

Aug. 18, 1942.

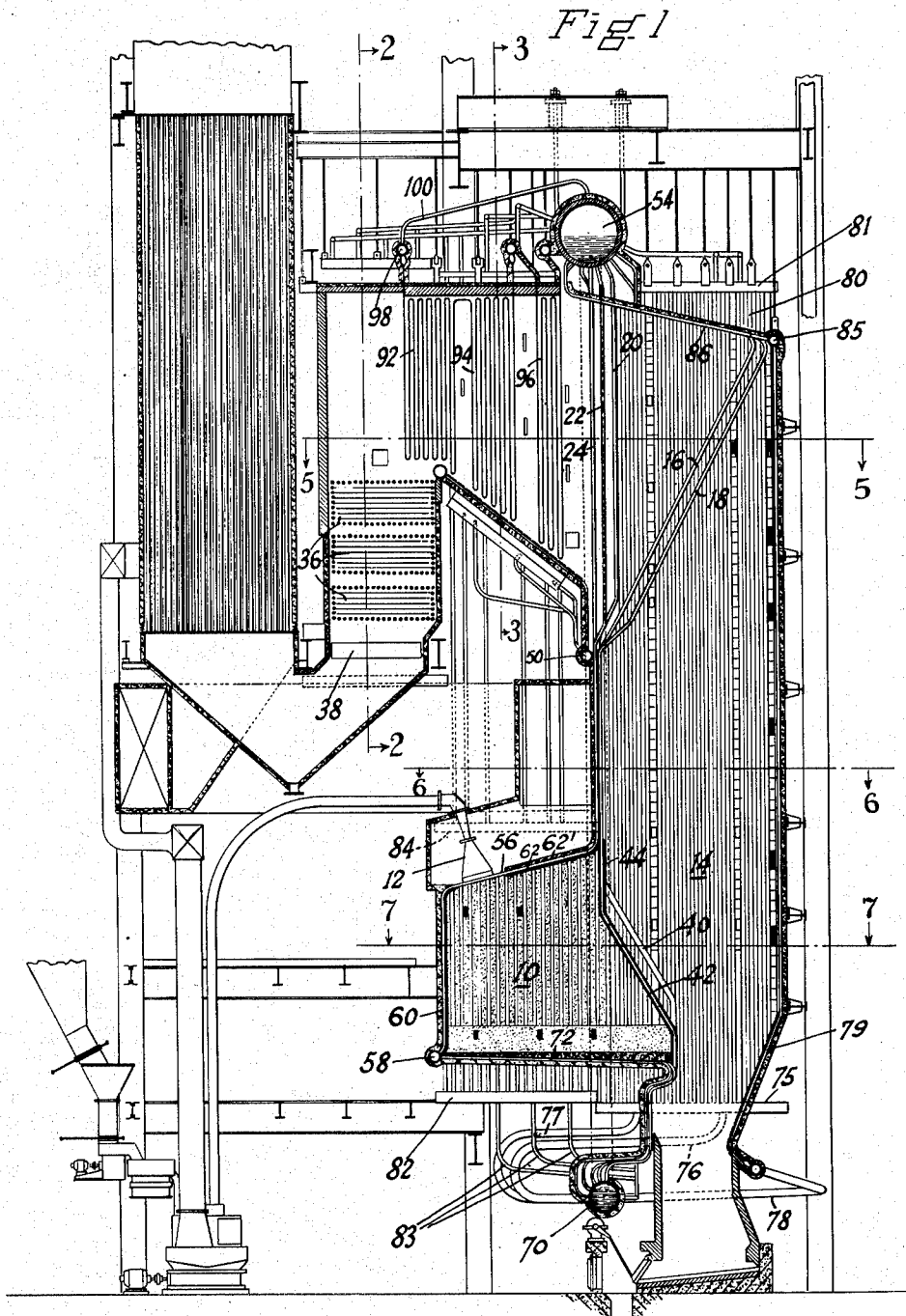
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2,293,040

