

Sept. 3, 1935.

E. LUNDGREN

2,013,565

BOILER

Filed May 13, 1932

3 Sheets-Sheet 1

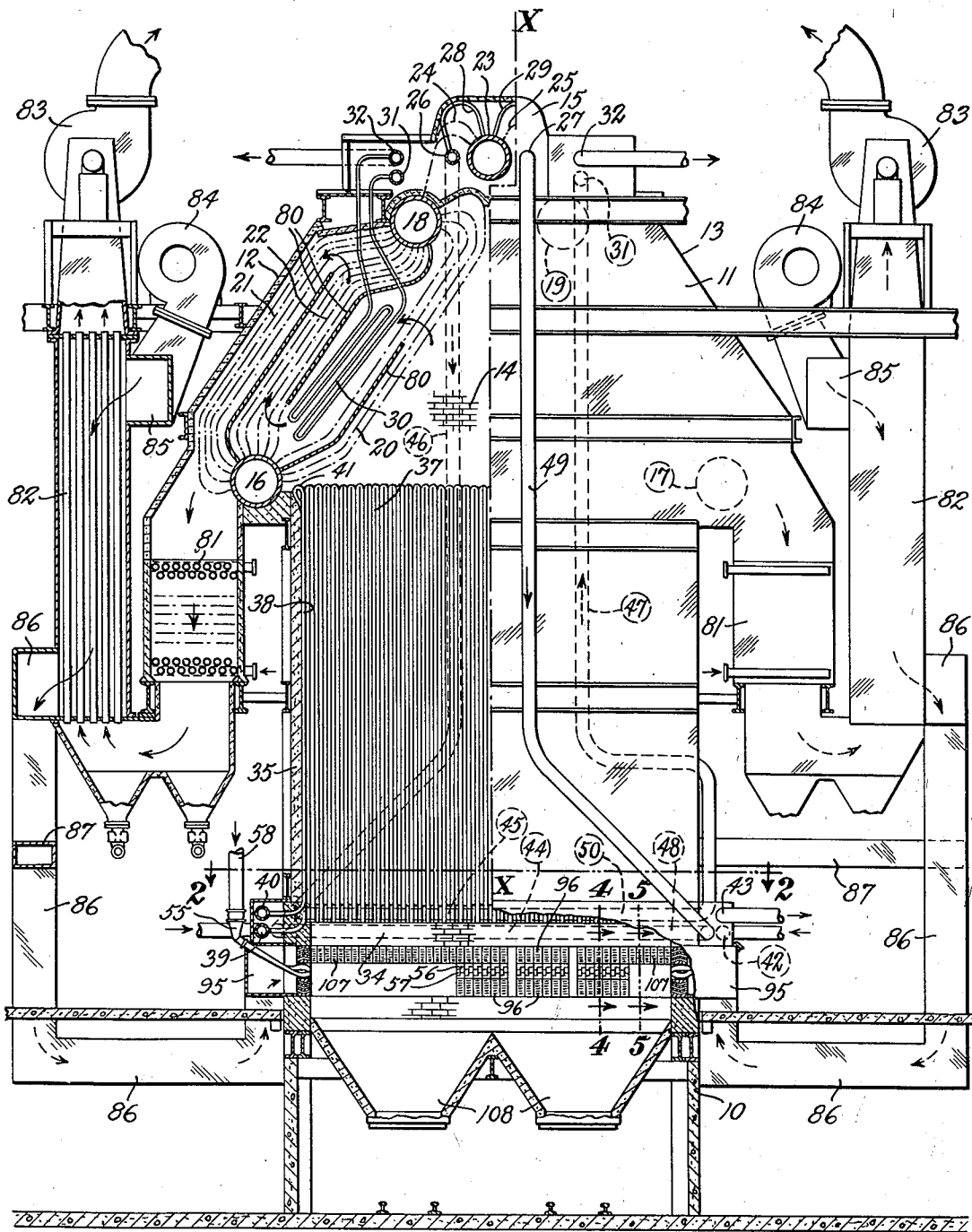


Fig. 1.

