

[54] **FLUE GAS DISTRIBUTOR AND RADIATOR FOR UNIFORM HEAT TRANSFER**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 472,328, May 22, 1974, abandoned.

[52] U.S. Cl. **122/333; 122/356; 110/98 R**

[51] Int. Cl. **F22b 21/00**

[58] Field of Search **122/332, 333, 336, 356; 110/98 R**

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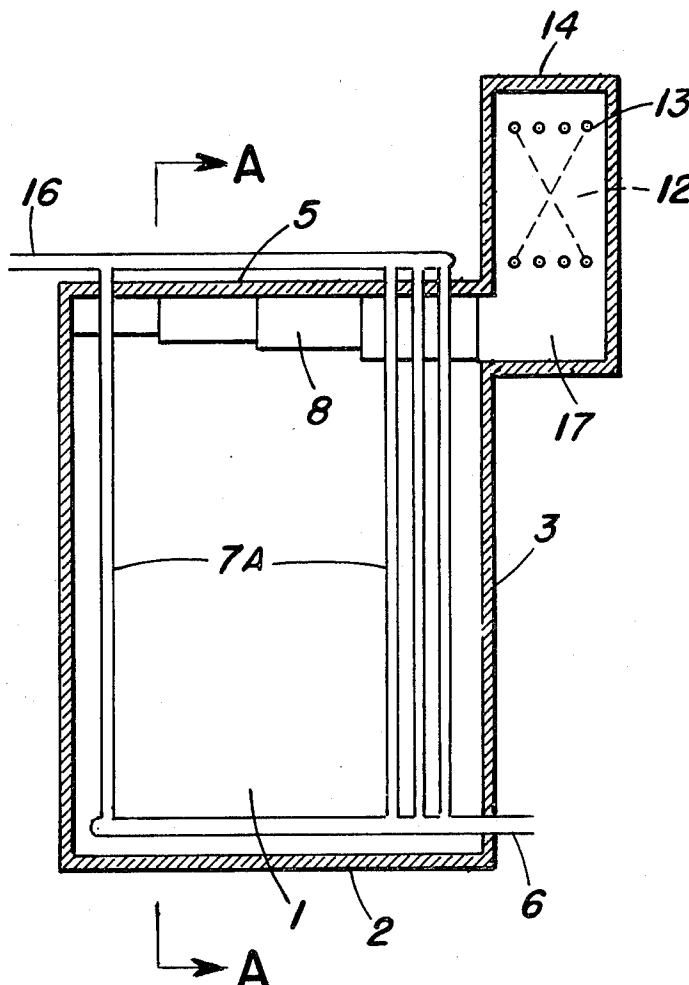
