July 9, 1940. M. FRISCH 2,207,247

STEAM GENERATOR

Filed July 17, 1935

Fig. 3.

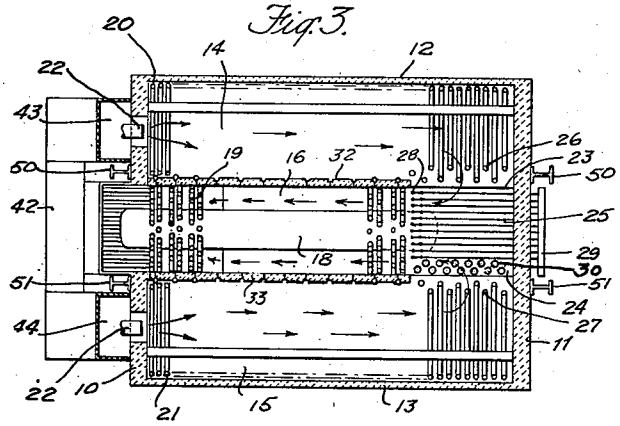


Fig. 4.

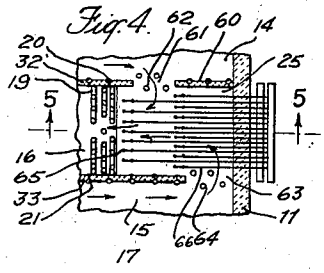


Fig. 5.

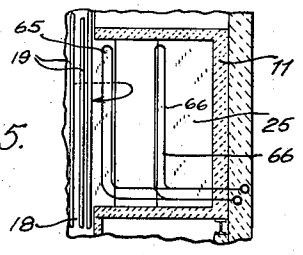


Fig. 1.

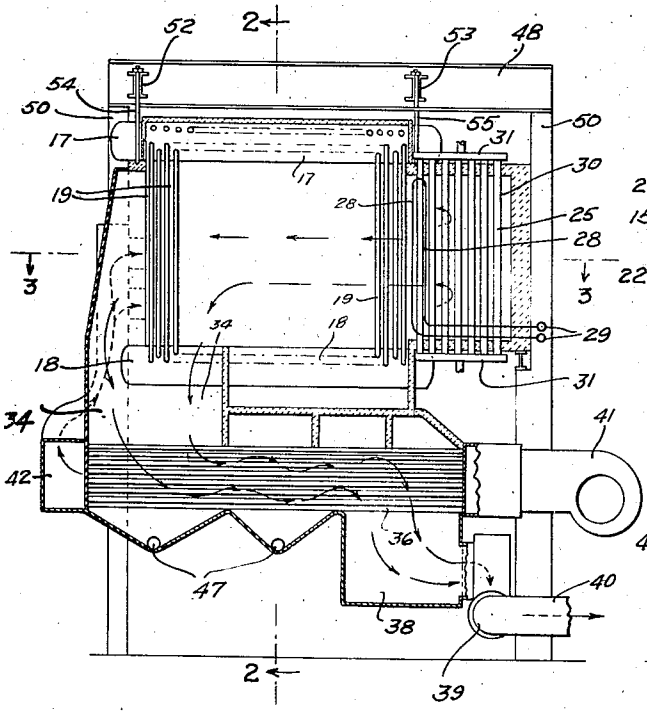
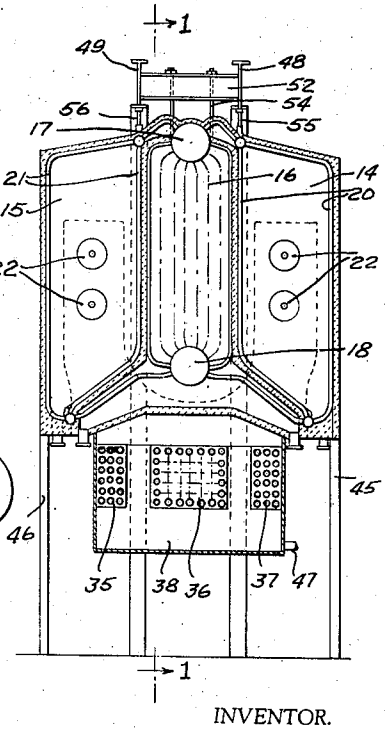


Fig. 2.



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STEAM GENERATOR

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Application July 17, 1935, Serial No. 31,757

16 Claims. (Cl. 122—485)

This invention relates to steam generators.