STEAM GENERATOR

Filed April 6, 1940

6 Sheets-Sheet 1



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2,293,040

STEAM GENERATOR

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Fig 2

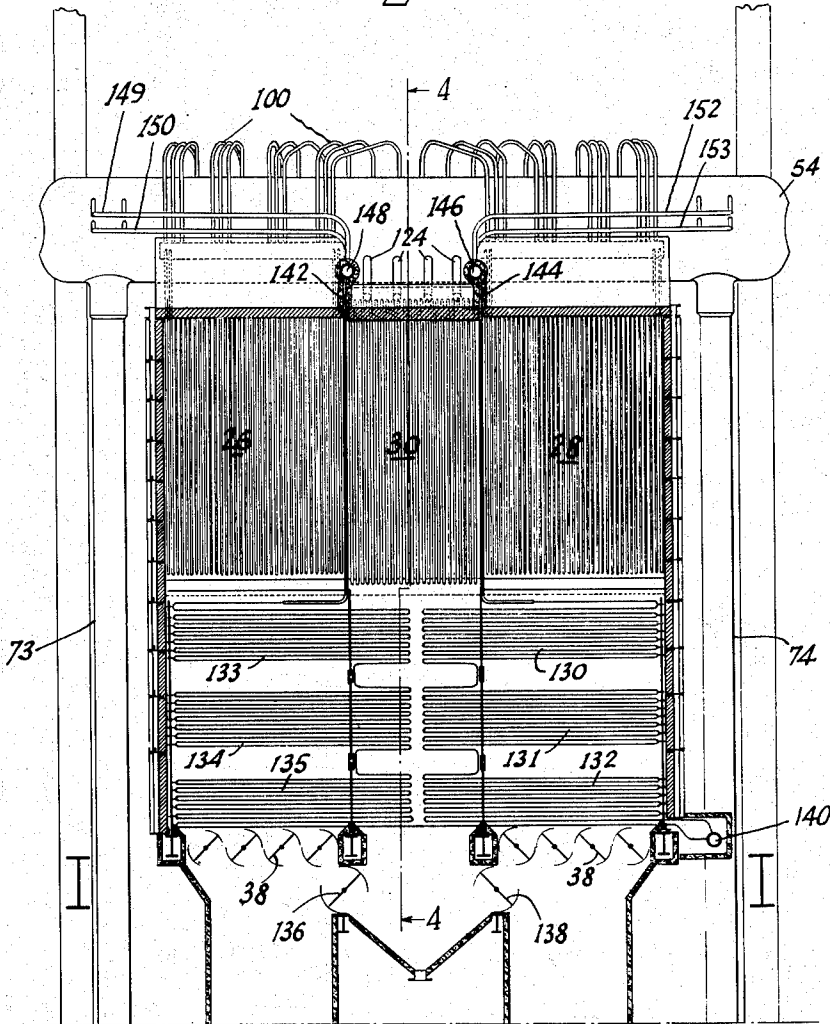
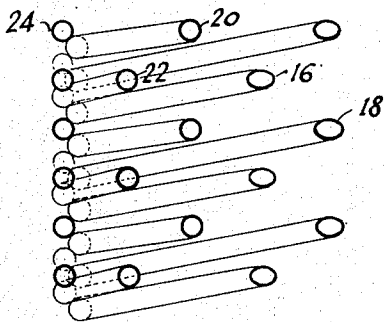


