Aug. 2, 1960 E. C. MILLER 2,947,289

STEAM TEMPERATURE CONTROL

Filed April 11, 1958

4 Sheets-Sheet 1

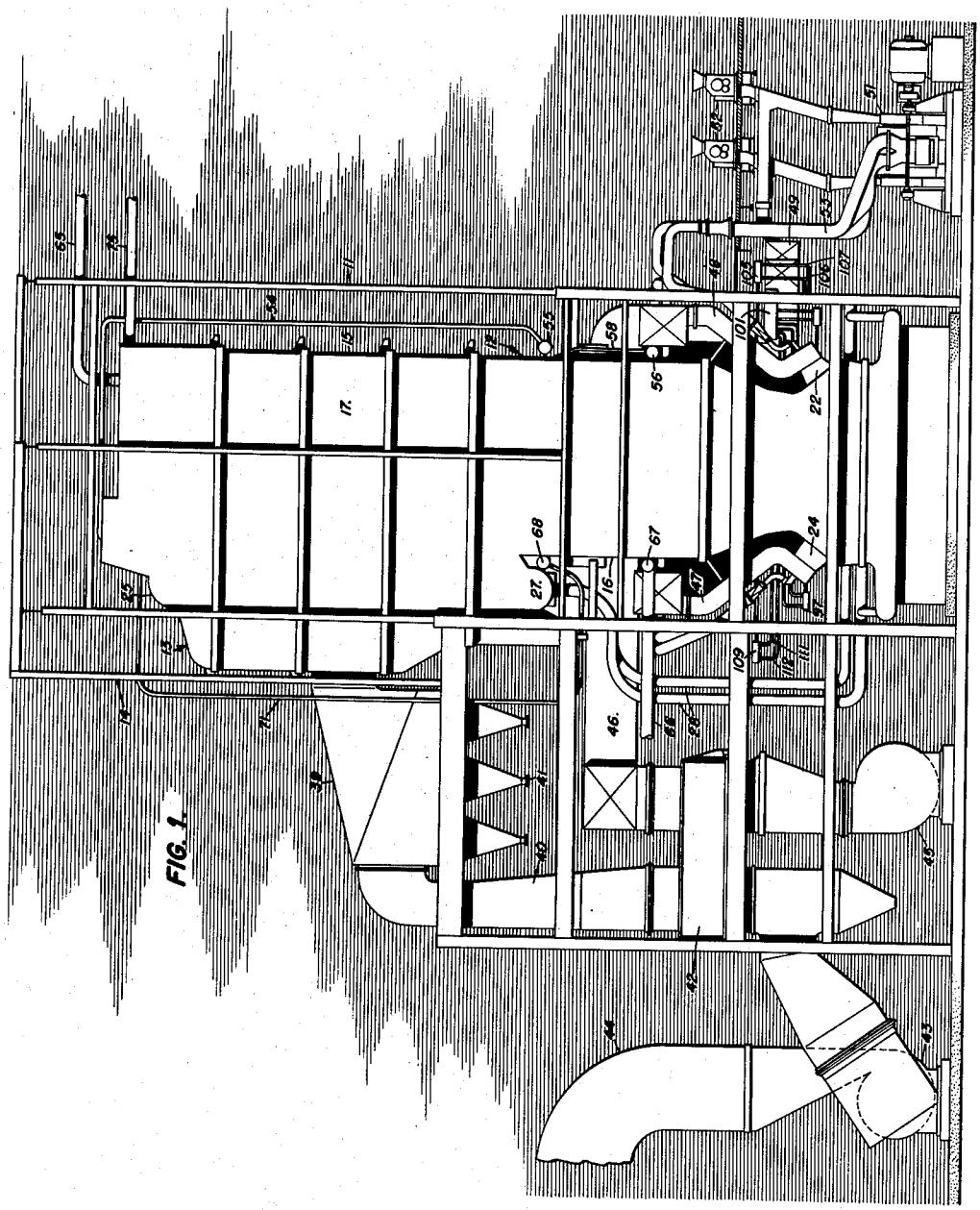


FIG. 1.