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3 Sheets-Sheet 2

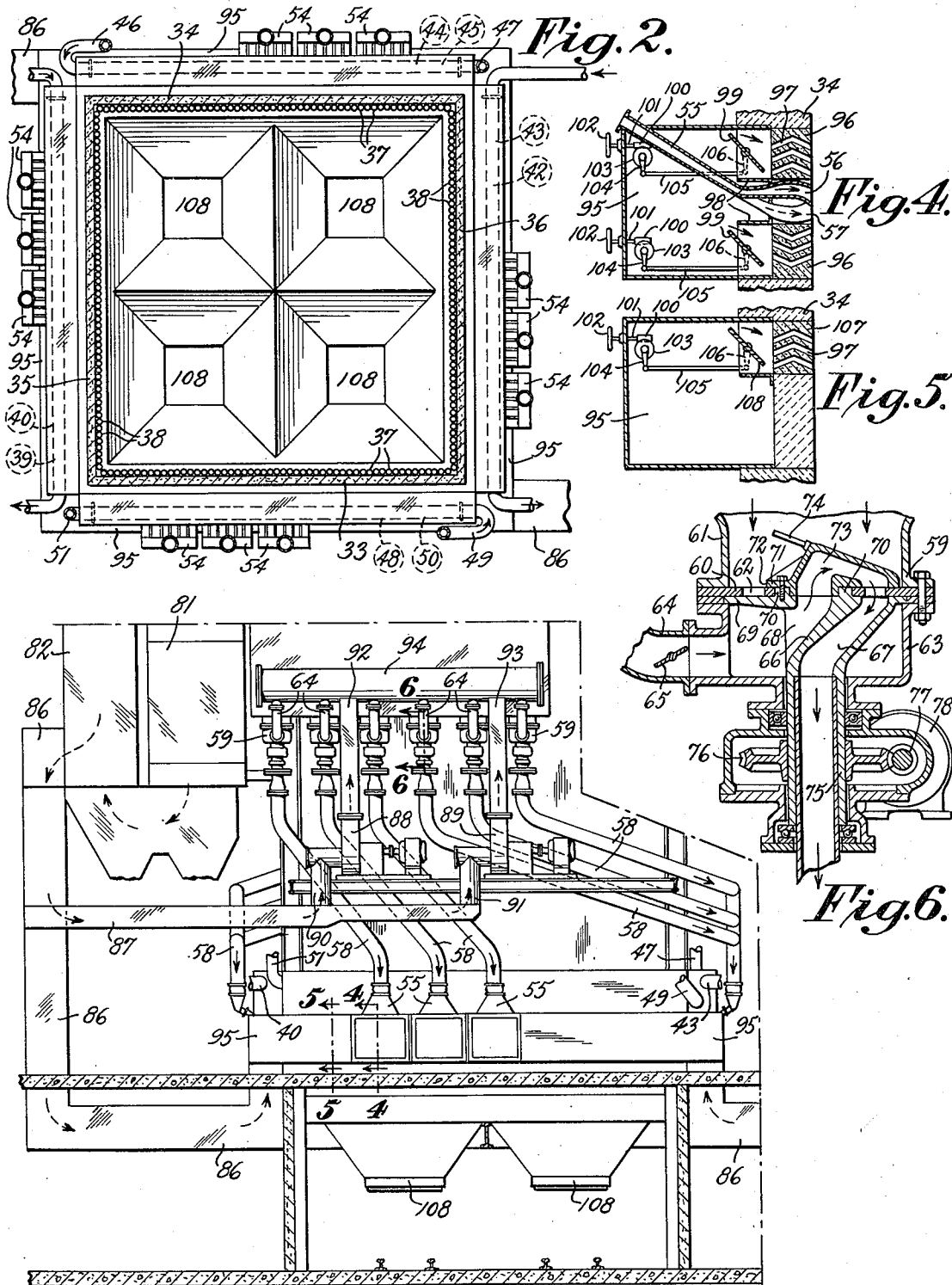


Fig. 3.

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3 Sheets-Sheet 3

Fig. 7.

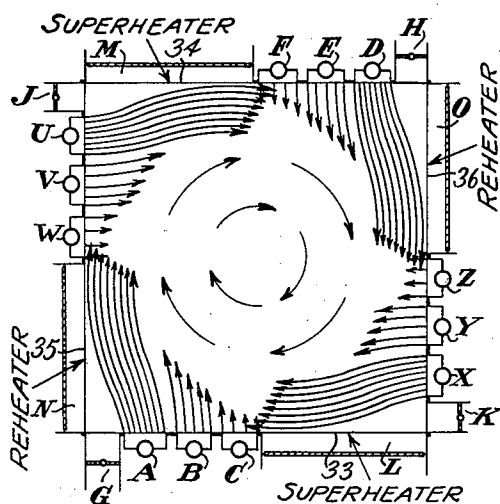


Fig. 8.

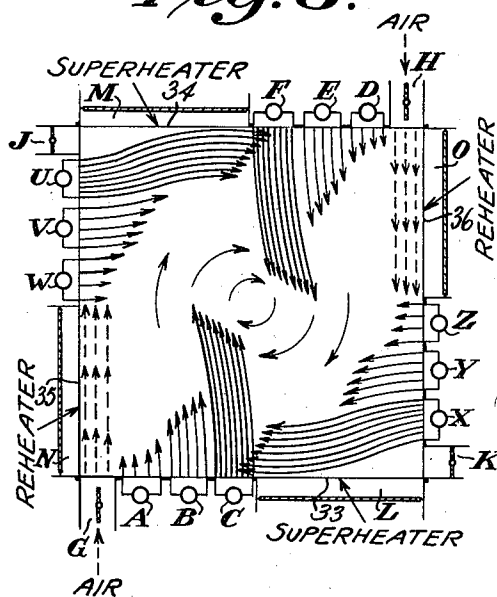


Fig. 9.