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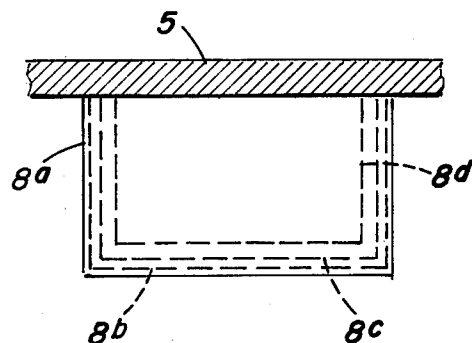
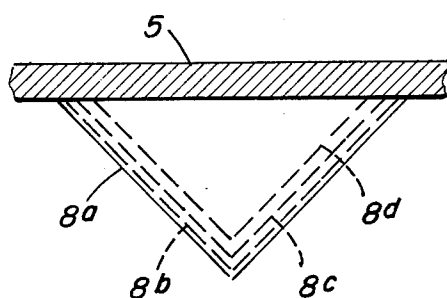
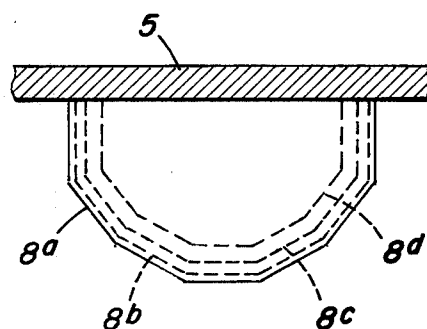
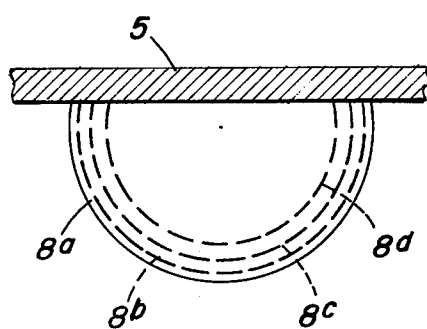
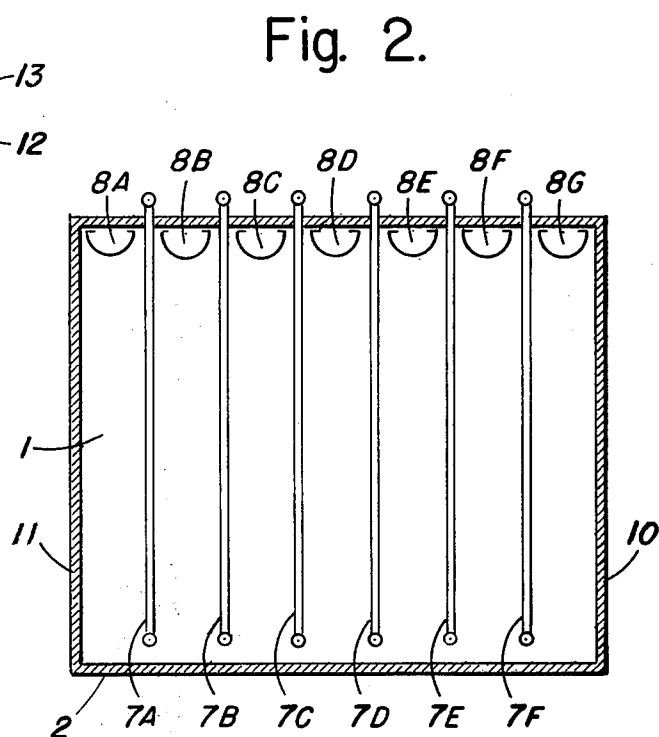
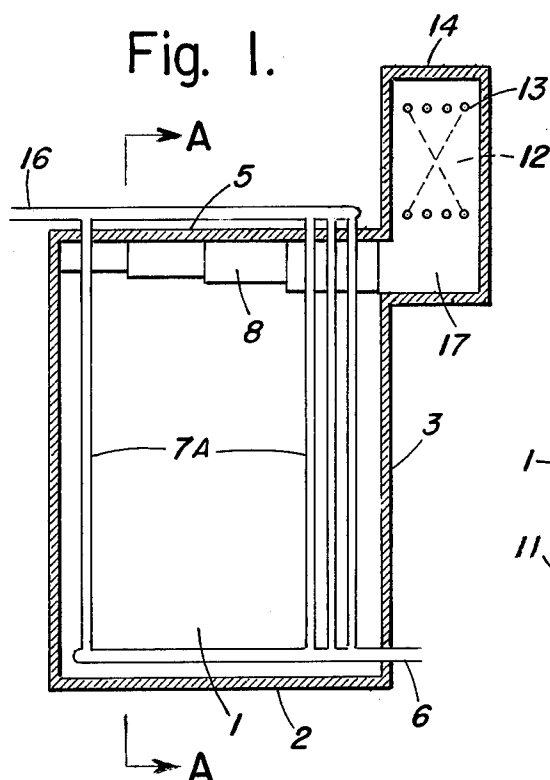
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ABSTRACT