Fig 12a



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Fig 3

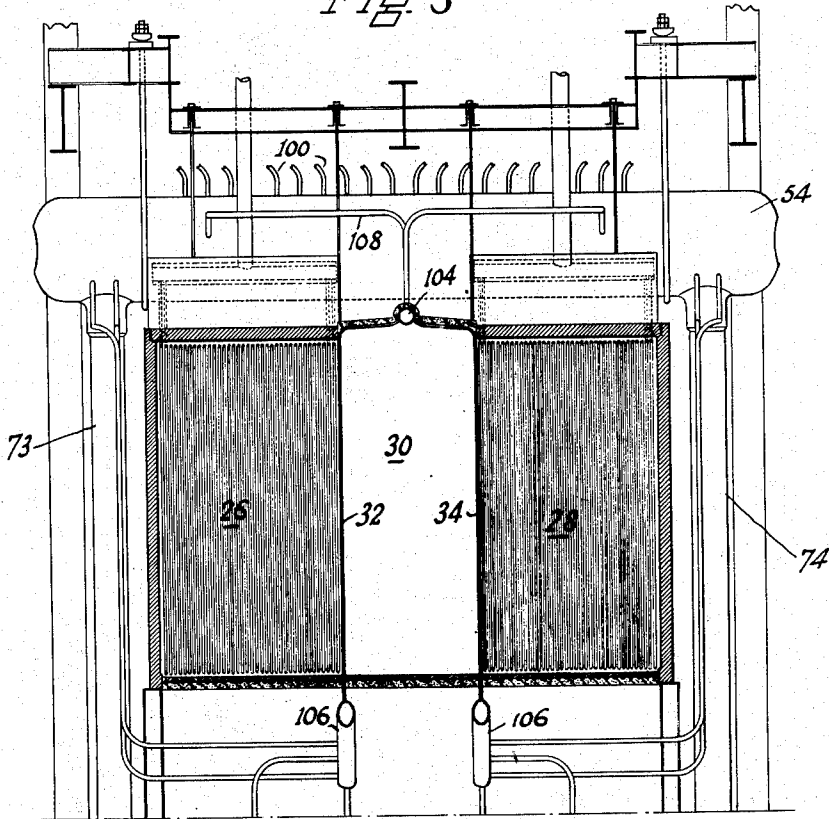


Fig 8

Fig 9

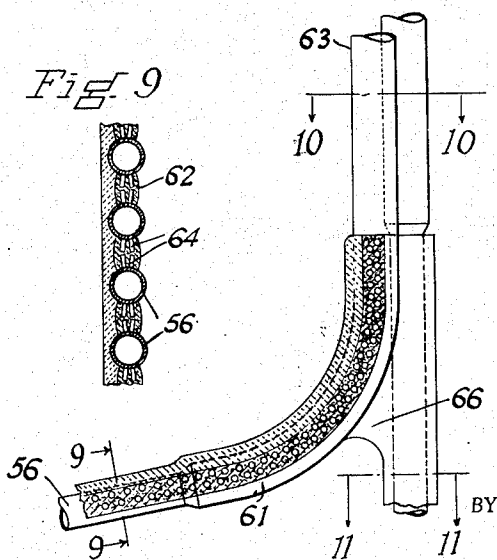


Fig 10

Fig 11

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Fig. 4