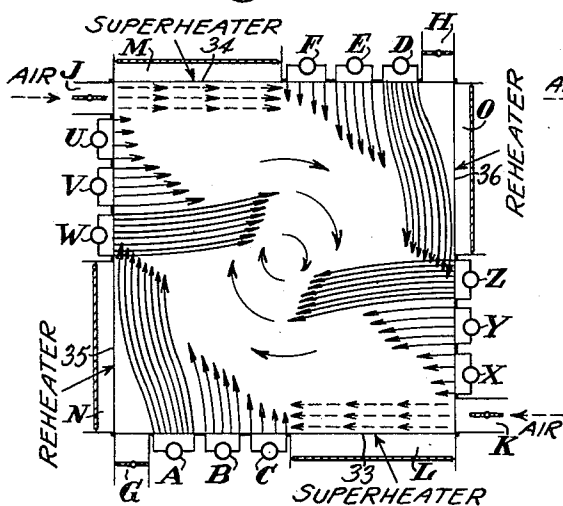
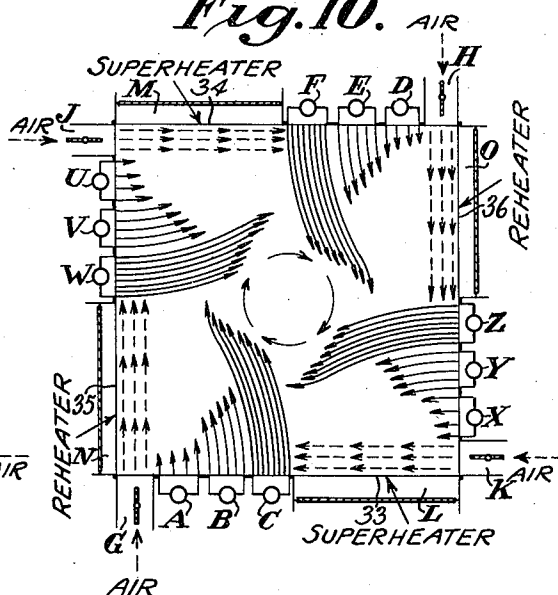


Fig. 10.



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UNITED STATES PATENT OFFICE

2,013,565

BOILER

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Application May 13, 1932, Serial No. 611,070

18 Claims. (Cl. 122—235)

This invention relates to steam generators and more particularly relates to boilers and to novel means for controlling the furnace temperatures of boilers.

5 In its broad aspect, the invention contemplates the provision of means for closely and selectively controlling the temperature of fluids passing through radiant heat absorption bodies disposed in or forming part of the furnace walls of a boiler.

10 More specifically, the invention aims to provide novel means for readily, efficiently and selectively controlling the degree of superheat and reheat of steam passing through radiant superheating and reheating tubes located in one or more walls of the furnace of a boiler.

15 The nature of the invention will become apparent from the following description considered in connection with the accompanying drawings forming a part hereof and which illustrate preferred means for carrying out the invention. Inasmuch as other means and other arrangements and combinations of the several parts may be varied without departing from the spirit of the invention, it is understood that no intention is
25 entertained to limit the scope of the invention except by the claims appended thereto.

In the drawings:

30 Fig. 1 is a view partly in longitudinal section and partly in elevation, of a high pressure boiler constructed in accordance with, and utilizing, the present invention;

Fig. 2 is a transverse sectional view of the boiler taken substantially on line 2—2 of Fig. 1;

35 Fig. 3 is a fragmentary view in elevation of the lower portion of the front of the boiler on an enlarged scale;

Fig. 4 is a sectional view on an enlarged scale taken substantially on line 4—4 of Fig. 3;

40 Fig. 5 is a sectional view on an enlarged scale taken substantially on line 5—5 of Fig. 3;

Fig. 6 is a fragmentary sectional view taken substantially on line 6—6 of Fig. 3 and on an enlarged scale; and

45 Figs. 7, 8, 9 and 10 are diagrammatic transverse sectional views of the boiler furnace similar to Fig. 2 which illustrate the manner in which the desired degrees of superheat and reheat may be selectively obtained in accordance with this invention.

50 Like characters of reference refer to like parts throughout the several views.

55 Generally speaking, the aims and objects of the invention are attained by disposing the tubes of primary and secondary or reheat radiant superheaters in one or more of the walls of the

furnace of the boiler and utilizing a plurality of jet fuel burners and suitably disposed air conduits in the lower part of each wall and controlling the operation of each of the burners and the quantity of air introduced through each of the air conduits to thereby control the position, shape and intensity of the flame issuing from each burner so that substantially any desired degree of superheat and reheat may selectively be obtained.

Referring to the drawings, reference character 10 designates the setting of a high pressure, bent water tube, boiler having a front wall 11, side walls 12 and 13, rear wall 14 and a roof 15. The boiler is substantially symmetrical with respect to the dot and dash line indicated X—X in Fig. 1, consequently for convenience of illustration, only one side of the boiler has been shown in detail. As shown, two mud drums 16 and 17 are mounted in the setting adjacent and parallel to the side walls 12 and 13 and two steam and water drums 18 and 19 are mounted in the upper part of the setting. A bank of boiler tubes 20, a bank of downcomers 21 and a bank of tubes 22, part of which serve as downcomers, connect mud drums 16 and 17 with the steam and water drums 18 and 19 respectively. A single dry steam drum 23 is connected to each of the steam and water drums 18 and 19 by banks of tubes 24 and 25 respectively. Two saturated steam collecting headers 26 and 27 are disposed along each side of the dry steam drum 23 and are connected to the latter by tubes 28 and 29 respectively. A convection superheater 30 is mounted between the tube banks 20 and 22 on each side of the boiler. These superheaters are each provided with an inlet header 31 and an outlet header 32.