In a heater for indirect heating of fluids passing through tubes in a radiant heating section, the improvement comprising providing a plurality of generally horizontally disposed ducts in the upper portion of the radiant chamber, provided with openings by which flue gases may enter the duct and be exhausted to the convection section and stack, thus improving the overall flue gas distribution in the radiant chamber.

15 Claims, 10 Drawing Figures





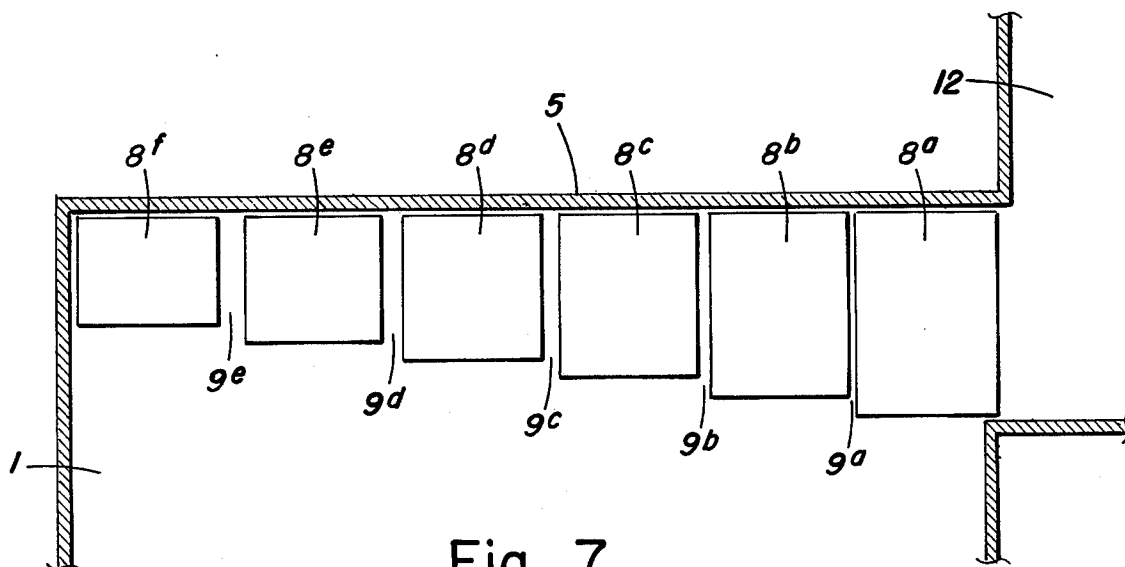


Fig. 7.

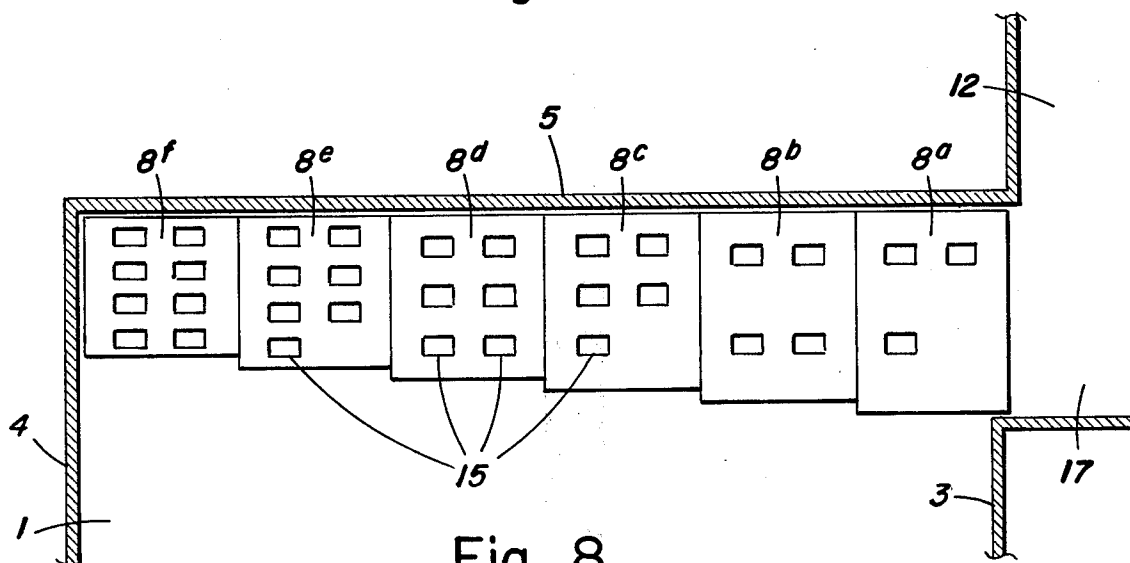


Fig. 8.

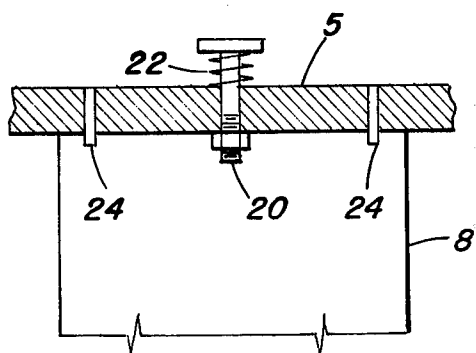


Fig. 9.

