Oct. 30, 1962 N. S. BLODGETT 3,060,907

STEAM GENERATING UNIT

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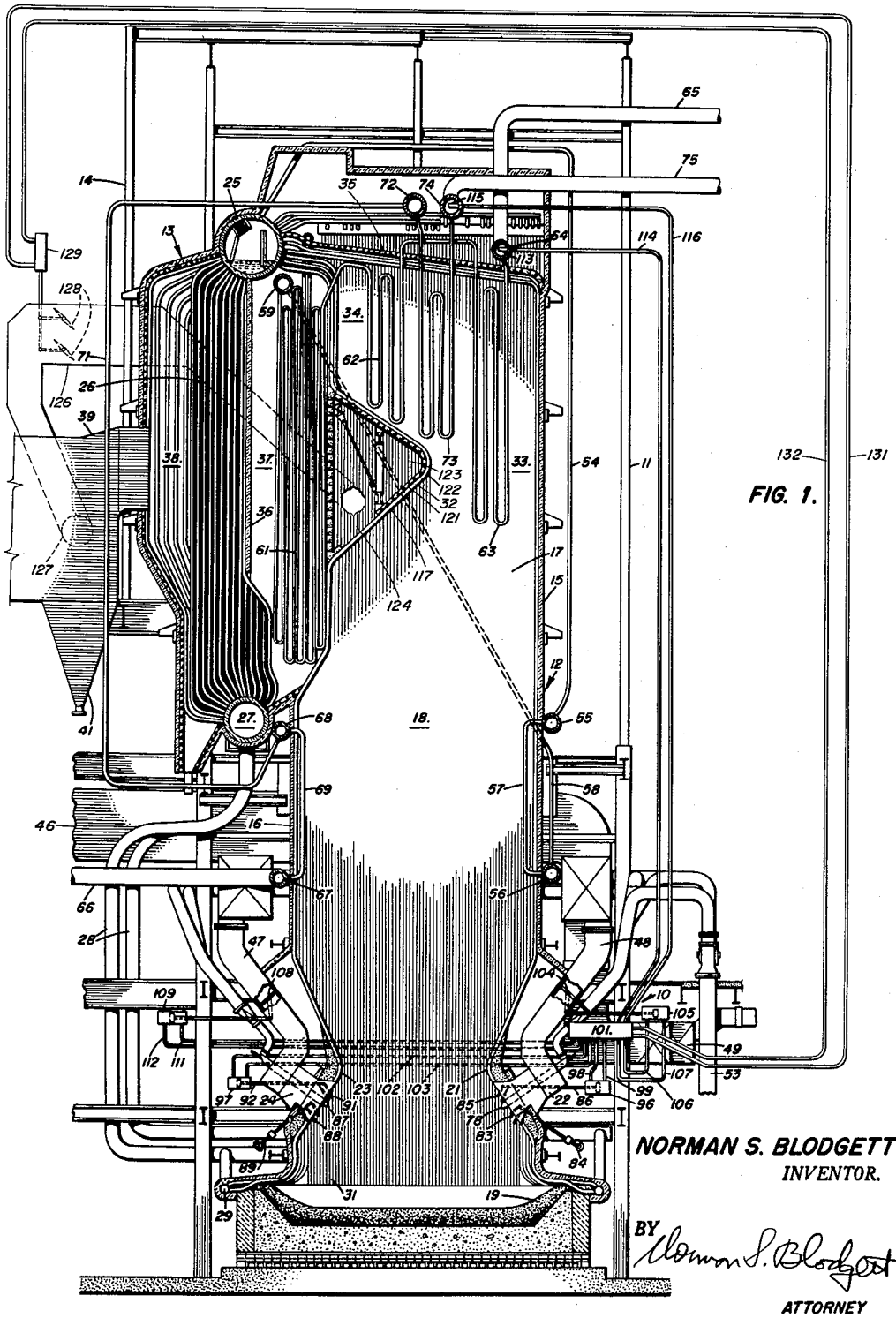


FIG. 1.