As illustrated, the boiler furnace is rectangular in form and has vertical end or front and back walls 33 and 34 respectively and vertical side walls 35 and 36, all of which are formed of suitable refractory material. Broadly speaking, all of the walls are lined or covered with radiant heat absorbing surfaces. More specifically, the end walls 33 and 34 are formed, lined or covered with primary radiant superheater tubes 37 and the side walls 35 and 36 are formed, lined or covered with secondary radiant superheater or reheater tubes indicated 38. The tubes of both the primary and reheater superheaters are vertically disposed and are preferably placed close together to form substantially continuous walls of radiant heat absorbing surfaces. As shown, the radiant superheater and reheater each consists of a plurality of tube loops with the ends of the tubes connected to inlet and outlet headers, 55

For example, the reheater in side wall 35, Fig. 1, consists of inlet and outlet headers 39 and 40 respectively and a plurality of loops of the tubes 38, looped at their upper ends, the loops being designated 41, so that the path of the steam through the reheater is from the inlet header 39 upwardly in a vertical direction through the tubes 38 to the loops 41 and downwardly in a vertical direction to the outlet header 40. The reheater in side wall 36 is arranged substantially in the same manner with inlet and outlet headers 42 and 43 respectively. The radiant superheaters in end walls 33 and 34 are also arranged in substantially the same manner as the radiant reheaters in side walls 35 and 36. The radiant superheater in end wall 34 has inlet and outlet headers 44 and 45 respectively, with the inlet header 44 connected by a steam pipe 46 with the saturated steam collecting header 26 and with its outlet header 45 connected by steam pipe 47 to the inlet header 31 of convection superheater 30 disposed on the right hand side of the boiler, as viewed in Fig. 1. The radiant superheater in end wall 33 is arranged similarly to the radiant superheater in end wall 34 and has its inlet header 48 connected by steam pipe 49 with saturated steam collecting header 27 and with its outlet header 50 connected by a steam pipe 51, Fig. 2, to inlet header 31 of convection superheater 30 located on the left hand side of the boiler, as shown in Fig. 1. It is understood of course that in lieu of the connections just described any other suitable or desirable connections between the saturated steam collecting headers 26 and 27 and the radiant and convection superheaters may be utilized, and if desired, the steam from the saturated steam collecting headers 26 and 27 may be caused to pass through the convection superheaters prior to its passage through its radiant superheaters.

The furnace is fired by means of a plurality of burners 54 adapted to burn pulverized coal, oil, gas or other jet fuel and which will be termed "jet fuel" burners for convenience. In the form shown, the burners are supplied with pulverized coal and the burners are arranged and disposed in the walls of the furnace in accordance with the present invention. The burners are substantially like the inter-tube type of burner disclosed in the pending application of Martin Frisch, Serial No. 444,906, filed April 17, 1930, but with slight modifications to make them suitable for firing through a refractory wall. As shown, each burner comprises a fan tail distributing nozzle 55, each of which is connected to a plurality of nozzles arranged in two series, an upper series 56 and a lower series 57. As shown in Figs. 1 and 2, the nozzles in each series are arranged alternately, the nozzles in the upper series 56 being adapted to direct the flames issuing therefrom in a downwardly inclined direction and the nozzles in the lower series 57 being adapted to direct the flames issuing therefrom in an upwardly inclined direction. In the form disclosed, three burners, each having a plurality of nozzles, are disposed in each wall of the furnace in the lower part thereof and are arranged closely adjacent each other and adjacent one end of the wall as clearly shown in Figs. 1 and 2. The burners 54 are preferably arranged so that the flames issuing therefrom will ordinarily be directed at substantially right angles or normally from the wall in which the burners are mounted.

The pulverized coal and air are delivered to the burners 54 through conduits 58 from feeders

59, one of which is provided for each burner. These feeders are substantially of the type shown in Patent No. 1,896,354, granted to Martin Frisch, February 7, 1933, but any other desired form of feeder may be utilized. In the form shown, each feeder consists essentially of a stationary cell plate 60 secured to a cylindrical pulverized coal housing 61 and having a plurality of substantially rectangular openings or cells 62 arranged circumferentially about the center of the cell plate. A housing 63, which forms an air chamber, is secured below the plate 60 and the outlet end of an air conduit 64 controlled by a damper 65 is connected to this housing. A rotatable member 66 having an inclined cylindrical passage 67 which registers with the cells 62 in plate 60 as it is rotated, and a central air passage 68 which opens into the housing 63 at its lower end, has a circular plate-like portion 69 at its upper end which has an axially extending boss 70 which engages in a central aperture in the cell plate 60. A substantially circular plate 71 overlies the cell plate 60 and is secured to the boss 70 of the rotatable member 66 for rotation therewith. This plate 71 has a segmental portion cut away at 72 to expose certain of the cells 62 but except for the cutaway portion, the plate overlies and covers all the cells 62. The plate 71 has a curved air passage 73 which connects at its central end with air passage 68 and at its outer end registers with the cells 62 in plate 60, one at a time as the member 66 is rotated. A rod 74 carried by the plate 71 moves through the pulverized coal in the housing 61 to insure that the cells are properly filled. Rotatable member 66 has a centrally disposed sleeve 75, to which is secured a gear 76 which is driven by a worm 77, which in turn is driven by a variable speed electric motor 78 or other suitable variable speed driving means.

