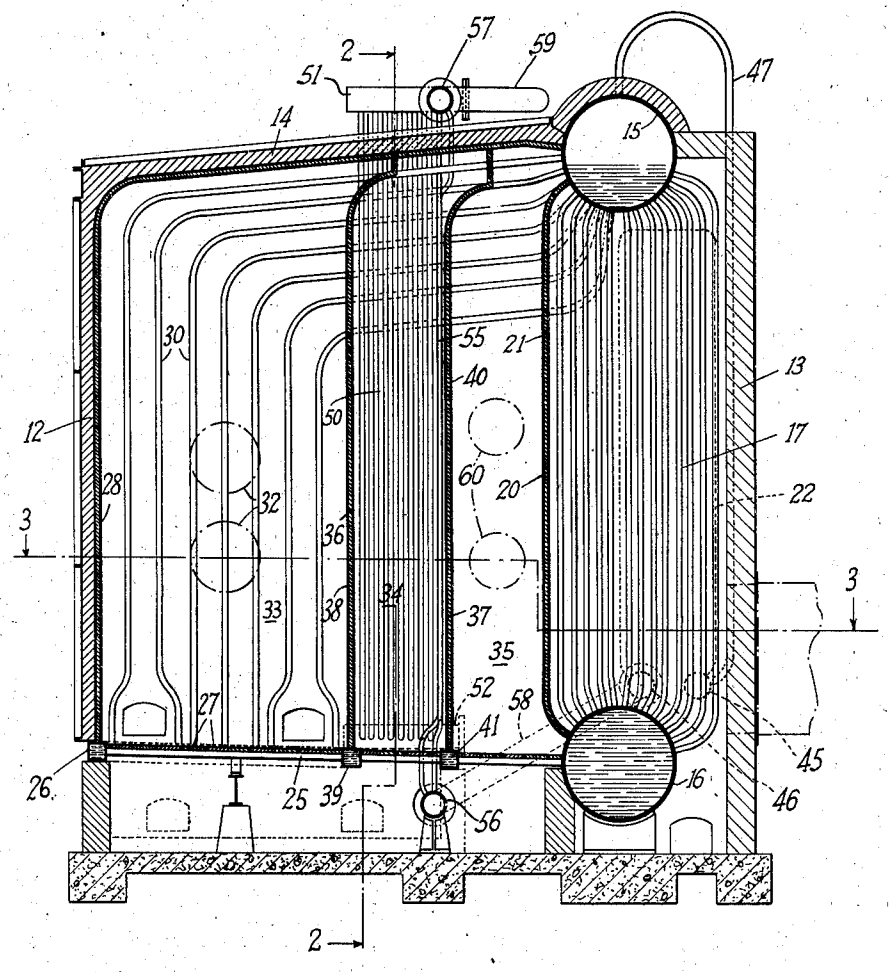
Oct. 27, 1942. E. G. BAILEY ET AL 2,299,732

