United States Patent

[11] **3,610,326**

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[33] **Switzerland**
[31] **9430/68**

[54] **APPARATUS FOR CONTROLLING HEAT EXCHANGE IN STEAM GENERATORS**
7 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **165/96,** 122/479, 165/32
[51] **Int. Cl.** **F28f 27/00**
[50] **Field of Search** 165/32, 96; 122/479

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ABSTRACT: The convection heated heating surfaces are formed of tube panels in which adjacent pairs of panels are movable with respect to each other into and out of a common plane to vary the amount of heating surface exposed to the flue gas. The panels can be formed with sinuous-shaped coils with the interconnecting bends bent out of the plane of the straight sections.

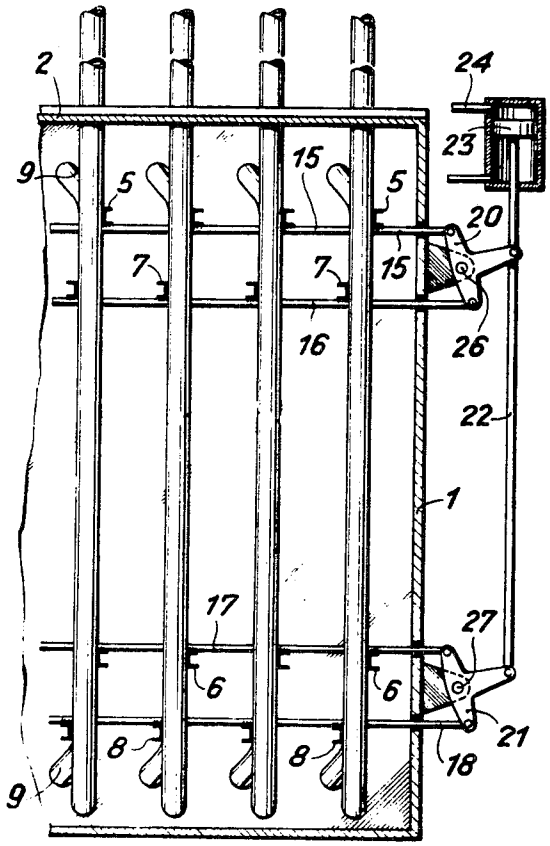

Fig. 1

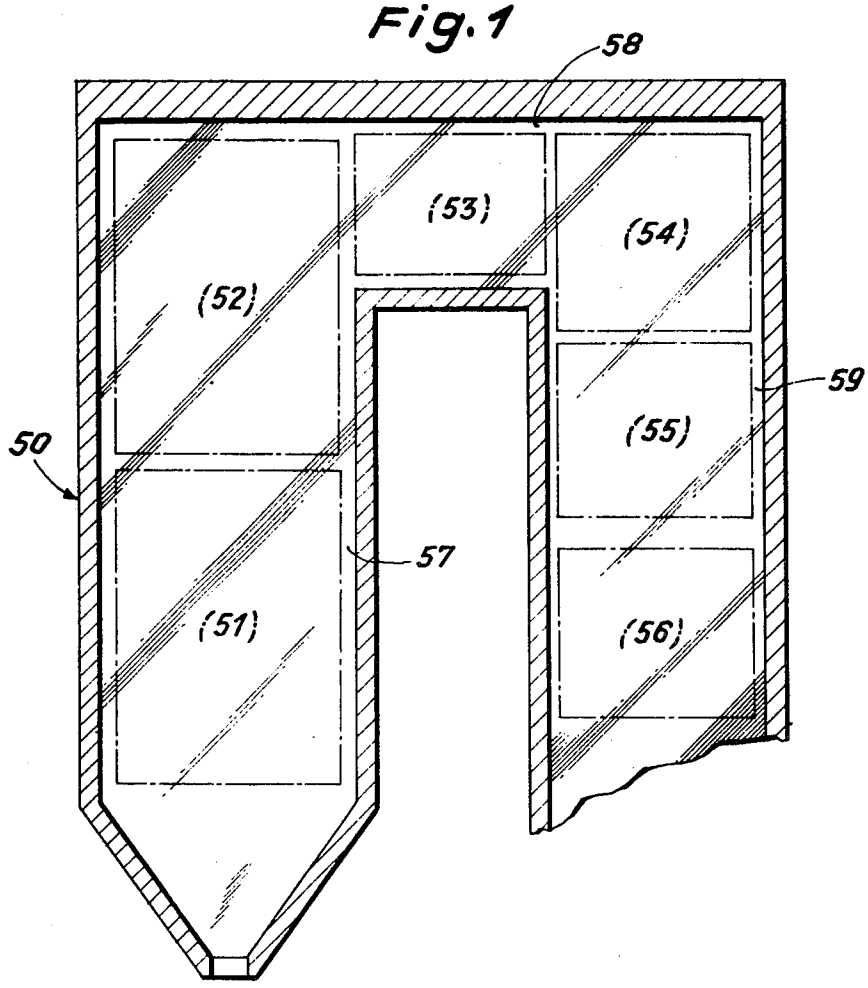

Fig. 6

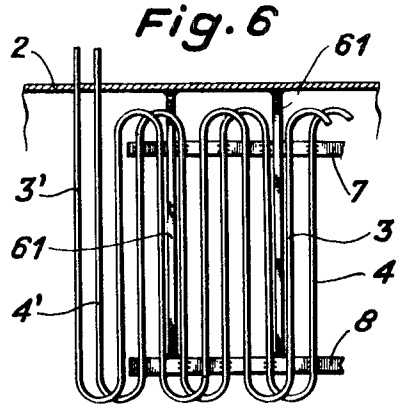

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Fig. 2

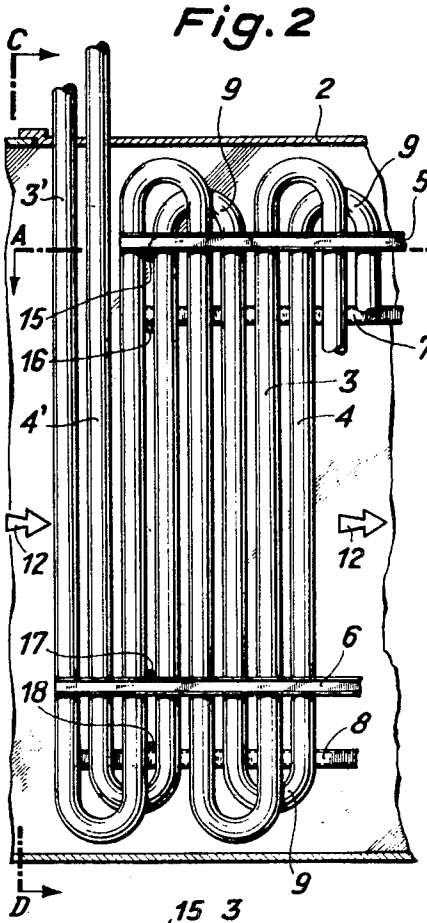
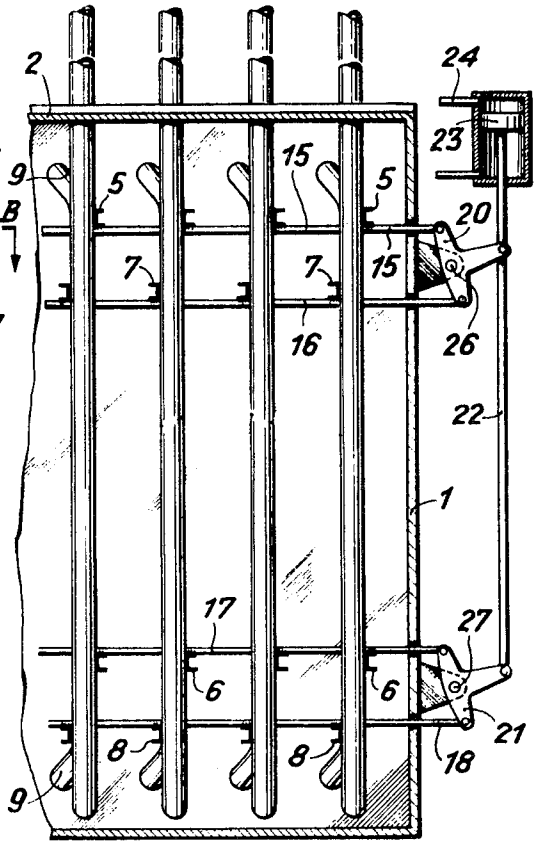