The operation of the feeder is as follows: Pulverized coal is delivered from a hopper or other suitable source of supply into the housing 61 and fills the cells 62 which are intermittently uncovered by the rotation of plate 71. Preheated air is forced from a source and by means presently to be described, into the housing 63 through conduit 64 and flows through passages 68 and 73 and as the member 66 is rotated, forces the pulverized coal from the cells 62 into the passage 67. The coal and air are forced through passage 67 and sleeve 75 into conduit 58 which is connected to one of the burners 54. It is thus apparent that the quantity of coal delivered to each burner may be closely controlled by controlling the speed of the motor 78 and that the quantity of air delivered to each burner may be controlled by means of the damper 65. In this manner the capacities of the burners are controlled and the intensity of the flame issuing from each burner may be precisely controlled as desired.

At this point it is deemed desirable to describe the course of the gases or products of combustion on leaving the furnace. From the furnace the gases flow in two separate paths over the boiler tubes 20, convection superheaters 30 and tube banks 22 and 21 in each set on opposite sides of the boiler, their course being directed by means of suitable baffles 80. After leaving the tube banks 21 the gases pass over the tubes in the economizers 81 and then pass through the tubes of air heaters 82 after which they are delivered to a stack or stacks by force draft fans 83.

Preheated air is delivered to the burner 54 in the following manner: Atmospheric air is delivered by blowers or fans 84 into conduits 85, 75

whence it is forced over the tubes of the air heaters 82 which may or may not be provided with suitable baffles to direct the course of the air over the tubes. From the heaters 82 the heated air passes into air ducts 86 which deliver it to points adjacent the burners 54 as will presently appear. A duct 87 which connects at one end with the duct 86, delivers part of the preheated air flowing through the duct 86 to primary air fans 88 and 89, Fig. 3, through short connecting ducts 90 and 91. The air fans 88 and 89 deliver the heated air through ducts 92 and 93 respectively to a manifold 94 from which the air is delivered through conduits 64 previously described to each of the feeders 59. As indicated in Fig. 3, each air duct 87 delivers air to two primary air fans which supply the air manifold 94 from which air for six feeders and burners is delivered. In other words, with the form disclosed two such air supply units are employed for supplying the twelve burners disposed in the four furnace walls.

Air ducts 86 deliver preheated air into ducts 95, one of which extends horizontally along the lower part of each furnace wall and for preferably the full length thereof in the zone of the burner nozzles 56 and 57.

Air direction tiles 96 are provided above and below each pair of nozzles of the burners, each of the tiles being provided with a plurality of superposed air passages 97, which in the tiles above the burner nozzles have their central portions above their inlet and outlet ends and in the tiles below the burner nozzles have their central portions below their inlet and outlet ends, as shown in Fig. 4. At the rear or inlet ends of the tiles 96 and disposed in suitable cages 98 are dampers 99 which may be operated by any suitable means, such as the worm and gear mechanism shown. This mechanism consists essentially of a worm gear 100 mounted on a shaft 101 carrying an operating hand wheel 102, and a worm wheel 103 driven by the worm gear and having a crank arm 104 connected to a rod 105 which is connected to crank arm 106 rigidly secured to the damper 99. With this operating means it will be apparent that the quantity and velocity of the air passing through the direction tiles 96 may be varied and controlled at will and that the air passing through the tiles above the burner nozzles will tend to lower the direction of the flames issuing from the nozzles and that the air streams passing through the tiles below the burner nozzles will tend to raise the direction of the flames issuing therefrom. The upward or downward direction of the flames may thus be controlled as desired.

Additional air direction tiles 107 extend horizontally along the lower part of each of the walls of the furnace, preferably in the plane or zone of the tiles 96 disposed above the burner nozzles. These tiles 107 preferably extend from the burners to the ends of each wall as shown in Figs. 1 and 2 and are similar to the tiles 96 disposed above the burners 54 with similar air passages 97 therethrough. Dampers 108 are mounted back of the tiles 107 in a manner similar to the manner in which the dampers 99 are mounted and these dampers are similarly operated. Air is delivered to the tiles 96 and 107 through the conduits 95 previously described. The air streams passing through the tiles 107, together with the air streams passing through the tiles 96, aid in controlling the degree of superheat and reheat by modifying the shape, position and intensity of the

flames issuing from the several burners in the walls of the furnace, as will be described.