STEAM GENERATOR

Filed Dec. 30, 1937 5 Sheets-Sheet 1

Fig. 1



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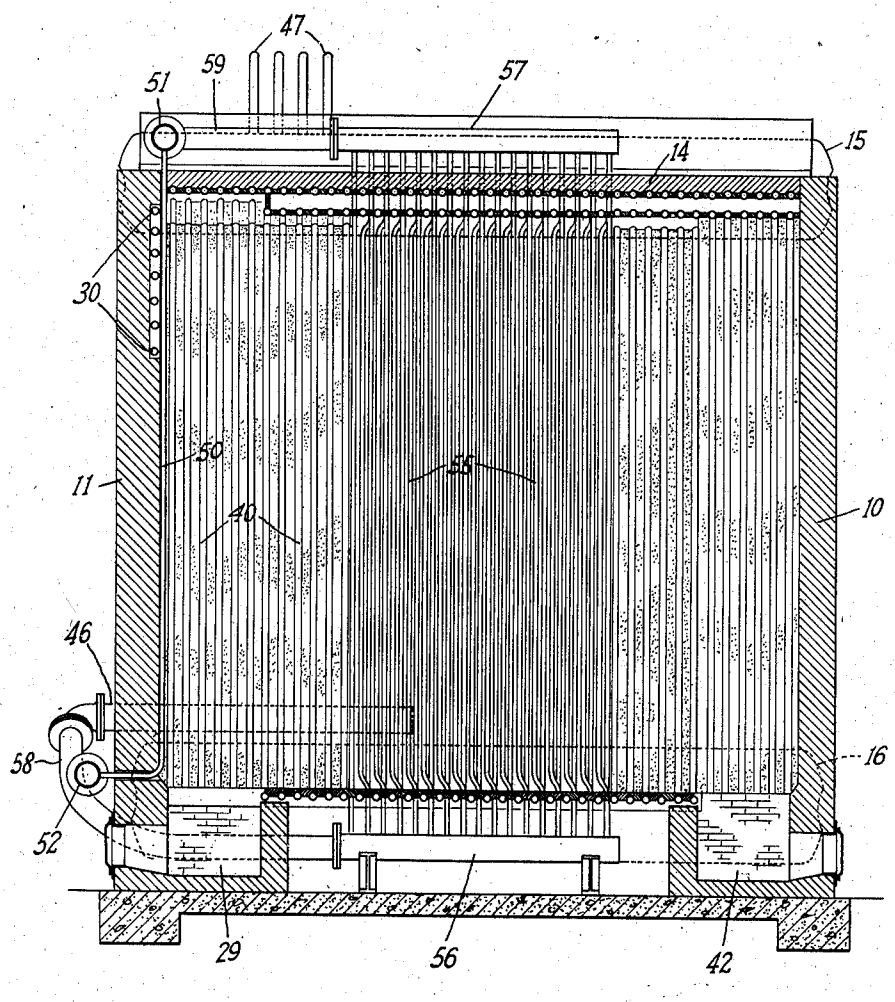
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STEAM GENERATOR

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Fig. 2



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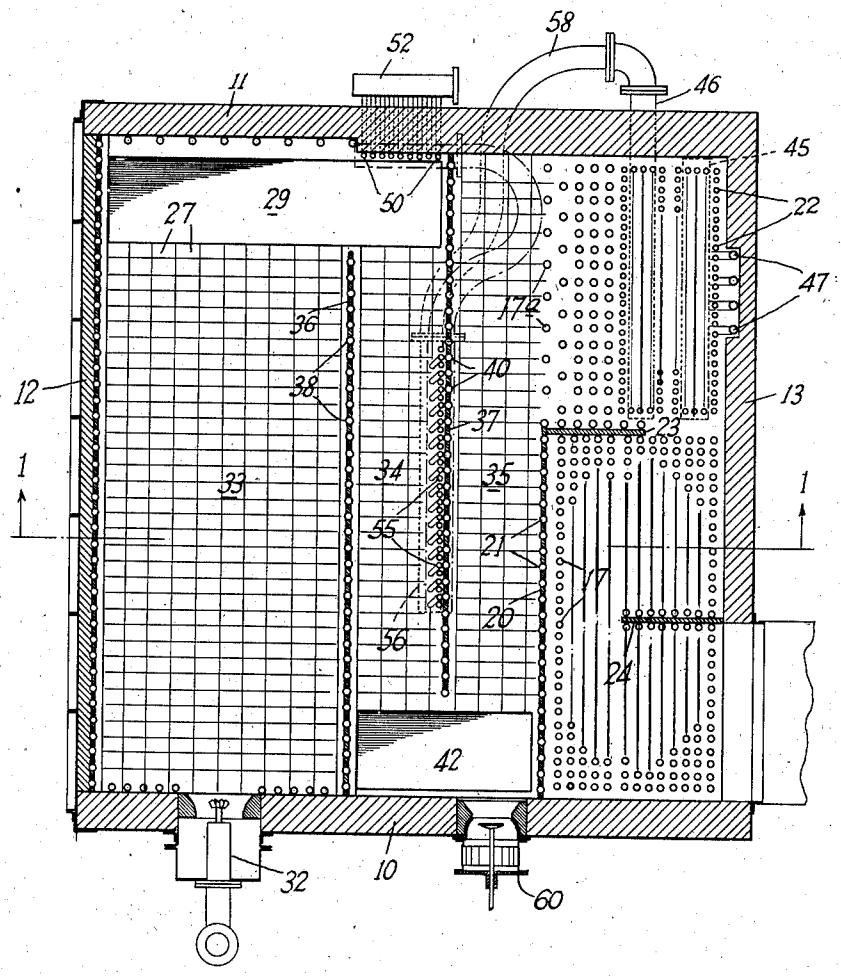
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STEAM GENERATOR

