

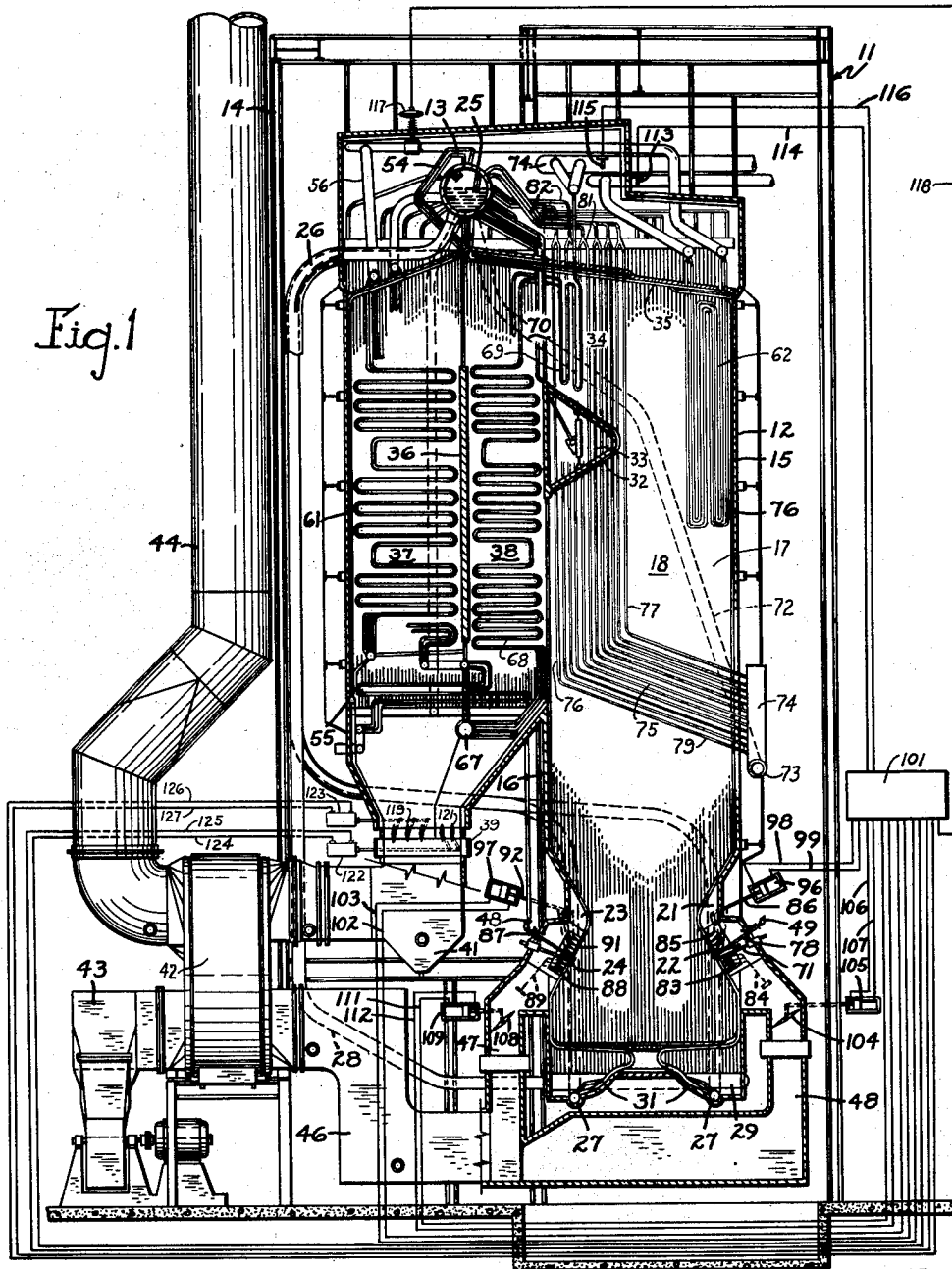
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N. S. BLODGETT
STEAM GENERATING UNIT

