct-

work components 46—50 to the inlet chamber 52 at the top of the open pass. The ductwork components of the recirculating gas system also includes an extension duct 54, a distributing manifold 56 with vertical ducts 58 leading to a gas header 59 positioned above the burners 12 for selective discharge of recirculated gas between the tubes 66 into the furnace 10.

The walls and other boundary surfaces of the furnace and the open pass may be considered as defined by vapor generating tubes connected into a natural circulation system including the steam and water drum 60 and the lower water drum 62. The left hand wall 64 of the furnace 10, as is indicated in Fig. 1, involves upright vapor generating tubes 66 having their lower ends connected to the drum 62 and their upper ends connected to the steam and water drum 60. These tubes have their successive parts disposed along the wall 64, the furnace roof 68, the upper part of the left hand wall of the open pass 16, and the roof 70 of the open pass and then within the boiler casing where they lead to the steam and water drum 60. Other vapor generating tubes such as 72 lead from the drum 62 along the floor 74 of the furnace and then upwardly along the right hand wall 76 of the furnace to the position of the furnace gas outlet 14. At this position some of these tubes are bent out of their wall alignment so as to form gas passages constituting the furnace gas outlet. Upwardly beyond the furnace gas outlet 14 these tubes lead along the upper part of the left hand wall of the gas pass 16 and then across the gas outlet of the recirculated gas system. At this position the wall tubes 76 and 66 are arranged in the groups indicated in Fig. 2 so as to provide the ports 80 through which the recirculated gases pass into the top of the open pass 16. Beyond the recirculated gas inlet chamber 52 the tubes 76 pass across the roof of the open pass. From this point some of the tubes continue directly to connection with the steam and water drum 60 and others of the tubes pass along the roof 82 of the upflow gas pass of the convection section.

Similar vapor generating tubes for the side walls of the furnace have their lower parts 84 connected by appropriate headers and circulators to the drum 62. The main parts of these tubes are arranged in wall forming alignment along the side walls of the furnace and the upper parts 86 of these tubes are connected to appropriate headers such as the header 88. This header is, in turn, connected into the circulation system by the circulators 90 which extend to connections with the steam and water drum 60.

The above described pressure parts of the circulation system are pendently supported by hangers 92 from steel work such as indicated at 94—96.

The walls of the furnace may have a lining 98 of high temperature refractory material, in the interests of maintaining optimum high furnace temperatures, and the floor 74 of the furnace may have such material covering the floor tubes, for the same purpose. Preferably, the floor is formed with a slag tap opening for the removal of the slag formed by the fusion of the incombusible components of the fuel. The division wall between the furnace 10 and the open pass 16 is defined by the main parts of the tubes 72 and on the open pass sides of these tubes, the tubes are preferably bare in the interests of optimum heat absorption from the combustion products in the open pass.

The upflow convection gas pass 20 is separated from the open pass 16 by a wall of vapor generating tubes 100. Below this wall these tubes have horizontally inclined parts extending across the flow of gases into the lower end of the upflow gas pass 20. These parts form the screens 102 and 104 which extend to the rear wall 106 of the unit. From that position the tubes are reversely inclined to define the rear wall 108 of the hopper bottom for the gas turning space 18. In the operation of the unit cooled particles of incombustible separate

from their suspending gases and pass downwardly through the throat 110 of the hopper construction 24 to a collection pit 112. The upper ends of the tubes 100 are appropriately connected to the steam and water drum 60. The lower ends lead from the header 114 which is in communication with the header 116 by means of the conduits 118. The header 116 receives separated water from the drum 60 through the downcomers 120 extending along the rear wall 116 of the unit and the separated water flows from the header 116 through the conduit 122 to the lower drum 62.

The side walls of the open pass and the upflow convection pass are formed by vapor generating wall tubes connected into the circulation system by appropriate headers and circulators in a manner similar to that described with reference to the furnace walls.

Water or other vaporizable liquid is pumped to the economizer inlet header 124 whence it flows through the bank of tubes 32 to the economizer outlet header 126. From this header it flows through the conduits 128 to the steam and water drum. This drum preferably has steam and water cyclones 130 of the nature of the cyclones shown in the U.S. Patent to Rowand et al. 2,289,970 of July 14, 1942. The steam separated thereby flows from the drum 60 through the steam supply conduits 132 to the inlet header 134 of the primary superheater and then through the banks of tubes 28—30. From these tubes steam flows to the primary superheater outlet header 136 and then through the conduit 138 to attemperator 140. From the latter the flow continues through the conduit 142 to the inlet header 144 of the secondary superheater and then through the banks of tubes 22 and 24. From these tubes steam flows to the secondary superheater outlet header 146, and thence to a point of use.

The convection section also includes a convection vapor reheater having an inlet header 150 connected by a conduit 152 with the outlet of a high temperature turbine stage. The vapor or steam to be reheated flows from the inlet header 150 through the banks of convection tubes 25—27 disposed in the convection section and leading to the reheater outlet header 154.

It is within the purview of the invention that the flow of recirculated gas, from the position 38 through the fan and its associated ductwork, and then through the ports 80 into the top of the open pass, is controlled from appropriate operative variables such as representations of steam flow and air flow, and vapor or steam temperatures to the end that the recirculated gas flow may be varied as load varies to maintain final steam temperature (i.e., at the secondary superheater outlet header 154) at a predetermined value. Such a control system involves appropriate dampers in the ductwork and/or appropriate means for regulating the speed or capacity of the fan 44.

Fig. 1 indicates a secondary air duct 160 leading from the air heater 38 to the windbox 162. The burners 12 are thereby supplied with secondary air for combustion.

