

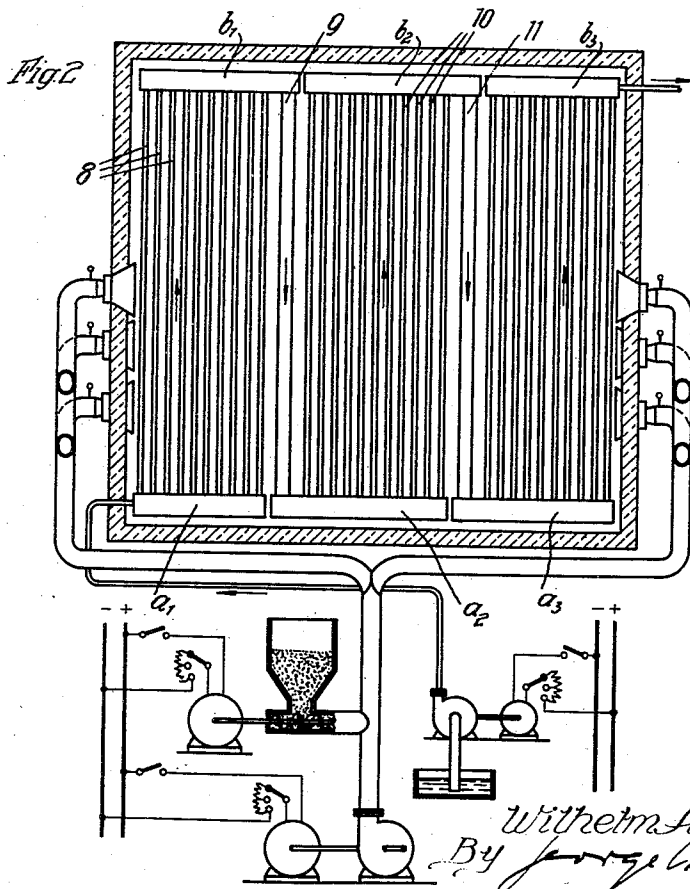
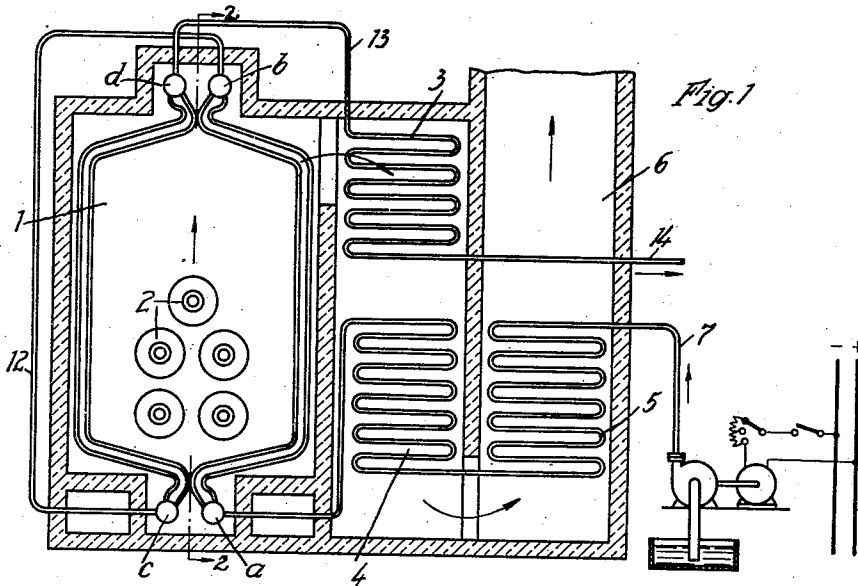
Oct. 31, 1933.

W. ABENDROTH

1,932,918

STEAM GENERATOR

Filed Oct. 29, 1931



Inventor:  
Wilhelm Abendroth.  
By *John A. Mitty.*

## UNITED STATES PATENT OFFICE

1,932,918

## STEAM GENERATOR

Wilhelm Abendroth, Berlin-Charlottenburg, Germany, assignor to Siemens-Schuckertwerke Aktiengesellschaft, Berlin-Siemensstadt, Germany, a corporation of Germany

Application October 29, 1931, Serial No. 571,806,  
and in Germany November 1, 1930

2 Claims. (Cl. 122—235)

Modern steam generators distinguish from the structures customary in the past, in the fact that a large part of the heat supplied by the fuel is directly utilized in the form of radiated heat.

5 The tubes are not protected against the direct action of radiated heat; the combustion space or combustion chamber is lined with the tubes, thereby rendering the possibility of providing for a very large heat surface load.