3,146,760

Filed July 16, 1962

2 Sheets-Sheet 1



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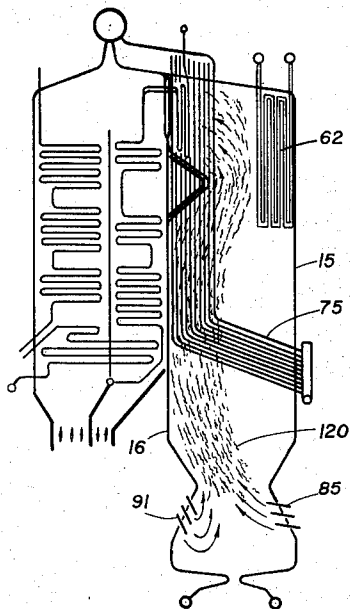


FIG. 2

HIGH LOAD

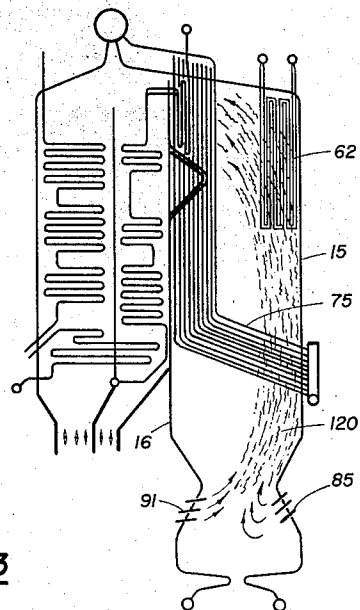


FIG. 3

LOW LOAD

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3,146,760

STEAM GENERATING UNIT

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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 the superheater heat exchange surface. Another method is that in which the temperature of the gases passing over convection superheaters is regulated by regulating the residence time of the gases in the main combustion chamber by the use of tilting burners. There is also the method of superheat control by gas recirculation, wherein relatively cool 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 the convection superheating units. Of course, there is also the old method of desuperheating or lowering the temperature of the superheated steam by injecting a spray of water. 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, however, 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 the flame-positioning method can be combined with desuperheating methods and with by-pass methods to extend the control range, these last two methods tend to affect the overall efficiency of the boiler. These and other 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 control range has been greatly increased.

Another object of the instant invention is the provision of steam temperature control means involving the use in combination of flame-positioning, desuperheating, and by-pass methods, wherein the last two methods are used only for small adjustments in temperature.

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 high load; and

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FIG. 3 is a similar schematic view of the unit as it appears during low load operation.

In the specification which follows, the expressions "longitudinal," "transverse," "downstream," "upstream," and the like 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 lined with refractory material. The front wall 15 is provided with an abutment 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 abutment 23 extends from the rear wall 16 and it is provided with a burner 24 mounted on its downwardly-directed surface.

The boiler 13 consists of a steam-and-water drum 25 joined by downcomer tubes 26 to lower headers 27, the drum 25 and headers 27 extending transversely of the unit. Similar downcomer tubes 28 extend from the steam-and-water drum 25 to headers 29 extending longitudinally of the unit under the side walls 17. Water-wall tubes 31 extend upwardly from the headers 27 under the slag basin 19 and along the front wall 15 and the rear wall 16; similarly, water-wall tubes also extend from the headers 29 along the side walls 17. All of the water-wall tubes are connected at the upper part of the furnace to the steam-and-water drum 25. Alternate water-wall tubes 31 on the back wall 16 are formed with forward loops 32 which form a nose 33. This nose serves to define an upper pass 34 with a roof 35 overlying the combustion chamber. A refractory wall 36 extends vertically downwardly from a position spaced from and below the steam-and-water drum 25; it serves to divide the rearward portion of the unit into back passes 37 and 38. A duct 39 leads from these back passes to a dust collector 41 which is connected in the conventional manner through a rotary regenerative air heater 42 and a breaching to a stack 44.

A forced draft fan 43 is connected through the air heater 42 to a duct 46 having branch ducts 47 and 48 leading to the burners 24 and 22, respectively. Pipes 48 and 49 are connected at their outer ends to a source of combustible gas and at their inner ends are connected, respectively, to the burners 24 and 22.

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 at the back wall of the back pass 37. This header is connected to a convection superheater 61 lying in the back pass 37. At its upper end the superheater 61 is connected by a pipe 56 connected to one end of a radiant superheater 62 arranged in the form of platens adjacent the front wall 15 near the roof 35. The outlet end of the superheater 62 is connected to a superheated steam header 63 which is connected, in a manner not shown, to the high-pressure section of a turbine.