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Fig. 3



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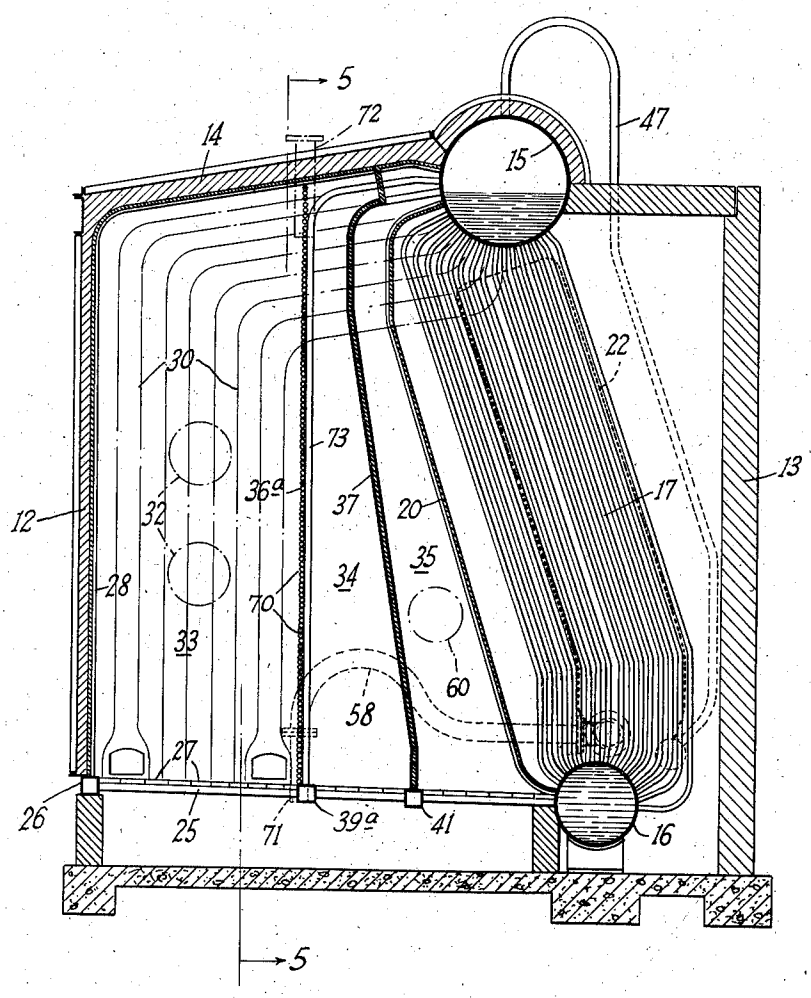
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STEAM GENERATOR