Suitable dust tight ash pits 108 are provided below the burners 54.

The operation is as follows: To obtain a high degree of superheat and reheat, the firing should be substantially as indicated diagrammatically in Fig. 7. Referring to this figure, burners A, D, U and X are operated at maximum or high capacity to provide relatively long flames of high intensity which are in general directed along the walls immediately adjacent to the walls in which these burners are mounted. Burners C, F, W and Z are operated at minimum or low capacity to provide very short flames and substantially little heat. Burners B, E, V and Y are operated at intermediate capacities to provide flames of lengths and intensities intermediate the lengths of the flames issuing from the burners A and C, D and F, and so forth. No air is admitted into the furnace through the air direction tiles 107 which extend from the burners to the ends of each wall, this being indicated in Fig. 7 by the closed position of the dampers in what will be termed air conduits G, H, J, K, L, M, N and O. With the arrangement of the radiant superheater and reheater tubes in the walls 33, 34, 35 and 36 of the furnace as previously described, it will be perceived that with the manner and intensity of firing just described and as indicated in Fig. 7, a high degree of superheat and reheat will be obtained. As indicated in this figure the gases or products of combustion whirl about in the furnace in a single column in the center of the furnace with the peripheral portions of the column at substantially the same distance from both the superheater and reheater tubes.

To obtain a high degree of superheat and a low degree of reheat, the burners should be operated in the manner indicated diagrammatically in Fig. 8. As indicated in this figure, burners C, F, U and X are operated at maximum capacities; burners B, E, V and Y are operated at intermediate capacities and burners A, D, W and Z are operated at minimum capacities. Air is introduced into the furnace through the conduits G and H in streams which flow along the walls 35 and 36 which are formed of tubes of the radiant reheater. These streams of air provide relatively cool insulating layers and prevent the absorption of a large amount of radiant heat in these reheater tubes. No air is introduced along the walls formed of the superheater tubes as indicated by the closed position of the dampers in conduits J and K, and air may or may not, as desired, be introduced through the conduits L, M, N and O. With this manner of firing it will be readily seen that the superheater tubes will absorb a relatively large amount of radiant heat and that the reheater tubes, due to the air streams described and to the fact that the flames issuing from the burners C and F are at some distance from the reheater tubes, will absorb but a relatively small amount of heat. As indicated in this figure, due to the action of the flames upon each other, the gases tend to swirl about in a column of irregular, transverse cross-sectional configuration as compared with the swirling column of gases of substantially circular, transverse cross-sectional configuration which is obtained by the method of firing indicated in Fig. 7. For example, the flame issuing from burner C tends to carry the end of the flame issuing from burner X and the products of combustion carried thereby toward the center of the furnace as clearly indi-

cated, and the flame from burner F likewise tends to carry the end of the flame from burner U toward the center of the furnace to provide a swirling column of products of combustion having a cross-sectional configuration which resembles a distorted ellipse with the peripheral portions of the column closer to the superheater tubes than to the reheater tubes.

Conversely, to obtain a high degree of reheat and a low degree of superheat the firing should conform to that indicated in Fig. 9. As indicated in this figure burners A, D, W and Z are operated at their maximum or high capacities, burners B, E, V and Y are operated at intermediate capacities and burners C, F, U and X are operated at minimum or low capacities. Air is admitted through certain of the air direction tiles 107 as indicated by the open position of the dampers in conduits J and K and the streams of air issuing from these conduits flow along the superheater tubes forming walls 33 and 34 and provide a relatively cool insulating layer to prevent the absorption of much heat by the superheater tubes. Air may or may not, as desired, be introduced through the conduits indicated L, M, N and O. The gases swirl about in the furnace in a column of irregular, transverse cross-sectional configuration which resembles a distorted ellipse as clearly indicated, this being due to the action of the flames issuing from the burners W and Z on the flames issuing from the burners A and D. In this instance, the peripheral portions of the column are closer to the reheater tubes than to the superheater tubes.

To obtain a low degree of superheat and reheat the firing should conform to that indicated in Fig. 10. As indicated in this figure burners A, D, U and X are operated at minimum or low capacities, burners B, E, V and Y are operated at intermediate capacities and burners C, F, W and Z are operated at maximum or high capacities. Air, as indicated by the open position of the dampers, is admitted into the furnace through each of the conduits G, H, J and K, and may or may not be admitted through conduits L, M, N and O. With the insulating layers provided by the air streams flowing along the superheater and reheater tubes as indicated, and with the burners in the central portions of each of the walls operating at maximum capacities and the other burners operating at intermediate and low capacities, it will be apparent that both a low degree of superheat and reheat will be obtained with this manner of firing. The gases swirl about in the center of the furnace in a cylindrical column of relatively small diameter and flow at approximately the same distance from both the superheater and reheater tubes.