The outlet of the high-pressure section of the turbine is connected to a reheater inlet header 67 located at the bottom of the back pass 38. This header is connected to a convection reheater 68 which lies in the back pass 38 adjacent the rear wall 16 of the furnace. The upper end of the convection reheater 68 is connected to a convection reheater 69 lying in the upper pass 34 adjacent a gas offtake 70 lying between the upper pass 34 and the

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back passes 37 and 38. The outlet of the convection reheater 69 is connected to a reheated steam header 74 which, in turn, is connected to the low-pressure section of the turbine.

The burners 22 and 24 are similar to the directional-flame type described in the Craig 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 gas-electric ignitor 71 and a gun 78 for introducing combustible gas into the burner. The conduit 49 leading from the source of combustible gas is connected to the gun and the water-wall tubes 31 are bent rearwardly and laterally 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, with lower vanes 88 whose angularity is adjustable by means of an actuating rod 89, and with 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 63 has mounted therein a temperature-measuring 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 arriving 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 description thereof is necessary adequately to describe the present invention.

As has been stated, each of the alternate tubes in the rear water-wall tubes 31 of the wall 16 of the furnace is bent forwardly to form a loop 32 which resides above the combustion chamber. Each tube is bent twice at angles of approximately 45° to the vertical and is then given a return bend to the vertical plane of the other tubes which were not provided with a loop. The loops extend forwardly to a position somewhat rearwardly of the mid-point between the front and rear walls of the furnace. On the loops are mounted refractory blocks to form the nose 33.

A downcomer pipe 72 extends from the steam-and-water drum 25 to a horizontal header 73 located outside of the furnace immediately adjacent the front wall 15. A series of vertical headers 74 extend upwardly from the header 73, these last-named headers being parallel to one another and evenly spaced across the width of the furnace outside of the front wall 15. From each of the

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headers 74 extends a series of closely-spaced water tubes to form platens 75, each lying in a generally vertical plane which extends at a right angle to the plane of the rear wall 16. Each platen 75 is provided with a rearward edge 76 which lies quite close to the inner surface of the rear wall 16 and a forward edge 77 which lies at an intermediate point in line with the most forward portion of the nose 33. Each platen extends vertically from the roof 35 downwardly to a point approximately halfway between the top and the bottom of the furnace. Furthermore, each platen is provided with a lower edge 79 which is inclined to the horizontal and extends upwardly and rearwardly from the front wall 15. The tubes making up the platen 75 extend through the roof 35 and are provided with bifurcated fittings 81 so that each pair of tubes is attached to a single tube 82 which extends upwardly and eventually is connected to the steam-and-water drum to release steam therein.

A desuperheater 117 is located in the pipe 56 between the low-temperature superheater 61 and the high-temperature superheater 62. A line 118 leads from the controller 101 to the desuperheater to regulate its function. Dampers 119 and 121 are located at the bottom ends of the back passes 37 and 38, respectively. The positioning of these dampers is regulated by linear actuators 122 and 123, respectively. The actuator 122 is controlled through lines 124 and 125 leading from the controller 101, while the actuator 123 is similarly controlled by lines 126 and 127.

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 abutments 21 and 23, it is very hot and substantially complete combustion takes place in this high-temperature cell. The gases passing upwardly into the restricted zone between the abutments 21 and 23 form a flame 120 which may be manipulated so as to flow close to the front wall 15, to flow 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 on 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 85 and 91 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, respectively.

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 relationship at high load, the flame is shown as rising close to the rear wall 16. The flame 120 passes along the rear wall 16 and close to the nose 33. From there the gas flow is directed under the roof 35 through the upper pass 34. In the process of doing this, most of the gases do pass through the water-wall platens 75 but they do not pass over or close to the radiant superheater 62. Because the gases have been cooled by passage between the platens 75 and have taken the longest path through the combustion chamber, the gas temperature is relatively low as it passes over the convection sections of the superheater and reheater, so that these temperatures are maintained at a low level rather than rising as is the usual case at high loads because of the increase in mass flow. These gases, of course, eventually pass through the gas offtake 70 leading from the furnace into the back passes. As has been stated, it is well known that uncorrected superheated steam temperature tends to be high at high load because of the rising characteristic of a convection superheat curve. In the pres-

ent case, the line of greatest mass flow of gases passes through the water tube platens 75. This means that the gases reach the convection superheaters at the highest temperature because there has been the greatest possibility of heat convection and radiation to these water tube platens. This results in a tendency to lower superheat temperature.