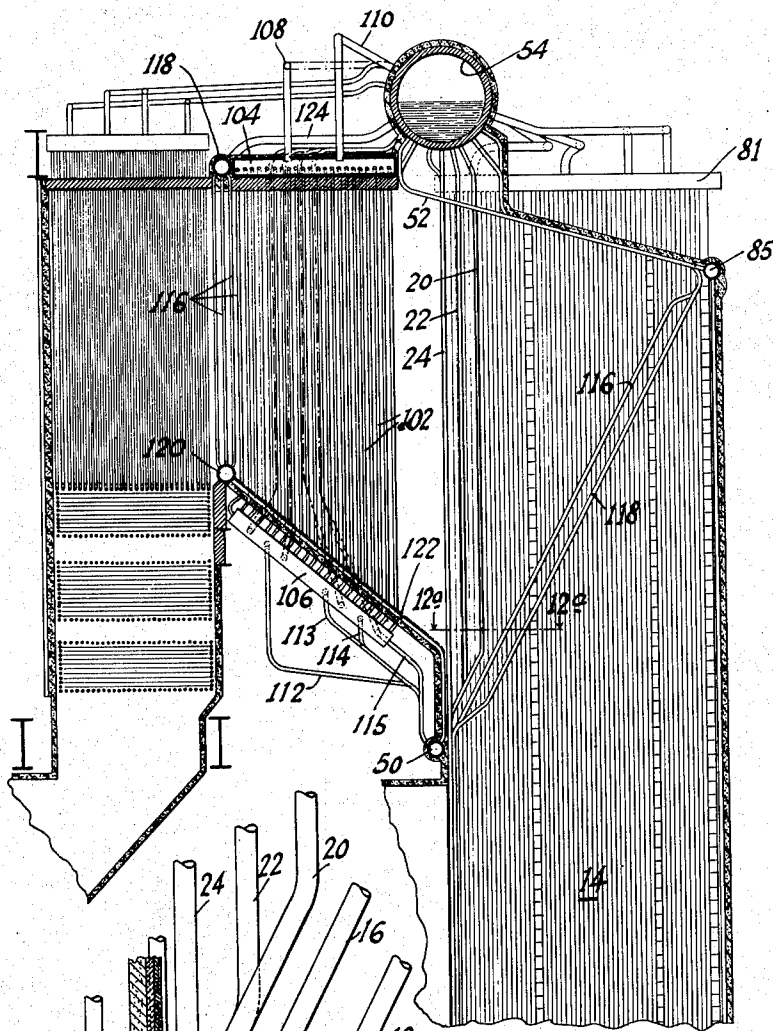


Fig 12

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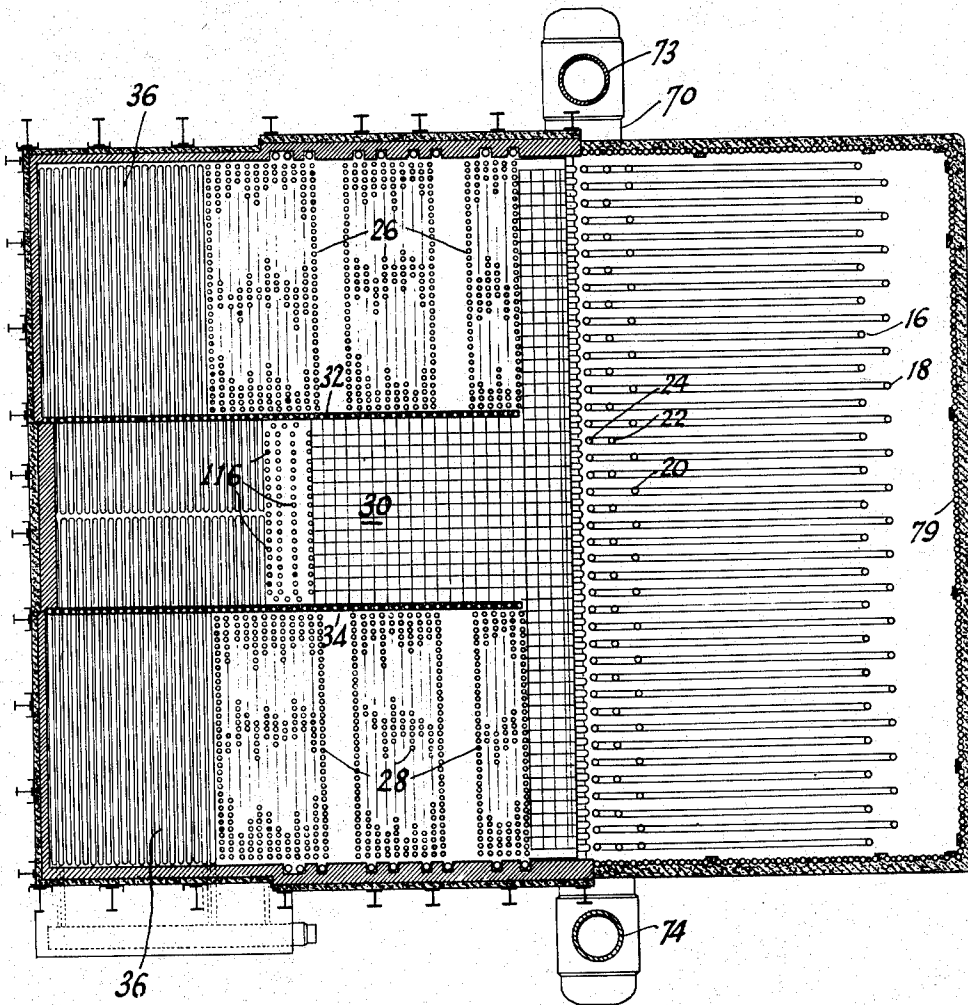
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Fig. 5