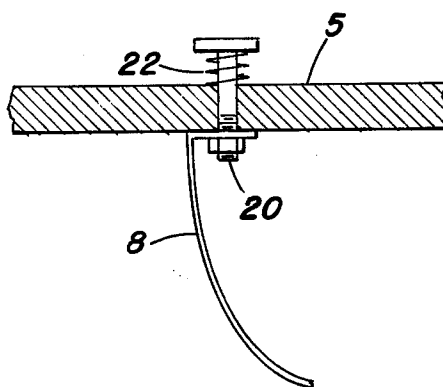


Fig. 10.

FLUE GAS DISTRIBUTOR AND RADIATOR FOR UNIFORM HEAT TRANSFER

RELATED APPLICATIONS

This application is a continuation-in-part of my application, Ser. No. 472,328, filed May 22, 1974, now abandoned, of the same title.

BACKGROUND OF THE INVENTION

This invention relates to an improvement in tubular fluid heaters in which a fluid (which may be a liquid or a gas) is heated by being passed through tubes in a radiant heating section. In some types of heaters the tubes are empty, while in other types they contain catalysts or other particulate material. Depending on the type of operation to be performed, the nature of the fluid may or may not be changed; that is, the heater may be used for carrying out chemical conversions, or it may be used for vaporizing a liquid or simply for raising the temperature of a liquid or a gas. One configuration of such a heater is that shown generally in FIG. 1, in which the tubes are vertically disposed in one or more rows within the heater, and the radiant chamber is generally square or rectangular in cross section. The radiant heat is supplied by one or more burners located either in the floor of the chamber or in the side walls, or both, and which are either utilized to heat the tubes directly, or indirectly by projecting flames onto the surrounding or adjacent wall or floor portions, which are formed of refractory materials. In the latter case, the heat reflected from said walls or floor is then transmitted to the tubes and to the fluid flowing therethrough.

In certain operations, particularly pyrolysis or steam reforming, it is quite important that the heat distribution be as uniform as possible throughout all portions of the radiant heating section. This has been found to be significant in these operations as the tube metal temperature is thus kept substantially constant at all points along the tube surface, and in preferred embodiments, the tube metal is maintained at essentially its maximum tolerable temperature from the inlet end to its outlet end. Operation of this type results in obtaining optimal heat transfer to the fluid flowing through the tubes and in the case of pyrolysis or steam reforming has been found to result in optimal yields and conversions.

When an apparatus of this type, having a horizontally offset convection section and stack is utilized, it has been found that there is a tendency for the combustion or flue gases rising from the burners to be swept towards the convection section in the upper part of the radiant chamber, thus resulting in somewhat uneven heating of the upper portions of the tubes, particularly those tubes in the corner removed from the convection section. Additionally, the sweep or flow of flue gases towards the convection section can result in eddy currents of flue gases in the corner removed from the convection section, thus increasing the uneven heating effect on the tubes in that area.

Accordingly, it is an objective of the present invention to provide means for improving the uniformity of heat transfer in the radiant section of such a heater. It is a further objective of this invention to provide a means for controlling the flow of flue or combustion gases from the radiant section of such a heater to the convection section.

It is a further objective of this invention to provide a means for reducing or eliminating eddy currents along the side walls resulting from uneven flue gas flow and distribution in the radiant section.

SUMMARY OF THE INVENTION

In general the invention comprises:

In an apparatus for indirect heating of fluids having a radiant chamber defined by a floor, a roof, side walls and end walls, and a convection chamber connected to the upper portion of the radiant chamber and laterally offset therefrom the radiant chamber containing at least one row of tubes for passing fluid to be heated therethrough, and means for providing radiant heat to the tubes and the fluid passing therethrough, the improvement comprising a plurality of horizontally disposed elongated ducts, located in the upper portion of the radiant chamber, disposed parallel to the row of tubes, and extending substantially across the radiant heating chamber, means for admitting combustion gases from the radiant chamber into the ducts, and means for transmitting said combustion gases from the ducts to the convection chamber.