Fig. 4



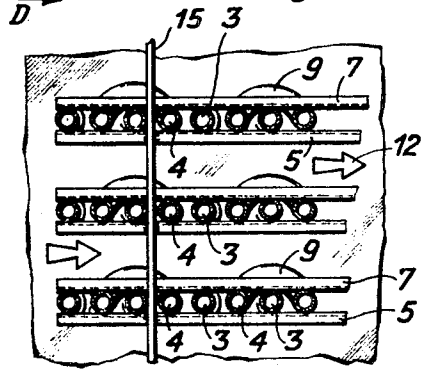


Fig. 3

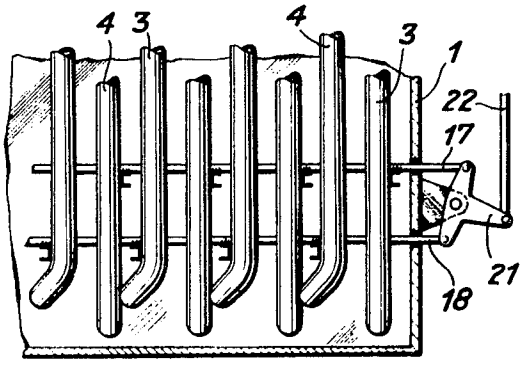


Fig. 5

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APPARATUS FOR CONTROLLING HEAT EXCHANGE IN STEAM GENERATORS

This invention relates to an apparatus for controlling heat exchange in a steam generator. More particularly, this invention relates to an apparatus for controlling the flow of flue gas across the tube panels of a steam generator.

Steam generators have been known to have heating surfaces which have been heated by radiation and by convection and in which at least some of the convection-heating surfaces have taken the form of a number of parallel tube panels disposed in the direction of flow of a flue gas. In these steam generators, the distribution of the heat exchange between the working medium flowing through the heating surfaces and the flue gas varies along the flue gas path in dependence upon the load. For example, when the steam generator is operating at full load, the flue gas transfers a certain proportion of heat from within the combustion chamber into the convection-heating surfaces; however, as the load decreases, the proportion of transferred heat also decreases. As a consequence, if the final temperature of the steam leaving the generator is to be constant, provision must be made to vary the heat exchange distribution along the flue gas path or to feed injection water into the generator. Further, this must be repeated for each reheater in the steam generator.

Heretofore, in order to provide for the variation of the heat exchange distribution, valves or flaps have been disposed in the flow of working medium to enable some of the flow to be guided around at least some of the heated heating surfaces. Flue gas flaps provided in the flue gas flue have a similar effect. Another known adjusting facility comprises using pivoted burners which enable the fire in the combustion chamber to be shifted axially. Another known adjusting facility is to circulate the flue gas by taking flue gas from the flue gas flue and injecting the removed flue gas back into the combustion chamber.

However, the use of valves or flaps in the flow of working medium is expensive, besides requiring expensive and bulky headers and distributors. Further, when flue gas flaps are used, extra heating surfaces and/or special flow channels must be provided, with the disadvantage of increasing the flue gas pressure drop in a way which cannot be used to improve the heat exchange coefficient. In the case of flue gas circulation, such requires an extra blower which becomes soiled and consumes extra power. Pivoted burners are inherently advantageous but cannot be used with every kind of fuel, nor are they sufficient on their own to control a number of temperatures, for instance, the temperature of the superheated high-pressure steam and the temperature of the reheated low-pressure steam.

Accordingly, it is an object of the invention to adjust the heat exchange on the flue gas side on at least one contact heating surface.

It is another object of the invention to provide a control apparatus which is of relatively inexpensive construction.

It is another object of the invention to provide a steam generator with a control apparatus which occupies a relatively small space.

It is another object of the invention to control the heat exchange distribution of a steam generator without a pressure drop.

Briefly, the invention provides at least one of the convection heating surfaces of a steam generator with a control apparatus for controlling the heat exchange distribution of the heating surface. The heating surface is constructed of tube panels which are mounted so as to be moved relative to each other to vary the spacing therebetween and, thus, the heat exchange between the flue gas and the working medium flowing through the tube panels. The control apparatus is connected to the tube panels so as to effect the relative movement of the panels, for example, automatically in response to the temperature of the steam generated.