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STEAM TEMPERATURE CONTROL

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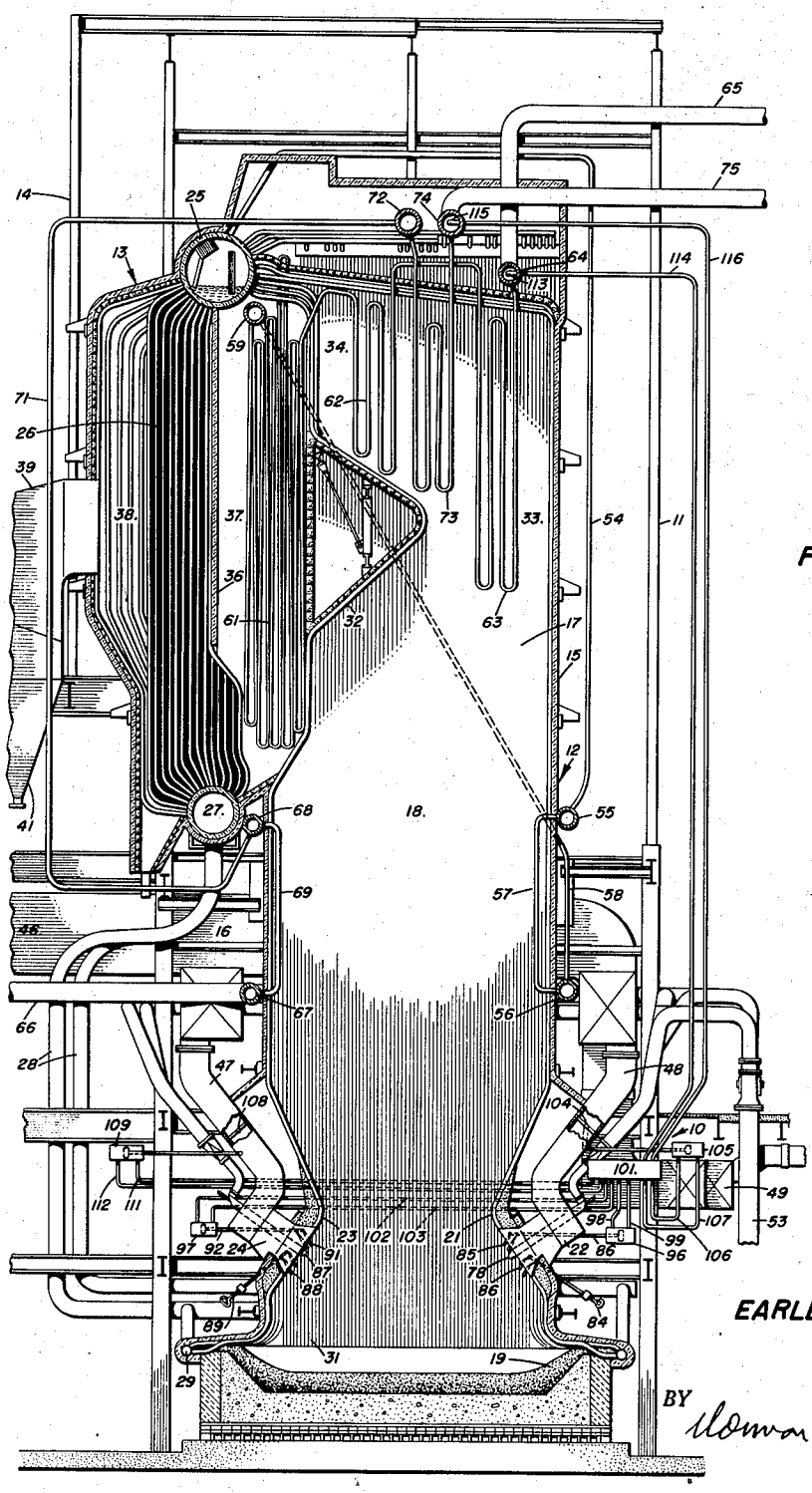


FIG. 2.

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STEAM TEMPERATURE CONTROL

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FIG. 3.

