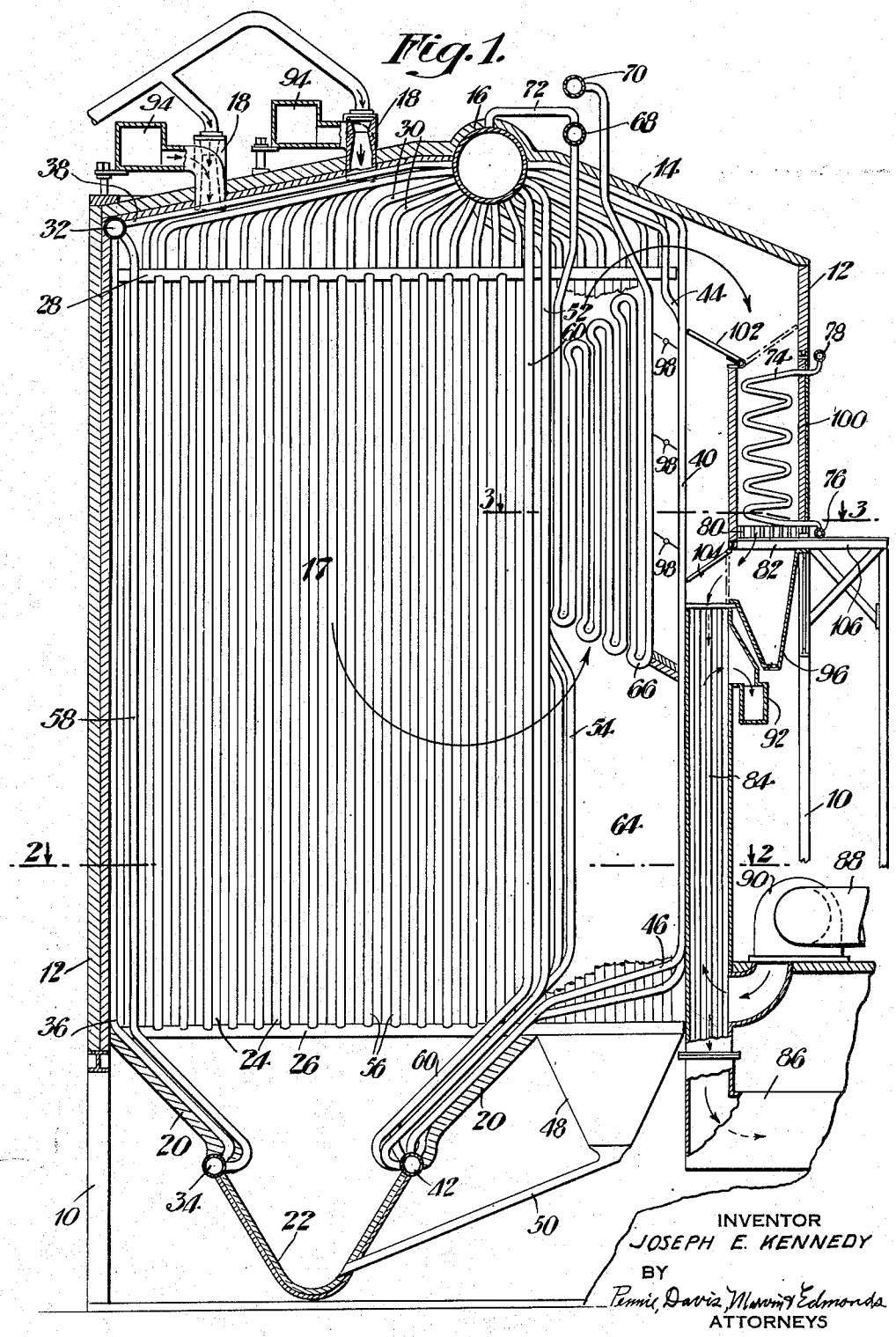
May 1, 1951 J. E. KENNEDY 2,551,137

STEAM GENERATOR UNIT

Filed March 3, 1945 3 Sheets-Sheet 1

Fig. 1.



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Filed March 3, 1945 3 Sheets-Sheet 2

Fig. 2.

