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HEAT EXCHANGER, BOILER AND THE LIKE

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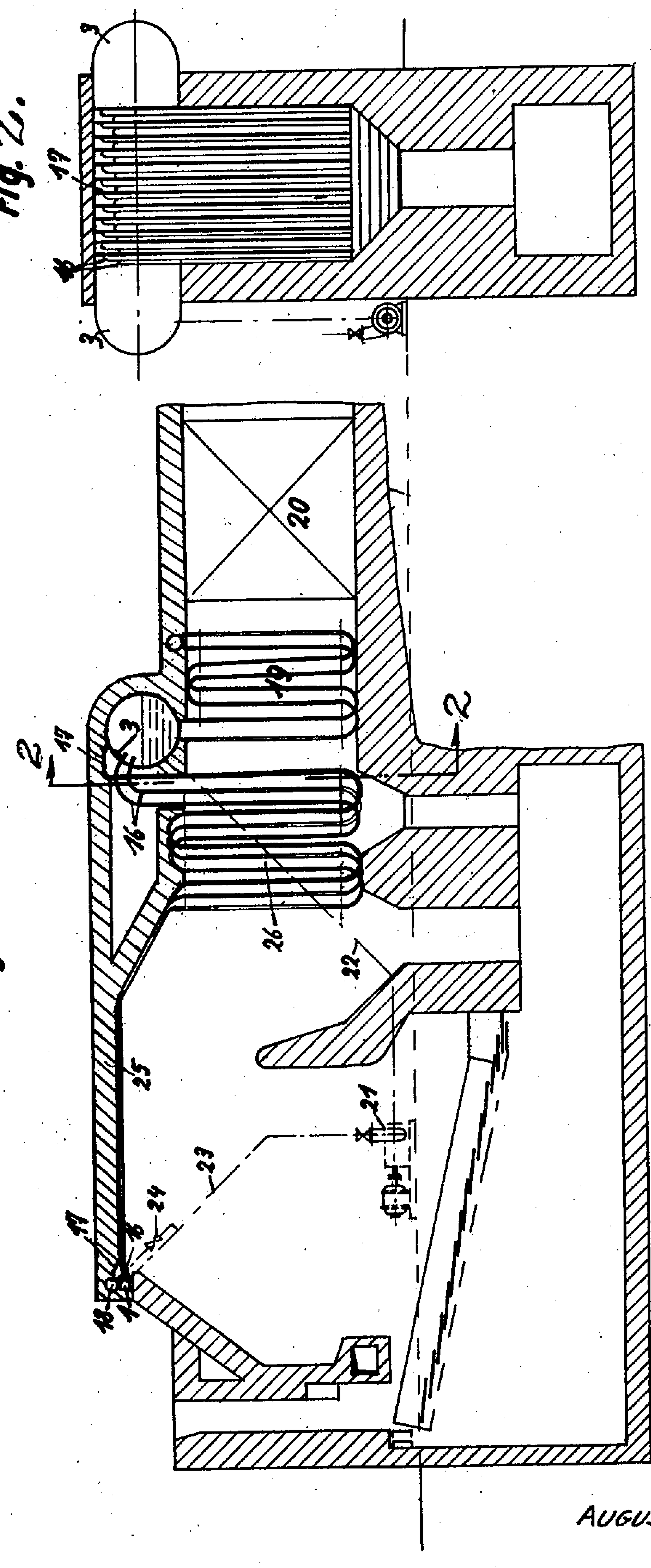

Fig. 2.

Fig. 1.

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HEAT EXCHANGER, BOILER, AND THE LIKE

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This invention relates to steam generators and especially to steam generators having a positive circulation of water therein. More particularly the invention relates to steam generators in which the heating surface is in the form of tubes which are subjected to radiant heat and to the heat of heating gases.