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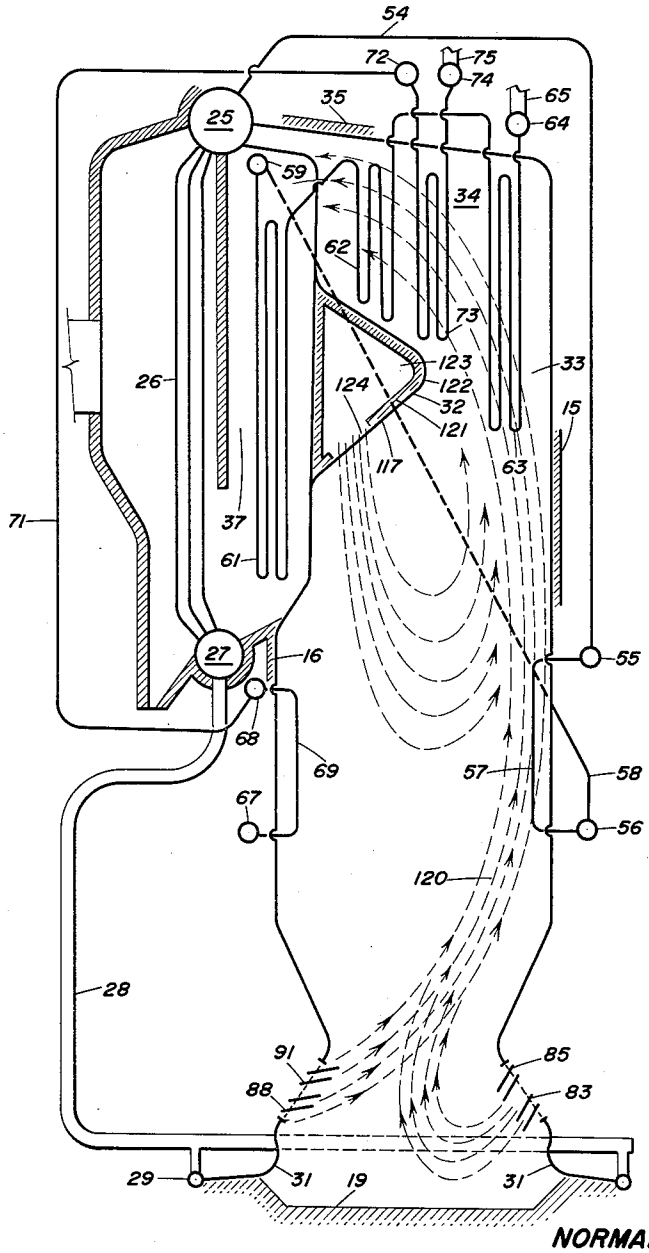


FIG. 2.

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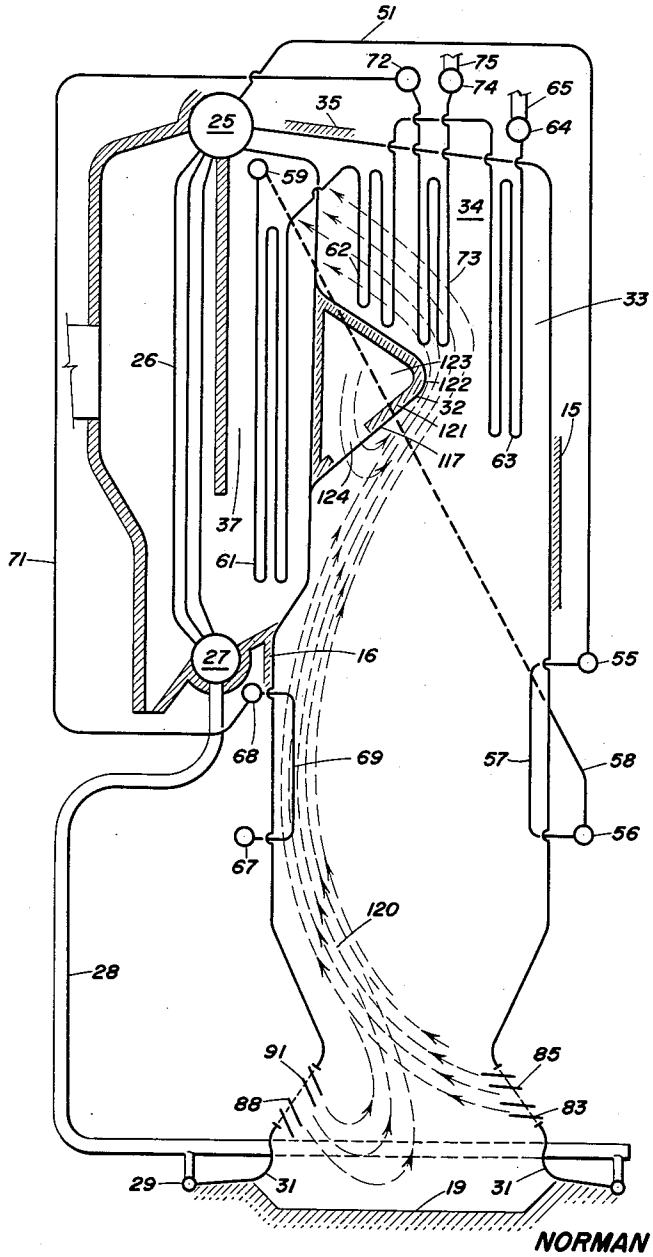