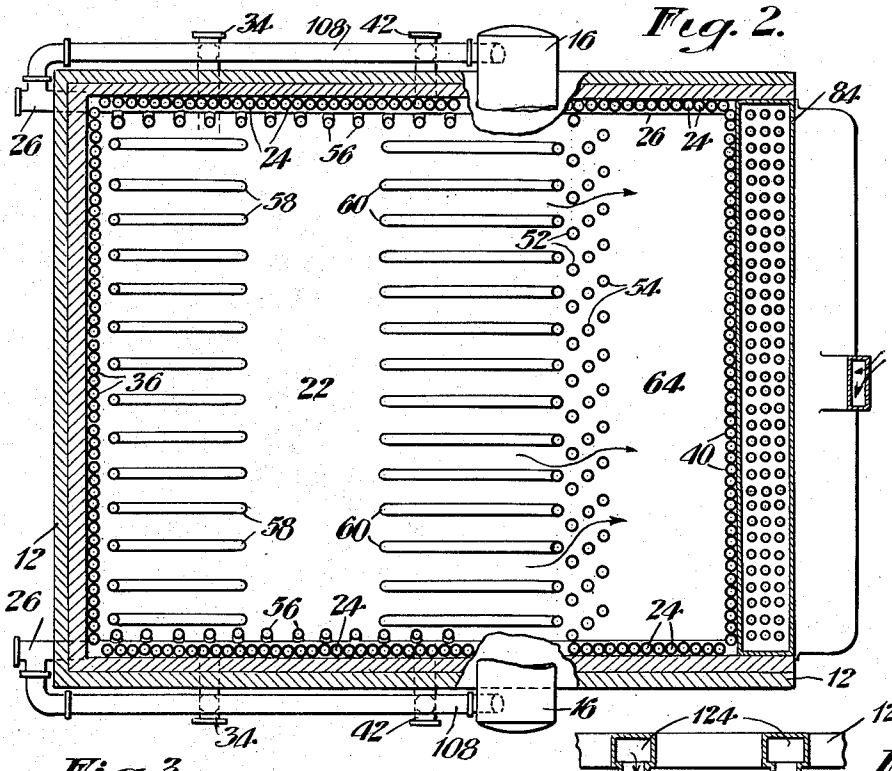


Fig. 3.

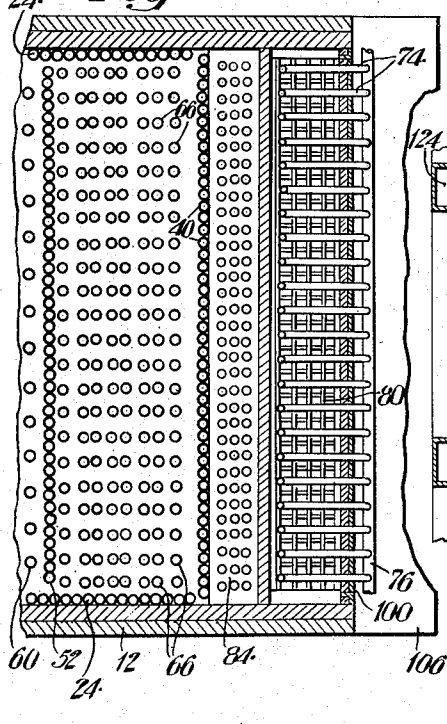
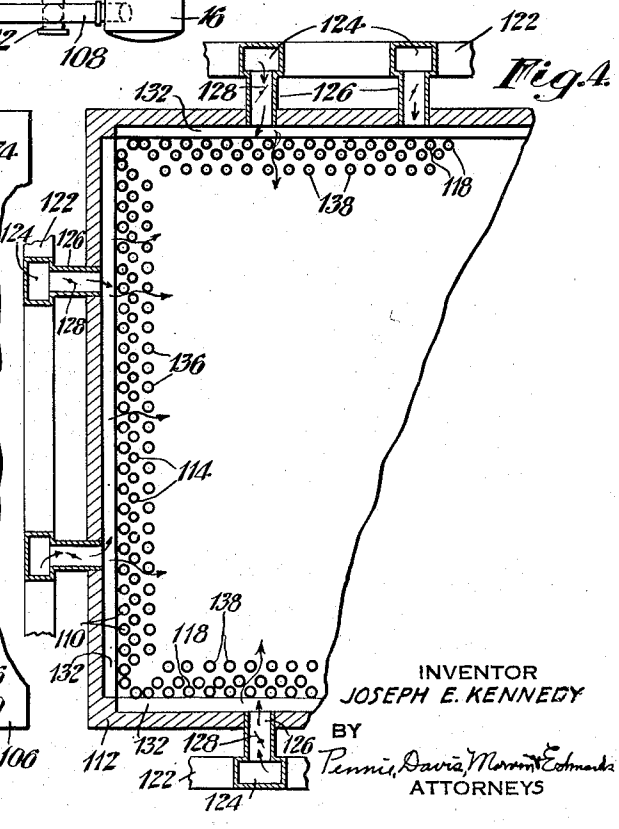