While the manner in which high and low degrees of superheat and reheat may selectively be obtained has been described and illustrated herein, it will readily be apparent to those skilled in the art to which this invention appertains, that to obtain any other degrees of superheat and/or reheat, it is merely necessary to operate the proper burners at the desired capacities and to admit the proper quantities of air through the desired air direction tiles 107. It will also be apparent that the air streams admitted through the air direction tiles 96 disposed above and below the nozzles of each of the burners will additionally materially aid in controlling the superheat and reheat by suitably modifying in the manner desired, the shape, position and intensity of the burner flames.

It will thus be perceived that the present invention provides means by which the degree of superheat and reheat may be closely and selectively controlled, it being necessary merely to operate the several burners in the manner indicated and at the desired capacities to obtain the desired degree of superheat and reheat.

Inasmuch as the structure, disposition and arrangement of the several parts of the boiler structure disclosed herein may be widely varied without departing from the spirit of the present invention, it will be understood that no intention is entertained to limit the extent of the invention except by the scope of the claims appended hereto.

What I claim is:

1. A boiler comprising a furnace having one or more walls formed of steam heating tubes, a plurality of burners disposed in each wall of the furnace and arranged to direct the flames issuing therefrom substantially normally to the wall in which the burners are mounted, means for introducing air into the furnace from each wall adjacent and parallel to an adjacent wall and means for controlling the burners and the quantity of air introduced into the furnace to control the degree of heat of the steam in said steam heating tubes.

2. A boiler comprising a furnace having one or more walls formed of radiant heat absorption surfaces, a plurality of jet fuel burners disposed in one or more walls of the furnace, means for supplying fuel and air to said burners, means for introducing air laterally of one of the burners in each wall of the furnace, means for controlling the number of burners active in each wall in which burners are mounted and for controlling the amount of fuel and air admitted to each of said burners and means for controlling the quantity of air introduced adjacent one or more walls of the furnace for controlling the amount of heat absorbed in said radiant heat absorption surfaces.

3. A boiler comprising a setting, a rectangular furnace in the setting, opposed walls of said furnace being formed of steam superheating tubes, the other opposed walls of said furnace being formed of steam reheating tubes, a plurality of jet fuel burners disposed in each wall of the furnace and means for selectively controlling the quantity of fuel and air admitted to each of the burners for selectively controlling the degree of superheat and reheat of the steam in said superheating and reheating tubes.

4. A boiler comprising a setting, a rectangular furnace in the setting, opposed walls of said furnace being formed of steam superheating tubes, the other opposed walls of said furnace being formed of steam reheating tubes, a plurality of jet fuel burners in each of the walls of the furnace, an air conduit having an outlet at one end of each wall of the furnace, means for controlling the quantity of fuel and air admitted to each of said burners and means for controlling the quantity of air introduced into the furnace through said air conduits for selectively controlling the degree of superheat and reheat of the steam in said superheating and reheating tubes.

5. A boiler comprising a setting having a rectangular furnace therein, opposed walls of said furnace being formed of steam superheating tubes, the other opposed walls of the furnace being formed of steam reheating tubes, a plurality of burners disposed in each wall adjacent an end of each wall, an air conduit having an

outlet at said end of each of said walls, means for controlling the quantity of fuel and air admitted to each of said burners and means for controlling the quantity of air introduced into the furnace through each of said air conduits to thereby control the degree of superheat and reheat respectively of the steam in said superheating and reheating tubes.

6. A boiler comprising a setting, a rectangular furnace in the setting, opposed walls of said furnace being formed of steam superheating tubes, the other opposed walls of the furnace being formed of steam reheating tubes, a plurality of jet fuel burners disposed in each wall adjacent one end thereof and directed so that the flames issuing therefrom are directed substantially normally from the wall in which the burners are located, an air conduit in each wall having an outlet at the said end of each of said walls, means for controlling the quantity of fuel and air delivered to each of said burners and means for controlling the quantity of air introduced into the furnace through each of said air conduits for controlling the degree of superheat and reheat respectively of the steam in the steam superheating and reheating tubes.

7. A boiler comprising a setting, a rectangular furnace in the setting, opposed walls of said furnace being formed of steam superheating tubes, the other opposed walls of said furnace being formed of steam reheating tubes, a plurality of jet fuel burners disposed in the lower part of each of the said walls and adjacent one end thereof and directed so that the flames issuing therefrom are directed toward the opposite wall, an air conduit having an outlet in the lower part of each wall and at said end of each wall and arranged so that the air delivered therefrom is directed along the wall adjacent said end of each wall, means for controlling the quantity of jet fuel and air admitted to each of said burners and means for controlling the quantity of air delivered along each wall by said air conduits for selectively controlling the degree of superheat and reheat respectively of the steam in said steam superheating and reheating tubes.

8. A boiler comprising a furnace having one or more walls formed of radiant heat absorption surfaces, a plurality of jet fuel burners disposed in one or more walls of the furnace, means for controlling the number or burners active in each of the walls in which burners are mounted and for controlling the amount of fuel and air admitted to each of said burners, means for introducing air above and below each of said burners, means for controlling the quantity of air introduced above and below each of said burners, and means for introducing air at one side of one or more burners, whereby the amount of heat absorbed in said radiant heat absorption surfaces is controlled.