FIG. 3.

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3,060,907

STEAM GENERATING UNIT

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4 Claims. (Cl. 122—479)

This invention relates to a steam generating unit and more particularly to apparatus arranged to generate steam and to regulate the temperature of superheated steam which is produced therein.

There have been many methods suggested in the past for maintaining the temperature of the superheated steam in a steam generating unit at a fixed value, irrespective of changes in load on the unit. Among these methods is that of by-passing portions of the gas away from sections of superheater heat exchange surface. Also, there is the method in which the temperature of the gases passing over convective superheaters is regulated by regulating the residence time of the gases in the main combustion chamber by the use of tilting burners. There is the method of superheat control by gas recirculation in which gases from the back passes are returned in regulated amounts to the main combustion chamber to increase or decrease the mass flow of gases over convection superheater units. Of course, there is also the old method of desuperheating the superheated steam by injecting a spray of water into it. Another method of controlling superheat is described in the patent to Miller No. 2,947,289, in which the flame rising vertically through the furnace is moved to various positions between the front wall and the rear wall in order to regulate superheat. There are some boiler conditions under which this last method of controlling superheat does not give a sufficient range of superheat temperature change. While it is true that this method can be combined with desuperheating methods and with by-pass methods of superheat control to give sufficient range, these last two methods tend to affect the overall efficiency of the boiler. These deficiencies in the prior art have been obviated by the present invention in a novel manner.

It is, therefore, an outstanding object of the present invention to provide a steam generating unit having apparatus for the control of superheat in which the heat discarded from the cycle at certain loads is reduced to a minimum value.

Another object of the invention is the provision of an apparatus for the control of superheat whose action is not detrimental to the overall operation of the steam generating unit.

Another object of the invention is the provision of an apparatus for the control of superheat which makes use of the flame-positioning method and in which the range of control has been greatly increased.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to one of its structural forms, as illustrated by the accompanying drawings in which:

FIG. 1 is a vertical sectional view of a steam generating unit embodying the principles of the present invention,

FIG. 2 is a schematic view of the unit to show its operation at low load, and

FIG. 3 is a similar schematic view of the unit taken during high load operation.

In the specification which follows, the expressions "longitudinal," "transverse" refer to those directions as applied to a steam generating unit in the ordinary practice

in that art and in general refer to the flow of gas through the unit.

Referring first to FIG. 1, wherein are best shown the general features of the invention, the steam generating unit, indicated generally by the reference numeral 11, is shown as consisting of a furnace 12 and a boiler 13 mounted on a supporting structure 14. The furnace 12 consists of a front wall 15 and a rear wall 16 which, with side walls 17, define a vertically-elongated combustion chamber 18. Underlying the combustion chamber is a slag basin 19 formed of refractory material. The front wall 15 is provided with a nose 21 located in its lower portion directly overlying the slag basin 19 and provided on its downwardly-directed surface with a burner 22. A similar nose 23 is provided in the rear wall 16 and a burner 24 is mounted on the downwardly-directed surface of that nose.