The broad general object of the invention is to provide a steam generator which incorporates the most desirable features of modern practice with the various component parts thereof so arranged that the generator may be readily adapted to meet very small, very large and all intermediate steam output requirements without the necessity for individually designing and constructing a generator for each new requirement. Somewhat more specifically, the invention provides a steam generator which may be adapted to various steam output requirements by changing only one dimension of the unit, its height, with the component parts so arranged that variations in this one dimension will result in a proportional variation in the furnace volume and the heating surface without any change in the width or length, and with the arrangement such as to require only very low head room for small units and less than the usual head room for large units than is now required by units of conventional design and comparable capacity.

Further obects of the invention are:

To provide a steam generator which occupies a minimum of space by reason of the elimination of the necessity for side aisles between generator units and the necessity for tube withdrawal spaces around the unit.

To provide a steam generator which includes all essentials necessary for high availability, reliability, low maintenance and high efficiency but with the elimination of all costly details of design and construction such as outside water wall connections which are required by the usual conventional designs.

To provide a steam generator in which a greater portion of the heat produced in the furnace is transferred by radiation than in conventional units and in which maximum heat absorption in the boiler proper with a lower draft loss than is customary in conventional types of generator units.

To provide a steam generator which eliminates the necessity for redesigning units for each new requirement and thereby reduce or entirely eliminate drawing room costs which ordinarily is a very large item of expense.

To reduce the cost of field erection of steam generators by designing the unit so that a larger proportion thereof may be assembled in the shop than is now customary.

To provide a steam generator which delivers dry steam with the use of a minimum number of drums,

To simplify the supporting framework of a steam generator so that a minimum amount will be required and to eliminate entirely the necessity for overhead structures for the support of auxiliaries such as fans by arranging the various components of the generator so that these auxiliaries may be located, if desired, either on the operating floor or on a basement floor if provided.

To provide a steam generator which will be suitable for outdoor operation and such that no building or protecting structure will be required.

To provide a steam generator in which it is possible to increase the load range obtainable by arranging the furnace volume with respect to the unit so that low rating operation need not result in excessive cooling of the flame.

To provide a steam generator in which superheat control may be readily effected.

To provide a steam generator in which the convection superheater is so arranged with respect to the other heating surface that there will be no direct flame impingement on the superheater and the gases, particularly where the unit is fired with pulverized coal, will make an abrupt change in direction of flow before entering the superheater so that a large proportion of the ash carried thereby will be thrown out into the furnace before the gases enter the superheater.

To provide a steam generator having a furnace so arranged with respect to the boiler that every part of the furnace volume is effective, thus permitting when necessary, higher rate of heat liberation than is now customary in practice.

To provide a steam generator which may be constructed without any brick work, if necessary, or if brick work is desirable, to have the amount thereof a minimum and of very simple design.

In the preferred embodiment of the invention, these obects are attained by providing a steam generator having a single pass two drum bent tube boiler disposed between and flanked by at least two water cooled combustion chambers of standard but minimum width required for the best performance with pulverized liquid or gaseous fuel, thereby providing the boiler with at least two exposures to radiant heat. The furnaces are entirely water cooled or may be water cooled except for the firing end and the opposite end, if desired. The furnaces are fired from the front of the boiler and the gases flow to the rear thereof where they are caused to turn through slag screens into a superheater. The gases make a change in their direction of flow of 180° so that any suspended ash or dirt will

be thrown out at the turn. The superheater is disposed at the inlet end of the boiler and by virtue of this location, possesses the characteristics of both a radiant and convection superheater. After passing through the superheater the gases flow through the boiler in one pass from rear to front in a direction parallel to the boiler drums and cross all of the boiler tubes, which are arranged in staggered rows from front to rear, with the result that heat transfer rates are obtained in a bent tube boiler which have hitherto been obtainable only in straight tube sinuous header boilers and with a much lower draft loss, because of the single pass gas flow through the boiler. The gases leave the boiler in the front at the center and flow to additional heat recovery apparatus such as an economizer and/or, as shown, an air heater which may be disposed below the boiler as shown, or at the rear or in any other desired location, and thence into an induced draft fan. The boiler tubes are staggered but are readily removable into the furnaces and the water wall and superheater tubes are also readily removable into the furnaces.

The invention will be understood from the following description considered in connection with the accompanying drawing forming a part thereof and in which:

Fig. 1 is a diagrammatic view in vertical longitudinal section of steam generating apparatus embodying the invention;

Fig. 2 is a transverse vertical sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a longitudinal horizontal sectional view taken on line 3—3 of Fig. 1;

Fig. 4 is a partial horizontal sectional view similar to Fig. 3, showing diagrammatically another form of superheater; and

Fig. 5 is a diagrammatic sectional view on line 5—5 of Fig. 4.