In steam generators with positive water circulation it is necessary to distribute the circulated water to the individual heating surfaces in accordance with the transfer of heat. Whereas in a steam generator with natural convection circulation an increased rate of steam generation causes a stronger circulation of the water over the heating surfaces exposed to higher heat as compared to those exposed to less heat, in a steam generator with positive water circulation the reverse may be true. That is to say, upon the heating surface subjected to higher heat a greater amount of steam is generated and this steam flowing through tubes or over heating surfaces creates a higher resistance to circulation of the water. Therefore, in a group of heating surfaces arranged in parallel, for a given total quantity of water circulated, the water delivered to the heating surfaces exposed to higher heat will be less in proportion to the amount of steam generated therein than that delivered to the heating surfaces exposed to less heat because the resistance of the latter heating surfaces is correspondingly less. The pressure which produces flow of the water in the so-called convection circulation is the result of the steam generation within the tube or upon the heating surface whereas in a steam generator in which the water is positively delivered by means such as a pump, the pressure is applied at the ends of the tubes or at the entrance to the heating surface. In a system of parallel tubes or paths of water flow, if the same pressure is applied by the pump at the entrance to all the tubes or paths, a greater amount of water will flow into the tubes subjected to less heat than into those subjected to greater heat. The reason for this is that the smaller amount of steam generated in the tubes subjected to less heat results in less resistance or back pressure against which the applied pressure of the pump must act than in the tubes subjected to greater heat.

This condition becomes particularly undesirable for steam generators with positive water circulation which have both heating surfaces subjected to radiant heat and surfaces subjected to convection heat, especially when these two kinds of heating surfaces are arranged in parallel with respect to the water flow, as is usually the case. The relative absorption of heat by heating surface under radiant heat as compared with the absorption by the convection heating surface changes with the load. As is well known the relative heat absorption of the heating surface under radiant heat decreases with the load of the boiler, whereas the relative heat absorption of the convection heating surface increases with the load. An unbalance or lack of equalization therefore occurs in the resistances to the steam and water flow through the tubes or over the heating surfaces which unbalance changes with the rate of firing or the load upon the boiler.

According to the present invention tubes arranged in parallel and having positive water circulation are positioned so that they are juxtaposed approximately in a bank forming a heating surface subjected to radiant heat, as when the tubes are located at the wall or roof of a furnace chamber. The same tubes are extended beyond the radiant heat zone and are bent upon themselves, for example in serpentine form to provide a group of heating surfaces subjected to the heat of the gases for generating steam by convection heating. The water is thus caused to flow in separate paths consecutively through the zones of radiant and convection heat.

One advantage of the invention consists in the fact that on account of the series arrangement of radiation and convection heating surfaces the sum of the heat absorbed by the parts, such as the tubes, through which the water separately flows, under changing load on the boiler maintains approximately a constant relation to the total heat absorption of the boiler and therefore a better distribution of the water to be circulated can be obtained. Moreover the invention provides the advantage that as the tubes are continuous and of long length to extend through both zones the number of the connection points, as to a header, is decreased and because of the larger total heat absorption and correspondingly larger steam production of each tube, the velocity of the mixture of steam and water in the tubes is increased which assists in increasing the heat transfer.

The invention also makes it possible to obtain the same advantage in a superheater having surfaces over which the steam being superheated flows in series over portions subjected to radiant heat and to convection heat. Here also the sum of heat absorption remains approximately constant for changing loads. The heat absorption of the superheater as a whole can be made proportional to the heat absorption of the steam generator at all loads by interspersing the superheater tubes between the steam generating tubes in the radiation part of the boiler and by arranging the same steam generator and superheater tubes by bending the tubes one or more times so as to form a group of steam generating and superheating surfaces traversed by the heating gases. In such an arrangement depending upon the number of superheater tubes interspersed between the steam generating tubes the heat absorbed by the superheater will bear a certain relation to the heat absorbed by the steam generator, so that the temperature of superheated steam will be substantially constant at all loads.

It is of particular advantage to have the steam flow in the superheater in a counter-flow relation to the heating gases not only in the convection steam generator but also at the radiation heating surface.