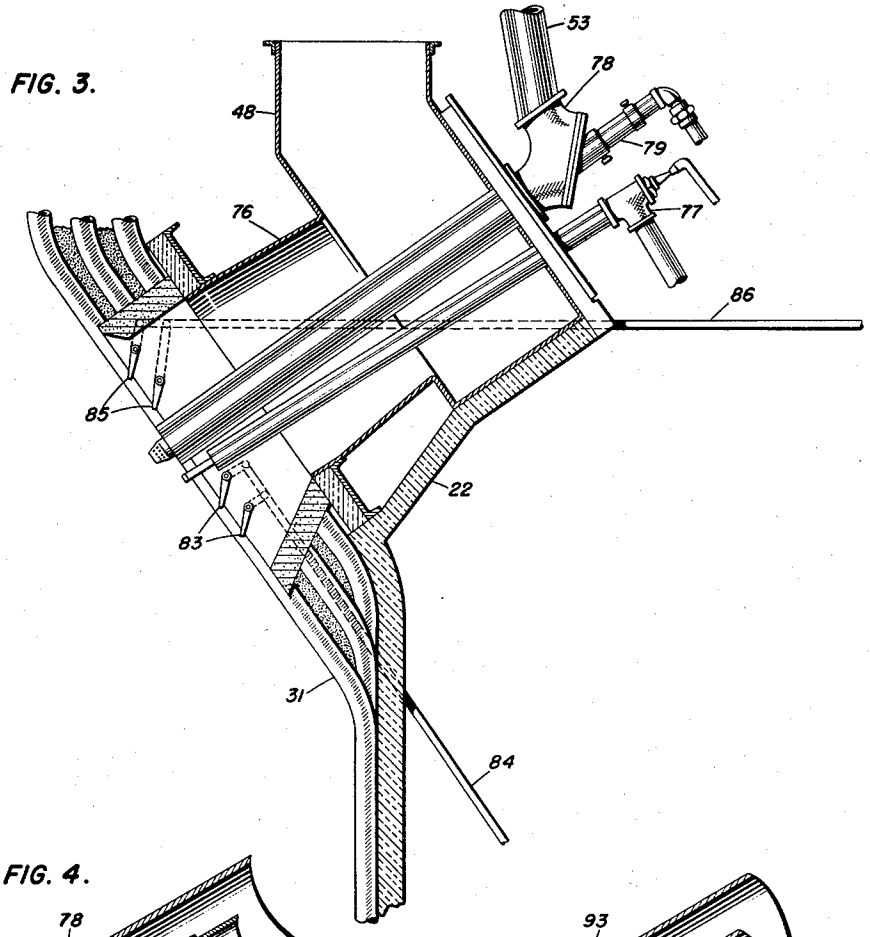
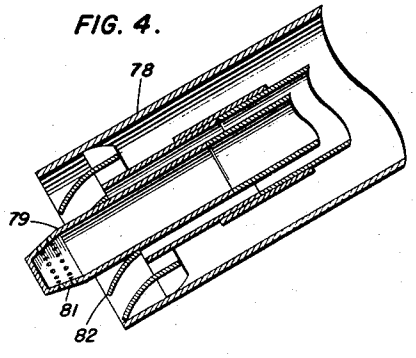


FIG. 4.



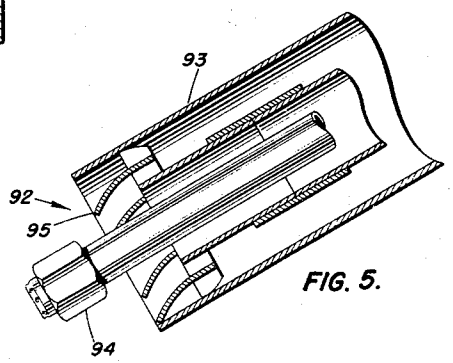


FIG. 5.

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STEAM TEMPERATURE CONTROL

Filed April 11, 1958 4 Sheets-Sheet 4

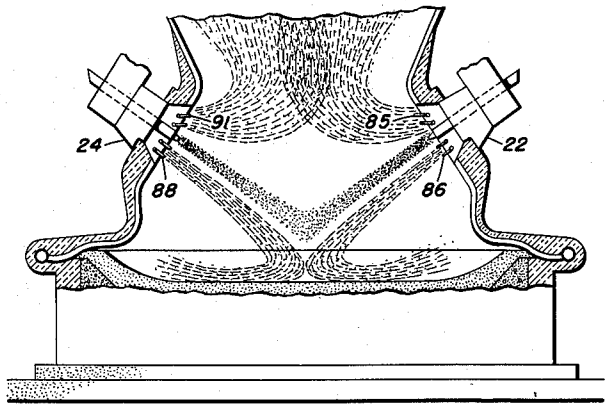


FIG. 6.

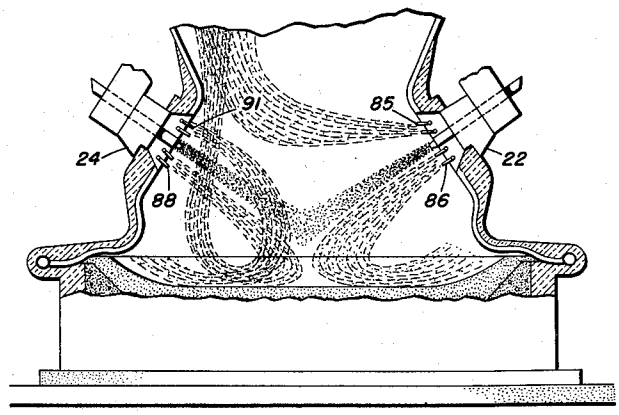


FIG. 7.