The tube panels are advantageously constructed of at least one sinuously shaped tube and are arranged so that the panels

are movable in pairs into and out of a common plane. In this way, the tube surface of the tube which is moved out of the common plane is increased with respect to the exposure to the flue gas which flows transversely of the common plane so that the heat exchange is increased.

The adjustment of the spacing between the tube panels provides a simple way of varying the heat exchange in the required manner without the use of parts becoming liable to disturbances.

These and other objects and advantages of the invention will become more apparent from the following detailed description and appended claims taken in conjunction with the accompanying drawings in which:

FIG. 1 diagrammatically illustrates a steam generator having a horizontal flue gas flue incorporating a control apparatus according to the invention;

FIG. 2 illustrates a longitudinal section of a part of the horizontal flue gas flue of FIG. 1;

FIG. 3 illustrates a view taken on line A–B of FIG. 2;

FIG. 4 illustrates a view taken on line C–D of FIG. 2;

FIG. 5 illustrates a view similar to FIG. 4 with the tube panels in a displaced position and

FIG. 6 diagrammatically illustrates a modified construction according to the invention.

Referring to FIG. 1, the steam generator 50 has a pair of radiation-heated heating surfaces 51, 52 disposed in a conventional manner in a combustion chamber 57, and a plurality of convection-heated heating surfaces 53, 54, 55, 56 disposed in a horizontal flue gas flue 58 and a downwardly oriented vertical flue gas flue 59, respectively. The lowermost heating surface 56 in the flue 59 forms an economizer while the lowermost heating surface 51 in the combustion chamber 57 forms an evaporator. The remaining heating surfaces 52 to 55 form superheaters, and where, applicable, reheaters.

Referring to FIGS. 1 and 2, the heating surface 53 in the horizontal flue 58 is constructed so as to vary the heat exchange between the flue gas flow from the combustion chamber 57 through the flue 58.

Referring to FIG. 5, the heating surface 53 is constructed of a number of tube panels 3, 4 which are distributed uniformly over the cross section of the flue 58 and disposed parallel to one another in the direction of the flue gas flow (as indicated by the arrows).

Referring to FIGS. 2 to 4, each pair of adjacent tube panels 3, 4 are constructed so as to be positioned within a common plane for one state of operation of the steam generator and as such fit one within the other. For example, each tube panel 3, 4 is formed of a sinuously shaped tube in which the straight vertical lengths of the tube of the panel 4 are joined by reversal bends 9 which are bent out of the panel of the plane (FIG. 4).

In order to effect a relative movement between the panels 3, 4 a control apparatus is connected to the respective panels 3, 4. This control apparatus includes a common crossmember 5 secured to the straight sections of each panel 3 near the tops transversely of the flue gas flow path and a common crossmember 6 secured to the straight sections of the panel 3 near the bottoms. Similarly, the straight sections of the other tube panel 4 are secured to a top crossmember 7 and a bottom crossmember 8. In addition, each panel 3, 4 is suspended on tube portions 3', 4' respectively, which extend through and are welded to a sheet metal flue gas flue cover 2 of the flue 58. In a corresponding manner, the opposite ends (not shown) of the panels 3, 4 extend through the top of the flue 58 for suspension purposes. The upper crossmembers 5 of all the tube panels 3 are interconnected by means of a pair of rods 15 (only one of which is shown for purposes of clarity) while the lower crossmembers of the panel 3 are interconnected by a pair of rods 17. In similar fashion, the upper and lower crossmembers 7, 8 connected to the tube panel 4 are connected to a pair of rods 16, 18 respectively. The rods 15–18 extend through one sidewall 1 of the flue 58 and are connected to a pair of three-armed levers 20, 21 (FIG. 4).