Fig. 4.



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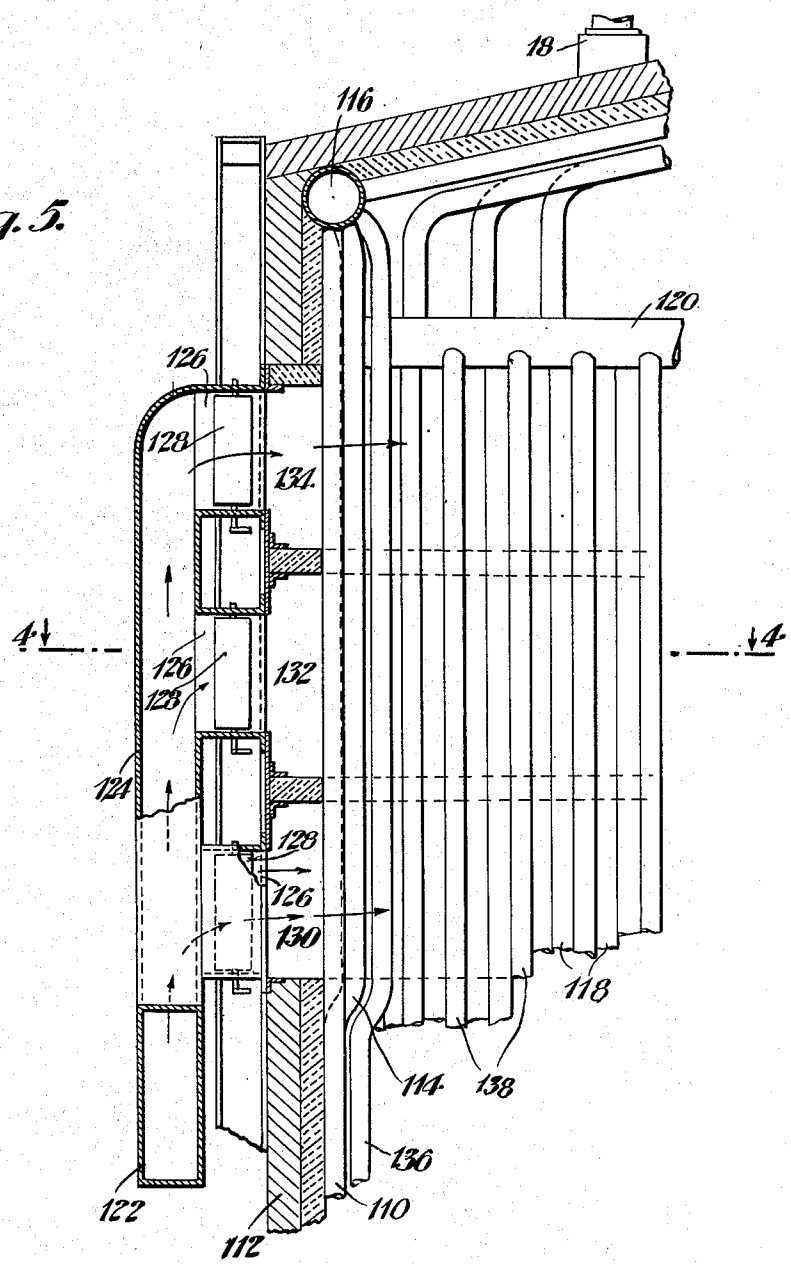
Filed March 3, 1945 3 Sheets-Sheet 3

Fig. 5.