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Fig. 4



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STEAM GENERATOR

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Fig. 5

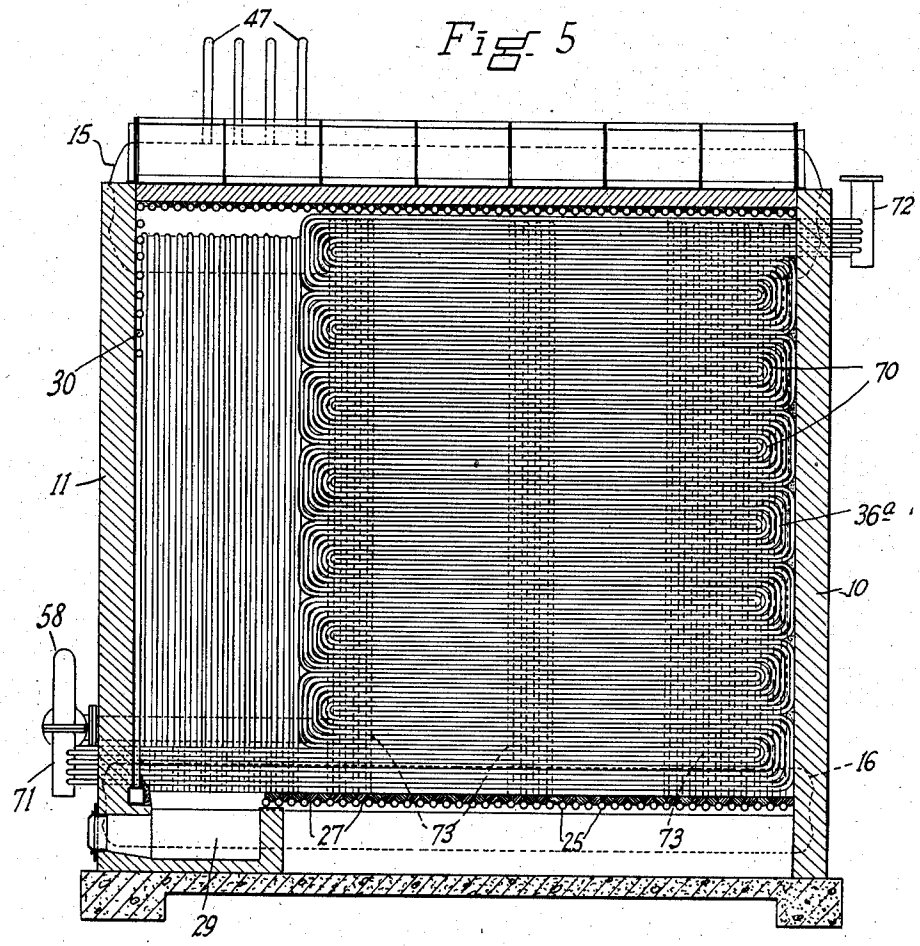


Fig. 6

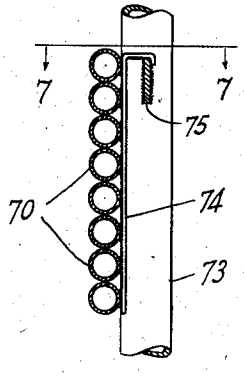
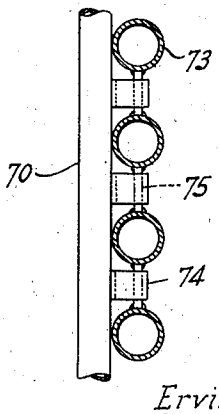


Fig. 7



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2,299,732

UNITED STATES PATENT OFFICE

2,299,732

STEAM GENERATOR

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Application December 30, 1937, Serial No. 182,394

10 Claims. (Cl. 122—478)

This invention relates to improvements in the construction and operation of steam generating units of the integral furnace type, such as disclosed in Bailey et al. U. S. Patent #1,999,984. In steam generating units of this type a fluid cooled furnace chamber is arranged laterally adjoining a vertical bank of steam generating tubes and separated so as to communicate with the space containing the tube bank only at the end thereof opposite that end of the furnace chamber in which the fuel burning means are located. A convection type steam superheater is usually positioned in the entrance end of the tube bank space.

When a unit of this type is intended to operate at high steaming capacities and high rates of heat release, an increase in the length of the combustion path is desirable to insure completion of combustion of slag-forming fuel in the furnace chamber and to avoid the heating gases entering the tube bank space at temperatures tending to produce tube slagging and/or overheating of the superheater tubes. In units constructed in accordance with this invention, the permissible combustion path in the furnace chamber is substantially increased in length and the temperature of the heating gases reduced to a safe value before reaching the tube bank space.

Another feature of this invention is an effective arrangement of a substantial amount of steam superheating surface of the radiant type in a boiler unit of the type described.