Referring to FIG. 4, each lever 20, 21 is pivotally mounted on a respective pivot 26, 27 fixed to the sidewall 1 of the flue 58 and is connected on opposite sides of the pivot to each of the pair of rods 15–18 associated therewith. In addition, the levers 20, 21 are interconnected by a rod 22 which forms the piston rod of a pressure-medium-operated servo piston 23 so as to be pivoted in unison about the pivots 26, 27. The servo piston 23 further communicates with a line 24 in the upper end which serves to conduct a pressure medium into and out of the piston 23 for retraction of the piston rod 22.

In operation, for the medium load of the steam generator (FIG. 4), the straight tube lengths of the panels 3, 4 are disposed in a common plane parallel to the flue gas flow path. As the load of the steam generator is increased to full load the pressure in the servo piston 23 increases via the line 24. The increase in pressure thus causes the piston rod 22 to move out of the piston 23. This, in turn, pivots the levers 20, 21 into the full load position (FIG. 5).

During pivoting of the levers 20, 21 the rods 15, 17 move in one direction while the rods 16, 18 move in the opposite direction so that the tube panels 3, 4 are moved relative to each other out of their common plane. The heat exchange surface presented to the flue gas flowing through the flue 58 is thus increased so that more heat is removed by the working medium in the tube panel 3, 4 from the flue gas in order to control, for example, the final temperature of the steam leaving the steam generator.

The spacing of the tube panels 3, 4 can be varied so that intermediate positions between the minimum and full load positions can be obtained in order to further regulate the temperature of the steam generated. In this case, the pressure medium applied to the servo piston 23 is controlled in dependence upon an appropriate temperature sensor, for example, in the flow path of the steam emanating from the generator.

Referring to FIG. 6 wherein like reference characters indicate like parts as above the radiation-heated heating surface can alternatively be constructed so that the tube panels 3, 4 are suspended on flat metal members 61 secured, as by welding, at their top ends to the flue gas flue cover 2 and at their bottom ends to the lower cross member 8. Only one tube panel 4 is shown connected to the member 61 for clarity, it being understood that the other tube panel 3 is supported in the same manner. The remainder of the control apparatus is constructed in a manner similar to that described above so that the tube panels 3, 4 are moved via the crossmember 7, 8 from a position in which the panels are aligned in a common plane to a position in which the panels are spaced apart.

Alternatively, where two adjacent tube panels are constructed from two separate tube coils, only one panel need be fixedly mounted while the other panel is movably mounted. Also, any tube panel can be constructed from more than two pipe coils, any one of which coils is movable with respect to the others.

What is claimed is:

1. A steam generator having a flue for passage of a flue gas therethrough and at least one convection-heated heating surface disposed in said flue for passage of a working medium therethrough in heat exchange relation with the flue gas, said heating surface including at least a pair of tube panels disposed parallel to the direction of flow of the flue gas, said tube panels being offset from each other and each being formed of a sinuously shaped tube having a plurality of straight lengths and reversal bends joining said straight lengths, said bends being bent out of the plane of said straight lengths, said panels being movable towards and away from each other into and out of a common plane and control means for adjusting the spacing between said pair of tube panels to vary the heat exchange relation between the flue gas and the working medium.

2. A steam generator as set forth in claim 1 wherein one of said tube panels is fixedly mounted with respect to said flue and the other of said tube panels is movably mounted with respect to said flue.

3. A steam generator as set forth in claim 1 wherein said control means includes at least one crossmember connected to said straight lengths of one tube panel, at least one crossmember connected to said straight lengths of the other tube panel, a pair of rods each respectively connected to one of said crossmembers, and means for moving said rods with respect to each other to move said tube panels relative to each other.

4. A steam generator as set forth in claim 3 wherein said means for moving said rods includes a pivotally mounted three-armed lever connected to said pair of rods and a servo piston connected to said lever for pivoting said lever to move said pair of rods in unison in opposite directions.

5. A steam generator as set forth in claim 4 which further includes a temperature sensor disposed in the path of the working medium and connected to said servo piston for actuating said piston in response to the temperature of the working medium.

6. A steam generator as set forth in claim 1 wherein the spacing of adjacent straight lengths in each tube panel is greater than the width of the straight lengths of the other tube panel received therein.

7. A steam generator as set forth in claim 1 wherein said control means includes at least a first cross member connected to said straight lengths of one tube panel to one side thereof and at least a second crossmember connected to said straight lengths of the other tube panel on one side thereof opposite from said first crossmember.