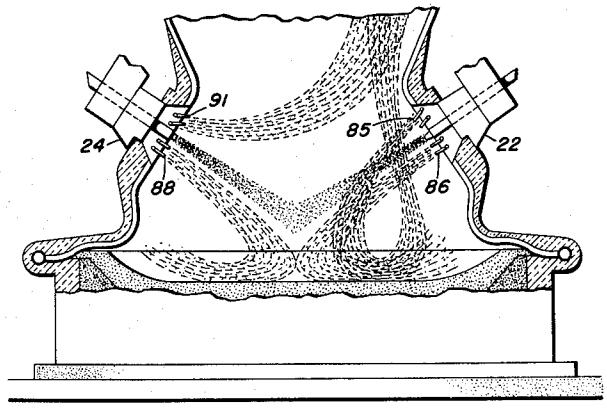


FIG. 8.

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United States Patent Office 2,947,289
Patented Aug. 2, 1960

2,947,289

STEAM TEMPERATURE CONTROL

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Filed Apr. 11, 1958, Ser. No. 728,005

12 Claims. (Cl. 122—479)

This invention relates to steam temperature control and more particularly to apparatus arranged to regulate the degree of superheat in a steam generating unit.

In the past, there have been many methods used in connection with steam generating units to maintain the temperature of the superheated steam at a fixed value, irrespective of changes in load on the unit. For instance, the flow of gases over the superheater elements has been controlled by the use of dampers; this practice has the disadvantage of being relatively insensitive and producing relatively high exit gas temperatures at certain loads so that the overall efficiency of the unit is decreased. Superheat temperature has also been controlled by desuperheaters wherein the steam generating unit produces superheated steam at the highest temperature necessary at a reduced load and the steam is cooled to produce the desired steam temperature at highest loads; this has the disadvantage of requiring extremely large superheater elements to take care of the extreme conditions. Superheat has also been controlled by recirculating a portion of the gases from the back passes of the unit to the furnace proper; this has the disadvantage of producing high dust loading of the furnace gases with resultant cutting and deterioration of the boiler tubes and increase of power requirements. Another method of controlling superheat that has been proposed is the use of the so-called "tilting burner," in which case the flame in the furnace is directed upwardly or downwardly to maintain the superheated steam at a constant value; the burners required for this practice are extremely complicated and expensive to build and maintain. Other methods and apparatus for controlling superheat have been suggested which are of lesser importance than those described above, but there is no practice which could be said to be a perfect one, since all previously-known methods of controlling superheat suffer from difficulties which render them less than ideal. 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 an apparatus for the control of superheat in a steam generating unit, which apparatus is inexpensive to manufacture, and to maintain.

Another object of the invention is the provision of an apparatus for the control of superheat whose operation 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 can be used for initial adjustments of superheat made necessary by inaccuracies in design and construction and is also extremely sensitive in maintaining superheat at constant temperature, irrespective of changes in load.

A still further object of the present invention is the provision of an apparatus for the control of superheat in which the mass flow of the steam generating unit is not increased.

A still further object of the invention is the provision of a steam temperature control in which at no time does the flame impinge on the furnace walls and in which slagging difficulties are avoided.

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 certain of its structural forms, as illustrated by the accompanying drawings, in which:

Figure 1 is a side elevational view of a steam generating unit embodying the principles of the present invention,

Figure 2 is a vertical sectional view of a portion of the unit,

Figure 3 is a sectional view, somewhat enlarged, of a burner used in the practice of the present invention,

Figure 4 is an enlarged view of a portion of the burner shown in Figure 3,

Figure 5 is an enlarged view of a portion of a modified burner, and

Figures 6, 7, and 8 are schematic views of a steam generating unit showing the operation under various conditions.

In the specification which follows the expressions "longitudinal," "transverse," and the like, reference is made 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 Figures 1 and 2, wherein are best shown the general features of the invention, the steam temperature control designated generally by the reference numeral 10 is shown in use with a steam generating unit 11. The steam generating unit consists generally of a furnace 12 and a boiler 13 mounted on a supporting structure 14. The furnace 12 consists of a forward wall 15 and a rearward wall 16 which with side walls 17 define a combustion chamber 18. Underlying the combustion chamber is a slag basin 19 formed of refractory material. The forward wall 15 is provided with a nose 21 located in its lower portion directly overlying the slag basin 19 and provided with a burner 22. A similar nose 23 is provided on the rearward wall 16 and a burner 24 is mounted on the downwardly directed surface of the nose.

The boiler 13 consists of an upper steam-and-water drum 25 joined by downcomer tube 26 to a lower drum 27, both drums extending transversely of the unit. Large downcomer pipes 28 extend from the lower drum 27 to a header 29 extending around the periphery of the slag basin 19. Water wall tube 31 extends upwardly from the header 29 along the forward wall 15, the rearward 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. A nose 32 extends forwardly of the furnace at the upper part of the rear wall 16 and provides a restricted passage 33 between the most forward portion and the forward wall 15. The nose 32 also serves to define an upper pass 34 between its upper surface 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 leads from the back pass 38 to a dust collector 41 which, in turn, is connected by a duct 40 to one side of a rotary regenerative air heater 42. The output side of the air heater is connected through an induced draft fan 43 to a breeching 44 leading to the stack, not shown.