Like characters of reference indicate the same or similar parts in the several views.

Referring to the drawing, the steam generator illustrated has a rectangular setting including a front wall 10, a rear wall 11 and side walls 12 and 13. The generator is provided with two spaced parallel furnaces 14 and 15 which are disposed adjacent the side walls 12 and 13 respectively of the setting. The generator is also provided with a steam generating section or boiler 16 which is disposed intermediate the spaced furnaces and is somewhat shorter in length than the furnaces. The furnaces and boiler are of rectangular configuration and are disposed in parallel relationship, as shown. The boiler consists of upper and lower drums 17 and 18, respectively, which are connected by a plurality of bent steam generating tubes 19, arranged preferably as shown in staggered relationship in a direction transverse to the direction of flow of the gases through the boiler, which direction is parallel to the axes of the drums 17 and 18. Tubes 19 are arranged in groups of two rows each with adjacent groups spaced in a direction longitudinally of the boiler section, sufficient distances apart to permit the tubes to be withdrawn through the lanes between tube groups into the adjacent furnaces. As shown, the furnaces 14 and 15 are provided with water walls 20 and 21, respectively, which extend for the full length of the furnace. The gases or products of combustion are produced in the furnace by suitable burners 22 which may burn pulverized coal, oil or gases. At their rear ends, the furnaces have outlets 23 and 24 at adjacent sides through which the gases flow into a chamber 25 disposed between the furnaces and the rear end of the boiler section 16. The tubes of the furnace water walls which extend over the outlets 23 and 24 of the furnaces are staggered as shown, to provide slag screens 26 and 27, respectively. A superheater 28 having L-shaped tubes, is disposed in the chamber 25 with the vertically extending portions of the tubes disposed adjacent the rear or inlet end of the boiler section 16 and with the horizontal portions of the tubes expanded into headers 29. A second superheater having straight tubes 30 extending between headers 31 is disposed in the chamber 25 parallel to the slag screen 27. This second superheater may of course be disposed on the opposite side of the chamber 25 if desired, parallel to the slag screen 26. The two superheaters are connected in series. If desired, the superheaters 28 and 30 may be sections of a single superheater with substantially the same result. No baffles are utilized in the boiler section. Refractory walls 32 and 33 are vertically disposed between the water wall tubes in the furnaces 14 and 15, respectively, and the steam generating tubes 19 and serve to separate the furnaces from the boiler section 16.

The gases leave the front end of the boiler 16 and flow downwardly through a passage 34 into and over the tubes of air heaters 35, 36 and 37, disposed in the lower portion of the setting. From the air heaters the gases flow through a chamber 38 into an induced draft fan 39 which discharges them into a flue 40 whence they flow into a stack or to any other point of disposal. Air is supplied to the burners by means of a forced draft fan 41 which delivers air to the tubes of the several air heaters. After flowing through the tubes of these air heaters, the heated air flows into an air box 42 and thence into spaced, vertically disposed air boxes 43 and 44 at the front ends of the furnaces which deliver the air to the burners 22 for both furnaces. Ash sluices 45 and 46 are provided at the bottoms of furnaces 14 and 15, respectively, and ash sluices 47 are provided at the bottom of the air heaters.

The boiler pressure parts and casing are suspended from girders 48 and 49, respectively, which are disposed in parallel relationship to the axis of the generator and which are supported at their ends by columns 50 and 51. The girders 48 and 49 support transverse I-beams 52 and 53 which directly support the boiler drums 17 and 18 and the boiler tubes 19 through saddles 54 and 55. The tubes and headers of the water walls and the casing of the boiler are supported from the main girders 48 and 49 through a plurality of hangers 55 and 56. This supporting means for the several parts of the generator eliminates the stresses due to thermal expansion and further eliminates the need of air-gas type expansion joints in the casing.