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UNITED STATES PATENT OFFICE

2,551,137

STEAM GENERATOR UNIT

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Application March 3, 1945, Serial No. 580,740

2 Claims. (Cl. 257—241)

1

My invention relates to improvements in steam generator units for large scale production of steam and superheated steam.

Steam generator installations for large scale use, such as those used in power plants and similar installations, involve very substantial investments. Such installations are commonly constructed with two or more relatively large water drums mounted in the lower part of the setting in addition to at least one steam and water drum at the upper part of the setting. Drums of this type not only involve the use of relatively large quantities of steel, but also add considerably to the investment in the plant and the cost of erection.

I have discovered that a large scale plant can be successfully built and operated without using water drums in the lower part of the generator setting and at the same time maintain a high efficiency for the installation.

The primary object, therefore, of my invention, is to provide improved steam generator unit which includes but a single steam and water drum which is mounted in the upper part of the setting.

A further object of my invention is to provide an improved steam generator unit for the production of steam and superheated steam on a large scale and which is relatively economical to build and in which the high efficiency of such units is maintained.

Another object of my invention is to provide an improved steam generator unit having a single combustion chamber which can be fired with powdered solid fuels or liquid fuels and in which improved means are provided in combination with a single drum for absorbing the radiant heat produced.

An important feature of my present invention is the provision of a steam generator unit having a single firing furnace chamber, the walls of which are comprised of steam generating tubes closely mounted together, a single drum for the generator unit mounted in the upper portion of the combustion chamber, and steam generating tubes mounted along the chamber walls in spaced relation to the wall tubes and to each other, whereby a considerable proportion of the heat developed in the combustion chamber is absorbed by the spaced tubes without appreciably reducing the heat absorption capacity of the wall tubes.

Another feature of my invention includes the provision in a steam generator unit as described above of a bank of steam superheating

2

tubes, and in which means is provided for passing hot furnace gases from the furnace combustion chamber upwardly through the bank of superheater tubes. The bank of superheater tubes is preferably separated from the furnace combustion chamber proper by a tube wall in which the tubes are closely mounted preferably in vertical arrangement so that the tube wall separates the superheater bank from the main combustion chamber, except that the lower portion of certain of the tubes of the tube wall are bent in an offset manner so as to provide passageways for the furnace gases from the combustion chamber side of the wall to the superheater side of the wall.

A further feature of my invention is to provide a steam generator setting which includes a readily removable economizer tube bank mounted adjacent one of the side walls of the setting and in which a platform is provided on the outside of the side wall so that the economizer tube bank may be removed from the setting for cleaning and repairing.

Another feature of my invention is to provide a steam generator unit which is of relatively simple construction and in which a combustion chamber and various heating compartments are provided and heated without the use of the usual baffles.

Other objects, features and advantages of my invention will be apparent to those skilled in the art from the following more detailed description thereof, taken in connection with the accompanying drawings constituting a part of this application.

In the drawings:

Fig. 1 is a vertical sectional view of a steam generator unit constructed in accordance with the features of my invention, with parts broken away to simplify the illustration.

Fig. 2 is a horizontal cross-sectional view of the improved steam generator unit taken on the line 2—2 of Fig. 1.

Fig. 3 is a broken horizontal sectional view taken on the line 3—3 of Fig. 1.

Figs. 4 and 5 are views of a modified form of construction of steam generator unit having the general features of construction shown in Figs. 1 to 3, in which Fig. 5 is a broken vertical sectional view and Fig. 4 is a horizontal sectional view taken on the line 4—4 of Fig. 5.

Referring to Figs. 1 to 3 of the drawings, the improved steam generator of the present invention is constructed on a foundation or setting 10. The unit is of substantially rectangular cross-section and provided with brick and insula-

tion side walls 12 of usual construction which may be supported in the usual manner by a steel framework and backing plate construction, not shown, The unit also includes a roof 14 comprising insulation which also covers a steam and water drum 16 mounted in the upper portion of the unit. The generator unit of the present invention comprises a furnace or combustion chamber 17 of generally rectangular cross-section, arranged for down-draft firing, and which occupies the greater portion of the cross-section of the unit. The height of the chamber is relatively great compared to its width, and it is fired, preferably with pulverized solid fuels, from burners 18 distributed over the roof section of the unit covering the combustion chamber. The bottom of the combustion chamber 17 includes converging downwardly sloping walls 20 which terminate in an ash pit 22 from which ashes are removed by suitable means, not shown.