Although the invention as above is described with reference to the details of a preferred embodiment, it is to be understood that the invention is not limited to all of the details thereto. It is rather to be taken as of a scope corresponding with the scope of the subjoined claims.

What is claimed is:

1. In an open pass vapor generating and superheating unit, means including vapor generating tubes defining a vertically elongated furnace chamber, means for burning a slag-forming fuel in suspension in the lower part of said furnace chamber at temperatures above the slag-fusion temperature, means constituting a furnace gas outlet in the rear wall of said furnace chamber adjacent the upper end thereof, means including other vapor generating wall tubes forming a downflow open pass extending downwardly from and connected to said furnace gas

outlet, an upflow convection gas pass construction leading upwardly from the lower end of the open pass, a vapor superheater having tubes disposed in the upflow gas pass, and a recirculated gas system having an inlet communicating with the gas flow path beyond the superheater and having an outlet opening into the upper part of said downflow open pass adjacent to said furnace gas outlet.

2. In an open pass vapor generating and superheating unit, means including vapor generating tubes defining a vertically elongated furnace chamber, means for burning a slag-forming fuel in suspension in the lower part of said furnace chamber at temperatures above the slag-fusion temperature, an outlet for molten slag in the lower part of said furnace chamber, means constituting a furnace gas outlet in the rear wall of said furnace chamber adjacent the upper end thereof, means including other vapor generating wall tubes forming a downflow open pass extending downwardly from and connected to said furnace gas outlet, an upflow convection gas pass construction leading upwardly from the lower end of the open pass, a vapor superheater having tubes disposed in the upflow gas pass, a recirculated gas system having an inlet communicating with the gas flow path beyond the superheater and having an outlet opening to the upper part of said downflow open pass adjacent to said furnace gas outlet, and means forming a collection zone at the bottom of the open pass for gas suspended slag particles, said slag collection zone being separate from said molten slag outlet.

3. In an open pass vapor generating and superheating unit, means including vapor generating tubes defining a vertically elongated furnace chamber, means for burning a slag-forming fuel in suspension in the lower part of said furnace chamber at temperatures above the slag-fusion temperature, means constituting a furnace gas outlet in the rear wall of said furnace chamber adjacent the upper end thereof, means including other vapor generating wall tubes forming a downflow open pass extending downwardly from a level above the level of and connected to said furnace gas outlet, an upflow convection gas pass construction leading upwardly from the lower end of the open pass, a vapor superheater having tubes disposed in the upflow gas pass, a recirculated gas system having an inlet communicating with the gas flow path beyond the superheater and having a horizontally disposed outlet opening to the upper part of the said downflow open pass above the level of said furnace gas outlet, and means forming a collection zone at the bottom of the open pass for gas suspended slag particles.

4. In an open pass vapor generating and superheating unit, means including vapor generating tubes defining a vertically elongated furnace chamber, means for burning a slag-forming fuel in suspension in the lower part of said furnace chamber at temperatures above the slag-fusion temperature, an outlet for molten slag in the lower part of said furnace chamber, means constituting a furnace gas outlet in the rear wall of said furnace chamber adjacent the upper end thereof, means including other vapor generating wall tubes forming a downflow open pass extending downwardly from the level of and connected to said furnace gas outlet, an upflow convection gas pass construction leading upwardly from the lower end of the open pass, a vapor superheater having tubes disposed in the upflow gas pass, a recirculated gas system having an inlet communicating with the gas flow path beyond the superheater and having an outlet opening downwardly into the upper part of said downflow open pass above the level of said furnace gas outlet, the outlet for the recirculated gas system including a series of ports distributed across the width of the unit and formed between parts of the vapor generating tubes, and means forming a collection zone at the bottom of the open pass for gas suspended slag particles, said slag collection zone being separate from said molten slag outlet.

5. In an open pass vapor generating and superheating unit, means including vapor generating tubes defining a vertically elongated furnace chamber, means for burning a slag-forming fuel in suspension in the lower part of said furnace chamber at temperatures above the slag-fusion temperature, means constituting a furnace gas outlet in the rear wall of said furnace chamber adjacent the upper end thereof, means including other vapor generating wall tubes forming a downflow open pass extending downwardly from a level above the level of and connected to said furnace gas outlet, an upflow convection gas pass construction leading upwardly from the lower end of the open pass, a vapor superheater having tubes disposed in the upflow gas pass, a recirculated gas system having an inlet communicating with the gas flow path beyond the superheater and having an outlet opening to the upper part of said downflow open pass above the level of said furnace gas outlet, the outlet for the recirculated gas system including a series of ports distributed across the width of the unit and formed between upright parts of the vapor generating tubes, and means forming a collection zone at the bottom of the open pass for gas suspended slag particles.

6. In an open pass vapor generating and superheating unit, means including vapor generating tubes defining a vertically elongated furnace chamber, means for burning a slag-forming fuel in suspension in the lower part of said furnace chamber at temperatures above the slag-fusion temperature, an outlet for molten slag in the lower part of said furnace chamber, means constituting a furnace gas outlet in the rear wall of said furnace chamber adjacent the upper end thereof, means including other vapor generating wall tubes forming a downflow open pass extending downwardly from a level above the level of and connected to said furnace gas outlet, an upflow convection gas pass construction leading upwardly from the lower end of the open pass, a vapor superheater having tubes disposed in the upflow gas pass, a recirculated gas system having an inlet communicating with the gas flow path beyond the superheater and having an outlet opening to the upper part of said downflow open pass above the level of said furnace gas outlet, the outlet for the recirculated gas system including a series of ports distributed across the width of the unit and formed between parts of the vapor generating tubes, and means forming a collection zone at the bottom of the open pass for gas suspended slag particles, said slag collection zone being separate from said molten slag outlet.

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