10 Experience has shown, in the case of the structure of a combustion chamber lined with tubes through which the working medium is forced, that problems appear which cannot be solved in customary ways. In order to understand the  
15 situation clearly, one must carefully consider the fact that in such a boiler with forced circulation, being in its highest development purely a tube boiler without the provision of any drum or water barrel, there is no possibility for a natural compensation of temperature differences in the individual tubes. In the case of boilers with natural  
20 circulation there occur convection currents due to the difference between the specific gravity at the beginning of a tube and at the end thereof. It is clear, therefore, that if a plurality of parallel tubes with natural circulation is differently heated, there will appear a greater convection current in the tubes more intensely subjected to heat, thereby, in a sense, automatically preventing  
30 undue tube loads.

In the case of a steam generator with forced circulation of the working medium, the quantity of the medium for the individual tube is definitely determined by the pressure of the pump and by  
35 the tube resistance to the flow of the working medium, leaving only such variables as will be discussed later on.

The absence of an automatic compensation in case of tube boilers has introduced extreme difficulties.

40 Still another circumstance of a difficult nature must be taken into account.

Assuming, for example, a steam generator substantially in the form of a vertically disposed  
45 shaft having a cross-section which is symmetrical relative to the axis of the shaft, and wherein the burners are arranged on the line of the axis, it appears theoretically correct that each of the tubes lining the combustion chamber should absorb the same quantity of heat. However, experience with the customary contact boilers has shown that the distribution of temperature is never perfectly equal around the entire cross-section, but that it varies within the individual  
55 heating surface sections according to the resistance of the tubes to the flow, and according to the other factors.

These temperature differences are much greater and, accordingly, much more dangerous in a case in which the radiated heat of the burners is directly utilized. Uncommonly great temperature differences have been observed even in cases of perfectly symmetrical tube arrangements.

It will be clear that a correct operation is not possible under such conditions, when using the customary arrangement of tubes. Repeatedly occurring tube damages caused by burning of the tubes demonstrates the extreme overloads to which the tubes can be subjected under such circumstances.

65 It will be clear that a correct operation is not possible under such conditions, when using the customary arrangement of tubes. Repeatedly occurring tube damages caused by burning of the tubes demonstrates the extreme overloads to which the tubes can be subjected under such circumstances.

A way was found for obviating these difficulties, by arranging the tubes so that corresponding tube sections of all the parallel tubes are disposed in the same heating zone.

This may be accomplished, for example, by means of employing narrowly wound tube spirals. However, this structure requires a special production process and can be applied economically probably only in case of boiler units of considerable size. Another way had to be found in order to satisfy the demand for a simpler and more economical structure.

According to the invention, this way was found for tube generators having a vertically disposed combustion chamber, by lining the chamber with individual groups of tubes, each comprising a plurality of parallel tubes, through which the working medium flows from the bottom to the top, these groups being connected by means of individual tubes through which the working medium circulates in opposite direction.

The orthodox idea of providing in all parallel tubes of the heating surfaces a similar heating condition for the working medium is abandoned. The introduction of non-equivalent groups of tubes, as defined above, renders the possibility of reducing the source of trouble.

Extensive experiments with such a steam generator have shown that it is in this way actually possible to overcome the detriment of non-uniform heating of the individual groups of tubes.

An advantage appears in the case of such a heating surface structure, namely, the overlapping of the forced current by the convection currents. The fact that the forced current is the decisive factor in the case of such boilers has already been mentioned. Now, when the tubes are arranged so that the current within the same takes the direction from the bottom to the top, it is clear that a convection current caused by heating can

overlap, or superimpose, the forced current of the working medium. Even if the resulting compensation is not as great as is the case in boilers having natural circulation, it will be found that it is capable of furnishing, within the limits of practical operation, a compensation for the effects of uneven or non-uniform heating.

It may be mentioned here that the difficulties which led up to the invention are not manifest in case of boilers having contact heating surfaces, or at least, they do not occur to an extent requiring special measures for overcoming detriments caused thereby. It is, therefore, possible to form the contact heating surface in the manner of a cross-current heat-exchanger, wherein the working medium flows in its principal direction opposite to the direction of the flow of the combustion gases, thus being progressively heated.

The structure of a steam generator according to the invention is shown in the drawing, in which

Figure 1 represents the entire structure; and

Figure 2 illustrates a section taken along the line 2—2 in Figure 1 looking in the direction of the arrows.

Numeral 1 designates the combustion chamber. At 2 are indicated the burners. The combustion gases rise within the combustion chamber from the bottom to the top. They take the direction indicated by the arrows, entering the flue wherein are disposed the superheater 3 and the preheater or feed heater 4. The direction of flow is again reversed and the gases pass the preheater 5, and escape finally at 6 into the smoke stack. The working medium is supplied through the tube 7, while the generated steam is withdrawn through the tube 14.