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STEAM GENERATOR

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Fig. 6

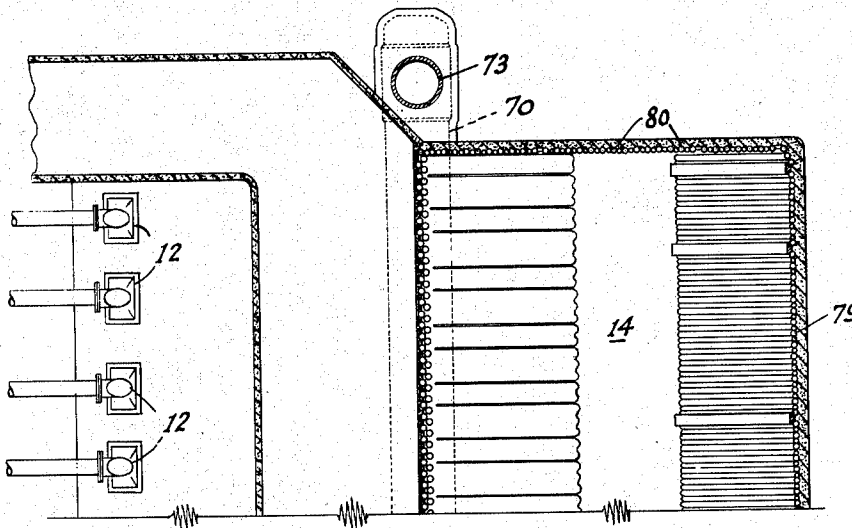
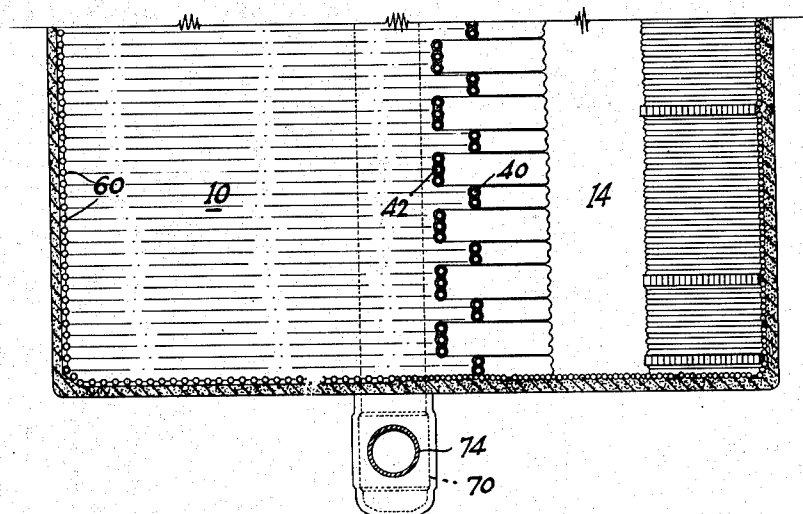


Fig. 7



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UNITED STATES PATENT OFFICE

2,293,040

STEAM GENERATOR

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Application April 6, 1940, Serial No. 328,279

8 Claims. (Cl. 122-235)

This invention relates to improvements in high pressure steam generators of the natural circulation type and these improvements involve effective circulation through fluid cooled tubes located in high temperature furnace zones, while utilizing the same fluid streams to further cool the furnace gases by means of convection heat transfer.

The invention is particularly applicable to large high pressure units which operate at pressures approaching the critical pressure of steam, where the density differential between water and steam causing natural circulation is reduced.

The invention is of particular advantage in its application to high pressure steam generating units having a plurality of combustion stages, with certain of the highly heated tubes cooling the walls of the primary stage.

The invention provides improved circulation for steam generating tubes through the most effective use of available circulating heads by eliminating disadvantageous resistances, by the increase of fluid flow areas with increased specific volume thereof, and by increasing the external tubular heat absorbing area per individual fluid stream.

I have found that in the interest of assured and adequate flow of water through the highly heated roof tubes of the primary furnace and the highly heated partition tubes between the primary furnace and the secondary furnace of a two-stage furnace boiler unit, it is of particular advantage to initiate and maintain separate and distinct fluid streams all the way from a position of relatively low steam content to a direct connection to the steam and water drum outside the heat absorbing zone. This is accomplished by so arranging long separate tubular elements that their lower parts are arranged to cool primary furnace walls while their upper parts extend across the gas path from the secondary furnace to act as convection heat transfer surfaces, screening the superheater from the secondary furnace chamber.

In order to insure the most effective use of the available water head to cause natural circulation through the distinct liquid flow paths, I utilize an outside unheated downcomer, and avoid the use of junction headers and similar resistances in positions where they would retard circulation. Compensation for the increased specific volume in the upper portion of the separate fluid flow paths, due to the higher ratio of steam to water is provided by increasing the flow area while

maintaining the independency of the individual fluid streams.

I also provide an advantageous modification of the size and spacing of the tubular elements; their lower parts, presenting radiant heat absorbing wall structures, are closely spaced and are of small diameter, while their upper parts, which extend in unsupported lengths across the gas path, are of larger diameter. These upper parts, in addition to their greater fluid flow area, have such greater stiffness and structural strength that they do not require additional supports within the path of the furnace gases. The tube portions extending across the gas flow are also arranged at greater center to center spacing so that there will be no undue restriction of gas flow therebetween.