A forced draft fan 45 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. A duct 49 leads from the duct 46 to an attrition-type pulverizer 51 which receives its fuel from drum-type feeders 52. Pipes 53 lead from the output of the pulverizer 51 to the burners 22 and 24.

As is evident in Figure 2, the steam-and-water drum 25 is provided with a separator of the usual type and tubes 54 lead from the upper part of the steam-and-

water drum to a header 55 arranged beside the forward wall 15 of the furnace. Below the header 55 is arranged another header 56 of a similar type and joining these headers and lying within the furnace against the forward wall 15 are radiant superheater tubes 57. Tubes 58 lead from the header 56 to a header 59 which is connected through a convection superheater 62 lying in the upper pass 34. The output of the superheater 62 is connected to superheater platens 63 hanging downwardly from the roof 35 into the restricted passage 33 in the upper part of the combustion chamber. 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 turbine, not shown. The output of the high-pressure section of the turbine, not shown, is connected by means of a pipe 66 to a header 67 arranged adjacent the rearward 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 rearward wall 16. 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 a low pressure section of the turbine, not shown.

Referring next to Figures 3 and 4, wherein are best shown the details of the burner 22, it can be seen that the air duct 48 is connected to a housing 76. Centrally of the housing is located a continuous spark ignitor 77 and a gun 78 for introducing 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 79 to insure ignition. The gas gun is provided with a perforated nose 81 which extends slightly forward of the innermost end of the fuel gun 78. Surrounding the gas gun within the fuel gun 78 are coal-spreader veins 82 which are so formed as to cause the coal to be projected in a downward direction. As is evident in Figure 2, 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 92. In Figure 5 can be seen a modified version of a fuel gun 96 for use in a burner of the type described wherein an oil gun 94 is provided in the central portion to insure ignition of the fuel. Here again, a coal spreader 95 provides for the projection of the fuel in a predetermined direction.

Referring now to Figure 2, it can be seen that 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 pivoting action through a mechanical linkage to the piston rod of a linear actuator 105 whose piston is moveable 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 which is connected to the controller 101 by means of conduits 111 and 112. This superheated steam header 64 has inserted therein a temperature indicating device 113 of the usual type which is connected through a line 114 to the controller 101. A 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, and is provided with 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, and 112, 102 and 103, leading to the 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.

The operation of the apparatus of the invention will now be readily understood in view of the above description. Fuel arrives at the feeders 52 and is mixed with a small amount of primary air coming from the duct 49 and enters the pulverizer 51 where it is comminuted. The pulverized fuel passes through the conduit 53 to the fuel guns 78 and 87 of the burners 22 and 24, respectively. The pulverized fuel is projected into the combustion chamber 18 in the general direction of the slag basin 19.

The lines of action of the fuel flow intersect at an imaginary point in the central part of the furnace a small distance above the basin 19. Air enters the unit through the forced draft fan 45 and after being preheated in the air heater 42 passes through the duct 46 into the separate ducts 48 and 47 leading to the burners 22 and 24, respectively. The air enters the burner housings and flows past the pivoted vanes into the furnace. Some of the air is controlled by the lower vanes 86 and 88 and this air blends with the fuel coming from the fuel guns forming a mass of turbulent fuel and air in the portion of the combustion chamber which underlies the noses 21 and 23. Ignition is maintained by the gas gun 79 whose ignition in turn is insured by the continuous spark ignitor 77. The air which passes over the vanes 85 and 91 also joins the mass of turbulent fuel and air in the lower part of the furnace overlying the slag basin 19 and takes part in the combustion process. It is the nature of this particular design of furnace that combustion takes place almost completely below the horizontal line defined by the innermost points on the noses 21 and 23. Gases pass from this lower portion of the furnace up through the combustion chamber 18 and leave the chamber through the restricted passage 33 and the upper pass 34, passing over the superheater 63, the convection reheater 73, and the convection superheater 74. While the gases pass upwardly through the combustion chamber 18, the radiant superheater 57 and the radiant reheater 69 receive heat by radiation. The gases then pass downwardly through the back pass 37 over the convection superheater 61 and upwardly through the back pass 38. They then pass through the duct 39, the dust collector 41, the duct 40, the air heater 42, the induced draft fan 43 and the breeching 44.