The inside of the generator unit is substantially completely lined with steam generating tubes closely mounted together to form substantially continuous walls. For example, each of the side walls is provided with closely set steam generating tubes 24 which terminate in a lower header 26 and an upper header 28. Steam formed in the tubes 24 collects in the upper header and is conducted into the steam and water drum 16 by means of tubes 30 which are distributed along the opposite headers 28. The left end wall of the unit includes an upper header 32 and a lower header 34, between which are mounted closely spaced vertical wall tubes 36. The header 32 is connected into the steam and water drum 16 by spaced tubes 38 which are distributed across the roof of the unit. The burners 18 are of flat construction so that they extend between the roof tubes 38.

The opposite end of the steam generating unit proper comprises a tube wall 40 of vertical closely mounted steam generating tubes which terminate at their lower ends in a header 42 and at their upper ends in the steam and water drum 16. The upper portion of the tube wall 40 is constructed for the passage of combustion gases by bending in alternate tubes of the wall 40, as indicated at 44. It will be apparent that when every other tube of the wall is bent in, in the manner shown, that combustion gases can pass between the tubes. Alternate tubes of the wall 40 are also bent in, as indicated at 46, at the bottom of the furnace, to permit ash to fall into a pit 48 which is provided with an inclined duct 50 so that the ash collected therein may flow into the pit 22. The tubes of the wall 40 are otherwise so close together as to prevent passage of all but traces of combustion gases.

The vertical combustion chamber 17 of the generator unit is defined by the side tube walls formed by the tubes 24, the end tube wall formed by the closely mounted tubes 36, and by a tube wall 52 comprising closely mounted steam generating tubes adapted to substantially prevent the passage of furnace gases, the upper ends of which are connected into the water and steam drum 16 while the lower ends are connected into the header 42 as indicated. Approximately the lower half of the wall 52 is provided with passageways so that combustion gases can flow from the combustion chamber 17 into contact with the wall 40. These passageways are formed by bending tubes 54 of the wall 52 so that the lower section of the wall includes passageways for the passage of gases, such passageways

being clearly indicated in Fig. 2 of the drawings.

The burners 18 distributed over the roof of the combustion chamber 17 produce an enormous quantity of retained heat, and it has been found that the efficiency of a combustion chamber of the type described can be greatly increased by providing additional steam generating tubes in front of the tube walls on all four sides of the combustion chamber. The side walls, for example, includes a row of tubes 56 which is substantially spaced from the tube wall and in which the tubes are substantially spaced from each other. These tubes may be from one to three tube diameters from the tube wall and are preferably two or three diameters apart. The end of the tubes 56 are bent and connected into the respective headers 26 and 28, as indicated. A similar row of tubes 58 is also mounted opposite the wall tubes 36 in approximately the relationship described for the wall comprising the tubes 56. The tubes 58 are headed into the headers 32 and 34, as indicated. A similarly arranged row of tubes is also provided in front of the tube wall 52 and comprises spaced tubes 60 which are headed into the water and steam drum 16 and the header 42, as indicated. The spacing of the tubes 60 from the wall 52 and from each other is approximately the same as indicated above for the tubes 56.

The rows of spaced tubes 56, 58 and 60 are subjected to direct radiation since they completely surround the combustion chamber, but they are spaced from each other to a sufficient extent to not interfere with the efficiency of the closely mounted wall tubes. It has been found, for example, that the temperatures back of the rows of spaced tubes may still be as high as 1350° F. and that the wall tubes will receive adequate radiation. The rows of spaced tubes therefore greatly increase the efficiency of the unit as well as its capacity in relation to its size. The tubes 24 and 56 may be 35 feet long or longer, which gives an idea of the size of the generator unit and the height of the combustion chamber.