The invention also has the further advantage that because of the interspersed arrangement of the superheater tubes and the steam generating tubes the superheater tubes are protected against burning out.

In the drawing a typical embodiment of the invention is shown, but the invention of course is not limited to this particular embodiment.

Fig. 1 shows a combination of steam generating tubes according to the invention with superheating tubes similarly arranged; and

Fig. 2 is a cross section upon line 2—2 of Fig. 1.

Fig. 1 illustrates a longitudinal section and Fig. 2 a cross section of a steam generator with a radiant heat and a convection heat superheater. The roof of the combustion chamber is lined with tubes placed side by side in relatively close spacing. Some of these tubes are used for generating steam and others are used for superheating the steam. The tubes are long enough to be bent into U or serpentine shape to form, in the gas passage leading from the furnace, the convection heating surface 26 in which the tubes are separated somewhat to permit passage of the gases thereover. In Fig. 1 the steam generating tubes are shown at 16 and superheater tubes at 17. The water is positively delivered by means such as the pump 21 and is fed through the tubes from distributing header 1. The mixture of water and steam formed in the generation of steam is introduced into the drum 3, where the steam is separated from the water. The steam flows from the drum 3 through the superheater tubes 17 in counterflow relation to the heating gases. It also flows along the radiation surface in a direction toward the collector 18 which is adjacent the header 1. From the header 18 the steam may be passed to the place of use. The heating gases passing through the group of heating surfaces formed by the steam generating tubes and superheater tubes may be delivered to the feed water preheater 19 for further cooling. An air preheater 20 also may be used if desired.

It is of advantage to connect the superheater tubes immediately to the steam space of the drum because thereby a practical simplification of the construction is obtained. Also by this means the steam may be taken off over the full length of the drum 3. The steam is thus discharged at many points just as the mixture of steam and water from the steam generating tubes 16 is introduced into the drum 3 at many points. During starting of the boiler or during the times when no steam flows through the superheater tubes when they nevertheless may be heated, the superheater tubes may be cooled by passing water through them by means of the circulation pump 21 (Fig. 1) which is used to produce circulation of the water through the steam generating tubes of the steam generator. Water from the drum 3 flows to the pump 21 through the pipe 22. The pump during normal operation forces the water through the pipe 23 into the water distributor 1. If no steam flows through the superheater tubes the valve 24 may be opened and water is forced through the collector 18 and the superheater tubes 17. The superheater surface in this event acts as a steam generator, whereby a reliable cooling is secured.

What I claim is:—

1. Steam generator comprising a furnace, a plurality of tubes exposed to the radiant heat of said furnace and extending beyond the furnace in spaced relation to form a tube bundle for absorption by convection of the heat of the heating gases discharged from the furnace, a steam superheating tube in interspersed relation to the portions of the tubes exposed to radiant heat for superheating the steam by radiant heat, said steam superheating tube also extending in interspersed relation with said tube bundle to receive heat from the gases by convection.

2. Steam generator comprising a furnace, a plurality of tubes exposed to the radiant heat of said furnace and extending beyond the furnace in spaced relation to form a tube bundle for absorption by convection of the heat of the heating gases discharged from the furnace, a steam superheating tube in interspersed relation to the portions of the tubes exposed to radiant heat for superheating the steam by radiant heat, said steam superheating tube also extending in interspersed relation with said tube bundle to receive heat from the gases by convection, said steam generating tubes being connected to a drum to discharge steam thereto, said steam superheating tube being also connected to said drum to receive steam therefrom.

3. Steam generator comprising a furnace, a plurality of tubes exposed to the radiant heat of said furnace and extending beyond the furnace in spaced relation to form a tube bundle for absorption by convection of the heat of the heating gases discharged from the furnace, a steam superheating tube in interspersed relation to the portions of the tubes exposed to radiant heat for superheating the steam by radiant heat, said steam superheating tube also extending in interspersed relation with said tube bundle to receive heat from the gases by convection, said steam generating tubes having water delivered to one end thereof and discharging steam from the other end thereof, said steam superheating tube being arranged to receive adjacent the discharge ends of the steam generating tubes the steam discharged from said steam generating tubes and being arranged to discharge the superheated steam at the end of said steam superheating tube remote from said discharge ends of said steam generating tubes.