Feedwater enters the boiler 13 in the lower part of the steam-and-water drum 25 and passes therefrom downwardly through the downcomer tubes 26 to the drum 27. Some of the water arriving there passes downwardly through the downcomer tubes 28 to the header 29 and then flows upwardly through the waterwall tubes 31 where it is converted to steam, which steam passes into the steam-and-water drum 35 and is purified. Purified steam passes out of the drum through the pipe 54 into the header 55, passes through the radiant superheater 57 into the header 56 and then goes upwardly through the tube 58 to the convection superheater 61. The steam then passes through the convection superheater 62 in the upper pass 34 and from there through the superheater platen 63 to

the superheated steam header 64. At that point the steam temperature is measured by the device 113 and the steam passes through the pipe 65 to the turbine. After expansion through the high-pressure section of the turbine, the steam is returned through the pipe 66 to the header 67 and from there through the radiant reheater 69 to the header 68. Reheat steam then passes through the pipe 71 to the input header 72. From there the reheat steam passes through the convection reheater 73 to the reheated steam header 74 where its temperature is measured by the device 115. After that the steam passes through the pipe 75 to the turbine.

Referring now to Figure 6, the condition is shown wherein the vanes 85 and 91 are directed toward one another and the setting of the dampers 104 and 108 are the same so that the quantity of fuel is evenly divided between the burner 22 and the burner 24. The air flowing through the vanes 86 and 88 picks up a quantity of fuel from the fuel gun and generates a pair of flames which strike one another and spread downwardly along the surface of the slag bottom 19. The air flowing through the vanes 85 and 91 also causes a centralizing of the combustion process and a centralizing of the gases flowing upwardly through the furnace. Actually, with the air flow through the vanes 85 and 91 evenly matched in quantity and in direction, the velocity of flow of gases between the noses 21 and 23 and upwardly through the rest of the furnace is fairly evenly distributed from the front wall 15 to the rearward wall 16. The result is a rather long residence time of the gas on an average in the furnace and a considerable absorption of heat by the waterwall tubes 31. The result is that the gas passing over the convection superheater and the convection reheater is at a relatively low temperature. Furthermore, with the gas flow distributed fairly evenly between the front and rear walls of the furnace, the amount of radiation absorbed by the radiant reheater 69 and the radiant superheater 57 is small, even though the residence time in the combustion chamber is fairly long. This is true because no great concentration of gases is closely adjacent either of these radiant elements and because the radiation absorbed is, of course, inversely proportional to the square of the distance. When, however, the vanes 85 are raised and the vanes 91 are lowered, the situation portrayed in Figure 7 results. Assuming that the dampers 104 and 108 permit equal flow of air to the burners 22 and 24, the air flowing from the vanes 85 will force the air from the vanes 91 downwardly and the pattern shown in the illustration will take place. The result would be that the flow of gas will be compressed toward the rearward wall 16 and the average velocity of the gas particles in the furnace will be increased, thus resulting in a shorter residence time in the furnace and a higher temperature of gases leaving the furnace and passing over the convection superheater and reheater. Since the mass flow of particles takes place closer to the radiant reheater 69 and further away from the radiant superheater 57, it would be expected that the radiant superheat would be low whereas the temperature due to passage of steam through the radiant reheater 69 would be high compared to that found when the situation is that which is portrayed in Figure 6. However, the short residence time of the gases in the furnace will cause the temperature of reheat and superheat resulting from the convection sections to be higher, so the net result will be high superheat and high reheat. It should be noted that in this situation the air passing through the vanes 86 and 88 remains approximately the same, and is not appreciably disturbed by the adjustment of the vanes 85 and 91 so that slag on the slab bottom 19 remains molten and in a pool, as is desired. The situation in Figure 7 could be obtained in a lesser degree, of course, by raising the vanes 85 and keeping the vanes 91 fixed where they were before; for instance, in a horizontal position. The effect on superheat and reheat would, of course, be smaller. Another adjustment which may be made is that shown in Figure 8 wherein the vanes 91 are raised and the vanes 85 are lowered so that the flow of gases is compressed toward the forward wall 15. Here again, the average velocity of the particles of gas is substantially increased so that the residence time in the furnace is less and the temperature of gases leaving the furnace is greater, thus resulting in an increase of reheat and superheat in the convection sections thereof which is greater than that found with the situation portrayed in Figure 6. However, in this case, the radiant superheater 57 will receive a greater amount of radiation whereas the reheater 69 will receive less. The result will be that radiant reheat will be lowered below that encountered in the situation in Figure 6, whereas the radiant superheat will be raised over the Figure 6 situation. The overall superheat and reheat will, of course, be high but the superheat will be higher than that encountered in Figure 7 since the radiant superheater 57 has received more radiant heat than in that case. However, the overall reheat will be lower than that encountered in the situation in Figure 7 since the radiant reheater 69 has received less than in that situation. The operation shown in Figure 8 could, of course, be obtained by leaving the vanes 85 fixed, say in a horizontal position, and merely raising the vanes 91 to dominate the situation.