In compliance with the law relating to patents, and particularly section 4888 R. S., the invention will be described with reference to a preferred embodiment, and other objects of the invention will appear as the description proceeds.

The description has reference to the accompanying drawings in which;

Fig. 1 is a vertical section through the illustrative steam generating installation;

Fig. 2 is a transverse vertical section on the line 2-2 of Fig. 1 and looking in the direction of the arrows;

Fig. 3 is a transverse vertical section taken on section line 3-3 of Fig. 1 and looking in the direction of the arrows. This section is taken through the superheater, and it particularly shows the furnace gas bypass for the superheater;

Fig. 4 is a vertical section on the line 4-4 of Fig. 2, this view illustrating the arrangement of the wall tubes defining a side of the furnace gas bypass;

Fig. 5 is a plan, or horizontal section, taken in the plane indicated by the section line 5-5 of Fig. 1;

Figs. 6 and 7 are partial horizontal sections taken respectively on section lines 6-6 and 7-7 of Fig. 1;

Fig. 8 is a detail view illustrating the arrangement of the partition wall tubes and the roof tubes for the first furnace chamber;

Fig. 9 is a transverse section of the roof of the first furnace chamber, taken on the line 9-9 of Fig. 8;

Fig. 10 is a horizontal section of the line 10-10 of Fig. 8, illustrating the arrangement of the tubes in that part of the walls of the second

furnace chamber immediately above the first chamber;

Fig. 11 is a horizontal section on the line 11—11 of Fig. 8, and showing the full stud tube wall construction;

Fig. 12 is a detail view illustrating the arrangement of tubes at the lower ends of the tubular furnace screens extending across the upper part of the second furnace chamber;

Fig. 12a is a partial horizontal section on the section line 12a—12a of Fig. 4;

Fig. 1 of the drawings shows a first furnace chamber 10 fired by one or more pulverized fuel burners 12. The furnace gases pass from this chamber into the lower end of the second chamber 14, steam being generated by wall tubes which define the sides of both of these chambers.

The furnace gases pass from the upper part of the furnace chamber 14 between the furnace screen tube sections 16 and 18 and then across the upright screen tube sections 20, 22, and 24 to a superheating zone. Here, there are two superheater sections 26 and 28 disposed on opposite sides of the superheater by-pass 30.

Superheat is regulated by the desired proportioning of the flow of furnace gases between the by-pass 30 and over superheater sections 26 and 28, and for this purpose the by-pass walls 32 and 34 are continued rearwardly and downwardly of the superheater, and across the tubes of the economizer 36 to dampers 38.

The tubes 40 and 42, between the two furnace chambers are arranged in single plane alignment to form the partition wall 44 near the upper part of the first furnace chamber. At this location the tubes are covered with refractory material 46 maintained thereon by metallic studs 48, this construction of partition wall being particularly shown in Fig. 11 of the drawings.

Beneath the partition wall section 44, groups of the tubes 42 are disposed forwardly of groups of the tubes 40, an arrangement which is particularly indicated in Fig. 7 of the drawings. The purposes of this arrangement are to afford a screen between the first and second furnace chambers and to provide for the movement of furnace gases to the second furnace chamber.

The tubes 40 and 42 extend upwardly of the first furnace chamber to a position whence their sections 16 and 18 extend at vertical inclinations across the upper part of the second furnace chamber. Their upper ends 52 are in direct communication with the steam and water drum 54 as indicated in Fig. 4.

To take care of the increasing volume of the fluid within the tubes 40 and 42, the latter are of increased diameter upwardly of a position adjacent their junction with the roof tubes 56 of the first furnace chamber. The latter extend upwardly from the lower header 58 along the wall 60 and then along the horizontally inclined roof 62 to the roof and partition wall junction which is specifically illustrated in Fig. 8 of the drawings. Beyond this point, the tubes 56 are of increased diameter as indicated at 61, and just beyond the latter position they are curved so as to have their vertical parts 63 associated with the tubes 40 and 42 in the manner indicated in Fig. 10.