The boiler 13 consists of an upper steam-and-water drum 25 joined by downcomer tubes 26 to a lower drum 27, both drums extending transversely fo the unit. Large downcomer tubes 28 extend from the lower drum 27 to a header 29 extending around the periphery of the slag basin 19. Water-wall tubes 31 extend upwardly from the header 29 along the front wall 15, the rear wall 16, and the side walls 17. These water-wall tubes are connected at the upper part of the furnace to the steam-and-water drum 25. Alternate water-wall tubes on the back wall 16 are formed with forward loops 32 as will be described more fully hereinafter. These tubes serve to define an upper pass 34 between their forwardly projecting portions and the roof 35 of the furnace. A refractory wall 36 extends downwardly from the steam-and-water drum 25 and serves to divide the rearward portion of the unit into back passes 37 and 38. A duct 39 leads from the back pass 38 to a dust collector 41 which, in turn, is connected in the conventional manner through a rotary regenerative air heater, an induced draft fan and a breaching to a stack, all not shown.

The forced draft fan is connected through the air heater to a duct 46 having branch ducts 47 and 48 leading to the burners 24 and 22, respectively. A duct 49 leads from the duct 46 to an attrition-type pulverizer (not shown). Pipes 53 lead from the output of the pulverizer to the burners 22 and 24.

As is evident in FIG. 1, the steam-and-water drum 25 is provided with a steam separator of the usual type. Tubes 54 lead from the upper part of the steam-and-water drum to a header 55 arranged beside the front wall 15 of the furnace. Below the header 55 is arranged another header 56 of a similar type. Joining these headers and lying within the furnace against the forward wall 15 is a radiant superheater 57. Tubes 58 lead from the header 56 to a header 59 which is connected through a convection superheater 61 lying in the pass 37 to a convection superheater 62 lying in the upper pass 34. The output end of the superheater 62 is connected to superheater platens 63 hanging downwardly from the roof 35 into a restricted passage 33 between the forward wall 15 and the foremost portion of the tube loops 32. The output of the platen 63 is connected to a superheated steam header 64 which, in turn, is connected by a high pressure pipe 65 to the high-pressure section of the turbine (not shown).

The output of the high pressure section of the turbine is connected by means of a pipe 66 to a header 67 arranged adjacent the rear wall 16 of the furnace. A similar header 68 is mounted above the header 67 and the two are joined by a radiant reheater 69 which lies closely adjacent the inner surface of the rear wall. The header 68 is connected by a pipe 71 to an input header 72 connected to one end of a convection reheater 73 lying in

the upper pass 34 between the superheater 62 and the superheater platen 63. The output of the reheater 73 is connected to a reheater steam header 74 which, in turn, is connected by means of a high-pressure pipe 75 to the low pressure section of the turbine. The burners 22 and 24 are similar to those described in Patent No. 2,947,289. For instance, in the case of the burner 22, the air duct 48 is connected to a burner housing. Centrally of the housing is located a continuous spark igniter (not shown) and a gun 78 for intrdoucing pulverized coal into the burner. The conduit 53 leading from the pulverizer 51 is connected to the gun and in the central part of the gun is a gas gun to insure ignition. The water-wall tubes 31 are bent rearwardly in the vicinity of the burner 22 to form passages for the flow of fuel and air. At the mouth of the burner below the gun 78 are located pivoted vanes 83 which are connected through a mechanical linkage to an actuating rod 84. In the upper part of the burner are located pivoted vanes 85 which are connected through a mechanical linkage to an actuating rod 86. The burner 24 is similarly provided with a fuel gun 87, lower vanes 88 whose angularity is adjustable by means of an actuating rod 89, and upper pivoted vanes 91 whose angularity is adjustable by means of an actuating rod 89, and upper pivoted vanes 91 whose angularity is adjustable by means of an actuating rod 92.

The actuating rod 86 for the vanes 85 is connected to the piston rod of a hydraulic linear actuator 96, while the actuating rod 92 of the vanes 91 is connected to a similar actuator 97. The actuator 96 is connected by conduits 98 and 99 to a controller 101 and the linear actuator 97 is connected to the controller by means of conduits 102 and 103. The air duct 48 leading to the burner 22 is provided with a control damper 104 which is connected for pivotal action through a mechanical linkage to the piston rod of a linear actuator 105 whose piston is movable under the control of conduits 106 and 107 by which it is connected to the controller 101. In a similar manner, the duct 47 leading to the burner 24 is provided with a pivoted damper 108 which is connected through a linkage mechanism to the piston rod of a linear actuator 109. This actuator is connected to the controller 101 by means of conduits 111 and 112. The superheated steam header 64 has mounted therein a temperature-indicating device 113 of the usual type, and this device is connected through a line 114 to the controller 101. A similar temperature-measuring device 115 resides in the reheated steam header 74 and is connected by a line 116 to the controller 101. The controller 101 is of the usual type used in temperature control applications; it consists of an apparatus which is well known in the art for converting electrical signals in the lines 114 and 116 into hydraulic flow through the lines 106, 107, 98, 99, 111, 112, 102, and 103 leading to the various hydraulic linear actuators associated with the apparatus; since the controller is not part of the present invention in its detailed form, it is not felt that a specific descripion thereof is not necessary adequately to describe the present invention.