It can be seen, then, that by the tilting of the vanes in the manner indicated it is possible to force the mass flow of gases from a position in the center of the furnace to positions either near the rearward wall or near the front wall. This same effect may be accomplished by use of the dampers 104 and 108. When the dampers have equal settings so that the flow of air to the burners 22 and 24 is equal, the mass flow of gas will be more or less equally distributed between the front and rear walls and the average velocity of gas flow will be low, thus giving a long residence time and a low convection superheat. The radiation to the radiant superheater aud reheater will be at an average value. When the damper 104 is opened and the damper 108 is closed to cause a greater flow of air to the burner 22 than to the burner 24, the burner 22 will dominate the situation and force the mass flow of gases toward one of the walls of the furnace, so that the situation portrayed in either Figure 7 or Figure 8 takes place. When the damper 108 is opened and the damper 104 is closed so the air flowing through the burner 24 is much greater than that flowing through the burner 22, the burner 24 dominates and the position of the mass flow relative to the walls is reversed from the situation described just above. The result then is that the residence time of the gases in the furnace is very short and the temperature passing over the convection superheater and reheater is very high; the radiation to the radiant superheater 57 is greater or lesser than that to the radiant reheater 69 depending, of course, on which of the conditions shown in Figures 7 and 8 prevails.

It will be understood that the action of moving the mass flow of gases back and forth in the furnace to increase and decrease the residence time and to bring the mass flow in proximity or lack of proximity to certain radiant elements is possible either by changing the angularity of air flow by means of the vanes 85 and 91 or by changing the amount of air distribution to the two burners. Since in a furnace of the type shown the temperature in the lower part of the furnace below the noses 21 and 23 is extremely high and combustion takes place by a turbulent intermixing of fuel and air, there is no danger of lack of ignition due to the decrease of air to one burner and the increase to the other burner, as might be true in some furnace designs. It will be understood that the control may take place either by movement of the dampers 104 and 108 or by movement of the vanes 85 and 91 or by use of both. Signals of output radiant reheat arrive at the controller 101 through the lines 114

and 116, and these signals are translated by the controller into flow of oil through the lines leading to the linear actuators. If, for instance, both reheat and superheat are too low, the controller may permit oil to flow through the lines to the linear actuators to move the pistons in the cylinders so that the vanes 85 are raised and the damper 84 opened, while the vanes 91 are lowered and the damper 108 is moved to a more closed position. This will result in a greater overall superheat and reheat, but the emphasis is on increase in reheat because the mass flow will take place closer to the radiant reheater 69. If, however, one wishes to increase superheat more than one wishes to increase reheat, although at the same time both must be raised somewhat, the opposite action will take place; the controller will signal for the closing of the damper 104 and the lowering of the vanes 85 at the same time causing the linear actuators to raise the vanes 91 and open the damper 108 so that the situation shown in Figure 8 comes about.

It can be seen from an examination of the specification that in every condition of the furnace the slag pool in the bottom 19 is operated upon in exactly the same way so that the pool condition remains the same, irrespective of the operation of the gases in the upper part of the furnace and boiler.

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 of claims.

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

1. Apparatus for the control of superheat comprising an elongated furnace, a nose extending from the rear wall of the furnace partly across the furnace adjacent one end, a pass leaving the said one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear wall, each burner having means for projecting fuel therethrough in a fixed direction, means for controlling the total air flow through the burners, and means operative when the temperature of superheat changes from a predetermined value to cause a change in air flow through the burners, so that the position of the line of greatest mass flow is moved toward one burner and closer to the radiant superheater and the temperature of superheat is returned to the said predetermined value.

2. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving one end of the furnace in the rear wall, a convection superheater located in the said pass, a radiant superheater located in the upper part of the furnace closely adjacent a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having means for projecting fuel therethrough in a fixed direction, a slag bottom located adjacent the burners and located so that combustion takes place adjacent thereto, a nose extending from the rear wall partly across the furnace and located between the burners and the said pass, means for controlling substantially the entire air flow through the burners, and means operative when the temperature of superheat changes from a predetermined value to cause a change in air flow through the burners, so that the position of the line of greatest mass flow is moved toward one burner and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

3. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater located in the upper part of the furnace closely adjacent a wall of the furnace a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, each burner having a set of vanes for controlling the direction of air flow, said vanes being pivoted for movement about an axis transverse to the length of the furnace, and means operative when the temperature of superheat changes from a predetermined value to cause at least one set of vanes to move to a position such that its angularity relative to the axis of its burner is different from the angularity of the position occupied by the other burner, so that the position of the line of greatest mass flow is moved toward one burner and the temperature of superheat is returned to the said predetermined value.

4. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting the fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, each burner having a set of vanes for controlling the direction of air flow, said vanes being pivoted for movement about an axis transverse to the length of the furnace, and means operative when the temperature of superheat changes from a predetermined value to cause at least one set of vanes to move to a position such that its angularity relative to the axis of its burner is different from the angularity of the position occupied by the vanes of the other burner, so that the position of the line of greatest mass flow is moved toward one burner and closer to the radiant superheater and the temperature of superheat is returned to the said predetermined value.

5. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, a slag bottom located adjacent the burners and located so that combustion takes place adjacent thereto, each burner having a set of vanes for controlling the direction of air flow, said vanes being pivoted for movement about an axis transverse to the length of the furnace, and means operative when the temperature of superheat changes from a predetermined value to cause at least one set of vanes to move to a position such that its angularity relative to the axis of its burner is different from the angularity of the position occupied by the vanes of the other burner, so that the position of the line of greatest mass flow is moved toward one burner and closer to the radiant superheater and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

6. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, a slag bottom located adjacent the burners and located so that combustion takes place adjacent thereto, each burner having a set of vanes for controlling the direction of air flow, said vanes being pivoted for movement about an axis transverse to the length of the furnace, and means operative when the temperature of

superheat changes from a predetermined value to cause at least one set of vanes to move to a position such that its angularity relative to the axis of its burner is different from the angularity of the position occupied by the vanes of the other burner, so that the position of the line of greatest mass flow is moved toward one burner and closer to the radiant superheater, the average residence time in the furnace is decreased, the temperature of gases entering the pass is increased, and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

7. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, each burner having a means for controlling substantially the entire amount of air flowing therethrough and damper means operative when the temperature of superheat changes from a predetermined value to cause the damper associated with one burner to move to increase the flow of air therethrough, so that the position of the line of greatest mass flow is moved toward the said one burner and the temperature of superheat is returned to the said predetermined value.

8. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, each burner having a means for controlling substantially the entire amount of air flowing therethrough and damper means operative when the temperature of superheat changes from a predetermined value to cause the damper associated with one burner to move to increase the flow of air therethrough and the damper associated with the other burner to move to decrease the flow of air therethrough, so that the position of the line of greatest mass flow is moved toward the said one burner and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

9. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, each burner having a damper for controlling substantially the entire amount of air flowing therethrough, and control means operative when the temperature of superheat changes from a predetermined value to cause the damper associated with one burner to move to increase the flow of air therethrough and the damper associated with the other burner to move to decrease the flow of air therethrough, so that the position of the line of greatest mass flow is moved toward the said one burner and closer to the radiant superheater and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

10. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, a slag bottom located adjacent the burners and located so that combustion takes place adjacent thereto, each burner having a damper for controlling substantially the entire amount of air flowing therethrough, and control means operative when the degree of temperature of superheat changes from a predetermined value to cause the damper associated with one burner to move to increase the flow of air therethrough and the damper associated with the other burner to move to decrease the flow of air therethrough, so that the position of the line of greatest mass flow is moved toward the said one burner and closer to the radiant superheater and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

11. Apparatus for the control of superheat comprising an elongated furnace, a pass leaving the rear wall at one end of the furnace, a convection superheater located in the said pass, a radiant superheater residing in a wall of the furnace, a pair of opposed burners located at the other end of the furnace in the front and rear walls, each burner having a means for projecting fuel therethrough in a fixed direction, a nose extending partly across the furnace at the rear wall in a position located between the burners and the pass, a slag bottom located adjacent the burners and located so that combustion takes place adjacent thereto, each burner having a damper for controlling substantially the entire amount of air flowing therethrough, and control means operative when the temperature of superheat changes from a predetermined value to cause the damper associated with one burner to move to increase the flow of air therethrough and the damper associated with the other burner to move to decrease the flow of air therethrough, so that the position of the line of greatest mass flow is moved toward the said one burner and closer to the radiant superheater, the average residence time in the furnace is decreased, the temperature of the gases entering the pass is increased, and the temperature of superheat is returned to the said predetermined value, but the condition of the slag bottom remains unchanged.

12. Apparatus for the control of superheat, comprising an elongated furnace having front, rear, and side walls and having two opposed abutments extending entirely across the front and read walls adjacent the lower end of the furnace, a pass leaving the upper end of the furnace, a convection superheater located in the said pass, a radiant superheater located in the upper part of the furnace closely adjacent a wall of the furnace, a pair of opposed burners located on the downwardly-facing surfaces of the abutments, each burner having a means for projecting fuel therethrough in a fixed direction, each burner having a means for controlling the total amount of air flowing therethrough and damper means operative when the temperature of superheat changes from a predetermined value to cause the damper associated with one burner to move to increase the flow of air therethrough and the damper associated with the other burner to move to decrease the flow of air therethrough, so that the position of the line of greatest mass flow is moved toward the said one burner and the temperature of superheat is returned to the said predetermined value.

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