The spaces between the tubes 56 are closed by a "partial stud" wall construction which includes the refractory material 62 and the metallic studs 64 (see Fig. 9), and the Fig. 8 junction of the partition wall and the first furnace chamber roof may involve such junction of the partition

wall refractory material 46 and the roof refractory material 62 that an integral refractory body 66 is formed. Extending through this refractory in this zone, some of the studs of the tubes 40 and 42 may be attached by welding to some of the tubes 56 in order that proper junction of the partition wall and the furnace roof may be maintained.

Above the tube to tube wall construction indicated in Fig. 10, and upwardly of the header 50, the sections 63 of the tubes 56 are bent out of their row alignment and offset to form the upright screen sections 20, 22, and 24. In the illustrative embodiment the tube sections 63 are spaced on 6 inch centers in the furnace while their screen extensions 22 and 24 have lateral spacings of 9 inches and 18 inches. The latter are connected to the steam and water drum 54 as indicated in Figs. 1 and 4 of the drawings.

The tubes 44, and the tubes of groups 40 and 42 are spaced on 6 inch centers while their upper portions 16 and 18 extending obliquely across the furnace chamber 14 have 9 inch and 18 inch spacings and their diameters are increased to 4 inches O. D. to give structural strength.

The partition wall tubes 40 and 42 extend downwardly of the furnace chamber tubes and their lower ends are in communication with a drum or header 70. The latter has also connected thereto the floor tubes 72 which establish communication between the header 58 and the header 70.

In order that the above described furnace wall tubes, and the remaining wall tubes may be adequately supplied with water the header or drum 70 is of large capacity, and it is connected at its opposite ends by large diameter unheated downcomers 73 and 74 with the water space of the drum 54.

The remainder of the wall tube system for the furnace chamber 14 includes the wall tubes and header connections 75 to 88, inclusive, and these elements are connected into the circulatory system in an appropriate manner as indicated in the drawings. The riser tubes 86 from header 85 are interspersed with the inclined end portions of tubes 16 and 18 to cool and support the roof.

The superheater sections 26 and 28 are formed by the upright tube loops 92, 94, and 96 as indicated in Fig. 1 of the drawings, steam being supplied to the inlet header 98 by the tubular connections 100 which communicate with the steam space of the drum 54 as indicated in Fig. 1.

The walls 32 and 34 of the superheater gas bypass 30 are defined by an arrangement of water 102 connecting the headers 104 and 106, as indicated in Fig. 4 of the drawings. The upper headers 104 are in direct communication with the steam space of the drum 54 through the tubes 108 and 110 and the lower headers 106 are inclined as also shown in Fig. 4. Here, they are indicated as connected by the tubes 112—115 with the header 50.

Within the superheater gas bypass the gases pass across the upright tubes 116 which are shown as directly connecting the upper header 118 and the lower header 120. The latter is directly connected with the header 50 by the tubes 122, and the upper header 118 is directly connected with the drum 54 by the tubes 124.

From the upper part of the second furnace chamber the furnace gases pass in a general horizontal direction over the superheater tubes and through the bypass 30, but rearwardly of

the superheater the gases turn and pass downwardly across the tubes of the economizer sections 130 to 135, inclusive. Fig. 2 of the drawings shows the arrangement of these economizer sections with reference to the bypass 30 and the gas passes in which the superheater sections are disposed. It also shows the dampers 136 and 138 which must be operated in connection with the dampers 38 to maintain a desired superheat over a wide range of boiler loads.

The economizer sections are formed by looped tubes which are connected in series so as to receive water from the inlet header 140 and conduct it through the upright bypass wall tubes 142 and 144, to headers 146 and 148, and the tubular connections 149—153 to the drum 54.

Although the invention has been described with reference to the details of an installation which is a preferred embodiment of the invention, it is to be understood that the invention is not to be considered as necessarily limited to all of the details of that installation. The invention is rather to be taken as susceptible of embodiment in other installations coming within the scope of the sub-joined claims.

I claim:

1. In a steam generator and its setting, two laterally adjoining furnace chambers the second of which extends well above the first, a steam and water drum near the top of the setting, fuel burning means for the first furnace chamber, wall cooling tubes defining a roof portion of the first furnace chamber and extending upwardly beyond the first furnace chamber and along a wall of the second furnace chamber and to said drum, other wall cooling tubes having parts defining a partition wall separating said furnace chambers and having other parts extending along the same wall of the second furnace chamber and to the drum, and means connecting said tubes into the fluid system of the generator, each of said tubes maintaining its identity of flow circuit from a position of adjacency of the furnace chambers to the drum.