The walls of the combustion chamber 1 are lined with radiation heating surfaces formed by the tubes. The tubes are connected to the distributors *a*, *b*, *c*, *d*. The working medium rises from the distributing header *a*, through the tubes 8 and arrives in the first collecting header *b*—1 which is connected by means of the drop or return tube 9 with the header *a*—2. The working medium flows then through a second group of parallel tubes designated by numeral 10 to the header *b*—2 which is connected by means of the return tube 11 with the header *a*—3. The path of the working medium can be easily traced on the drawing, following this general scheme determined by the groups of parallel tubes each terminating in headers, which in turn are connected by means of the return tubes with the preceding and succeeding groups of tubes, respectively. The working medium leaving the header, such as *b*—3 of the row of headers *b*, shown in the drawing, is conveyed through a tube 12 to the first header in the row of headers designated by the reference character *c*, from where it flows successively through the groups or sections of parallel tubes and connecting return tubes. The tube 13 connects the last distributor header *d* with the superheater 3.

It will be apparent from Figure 2 that the groups or sections of heating surfaces constituting the total radiation heating surface are non-equivalent, since the heating of the working medium progresses in the direction of the flow. It has been demonstrated with this structure and arrangement that this inequality of heat absorbing action of the groups or sections of the heating surfaces, relative to the heating condition of the working medium forced therethrough, removes the difficulties heretofore experienced and this

notwithstanding the opinion formerly held to the effect that uniformity or equality of heating condition must be maintained in all parallel tubes.

It may be mentioned, in conclusion, that the arrangement of the drop or return tubes as shown causes mixing of the working medium as it leaves the individual parallel tubes of the heating surface groups and as it is conducted by means of these return tubes to the succeeding groups. If desired these return tubes may be insulated against the effect of the heating gases.

What is claimed is:

1. A forced flow radiant heat type of steam generator comprising a pump for forcing the working medium through the generator, a combustion chamber with heat absorbing tubes providing a heat absorbing lining upon the opposite walls of said chamber, means for directing burning fuel between the heat absorbing tubes which are disposed upon and line opposite walls of the combustion chamber so that the tubes may receive heat by radiation, said heat absorbing wall lining tubes being sub-divided into groups, each group having an inlet and an outlet header with the tubes of each group connected in parallel with one another to their headers, all of said groups being joined in series relation by connecting tubes connecting an outlet header of one group to an inlet header of another group, said connecting tubes, heat absorbing tubes and headers being so connected and disposed relatively to one another that the direction of flow of the working medium in the connecting tubes is opposite to that of the flow of the working medium in the groups of heat absorbing tubes and also providing for the flow of the working medium through all of the heat absorbing tubes in all of the groups in the same relative direction, said heat absorbing tubes, headers and connecting tubes further providing a completely closed system so that all of the working medium entering the first group of tubes and forced there-through by the pump flows serially through all of the various tube groups and so that all of the working medium supplied in liquid condition to the first group of tubes leaves the generator as steam at the outlet header of the last group of tubes.

2. A forced flow radiant heat type of steam generator comprising a pump for forcing the working medium through the generator, a combustion chamber with heat absorbing tubes providing a heat absorbing lining upon the opposite walls of said chamber, means for directing burning fuel between the heat absorbing tubes which are disposed upon and line opposite walls of the combustion chamber so that the tubes may receive heat by radiation, said heat absorbing wall lining tubes being subdivided into groups, each group having an inlet and an outlet header with the tubes of each group connected in parallel with one another to their headers, all of said groups being joined in series relation by connecting tubes connecting an outlet header of one group to an inlet header of another group, said connecting tubes, heat absorbing tubes and headers being so connected and disposed relatively to one another that the direction of flow of the working medium in the connecting tubes is opposite to that of the flow of the working medium in the groups of heat absorbing tubes and also providing for the flow of the working medium through all of the heat absorbing tubes in all of the groups in the same relative direction, said heat absorbing tubes, headers and connecting tubes further providing a completely closed system so that all of the working

medium entering the first group of tubes and forced therethrough by the pump flows serially through all of the various tube groups and so that all of the working medium supplied in liquid condition to the first group of tubes leaves the generator as steam at the outlet header of the last group of tubes, one of the aforesaid connecting tubes being connected to provide for the flow of all of the working medium from the outlet header of the last group of tubes upon one wall of the combustion chamber to the inlet header of the first group of tubes upon the opposite wall of the combustion chamber. 80

WILHELM ABENDROTH.

|    |     |
|----|-----|
| 10 | 85  |
| 15 | 90  |
| 20 | 95  |
| 25 | 100 |
| 30 | 105 |
| 35 | 110 |
| 40 | 115 |
| 45 | 120 |
| 50 | 125 |
| 55 | 130 |
| 60 | 135 |
| 65 | 140 |
| 70 | 145 |
| 75 | 150 |