As has been stated, each of the alternate tubes in the rear water-wall tubes of the wall 16 of the furnace has been bent forwardly to form a loop 32 which resides above the combustion chamber. Each tube is bent at an angle of approximately 45° to the vertical to provide a portion 117 extending forwardly from a position well above the lower drum 27 of the boiler. Each tube is then given a return bend to return to vertical along with the other tubes which were not provided with a loop. The loops extend to a position somewhat forwardly of the midpoint between the front and rear wall of the furnace. Mounted on the loops 32 are refractory blocks 121 forming a nose 122. The refractory blocks extend along the inclined portions 117 of the loops 32, along the return inclination and along the back wall to define a chamber 123 within the nose. The refractory blocks are omitted from a portion of the portion 117 somewhat forwardly of the rear wall 16 to provide an opening 124. Between the forward edge of the nose and the front wall is located the passage 33 leading to the upper pass 34. The convection superheater 62 is located entirely above the nose 122. At the same time, the convection reheater 73 is located above the nose at the forward portion of it and a portion of the reheater extends forwardly of the forward edge of the nose. The superheater platens 63 lie entirely within the passage 33 forwardly of the nose. The refractory blocks 121 fit tightly around the tubes and are bonded together by cement in the usual manner to provide a gas-tight baffle construction.

The interior of the chamber 123 is entirely vacant except, of course, for certain structural elements for supporting the nose and the refractory. Entering the chamber through one of the side walls 17 is an opening 125 formed by bending the tubes laterally in a well-known manner. Attached to this opening is a recirculated gas duct 126 which extends around the boiler on the exterior thereof and is attached at its other end to an opening 127 in the duct 39. The intermediate portion of the duct 126 is provided with regulating dampers 128 which are connected through suitable linkages to the piston rod of a hydraulic linear actuator 129. The actuator is connected by conduits 131 and 132 to the controller 101.

The operation of the apparatus will now be readily understood in view of the above description. The furnace 12 and the boiler 13 operate in the usual manner. Because of the restricted nature of the bottom of the combustion chamber 18 below the level of the noses 21 and 23, it is very hot and quite complete combustion takes place in this high-temperature cell. The gases passing upwardly in the restricted zone between the noses 21 and 23 form a flame 120 which may be manipulated so as to flow close to the front wall 15, close to the rear wall 16, or to flow in any position intermediate of the walls. In the sense of "flame," the applicant means the line of greatest mass flow and highest gas temperature which is usually indicated in a furnace as a flame; this flame may or may not be luminous, depending upon various factors such as the nature of the fuel and the completeness of combustion. The flame may be manipulated in a manner described in the above-identified patent of Miller by adjusting the angles of the vanes in the burners through the linear actuators 96 and 97 or by adjusting the air-flow through the burners by means of the actuators 105 and 109 which manipulate the dampers 104 and 108.

Referring now to FIGS. 2 and 3, it is evident that the position of the flame 120 is manipulated by changing the angularity of the vanes in the burners. In FIG. 2, which shows the relationships at low load, the flame is shown as rising close to the front wall 15. The flame 120 passes directly along the front wall 15 and through the passage 33 close to the front wall. From there, the gas flow is directed under the roof 35 through the upper pass 34. In the process of doing this, these gases pass over the superheater platens 63, the convection reheater 73, and the convection superheater 62; the gases eventually pass through the gas offtake leading from the furnace into the backpasses. Because the flame extends upwardly along the front part of the furnace, a zone of reduced pressure is created under the nose and the flow of recirculated gases takes place from the opening 124 downwardly well into the furnace where they mix with the gases rising along the front wall. Now, it is well known that uncorrected superheat tends to be low at low loads because of the rising character of a convection superheat curve. In the present case, the flame 124 and the greatest mass of gases pass by the most direct path from the burners to the convection sections of superheater. This means that they reach these superheaters at the highest temperature because there has been the least possibility of heat radiation to the walls of the furnace to cool the gases. This gives a tendency to a higher superheat temperature. Fur-