DETAILED DESCRIPTION OF THE INVENTION

The invention can be more clearly ascertained from the following description and the drawings, in which:

FIG. 1 represents a cross-sectional view of one type of heater in which the invention may be utilized, and which is particularly suitable for carrying out a process for steam reforming of hydrocarbons;

FIG. 2 represents a cross-sectional view of the heater of FIG. 1 taken along the line A—A;

FIGS. 3—6 represent cross-sectional views of different types of ducts which may be utilized according to the invention;

FIG. 7 represents a detail of the invention wherein the ducts are constructed of several sections and flue gases are admitted into the ducts through the expansion joints between the sections;

FIG. 8 shows another embodiment of the invention in which flue gases are admitted to the ducts through openings or slots in the body of the ducts;

FIG. 9 represents one means of attaching a duct to the roof of the radiant section and

FIG. 10 represents a cross-sectional view of FIG. 9 taken along line A—A.

FIGS. 1 and 2 show the invention as used in one type of heater, which has a substantially rectangular cross section and several rows of vertically arranged tubes. The heater has a radiant chamber 1 formed by side walls 3 and 4, end walls 10 and 11, roof 5 and floor 2. As shown in these figures the radiant chamber has a generally rectangular cross section and a generally rectangular plan. However, either the plan or cross section or both may be generally square, and additionally, the rectangular plan may be reversed in that the side walls 3 and 4, which are shown to be longer than the end walls 10 and 11, may be shorter than these end walls. The radiant chamber is connected by a generally horizontal passage 17 to a convection chamber 12, laterally offset from the radiant chamber and in which a number of convection tubes 13 may be disposed. The convection chamber 12 is connected to a stack, generally shown as 14, for venting the combustion gases.

Within the radiant chamber are disposed one or more rows of tubes 7A etc., which in this embodiment are

shown to be arranged in a vertical manner. A fluid to be heated is passed into the tubes through manifold 6 and is withdrawn from the upper end of the tubes through outlet manifold 16. Alternatively, the fluid could be introduced into the upper ends of the tubes through manifold 16 and withdrawn through manifold 6. Located in the floor 2 and/or side walls 3 and 4 of the radiant chamber are one or more burners for heating the tubes and/or walls of the chamber, and which generate combustion or flue gases, which are exhausted through the convection chamber 12 and stack 14. In a preferred version, the heater shown in FIGS. 1 and 2 is a steam reforming heating having burners located only in the floor, and in which the fluid enters the tubes at their lower ends and flow upwardly therethrough.

Located in the upper portion of the radiant chamber 1 are one or more elongated horizontally disposed ducts 8A etc., which serve to control the distribution of flue gases throughout the radiant chamber and their eventual withdrawal through the convection chamber and stack. As shown in FIG. 1, the ducts extend substantially, completely across the radiant chamber so that the flue gases may be conveyed therethrough into the convection chamber. As will be explained in greater detail herein below, these ducts contain means for admitting flue gases into the ducts and the flue gases are then exhausted from the duct directly into the bottom of the convection chamber 12. When there are multiple rows of tubes in the radiant section, a duct is positioned between each two rows of tubes, and additionally, a duct is positioned between each of the first and last rows of tubes and the adjacent walls 10 and 11 of the radiant chamber.

In a preferred embodiment, as shown in the Figures, the ducts are composed with increasing diameter from one end of the duct to the other, and connected by expansion joints. In such construction, the smallest diameter section will be at the opposite end of the duct from its discharge into the convection section. However, the ducts may be formed of identical sections having the same diameter. The ducts are fabricated from a high alloy steel, such as Incoloy, Inconel, or any other suitable alloy steel, capable of withstanding temperatures of between 1800° and 2200°F, as may exist in the interior of the radiant chamber. The ducts are fabricated from high alloy steel plate, and are most conveniently fabricated in a standard sheet metal bending operation. In a preferred embodiment, as shown in FIG. 3, the duct is fabricated from sheet metal and bent into a substantially semi-circular arrangement. However, if bending machines are not available for forming a semi-circle, the sheet metal can be bent at a number of locations to form a duct having a polygonal cross section as shown in FIG. 4. Other suitable cross sections are triangular (FIG. 5) and square or rectangular (FIG. 6).

As shown in FIGS. 7 and 8, the duct is equipped with openings for admitting flue gases into the interior of the duct. As shown in FIG. 7, in a preferred embodiment, these openings are the expansion joints 9a etc. themselves, through which the flue gases may be admitted into the ducts. Alternatively, as shown in FIG. 8, the body of the ducts may be provided with openings or slots 15, through which the flue gases may be admitted. Alternatively, flue gases may be admitted through both the expansion joints and such openings or slots. In a preferred embodiment the openings decrease in size and/or number from the end farthest away from the

convection chamber to the end discharging into the convection chamber. Thus, in Fig. 7, the width of the expansion joints 9a - 9e decreases along the duct approaching the discharge end. Similarly, in FIG. 8, the number and/or size of the slots 15 decreases towards the discharge end of the duct. By such construction combustion gases are induced to enter the duct at all points along its length, and the suction effect from the stack is greatly diminished.