9. A boiler comprising a furnace having one or more walls formed of radiant heat absorption surfaces, a plurality of jet fuel burners disposed in one or more walls of the furnace, means for controlling the number of burners active in each of the walls in which burners are mounted and for controlling the amount of fuel and air admitted to each burner, means for controlling the shape, position and intensity of the flames issuing from said burners comprising air conduits having outlets above and below each of said burners and at one side of one or more of the burners to thereby control the amount of heat

absorbed by said radiant heat absorption surfaces.

10. A boiler comprising a setting, a rectangular furnace in the setting, opposed walls of said furnace being formed of steam superheating tubes, the other opposed walls of said furnace being formed of steam reheating tubes, a plurality of jet fuel burners in each of the walls of the furnace, means for controlling the quantity of fuel and air admitted to each of said burners, air conduits having outlets above and below each of said burners and outlets at the ends of each of the walls of the furnace, whereby the amount of heat absorbed in said steam superheating and reheating tubes is selectively controlled.

11. A boiler comprising a furnace having opposed walls formed of steam heating tubes, burners in the furnace discharging products of combustion approximately parallel and normal to said walls, and means for regulating said burners to control the flow of products of combustion through the furnace to control the distance of the stream of said products of combustion from the said tubes to thereby control the degree to which the steam in the said tubes is heated.

12. A furnace having walls provided with vapor heating tubes exposed to heat radiated from products of combustion flowing through the furnace, means for producing a plurality of laterally disposed streams of products of combustion in each of a plurality of walls of the furnace, the streams being directed to form a whirling column of products of combustion in the furnace and means for controlling the volume of the several streams of products of combustion to control the transverse cross-sectional configuration of said column to vary the distances of the peripheral portions of said column from said walls and tubes to control the amount of heat absorbed by the vapor in said tubes.

13. A furnace having walls provided with vapor heating tubes exposed to heat radiated from products of combustion flowing through the furnace, means for producing a plurality of streams of products of combustion in the furnace so directed as to form a whirling column of products of combustion in the furnace, means for controlling the volume of the several streams of products of combustion to control the transverse cross-sectional configuration of said column to vary the distances of the peripheral portions of said column from said walls and tubes to control the amount of heat absorbed by the vapor in said tubes, and means causing air to flow along one or more of the walls having tubes to reduce the quantity of heat absorbed by the vapor in said tubes.

14. A furnace having walls provided with vapor heating tubes exposed to heat radiated from products of combustion flowing through the furnace, means for producing a plurality of laterally disposed streams of products of combustion in each wall of the furnace, the streams being directed to form a whirling column of products of combustion in the furnace and means for controlling the volume of the several streams of products of combustion to control the transverse cross-sectional configuration of said column to provide an irregular configuration therefor whereby portions of the periphery of the column are closer to one wall than another so that the quantity of heat absorbed by the vapor in the tubes in one of said walls is greater than in the tubes in another of said walls.

15. The method of operating a furnace having walls provided with vapor heating tubes exposed to heat radiated from products of combustion flowing through the furnace which comprises
5 producing a plurality of laterally disposed streams of products of combustion in each of a plurality of walls of the furnace, directing said streams so as to form a whirling column of products of combustion in the furnace and controlling
10 the volume of the several streams of products of combustion to control the transverse cross-sectional area of the column to control the distances of the periphery of the column from the tubes in the walls of the furnace whereby the
15 amount of heat absorbed by the vapor in the tubes may be regulated.

16. The method of operating a furnace having walls provided with vapor heating tubes exposed to heat radiated from products of combustion
20 flowing through the furnace which comprises producing a plurality of laterally disposed streams of products of combustion in each of a plurality of walls of the furnace, directing said
25 streams so as to form a whirling column of products of combustion in the furnace and controlling the volume of the several streams of products of combustion to control the transverse cross-sectional area of the column to control the distances
30 of the periphery of the column from the tubes in the walls of the furnace whereby the amount of heat absorbed by the vapor in the tubes may be regulated, and causing air to flow along one or more of the walls having tubes to reduce the

quantity of heat absorbed by the vapor in said tubes.

17. The method of operating a furnace having a plurality of walls provided with vapor heating
5 tubes exposed to heat radiated from products of combustion flowing through the furnace which comprises producing a plurality of laterally disposed streams of products of combustion in each
10 of a plurality of walls of the furnace, directing said streams to form a whirling column of products of combustion in the furnace and controlling the volume of the several streams of products of
15 combustion to control the transverse cross-sectional configuration of the column to provide an irregular configuration whereby portions of the periphery of the column are closer to one wall than another.

18. The method of operating a furnace having walls provided with vapor heating tubes exposed to heat radiated from products of combustion
20 flowing through the furnace which comprises producing laterally disposed streams of products of combustion in each wall, directing the streams substantially normally from the walls in which
25 they are produced whereby a whirling column of products of combustion is formed in the furnace, and selectively controlling the volume of the streams to vary the transverse cross-sectional area of the column to control the distance of the
30 periphery of the column from the tubes in the walls of the furnace whereby the amount of heat absorbed by the vapor in the tubes may be regulated.

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