thermore, the flame is closer to radiant superheater sections **57** and the superheater platens **63** which absorb considerable heat by radiation from the combustion chamber. Furthermore, the gases which flow from the opening **124** downwardly through the furnace to mix with the gases from the burners to pass upwardly once more through the forward pass **33** constitute a form of gas recirculation which increases the mass flow of gases over the convection superheater surfaces, thus raising the temperature of steam in the superheaters. This recirculation of gases takes place automatically by regulation by the controller **101** which acts through the conduits **131** and **132** and the actuator **128** to increase the amount of gas recirculated at low load.

Referring to FIG. 3 which shows the relationships which exist at high load, the flame **120** is shown as being positioned close to the rear wall **16**, so that a large percentage of the gases have a tendency to go directly around the nose and through the gas offtake to the backpass **37**. The controller **101** is set at high load to regulate the dampers **128** so that only a small of gas is recirculated. The gases from the burners pass over the underside of the nose and pick up the recirculated gas from the opening **124**. The combination of the lower quantity of recirculated gas and the flame up the back wall has a tendency to lower the temperature of superheat. First of all, there is little recirculation downwardly through opening **124** as was provided at low load. Secondly, those gases which pass over the convection superheater **62** have reached this area by a longer path, since they are forced to first pass along the rear wall of the furnace and then move forwardly in the furnace so that their residence time in the furnace is longer (and their temperature when they reach the convection superheater is lower). Furthermore, the flow of gases over the convection units is smaller in amount; that is to say, the mass flow over the convection superheater is less. Also, with the flame at the rear of the furnace, the radiation to the radiant superheater **57** and the radiant parts of the superheater platen **63** is less. All of these factors have a tendency to maintain superheat at a predetermined value, despite the normal tendency for superheat to be high at high load. At intermediate loads, of course, the movement of the flame to positions between the front and rear walls will produce variations of these factors and will permit close regulation of superheat temperature.

An examination of FIGS. 2 and 3 shows the decided benefits of combining the flame-positioning control with the introduction of recirculated gas through the lower surface of the nose. At low load, as shown in FIG. 2, the suction produced by the flame going up the front wall causes the recirculated gas to be projected downwardly into the furnace a considerable distance before turning to meet the main flame. Now, at low load a large amount of recirculated gases is used and it is important that the recirculated gases and the main burner gases be thoroughly mixed before they arrive at the convection surfaces. By starting the mixing and introduction well down in the furnace, as will take place with the present construction, many of the disadvantages of gas recirculation control and of flame-positioning control are obviated. At the same time, when the apparatus is operated at high load, as shown in FIG. 3, the movement of the flame up the back wall means that very thorough mixing still takes place between the burner gases and the recirculated gases; at high load, of course, only a small amount of recirculated gases is used, but, neverthless, it is important that these gases be thoroughly mixed with the gases coming from the burner. Now, with the present apparatus, the main burner gases wipe over the lower surface of the nose and over the opening **124**, thus producing a very thorough mixing. Since the velocity of the recirculated gases is very low and the recirculated gases do not have enough energy normally to produce good mixing, this is an important feature. Without this arrangement the recirculated gases would have a tendency to pass upwardly along the nose and form a striation of low temperature gases along the nose which would result in temperature difficulties in the convection superheater.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent, is:

1. A steam generating unit, comprising a vertically-elongated combustion chamber having front, rear, and side walls, a radiant superheater associated with the front wall and a radiant reheater associated with the rear wall, opposed abutments extending from the front and rear walls and defining a high-temperature cell located at the bottom of the combustion chamber, directional-flame burners mounted on the under sides of the abutment for producing a mass of hot products of combustion, a gas-offtake at the upper part of the rear wall, a nose extending across the combustion chamber immediately below the gas off-take, a convection superheater overlying the nose, the nose having a recirculated gas chamber therein and having an inclined undersurface on which the recirculated gas chamber opens, a back pass into which the gases flow after passing over the convection superheater, a recirculated gas duct connecting the gas chamber to the back pass, dampers located in the duct automatically adjusted in response to superheat temperature to cause large amounts of gas to flow to the gas chamber at low load and small amounts at high load, and positioning means associated with the directional-flame burners to locate the line of greatest mass flow at a desired position between the front and rear walls, the said means causing the flame to be located from a position adjacent the rear wall at high load to a position adjacent the front wall at low load to aid in maintaining the temperature of superheated steam at a pre-determined value.