Another feature is the provision of auxiliary fuel burning means for use in starting up the unit without endangering the radiant superheater, and for controlling the superheat temperature during normal operation.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described preferred embodiments of the invention.

Of the drawings:

Fig. 1 is a partly diagrammatic vertical section taken on the line 1—1 of Fig. 3 illustrating a steam generating unit constructed in accordance with the invention;

Fig. 2 is a vertical section taken on the line 2—2 of Fig. 1;

Fig. 3 is a horizontal section taken on the line 3—3 of Fig. 1;

Fig. 4 is a view similar to Fig. 1 illustrating a modified construction;

Fig. 5 is a longitudinal vertical section taken on the line 5—5 of Fig. 4;

Fig. 6 is an enlarged view of a portion of the radiant superheater shown in Fig. 4; and

Fig. 7 is a fragmentary horizontal section taken on the line 7—7 of Fig. 6.

In the steam generating unit illustrated in Figs. 1 to 3, a setting substantially rectangular in horizontal and vertical cross-section is defined by a front wall 10, rear wall 11, opposite side walls 12 and 13, and a roof 14. A steam and water drum 15 and lower water drum 16 are horizontally arranged along one side of the setting and connected by a bank of vertically disposed water tubes 17. A partition 20 extends between the drums from the front wall 10 along the inner side of the main tube bank for a major portion of its length with its rear end spaced from the rear wall 11 to form a heating gas entrance throughout the height of the tube bank into the portion of the setting space occupied by the tube bank. The partition 20 is formed by a row of tubes 21 connected to the drums 15 and 16 and refractory closing the intertube spaces and held in position on the tubes in any suitable manner. The innermost rows of tubes 17a between the end of the partition 20 and rear wall 11 are arranged to form a boiler slag screen, as shown in Fig. 3, and a group of inverted U-shaped superheater tubes 22 is positioned at the outer side of this section of the bank. Transverse baffles 23 and 24 extend from the partition 20 and side wall 13 respectively to define a plurality of serially connected transverse gas passes in the space occupied by the tube bank.

The remaining portion of the setting space includes the furnace chamber of the unit. This portion of the setting is entirely fluid cooled, the cooling provisions including a row of horizontally inclined tubes 25 connected to the lower drum 16 at their inner ends and to a side wall header 26 at their outer ends. Metallic blocks 27 thereon unite to form a substantially horizontal smooth floor. A row of tubes 28 extend upwardly along the side wall 12 and are bent laterally at their upper ends along the roof 14 and connected to the drum 15. The tube row 25 and associated blocks terminate adjacent the rear wall 11 above an ash pit 29 extending across the rear end of the furnace chamber. The front

wall 10 is protected by a row of vertically disposed tubes 30 connected at their upper and lower ends to the drums 15 and 16 respectively. A similar row of tubes 31 extend along the rear wall 11. Fuel burners 32 adapted for the burning of a fluid fuel, such as pulverized coal, in suspension at relatively high rates of heat release, are mounted in ports in the front wall 10, as indicated in Figs. 1 and 3.

In accordance with our invention, this portion of the setting space is divided into a plurality of serially connected laterally adjoining sections 33, 34, and 35 by fluid cooled vertically disposed partitions 36 and 37 extending from the floor to a point adjacent the upper drum 15. The outer section 33 is of greater width than either of the sections 34 and 35 and forms the main combustion space or furnace chamber, while the inner sections 34 and 35 constitute serially connected fluid cooled open passes connecting the rear end of the outer section to the rear portion of the tube bank space. The partition 36 is formed by a row of vertical water tubes 38 and refractory in the intertube spaces held in position by studs welded on the tubes. The tubes 38 have their upper ends bent and directly connected to the drum 15 and their lower ends to a longitudinal header 39 incorporated in the row of floor tubes 25 intermediate their length. The partition 37 is similarly formed by refractory end tubes 40 extending between the drum 15 and a header 41, also incorporated in the row of floor tubes 25. The partition 36 extends rearwardly from the front wall 10 to a point adjacent the ash pit 29, while the partition 37 extends forwardly from the rear wall 11 to a point spaced from the front wall. The portion of the floor in the inner sections 34 and 35 forwardly of the partition 37 is omitted to provide a second transverse ash pit 42. The partitions 36 and 37 converge at their upper ends toward the drum 15 and the spaces between the partitions and between the partition 36 and the roof 14 are closed by refractory.