A part of the ash from the burning of pulverized solid fuels in the burners 18 collects in the pit 22 at the bottom of the combustion chamber while the combustion gases pass through the lower portion of the tube wall 52 into a narrow vertical chamber 64 between the tube walls 40 and 52 in which is mounted a steam superheater comprising looped tubes 66. The superheater preferably extends entirely across the unit as indicated in Fig. 3 and comprises a plurality of the looped tubes 66, the inlet ends of which are connected into a header 68 while the outlet ends are connected into a header 70. Steam is supplied to the header 68 from the water and steam drum 16 through one or more steam lines 72. Superheated steam may be distributed from the header 70 to any desired power or heating unit. The combustion gases from the chamber 64 after heating the superheater pass through the upper portion of the wall 40 and downwardly in contact with an economizer tube bank comprising a plurality of coiled or looped tubes 74 arranged across the unit and connected into a water inlet header 76 and a water outlet header 78, from which water may be supplied to the steam generator unit by connections and means, not shown.

The combustion gases leaving the economizer unit pass through a grating 80 which supports the economizer tube bank above cross-beams 82 which are welded or otherwise secured into the

steel structure of the steam generator unit. The hot combustion gases then pass through the tubes of an air heater 84 and into a flue duct 86 which leads to an exhaust fan or stack, not shown. Air to be preheated is introduced from a duct 88 and forced by a blower 90 up around the tubes of the air heater 84 from which the air is conducted through an insulated duct 92 into hot air ducts 94 for the burners 18.

Any fine ash which may have been carried by the combustion gases from the combustion chamber over into contact with the economizer tubes 74 is dropped out in a trap 96. It will be noted that the steam superheater bank is spaced somewhat from the tube wall 40 so that a passage is provided through which a portion of the hot combustion gases can pass along the tube wall 40 without flowing entirely in contact with the tubes 66 of the superheater. This passage is used in connection with three vertically spaced dampers 98 for regulating the temperature to which the steam is superheated. It will be apparent that if all the dampers 98 are open or vertical, a substantial part of the combustion gases will bypass a substantial part of the superheater and flow directly along the tube wall 40; whereas if the dampers are in the position shown, all of the combustion gases will be forced to contact tubes 66 throughout their complete length. One or more of the dampers may be operated to obtain the desired temperature for the superheated steam.

One of the common difficulties with steam generating units is the inaccessibility of the economizer tube bank from the standpoint of making repairs and tube replacements. In the present instance, a construction has been provided to facilitate the removal of the economizer tube bank from the setting for the purpose of making repairs and replacing tubes. Accordingly, the wall 12 adjacent the economizer is provided with one or more removable panels 100 so that the economizer is exposed from the side of the unit. However, in order to facilitate repairs, the chamber in which the economizer is mounted is provided with a hinged door 102 which may be swung to the dotted line position so that the combustion gases no longer contact the economizer tube bank but pass directly down outside the wall 40 into the tubes of the air heater 84. A similar door 104 is provided at the top of the air heater to close off the passage between the grating 80 and the air heater by swinging the door 104 to the dotted line position. With the doors 102 and 104 set in the dotted line positions, the panel or panels 100 may be removed, the headers 76 and 78 disconnected from the inlet and outlet lines, and the economizer shifted outside the unit to a platform 106 which is a steel structure, including the beams 82, of sufficient strength to accommodate the economizer during any tube replacement or repairs.

The steam generator unit of the present invention is provided with but a single drum, that is, the steam and water drum 16 at the top of the combustion chamber. Since steam is generated in the wall tubes in all of the vertical or inclined tubes in the unit, the circulation is necessarily upward into the steam drum 16, the headers 28 and the header 32. The steam and water flows from the headers 28 and 32 into the steam drum 16. The circulation of water back to the lower headers 26, 34 and 42 from the steam and water drum 16 is effected by means of down-comer pipes 108 (Fig. 2) from the opposite ends of the water and steam drum 16 to the ends of the headers 26, 34 and 42, as indicated. The lines 108 are shown as being connected only into one end of the headers 26 but both ends of each of these headers may be connected into the respective lines 108, if desired.