4. Steam generator comprising a furnace having a wall, a gas passage connected to receive the combustion gases from said furnace, a plurality of tubes extending along said wall and into said gas passage, the portions of said tubes in said gas passage being bent to position portions of the lengths thereof in spaced relation to each other for absorption of the heat of the gases passing from said furnace through said gas passage, some of said tubes being connected at one end thereof

to receive water from a common water header and being arranged to discharge from the other end thereof the generated steam and any water flowing to said discharge end with the steam, others of said tubes for superheating steam being connected to a common steam discharge header and arranged to receive steam for flow through said steam superheating tubes toward said discharge header, whereby said steam being superheated receives successively in each tube heat both by radiation and convection heat transfer in similar relation to the heat absorbed by the steam generating tubes.

5. Steam generator comprising a furnace having a wall, a gas passage connected to receive the combustion gases from said furnace, a plurality of tubes extending along said wall and into said gas passage, the portions of said tubes in said gas passage being bent to position portions of the lengths thereof in spaced relation to each other for absorption of the heat of the gases passing from said furnace through said gas passage, some of said tubes being connected at one end thereof to receive water from a common water header and being arranged to discharge from the other end thereof the generated steam and any water flowing to said discharge end with the steam, others of said tubes for superheating steam being connected to receive the steam discharged from said steam generating tubes and being connected to a common steam discharge header at the ends of said steam superheating tubes remote from the steam discharge end of the steam generating tubes, whereby the steam generated in said steam generating tubes is superheated in said superheating tubes first by convection action in counterflow relation to the heating gases and then by the radiant heat of the furnace.

6. Heat exchanger comprising a plurality of fluid confining tubes including steam superheating tubes and steam generating tubes, said fluid confining tubes extending in the same general direction in a zone of radiant heat, said tubes having a portion of their lengths extending out of said radiant heat zone and into a passage through which heating gases flow, said portions within said gas passage being in spaced relation for the flow of gases therebetween and being bent into a plurality of coils to form a bundle of tubes arranged to receive heat from said gases by convection, said tubes each providing a single path of fluid flow consecutively through said zones, said steam superheating tubes having the portions thereof exposed to radiant heat interspersed with the portions of the steam generating tubes exposed to radiant heat.

7. Heat exchanger comprising a plurality of fluid confining tubes including steam superheating tubes and steam generating tubes, said fluid confining tubes extending in the same general direction in a zone of radiant heat, said tubes having a portion of their lengths extending out of said radiant heat zone and into a passage through which heating gases flow, said portions within said gas passage being in spaced relation for the flow of gases therebetween and being bent into a plurality of coils to form a bundle of tubes arranged to receive heat from said gases by convection, said tubes each providing a single path of fluid flow consecutively through said zones, said steam superheating tubes having the portions thereof exposed to radiant heat interspersed with the portions of the steam generating tubes exposed to radiant heat, said superheater tubes being so arranged in the gas passage with respect to their inlet ends that the steam flows through said tubes in counter flow relation to the heating gases.

8. Heat exchanger comprising a plurality of fluid confining tubes including steam superheating tubes and steam generating tubes, said fluid confining tubes extending in the same general direction in a zone of radiant heat, said tubes having a portion of their lengths extending out of said radiant heat zone and into a passage through which heating gases flow, said portions within said gas passage being in spaced relation for the flow of gases therebetween and being bent into a plurality of coils to form a bundle of tubes arranged to receive heat from said gases by convection, said tubes each providing a single path of fluid flow consecutively through said zones, said steam superheating tubes having at least a portion of their lengths interspersed with the steam generating tubes, said interspersed portions being selected for both types of tubes from those portions thereof which are exposed to radiant heat and to convection heat.

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