With this arrangement the burning fuel streams discharged by the burners 32 first pass substantially horizontally and rearwardly through the outer furnace section 33. This portion of the flame path is wholly unobstructed and a substantial amount of heat is absorbed mainly by radiation by the tubes 25, 28, 30, 31, and 38. The burning fuel and gases turn about the rear end of the partition 36 and forwardly through the open pass 34 between the partitions 36 and 37, radiating heat to the partition tubes 38 and 40 and floor. The furnace gases then turn around the front end of the partition 37 and rearwardly through the open pass 35 between the partitions 37 and 20, further reducing the gas temperature by heat radiation to the partition tubes 40 and 21 and floor before reaching the first pass across the tube bank. The gases on entering the tube bank space successively contact with the slag screen tubes 17a, the tubes 17, and the superheater tubes 22 in the first tube bank pass, and then with the water tubes 17 in the second and third tube bank passes before leaving the unit. A pair of relatively narrow fluid cooled open passes are thus provided between the high temperature outer section and the tube bank space, substantially increasing the available length of the furnace chamber with but little increase in the floor space occupied by and in the draft loss through the unit, and substantially reducing the furnace gas temperature before the gases reach the tube bank. The partitions are also effective in completely shielding the tubes in the first tube bank pass from heat radiation from the high temperature outer section 33.

The convection heated superheater tubes 22 are connected into inlet and outlet headers 45 and 46 respectively, as indicated in Fig. 1, the header 45 receiving steam from the upper drum 15 through tubes 47. In addition to the convection superheating surface described, the unit desirably includes a substantial amount of radiant heat absorbing superheater surface connected in series with the convection surface. In the unit described the radiant superheater surface is divided into two sections, one section consisting of a row of vertical tubes 50 extending along the rear wall 11 at the rear end of the open pass 34 between external inlet and outlet headers 51 and 52 respectively, and the other section being formed by a row of vertical tubes 55 extending along the side of the pass 34 formed by the partition 37. The tubes 55 are connected at their lower and upper ends to external inlet and outlet headers 56 and 57 respectively.

With this arrangement of the superheating surface, the steam generated first passes through the outlet tubes 47 to the header 45, convection heated superheater tubes 22, and outlet header 46, the latter being connected to the inlet header 56 of the partition radiant section by an external conduit 58. The superheated steam is further superheated while passing through the superheater tubes 55 to the outlet header 57. From the header 57 the steam is delivered through a conduit 59 to the inlet header 51 of the rear wall radiant section. The steam then flows downwardly through the superheater tubes 50 to the outlet header 52 from which it passes to the point of use. The described radiant superheating surface substantially increases the superheating capacity of the unit without obstructing the furnace chamber or increasing the draft loss through the unit.

The described location of the radiant superheater surface is also advantageous when starting up the unit and at other low load periods in which little or no steam is being passed through the radiant superheating surface. As shown in Figs. 1 and 3, a pair of fluid fuel burners 60 are mounted in the front wall 10 at the front end of the open pass 35, and arranged to discharge rearwardly therein. The auxiliary burners 60 alone are operated when starting up so that at such periods the furnace gases pass only through the open pass 35 before reaching the tube bank space. Under these conditions the radiant superheating surface will be in no danger of being overheated. When the rate of steam generation has increased sufficiently to provide an adequate steam flow through the superheater sections the fuel burners 32 are put into operation.

The auxiliary fuel burners 60 are also beneficial in affording regulation of the final superheat temperature by varying the superheating effect of the convection heated surface. For example, with the fuel burners 32 in operation the auxiliary fuel burners 60 can be put into operation at a controlled rate of fuel discharge to supply a desired additional amount of heating gases to the furnace pass 35, which gases subsequently contact with the superheater tubes 22 and correspondingly increase the convection superheating effect. With a given load, the burners 60 and 32 may be regulated to vary the ratio of the convection superheating effect to the radiant superheating effect.