In operation, the gases or products of combustion produced at the front ends of the furnaces, flow in a horizontal direction through the two furnaces to the rear ends thereof in one pass through each furnace and at the rear ends of the furnaces the gases make an abrupt change in direction of flow and pass through the slag screens 26 and 27 into the chamber 25 wherein they again abruptly change their direction of flow and pass over the superheater 28 and into and through the boiler section 16 in a horizontal direction. The gases in flowing from the furnaces into the boiler section make a change in direction of flow of 180° in the embodiment of the invention illustrated. In flowing from furnace 15 into the

chamber 25, the gases pass over the superheater 30. The gases flow through the boiler in one pass from rear to front in a direction parallel to the boiler drum and across all of the boiler tubes with the result that a very high heat transfer rate is obtainable with a relatively low draft loss. The boiler has two exposures to radiant heat from the furnaces 14 and 15. Even though the boiler tubes are staggered in a direction transverse to the direction of flow of the gases through the boiler section, the boiler tubes 19 may be readily removed individually into the furnaces. Quite obviously, the water wall tubes and the superheater tubes may also be readily removable into the furnaces.

With the superheaters or superheater sections disposed as described, superheat control is readily obtainable by regulating the firing in furnace 15. With this arrangement, it is possible to obtain any desired load-superheat relationship by firing one furnace more strongly than the other. For example, at low loads, the furnace 15 will be fired more heavily. But regardless of the firing of the furnaces, all the gases produced in the generator pass over all of the boiler heating surface. The slag screen 27 provided by the proper positioning of tubes of the water wall 21, protects superheater 30 from the slag and frame of the furnace. Slag screens 26 and 27 protect the superheater 28 disposed in the chamber 25 and also protect the boiler tubes 19. The superheaters are drainable and by virtue of their location, partake of the characteristics of both radiant and convection superheaters.

Another superheater arrangement is shown in Figs. 4 and 5. Referring to these figures, the refractory walls separating the furnaces and the boiler are arranged so that the gases from one furnace pass over only one of the superheaters, while the gases from the other furnace pass over both superheaters. As shown, a short wall 60 extends forwardly from the rear wall 11, in line with the wall 32 but terminates short thereof to provide a gas passage 61 having the tubes 20 arranged thereacross to provide a slag screen 62. Wall 33 is extended toward the rear wall 11 to provide a gas passage 63 of about the same flow area as the passage 61. Tubes 21 are arranged across the passage 63 to provide a slag screen 64. An L-shaped superheater section 65 has its vertically extending portion disposed across the inlet end of the furnace, forwardly of the rear end of wall 32, and a similar superheater section 66 has its vertically extending portion disposed forwardly of the rear end of wall 33 and rearwardly of the forward end of wall 60. The superheater sections may be connected in series, or may be connected otherwise, or the superheater sections may be separate superheaters. With this arrangement, superheat control is readily obtained by varying the firing in the two furnaces as desired. The gases from furnace 14 pass only over the superheater 65 while the gases from furnace 15 pass over both superheaters.

With this arrangement of component parts of a steam generator, it will be perceived that a change in the vertical dimension only of the generator and the several component parts thereof will result in a proportional increase in furnace volume and heating surface, in consequence of which steam generating units may be provided for any steam output requirements whether large or small, by merely varying the height of the unit without changing either the width or length thereof. In consequence, the same design may be utilized for all steam output requirements, thereby eliminating the necessity for separately designing generators for every new use. By the use of a plurality of water cooled furnaces, it is possible to maintain the desirable ratio of water-cooled surface to the furnace volume or to the rate of fuel firing, as the size of the generator is increased. The arrangement is so compact that very small units require only very low head room and large units require proportionately greater head room but less than is required in conventional designs for the same steam output capacity.

Since all of the tubes of the generator are removable into the furnaces, there is no need for side aisles between units to provide tube withdrawal spaces. Accordingly, a series of units constructed in accordance with the invention, may be installed side by side with a passage only at an end of the row of units or at some intermediate point which will permit access to the rear of the row of units. However, such aisles as may be necessary to the rear may be much narrower than in conventional arrangements because no access to any part of the units through the sides thereof is necessary for any purpose.

Additionally, the heat recovery devices such as air heaters and economizers as well as the fans, may be disposed below the boiler and furnaces, and may be located either on the operating floor or on a basement floor if provided. This arrangement entirely eliminates the necessity for overhead supporting structures for these devices.

Soot blowers and any other essential equipments may be located at the front of the units on the operating aisles and all parts of the boiler are accessible for repairs from within the furnace. For removing the ash when pulverized coal firing is used, a simple and low cost ejector system may be installed with several openings connecting to the furnaces and with valves which are readily controllable from the front of the boiler. Such ash as may stick to the ash receiving hoppers at the bottom of the boiler and which cannot be blown away by the soot blowers can be similarly removed.