Figs. 4 and 5 are similar, respectively, to Figs. 2 and 1, except that they show a modified form of unit or a modification of the upper portion of the unit shown in Figs. 1 and 2 for the purpose of admitting tertiary air to the three outer sides of the combustion chamber.

Referring more particularly to the modified showing in Fig. 5, the view corresponds to a portion of the upper left hand corner of the furnace shown in Fig. 1. In Fig. 5 a tube wall 110 comprised of closely mounted tubes along the outside wall 112 is modified so that alternate tubes, or at least some of the tubes, of the wall 110 are bent in slightly at 114 so that the tubes of the wall 110 will be spaced from each other over approximately the upper one third of the furnace so that air may be admitted to the upper portion of the combustion chamber from the end and side walls of the furnace. The tubes of the wall 110 terminate at the top in a header 116 which corresponds to the header 32. The upper portion of the side walls of the furnace are modified in a similar way by bending in alternate tubes of the side tube walls 118, the upper ends of the tubes terminating in opposite upper headers 120, corresponding to the headers 28. Air to be supplied to the upper section of the combustion chamber may be a portion of the hot air from the duct 92 which is delivered to a horizontal duct 122. Riser ducts 124 distribute air from duct 122 through branching ducts 126, each of which is provided with a damper 128. These dampers may be operated by a hand lever or other connecting leverage means, as indicated. The ducts 126 deliver air into vertically spaced horizontal channels 130, 132 and 134, respectively, which open against the tube wall 110 along the section where the alternate tubes are bent in as at 114. Air therefore may be delivered into any one of the channels 130, 132 or 134, or all of them, to aid in burning the pulverized solid fuel introduced through burners the same as burners 18 shown in Fig. 1.

The modified form of furnace of Fig. 5 is provided with a row of steam generator tubes 136 which is spaced from the tube wall 110 and in which the tubes are spaced from each other in substantially the manner described above in connection with the rows of spaced tubes mounted opposite the tube walls of the combustion chamber 17. Tubes 136 terminate in the header 116. A similar row of tubes 138 are provided opposite each of the tube walls 118 and these tubes terminate in the upper headers 120. The tubes 136 and 138 are of great advantage when air is admitted through the side walls, since they absorb the increased heat.

Fig. 4 shows the arrangement of means for supplying tertiary air from the three sides of the combustion chamber which have outside walls, the arrangement along each wall being the same as that shown in Fig. 5. The use of tertiary air in the upper portion of the furnace in the manner shown in Figs. 4 and 5 has been found to be very effective, particularly in the burning of pulverized anthracite coal, the primary air being supplied along with the pulverized coal, the secondary air being conducted from the ducts 94 alongside the flat burners 18, and deflected

into the burning fuel immediately below the tips of the burners, while the tertiary air is introduced into the upper portion of the furnace through the tube walls, as shown in Figs. 4 and 5. The dampers 128 may be used to restrict the introduction of air to any of the three levels represented by the horizontal distribution passages 130, 132 and 134.

The improved steam generator unit of my invention is adaptable for construction in various sizes while still maintaining a very high efficiency.

From the foregoing description it will be apparent that various modifications in the details of construction and arrangement may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

What is claimed as new is:

1. In an economizer construction, walls including an outside wall defining an economizer chamber through which heating gases are adapted to pass, an economizer tube bank mounted in said chamber and arranged to be heated by the heating gases passing therethrough, a bypass chamber for heating gases parallel to the economizer chamber and separated therefrom by one of said walls, a swinging door associated with the wall separating said chambers at both the inlet and outlet ends of the economizer chamber and adapted to close off either of said chambers to the passage of heating gases, and a platform on the outside of and alongside said outside wall adjacent to the position of the economizer tube bank and extending laterally from said wall at a position directly below the economizer tube bank, a section of said outside wall above said platform and along the position of the economizer

tube bank being readily removable so that access may be had to the economizer tube bank, the arrangement being such that said doors may close off the economizer chamber so that the economizer tube bank may be removed from the economizer chamber onto the platform for cleaning and repairs while continuing the passage of said heating gases through said bypass chamber.

2. An economizer construction as defined by claim 1 characterized in that the platform includes supporting structural members extending through said outside wall and under the economizer tube bank as a supporting means therefor in the economizer chamber.

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