In the modified construction shown in Figs. 4–7, the parts numbered the same as in Figs. 1–3 are similarly constructed and substantially similarly arranged. In the modified construction the radiant superheater section is formed by a group of horizontally arranged multi-looped sinuous tubes 70 arranged to form the partition 36ª separating the outer section from the first inner section or open pass. The superheater tubes are arranged with their leg portions in contact with the leg portions of adjacent tubes and their lower and upper ends connected to inlet and outlet headers 71 and 72 respectively. The horizontal tube legs are supported in position by spaced groups of tubes 73 extending vertically from a floor header 39ª and connected to the drum 15. As indicated in Fig. 5, a larger number of tubes 73 are installed along the front portion of the superheater to protect the corresponding portions of the superheater tubes when the burner 60 is used for starting-up. As shown in Figs. 6 and 7, hook bars 74 are welded to the tube legs and carried by corresponding lugs 75 welded on selected tubes 73. With this construction, most of the superheater tube surface will receive heat by radiation not only from the outer furnace section 33 but also from the open pass 34 to their opposite sides.

While in accordance with the provisions of the statutes we have illustrated and described herein the best forms of the invention now known to us, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

We claim:

1. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at the rear end of said space, a plurality of vertical partitions extending longitudinally of said chamber and arranged to divide the same into an outer section and a plurality of serially connected inner sections connecting the rear end of said outer section to the rear end of said tube bank space, means for fluid cooling each of said chamber sections including heat absorbing tubes connected into the steam boiler circuit, fuel burner means at the front end of said outer section for burning fuel in suspension, and auxiliary fuel burner means arranged to discharge fuel directly into one of said inner sections in the same direction as the heating gas flow therein from said outer section.

2. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at the rear end of said space, a plurality of vertical partitions extending longitudinally of said chamber and arranged to divide the same into an outer section and a plurality of serially connected inner sections connecting the rear end of said outer section to the rear end of said tube bank space, means for fluid cooling the side walls of each of said chamber sections including fluid conduit tubes incorporated in each of said partitions and connected into the steam boiler circuit, fuel burner means at the front end of said outer section for burning fuel in suspension, and auxiliary fuel burner means at the front end of the inner section adjoining said tube bank space for burning fuel in suspension.

3. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at one end of said space, a second vertical partition extending longitudinally of and laterally spaced from said tube bank and extending in substantially the same direction as said first partition and arranged to divide said chamber into serially connected outer and inner sections serially connected to said tube bank space, means for burning fuel in said outer chamber section, a radiant heated superheater extending along said second partition, and separate means arranged to discharge fuel directly into said inner chamber section and to provide heating gases discharging therefrom in the same direction as the heating gas flow therein from said outer section.

4. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at one end of said space, means defining a second vertical partition extending longitudinally of and laterally spaced from said tube bank and extending in substantially the same direction as said first partition and arranged to divide said chamber into a plurality of serially connected inner and outer sections connected to said tube bank space, said second partition-defining means including a horizontally arranged sinuous superheating tube, and means for burning fuel in the outer section of said chamber.

5. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at one end of said space, means defining a second vertical partition extending longitudinally of and laterally spaced from said tube bank and extending in substantially the same direction as said first partition and arranged to divide said chamber into a plurality of serially connected laterally adjoining sections connected to said tube bank space, said second partition-defining means including a horizontally arranged sinuous superheater tube arranged to receive heat by radiation at opposite sides thereof, vertical water tubes arranged to support said superheater tube, and fuel burner means at one end of the outer chamber section for burning fuel.

6. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at one end of said space, a plurality of vertical partitions extending longitudinally of and laterally spaced from said tube bank and extending in substantially the same direction as said first partition and arranged to divide

said chamber into an outer section and a plurality of serially connected substantially unobstructed laterally adjoining inner sections serially connecting said outer section to said tube bank space, means for fluid cooling the walls of said inner sections, fuel burner means at one end of said outer section for burning fuel in suspension, a convection heated superheater within said tube bank space, and a second superheater in said chamber heated mainly by radiation from said fuel burner means and serially connected to said convection superheater.

7. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed tubes connecting said drums, a partition extending along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at the rear end of said space, a plurality of vertically disposed partitions extending longitudinally of and laterally spaced from said tube bank and arranged to divide said chamber into an outer section and a plurality of serially connected laterally adjoining inner sections connecting the rear end of said outer section to the rear end of said tube bank space, fuel burner means at the front end of said outer section for burning fuel in suspension, a convection heated superheater section within said tube bank space, heat exchange tubes in said outer and inner sections connected into said steam boiler, a radiant heated superheater section in said chamber subject to radiant heat from said fuel burner means and serially connected to said convection superheater section, and an auxiliary fuel burner arranged to introduce fuel into one of said inner sections between said radiant superheater section and said tube bank space and to provide heating gases discharging therefrom in the same direction as the heating gas flow therein from said outer section.

8. In a steam generating unit, the combination of a combustion chamber and a boiler section at one side thereof, the walls of said combustion chamber being lined with water tubes exposed to the radiant heat of the burning fuel in said chamber, said boiler section including an upper transverse steam and water drum and a lower transverse water drum substantially vertically below said first mentioned drum, a bank of of tubes in said boiler section connecting said upper and lower drums, means for connecting the tubes in said combustion chamber to said steam and water drum, said combustion chamber having a vertical wall extending upwardly therein and dividing said combustion chamber into a pair of serially connected passes arranged and having connections providing heating gas flows therein in opposite directions, steam generating tubes for cooling said wall and arranged to receive heat from both of said passes, means for connecting said steam generating tubes to said steam and water drum, a fuel burning device constructed and arranged to provide a flow of heating gases through both of said passes, and a separate fuel burning device constructed and arranged to provide a flow of heating gases through only one of said passes in substantially the same direction as the heating gas flow therein from said other fuel burning device.

9. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed steam generating tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at one end of said space, a heating gas exit from said space arranged to provide a substantially horizontal gas flow through said space longitudinally of said tube bank, a plurality of vertical partitions extending longitudinally of and laterally spaced from said tube bank and arranged to divide said chamber into an outer section and a pair of serially connected inner sections serially connecting said outer section to said tube bank space, said partitions being relatively arranged to provide a substantially horizontal gas flow through the inner chamber section adjoining said tube bank space in a direction opposite the gas flow through said tube bank space, heat exchange tubes extending along each of said last mentioned partitions and connected into said steam boiler and including radiantly heated superheater tubes, fuel inlet means for supplying fuel to said outer chamber section and radiantly heating said superheater tubes, and separate fuel inlet means for supplying fuel to one of said inner sections in the path of gas flow between said superheater tubes and said tube bank space and providing heating gases discharging therefrom in the same direction as the heating gas flow therein from said outer section.

10. A steam boiler comprising upper and lower horizontally arranged drums, a bank of vertically disposed steam generating tubes connecting said drums, a partition extending vertically along one side of said tube bank and separating the space containing said tube bank from a laterally adjoining chamber except at one end of said space, a heating gas exit from said space arranged to provide a substantially horizontal gas flow through said space longitudinally of said tube bank, a plurality of vertical partitions extending longitudinally of and laterally spaced from said tube bank and arranged to divide said chamber into an outer section and a pair of serially connected inner sections serially connecting said outer section to said tube bank space, means for fluid cooling the boundary walls of each of said chamber sections including steam generating tubes extending vertically along each of said last mentioned partitions and connected to said upper drum, pulverized fuel inlet means for supplying fuel to and burning the fuel in suspension in said outer chamber section, and said partitions being relatively arranged and constructed to provide a substantially horizontal gas flow longitudinally through the inner chamber section adjoining said tube bank space in a direction opposite the gas flow through said tube bank space, and an ash pit at the bottom of one of said inner sections.

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