2. In a steam generator, two adjoining furnace chambers connected for a series furnace gas flow to a convection section, partition wall tubes separating the furnaces and having extensions disposed above one of the furnace chambers and across the path of the furnace gases near the upper part of the other furnace chamber, one chamber having roof cooling tubes with extensions disposed along a side of the other chamber and across the path of the furnace gases near the top of the second chamber, means for firing one of the chambers, and means connecting the tubes into the fluid system of the generator.

3. In a steam generator, a fluid system comprising a steam and water drum at the upper part of the generator, and water drum at the lower part of the generator, first and second furnace chambers adjoining near the lower drum, external downcomers connecting the lower drum to the water space of the steam and water drum, one set of steam generating tubes having lower parts forming a high temperature screen extending across the path of the furnace gases passing from the first of said chambers into the second and having upper parts forming a low temperature screen extending across the path of the furnace gases near the top of the second chamber and at a level well above the first, a second set of steam generator tubes lower parts of which form roof tubes for the

first chamber while their upper parts form another low temperature screen extending across the path of the furnace gases near the top of the second chamber, and means for burning fuel in the first chamber, the tubes of all said sets directly connecting the water drum with the steam and water drum.

4. In a steam generator, a steam and water drum disposed at the upper part of the generator, means forming a water chamber disposed at the lower part of the generator, an unheated downcomer connecting the drum and the water chamber, means forming a plurality of adjoining furnace chambers disposed between the drum and the water chamber, and a partition wall including water tubes separating said furnace chambers and having their upper and lower ends connected directly to the drum and said water chamber respectively, said furnace chambers being arranged in series so that the gases from one pass through a partition wall opening to the other, the lower parts of said tubes extending across said opening, some of said tubes having upper portions extending across the gas path from one of said furnace chambers with others of said tubes having portions disposed in staggered relationship thereto.

5. In a steam generator, a steam and water drum disposed at the upper part of the generator, means forming a water chamber at the lower part of the generator, an unheated downcomer connecting the drum and said water chamber, means forming a primary furnace chamber, means forming a secondary furnace chamber receiving furnace gases from the primary furnace chamber, means for burning fuel in the primary furnace chamber, the roof of the primary furnace chamber including a row of tubes, a partition wall dividing the primary and secondary furnace chamber and including a row of water tubes, and means to direct water from the water chamber to the lower ends of said rows of tubes, the upper parts of tubes of both of said rows extending across the gas outlet of the secondary furnace chamber, the upper ends of all of said tubes being directly connected to the steam and water drum.

6. In a steam generator, a furnace, and a plurality of contiguous rows of spaced fluid cooling tubes located adjacent the wall of the furnace of the generator, some of said tubes having upper portions of greater diameter extending obliquely across the path of the furnace gases and arranged in staggered relationship, the transverse spacing of said upper portions being greater than the transverse spacing of the portions of the tubes which are located in said rows, the transition of spacing being accomplished by bends in the tubes at positions adjacent the lower ends of the upper portions.

7. In a vapor generator of the multiple stage type, means for burning fuel in a primary furnace chamber walls of which are defined by vapor generating tubes, means including vapor generating wall tubes defining walls of a second furnace chamber receiving furnace gases from the primary furnace at the lower part thereof, a convection section receiving furnace gases from the second furnace chamber, some of the vapor generating wall tubes of the second furnace chamber having upper portions extending obliquely across the path of the furnace gases at the upper part of the second furnace chamber to form a first furnace gas screen, and others of the wall tubes of the second furnace chamber

having portions forming a second screen ahead of the convection section and rearwardly of the first screen, relative to furnace gas travel, said first screen wall tubes having upper portions beyond the first screen bent to extend along a roof of the second furnace chamber.

8. In a steam generator, an elevated steam and water drum, first and second adjoining furnace chambers connected for series gas flow to a convection section, fuel burning means for the first furnace chamber, an upright partition wall including steam generating tubes between the fur-

nace chambers, the first chamber having roof cooling tubes, individual extensions of said last mentioned tubes being disposed so as to form a screen across the path of the gases leaving the second chamber at a position above the roof of the chamber, the roof tubes and their extensions providing continuous flow paths from a position below the roof to a position beyond said screen, and means connecting the wall tubes and the roof tubes into the fluid system of the generator.

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