Referring to FIG. 3, which shows the relationships existing at low load, the flame 120 is shown as positioned close to the front wall 15, so that a large percentage of the gases tend to avoid the water tube platens 75. At low load there is a tendency, because of the lower mass flow, for the superheat to be low but, because the gases are not cooled by passage between the water tube platens 75, the gases when they reach the upper pass 34 and the back passes 37 and 38 (in which reside the convection superheaters and reheaters) are considerably hotter than would be the case if they had passed between the water tube platens. Because these water tube platens 75 have considerable longitudinal dimensions and extend vertically through a considerable portion of the furnace, the cooling effect can be quite considerable. By proper adjustment of the settings of the vanes at various loads the flame can be adjusted backward and forward to different positions between the front and rear walls to aid considerably in maintaining the superheat and reheat at desired constant values.

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 combustion chamber having two opposed walls, fuel-burning apparatus located on the said opposed walls at the lower end of the combustion chamber for producing a mass of hot gas, a gas off-take opening from the upper part of one of the said opposed walls of the combustion chamber, a plurality of water tube platens located in the chamber, each platen having a rearward edge located adjacent the said one of the said opposed walls and a forward edge spaced a substantial distance from the other of the said opposed walls, a convection superheater located downstream of the combustion chamber, and positioning means associated with the fuel-burning apparatus to locate the line of greatest mass flow of gas at a desired position between the said one wall and a wall opposed to the said one wall, the said positioning means causing the said line of greatest mass flow of gas to be located adjacent the said opposed wall at low load so that only a small portion of the gas passes over the platens on its way to the convection superheater and causing the line of greatest mass flow of gas to be located adjacent the said one wall at high load so that a large portion of the gas passes over the platens on its way to the convection superheater to aid in maintaining the temperature of superheated steam at a predetermined value.

2. A steam generating unit, comprising a vertically-elongated combustion chamber having front, rear and side walls, fuel-burning apparatus located at the lower end of the combustion chamber for producing a mass of hot gas, a gas off-take opening from the upper part of the rear wall, a nose extending across the combustion chamber immediately below the gas off-take, a plurality of water tube platens located in the chamber, each platen

having a rearward edge located adjacent the rear wall and a forward edge spaced a substantial distance from the front wall, convection superheater elements located downstream of the nose, and positioning means associated with the fuel-burning apparatus to locate the line of greatest mass flow of gas at a desired position between the front and the rear wall, the said positioning means causing the said line of greatest mass flow of gas to be located adjacent the front wall at low load so that a small portion of the gas passes over the platens on its way to the convection superheater elements and causing the line of greatest mass flow of gas to be located adjacent the rear wall at high load so that a large portion of the gas passes over the platens on its way to the convection superheater elements 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, opposed abutments extending from the front and rear walls to define a high-temperature cell at the lower end of the combustion chamber, fuel-burning apparatus located in the high temperature cell for producing a mass of hot gas, a gas off-take opening from the upper part of the rear wall, a nose extending across the combustion chamber immediately below the gas off-take, a plurality of water tube platens located in the chamber, each platen having a rearward edge located adjacent the rear wall and a forward edge spaced a substantial distance from the front wall, convection superheater elements located above the nose adjacent the gas take-off, and positioning means associated with the fuel-burning apparatus to locate the line of greatest mass flow of gas at a desired position between the front and the rear wall, the said positioning means causing the said line of greatest mass flow of gas to be located adjacent the front wall at low load so that a small portion of the gas passes over the platens on its way to the convection superheater elements and causing the line of greatest mass flow of gas to be located adjacent the rear wall at high load so that a large portion of the gas passes over the platens on its way to the convection superheater elements to aid in maintaining the temperature of superheated steam at a predetermined value.

4. A steam generating unit as set forth in claim 3, wherein the fuel-burning apparatus consists of directional-flame burners located on the undersides of the abutments.

5. A steam generating unit as set forth in claim 3, wherein the water tube platens lie in parallel spaced planes extending perpendicular to the rear wall and extending vertically substantial distances above and below the said nose.

6. A steam generating unit as set forth in claim 3, wherein a back pass extends vertically from the gas off-take, a baffle extending through the back pass and dividing it into a first and a second portion, a convection superheater located in the first part, a convection reheater located in the second part, and dampers controlling the division of gas flow between the first and second parts.

7. A steam generating unit as set forth in claim 5, wherein the platens are provided with lower edges which are inclined downwardly and forwardly from the rear wall.

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