With the arrangement disclosed, it is apparent that the furnaces may be built in sections by sectionalizing the headers and that they may be shop assembled and shipped as units complete with insulation and casing.

Steam generating units embodying the invention are suitable for outdoor operation without any housing means therefor since all of the component parts are included within or below the casing of the unit.

Although the invention has been disclosed in connection with a steam generating unit having two furnaces disposed in parallel relationship with each other and with the boiler section, it will be understood that more than two furnaces may be utilized in a unit without transcending the principles of the invention. It will also be understood that various changes may be made in the location and arrangement of the several component parts of the steam generating units without departing from the invention. Accordingly, it will be understood that no intention is entertained to limit the invention except by the scope of the claims appended.

What is claimed is:

1. A steam generator comprising a steam generating section and a plurality of furnaces connecting with said section and laterally disposed with respect thereto and separated there-

from by wall means, means forming a chamber connecting with the ends of the furnaces and with the end of said section, the arrangement being such that the products of combustion flow through the furnaces, the chamber and said section in a substantially horizontal direction and make an abrupt change in direction of flow in said chamber to separate out ash entrained in said products of combustion, and a superheater disposed in said chamber, some of the tubes of the superheater being disposed in the path of the products of combustion flowing only from one of the furnaces to provide superheat control.

2. A steam generator comprising a steam generating section and a plurality of furnaces connecting with said section and laterally disposed with respect thereto and separated therefrom by wall means, means forming a chamber connecting with the ends of the furnaces and with the end of said section, the arrangement being such that the products of combustion flow through the furnaces, the chamber and said section in a substantially horizontal direction and make an abrupt change in direction of flow in said chamber to separate out ash entrained in said products of combustion, a superheater disposed in said chamber, some of the tubes of the superheater being disposed in the path of the products of combustion flowing only from one of the furnaces to provide superheat control and a slag screen for the superheater.

3. A steam generator comprising a setting, a steam generating section and a plurality of separate furnaces in the setting separated by wall means from the steam generating section but connected at end portions thereof with an end portion of said section, means for producing a stream of products of combustion in each furnace to flow through the furnace and said section and a superheater having tubes disposed in the path of flow of the products of combustion passing from one of the furnaces into said section and other tubes disposed in the path of flow of the products of combustion passing from a plurality of furnaces into said section.

4. A steam generator comprising a setting, a steam generating section and a plurality of separate furnaces in the setting separated by wall means from the steam generating section but connected at end portions thereof with an end portion of said section, means for producing a stream of products of combustion in each furnace to flow through the furnace and said section, a superheater having tubes disposed in the path of flow of the products of combustion passing from one of the furnaces into said section and other tubes disposed in the path of flow of the products of combustion passing from a plurality of furnaces, and means for varying the volume of products of combustion produced in each furnace to thereby provide superheat control.

5. A steam generator comprising a setting, a steam generating section and a plurality of separate furnaces in the setting connecting with said section, a burner disposed in an end portion of each furnace to produce products of combustion therein, the arrangement being such that the products of combustion produced in each furnace flow substantially from end to end of the respective furnaces and thereafter flow into and through said section, a slag screen disposed in the path of flow of the products of combustion passing from each furnace into said section, and a superheater having tubes disposed between at least one of said slag screens and said steam generating section.

6. A steam generator comprising a setting, a steam generating section and a plurality of separate furnaces in the setting connecting with said section, a burner disposed in an end portion of each furnace to produce products of combustion therein, the arrangement being such that the products of combustion produced in each furnace flow substantially from end to end of the respective furnaces and thereafter flow into and through said section, a slag screen disposed in the path of flow of the products of combustion passing from each furnace into said section and a superheater having separate tube groups disposed between the slag screens and the steam generating section, the arrangement being such that the products of combustion from one of the furnaces passes in heat exchange relationship with less than all of said superheater tube groups.

7. A steam generator comprising a setting, a steam generating section and a plurality of separate furnaces in the setting connecting with said section, a burner disposed in an end portion of each furnace to produce products of combustion therein, the arrangement being such that the products of combustion produced in each furnace flow substantially from end to end of the respective furnaces and thereafter flow into and through said section, a slag screen disposed in the path of flow of the products of combustion passing from each furnace into said section, and a superheater having separate tube groups disposed between the slag screens and the steam generating section, the arrangement being such that the products of combustion from one of the furnaces passes in heat exchange relationship with all of the superheater tube groups and the products of combustion from another of the furnaces passes in heat exchange relationship with less than all of the superheater tube groups, whereby variations in the volume of the products of combustion produced in the respective furnaces will afford superheat control.