FIGS. 9 and 10 show one method for suitably mounting the ducts from the roof 5 to permit for expansion. The ducts are mounted by use of a bolt 20 to which is attached a spring 22 and which is bolted to a portion of the duct which is bent over and serves as a flange for bolting purposes. The spring 22 provides tension to hold the duct in position. The effect of expansion on the bolt also exists with respect to the spring, but sufficient tension is still maintained. Positioners 24 may be installed in the roof 5 to assist in positioning the duct away from the refractory material of the roof.

The ducts are preferably positioned flush against the wall 4 of the radiant chamber at the end opposite their discharge end, although they may be positioned slightly away from the wall to permit expansion. The discharge ends preferably extend slightly into the horizontal passage 17, with brickwork provided in the spaces below and between the duct discharge openings. However, the ducts may end just short of the horizontal passage 15 without substantially affecting their performance.

By the use of this invention, flue gases rising from the burners in the floor and/or walls of the radiant chamber will be drawn straight upwards through the expansion joints and/or slots into the ducts and then exhausted horizontally into the convection chamber. In this manner, it is assured that the flue gases will flow substantially straight upwards, rather than being swept at an angle by the suction from the convection chamber and stack, and therefore by the use of this invention, the tubes in the upper corner of the radiant chamber on the side opposite the convection section will receive substantially uniform heat along their entire lengths, as well as being heated substantially to the same degree as the other tubes in the radiant chamber. Additionally, being constructed of sheet metal material, the duct itself will serve as a re-radiator of heat in the upper section of the radiant chamber and thus assist in maintaining an overall uniform tube metal temperature.

Additional embodiments and modifications of this invention will no doubt be apparent to those skilled in the art and accordingly, the invention shall not be deemed to be limited except as defined in the claims which follow.

I claim:

1. In an apparatus for indirect heating of fluids having a radiant chamber and a convection chamber connected to the upper portion of the radiant chamber and laterally offset therefrom, the radiant chamber containing at least one row of tubes for passing a fluid to be heated therethrough, and means for providing radiant heat to the tubes and the fluid passing therethrough, the improvement comprising a plurality of horizontally disposed elongated ducts, located in the upper portion of the radiant chamber, disposed parallel to the row of tubes and extending substantially across the radiant chamber, means for admitting combustion gases from the radiant heating means into the ducts, and means for

transmitting combustion gases from the ducts to the convection chamber.

2. Apparatus according to claim 1 wherein the tubes are vertically disposed and the radiant chamber has a substantially rectangular cross-section.

3. Apparatus according to claim 1 containing a plurality of parallel rows of tubes, having a duct between each row of tubes and a duct between each of the first and last rows and the adjacent wall of the radiant chamber.

4. Apparatus according to claim 1 wherein each duct comprises a plurality of sections connected by expansion joints.

5. Apparatus according to claim 4 wherein the section of the duct increases in cross-sectional area in the direction of flow of combustion gases therethrough.

6. Apparatus according to claim 1 wherein the means for admitting combustion gases into the ducts comprises openings in the walls of the ducts.

7. Apparatus according to claim 6 wherein the size of the openings decreases in the direction of gas flow through the ducts.

8. Apparatus according to claim 1 wherein the convection chamber is connected to the radiant chamber by a substantially horizontal passage.

9. Apparatus according to claim 1 wherein the fluid flows upwardly through vertically disposed tubes.

10. Apparatus according to claim 1 wherein the ducts are supported from above by a plurality of bolts connected to the roof of the radiant chamber.

11. Apparatus according to claim 10 wherein the bolts include spring means attached to the upper portion thereof.

12. Apparatus according to claim 1 comprising a steam reforming heater.

13. Apparatus according to claim 1 wherein the means for providing radiant heat comprise a plurality of burners.

14. Apparatus according to claim 1 wherein the ducts have a substantially semi-circular cross-section.

15. Apparatus according to claim 1 wherein the ducts have a polygonal cross-section.

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