2. A steam generating unit, comprising a vertically-elongated combustion chamber having front, rear, and side walls, a radiant superheater associated with one wall, opposed abutments extending from opposed walls and defining a high-temperature cell located at the bottom of the combustion chamber, directional-flame burners mounted on the undersides of the abutments for producing a mass of hot products of combustion, a gas-offtake at the upper part of the wall opposite the said one wall, a nose extending across the combustion chamber immediately below the gas off-take, a convection superheater overlying the nose, the nose having a recirculated gas chamber therein and having an inclined undersurface on which the recirculated gas chamber opens, a back pass into which the gases flow after passing over the convection superheater, a recirculated gas duct connecting the gas chamber to the back pass, dampers located in the duct automatically adjusted in response to superheat temperature to cause large amounts of gas to flow to the gas chamber at low load and small amounts at high load, and positioning means associated with the directional-flame burners to locate the line of greatest mass flow at a desired position between the said one wall and the said opposite wall, the said means causing the flame to be located from a position adjacent the said one wall at high load to a position adjacent the said opposite wall at low load to aid in maintaining the temperature of superheated steam at a predetermined value.

3. A steam generating unit, comprising a vertically-elongated combustion chamber having front, rear, and side walls, a radiant superheater associated with the front wall and a radiant reheater associated with the rear wall, opposed abutments extending from the front and rear walls and entirely across the chamber from side wall to side wall to define a high-temperature cell located at the bot-

tom of the combustion chamber, intertube, adjustable-vane directional-flame burners mounted on the undersides of the abutments for producing a mass of hot products of combustion, a gas-offtake at the upper part of the rear wall, a nose consisting of refractory mounted on water wall tubes extending across the combustion chamber immediately below the gas off-take, a convection superheater overlying the nose, the nose having a recirculated gas chamber therein and having an inclined undersurface on which opens a passage between the tubes into the recirculated gas chamber, a back pass into which the gases flow after passing over the convection superheater, a recirculated gas duct connecting the gas chamber to the back pass, a main control receiving signals indicative of the temperature of steam leaving the superheater, of the temperature of steam leaving the reheater, and of load on the unit, dampers located in the duct automatically adjusted by the main control in response to superheat temperature to cause large amounts of gas to flow to the gas chamber at low load and small amounts at high load, and positioning means connected to the main control and associated with the directional-flame burners to locate the line of greatest mass flow at a desired position between the front and rear walls, the said means causing the flame to be located from a position adjacent the rear wall at high load to a position adjacent the front wall at low load to aid in maintaining the temperature of superheated steam at a pre-determined value.

4. A steam generating unit, comprising

(*a*) front, rear, bottom, and side walls defining a vertically-elongated combustion chamber,

(*b*) a radiant superheater associated with the upper portion of one wall,

(*c*) at least one abutment extending across the chamber adjacent the bottom wall and defining with the bottom wall a high-temperature cell located at the lower end of the combustion chamber,

(*d*) directional-flame burners mounted on the underside of the abutment for producing a mass of hot products of combustion,

(*e*) a gas off-take at the upper end of the combustion chamber,

(*f*) a gas recirculation opening at the upper portion of a wall opposite the said one wall,

(*g*) a back pass into which the gases flow after passing through the gas off-take,

(*h*) a recirculated gas duct connecting the back pass to the said opening,

(*i*) a main control receiving signals indicative of the temperature of steam leaving the superheater and of load on the unit,

(*j*) dampers located in the duct automatically adjusted by the main control to cause large amounts of gas to flow to the opening at low load and small amounts at high load,

(*k*) a convection superheater located in the said back pass,

(*l*) and positioning means connected to the main control and associated with the directional-flame burners to locate the line of greatest mass flow at a desired position between the said one wall and the said opposite wall, the said means causing the flame to be located from a position adjacent the said opposite wall at high load to a position adjacent the said one wall at low load to aid in maintaining the temperature of superheated steam at a pre-determined value.

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