8. Steam generating apparatus comprising a setting, a steam generating section in the setting, a superheater in the setting having a plurality of tube groups, means for producing a plurality of separate streams of products of combustion for flow through said section, and means causing one of said streams to flow over one of said tube groups prior to entering said section and another stream to flow over a plurality of said tube groups prior to entering said section.

9. Steam generating apparatus comprising a setting, a steam generating section in the setting, a superheater in the setting having a plurality of tube groups, means for producing a plurality of separate streams of products of combustion for flow through said section, means causing one of said streams to flow over one of said tube groups prior to entering said section and another stream to flow over a plurality of said tube groups before entering said section, and means for controlling the volume of at least one of said streams of products of combustion to thereby control the degree of superheat obtained.

10. Steam generating apparatus comprising a setting, a steam generating section in the setting, a superheater in the setting having a plurality of tube groups, means for producing a plurality of separate streams of products of combustion for flow through said section, and means causing one of said streams to flow over one of said tube groups prior to entering said section and another

stream to flow over all of said tube groups prior to entering said section.

11. The method of superheating steam which comprises the steps of passing steam through a plurality of separate super-heating zones, causing a stream of products of combustion to flow through one of said zones, causing a separate stream of products of combustion to flow through a plurality of said zones, causing said streams to abruptly change their directions of flow prior to flowing through said zones, and passing said streams over slag removing surfaces prior to flowing through said zones.

12. A steam boiler having upper and lower drums, a bank of water tubes connected to said drums along the length thereof, means forming a furnace chamber laterally adjoining the space containing said tube bank and communicating with one end thereof, said means comprising a vertically disposed partition extending between and separating said furnace chamber and tube bank space except at one end thereof, means forming a second furnace chamber communicating with the same end of the space containing said tube bank, means for separately burning fuel in and effecting a flow of heating gases through each of said furnace chambers and then through said tube space towards the opposite end thereof, and a steam superheater arranged across the path of the heating gases leaving said second furnace chamber and receiving heat mainly from said second furnace chamber.

13. A steam boiler having a pair of horizontally disposed upper and lower drums, a bank of vertically disposed water tubes connected to said drums along the length thereof, means forming a main furnace chamber laterally adjoining the space containing said tube bank and communicating with the rear end thereof, said means comprising a vertically disposed partition extending between and separating said furnace chamber and tube bank space except at the rear end thereof, means forming an auxiliary furnace chamber laterally adjoining the space containing said tube bank and communicating with the rear end thereof, means at the front end of each of said furnace chambers for burning fuel in suspension therein and effecting a flow of heating gases longitudinally through each of said furnace chambers and then through said tube space towards the front end thereof, and a steam superheater arranged at the rear end of said tube space and receiving heat mainly by convection from the heating gases from said auxiliary furnace chamber.

14. A steam boiler having upper and lower drums, a bank of water tubes connected to said drums along the length thereof, means forming a main furnace chamber laterally adjoining the space containing said tube bank and communicating with one end thereof, means forming an auxiliary furnace chamber adjoining the opposite side of the space containing said tube bank and communicating with the same end thereof, means for burning fuel in and effecting a flow of heating gases through each of said furnace chambers and then through said tube space, and a steam superheater arranged to receive heat mainly from said auxiliary furnace chamber.

15. A steam boiler having a pair of horizontally disposed upper and lower drums, a bank of vertically disposed water tubes connected to said drums along the length thereof, means forming a main furnace chamber laterally adjoining the space containing said tube bank and communicating with one end thereof, means forming an auxiliary furnace chamber laterally adjoining the opposite side of the space containing said tube bank and communicating with the same end thereof, means at the opposite end of each of said furnace chambers for burning fuel therein and effecting a flow of heating gases longitudinally through each of said furnace chambers and then through said tube space, and a steam superheater arranged across the path of the heating gases leaving said auxiliary chamber and receiving heat mainly from said auxiliary furnace chamber.

16. Steam generating apparatus comprising a setting, a plurality of furnaces in the setting, means for firing each furnace, a chamber into which the products of combustion flow from each furnace, steam generating surface in the setting disposed in the path of the gases which flow from said chamber, a superheater in the setting having a plurality of tube groups, one of said superheater tube groups being located in heat exchange relationship with the products of combustion of one furnace only prior to entering said chamber, and another of said superheater tube groups being located in heat exchange relationship with the products of combustion which flow from said chamber.

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