A radiant burner comprises a mixing chamber for a combustible gaseous mixture delimited by an emission plate through which the mixture passes and on the outer surface of which the mixture is ignited, the plate being surmounted by an anti-convection screen. An auxiliary emission plate is provided between the emission plate and the screen, spaced from both emission plate and screen and provided with passages by which the spaces on either face of the auxiliary emission plate are placed in communication.
3,847,536

RADIANT BURNER OPERATING AT HIGH TEMPERATURE

This invention relates to a radiant burner designed to burn a combustible gaseous mixture, the basic fuel being either a gas or a sprayed liquid. More particularly, but not exclusively, the invention concerns a burner which is able to reach high temperatures and especially temperatures exceeding 1,200°C.

All known radiant burners possess a certain number of inherent disadvantages in their structure and in their method of operation. Radiant burners must:

a. be hygienic in use; that is to say allow as complete a combustion of gas as possible and avoid loss of efficiency by smoke to the maximum extent;
b. have an optimum output for as high a radiation factor as possible; and
c. be able to reach the highest possible temperatures without risk of a flash-back.

It has not been possible to combine all these characteristics in known burners, which can be divided into four large groups.

Burners in the first group, consisting of radiant tubes inside which combustion occurs, do not allow a homogeneous temperature distribution and are difficult to use, their operating flexibility being low. By operating flexibility we mean the possibility of using the burner in optimum conditions in terms of a given range of temperatures. Thus, in the case of this group of burners, the optimum operating condition can only be reached within a narrow temperature range.

The second group of burners consists of so-called ‘impact’ burners in which the flame strikes a refractory element which radiates the heat. These burners have the same faults as those in the first group.

Burners in the third group consist of those in which the flame is situated at the outlet of a ceramic plate which may be surmounted by a front metal grill. These burners which have a better flexibility of operation than the burners mentioned above, are not however capable of exceeding temperatures of from 980° to 1,000°C.

Burners in the fourth group consist of those having a gas outlet element in metal which is fixed underneath a metal grill. This type of burner enables temperatures of over 1,000°C to be reached, but here again flexibility of operation is relatively low.

According to the present invention there is provided a radiant burner for a combustible gaseous mixture comprising mixing chamber for gaseous mixture and delimited by an emission plate adapted to permit passage of the gaseous mixture therethrough, said mixture being, in use, ignited on the outer surface of said emission plate, said emission plate being surmounted by an anti-convection screen spaced from the said emission plate, wherein an auxiliary emission means is provided between the emission plate and the screen and spaced from both the plate and the screen, said auxiliary emission means comprising a plate of refractory material covering substantially the whole of the burner surface and having a large number of channels therethrough connecting the space between the emission plate and the auxiliary emission plate with the space between the latter and the screen and enabling the products of combustion to be expelled. The refractory material may advantageously be a suitable metal.

The screen is advantageously formed by a grill, for example of woven refractory metal wire and the emission plate is a ceramic plate through which are drilled holes enabling gases to pass from the mixing chamber to the outer surface of the emission plate.

The ceramic plate may have grooved outer surface for increasing radiation.

An embodiment according to the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a burner according to the invention, with partial removal of some parts for clarity;

FIG. 2 is a section along line II—II in FIG. 1;

FIG. 3 is a section along line III—III in FIG. 1; and

FIGS. 4 to 6 are graphs showing the results of tests on burners according to the present invention.

The burner shown in the drawings consists of a hollow box 1 providing a mixing chamber 2 for smoothing out the combustion process. This box 1 has an inlet or sleeve 3 fixed to its base by which the combustible mixture enters box 1. The sleeve is connected to a supply installation (not shown). Sleeve 3 is also provided with a flap 4 enabling the burner to be fixed to a support (not shown).

The box 1 is flared in a direction away from sleeve 3 and at its larger end has a downwardly extending peripheral skirt 5 on which a first frame 6 is mounted, the frame 6 retaining in position an emission plate 7 which, in the example shown, is made up of an assembly of ceramic plates through which are drilled passages 8, only a few of which are shown.

Frame 6 has an upper edge 9 resting on the periphery of plate 7 and on which in turn rests a flange 10 of a second perimetrical frame 11 on which an anti-convection grill 12 is supported. As shown, the grill 12 is made of woven refractory metal wire. It may alternatively be made of punched or pierced expanded metal.

The lateral ends of the wires in this grill are turned over at 15 to restrict the movement of the grill on its frame 11.

A third frame 14 encloses all the elements described above and is fixed to the first frame 6 and to the skirt 5.

The frames 6, 11 and 14 are assembled in air-tight fashion so as to be sealed against the entry of any secondary air. An auxiliary emission panel 15, consisting of a sheet of refractory metal, through which a large number of holes 16 are drilled, is placed between grill 12 and emission plate 7. This panel is so supported on lugs 17 and 18 fast with frame 11 that it is free to expand relative to frame 11. A space 19 is provided between panel 15 and emissary plate 7 and a space 20 is provided between panel 15 and grill 12. Advantageously the distance between plate 7 and panel 15 is approximately double that between panel 15 and grill 12.

In order to increase the mechanical strength of panel 15 and grill 12, both may advantageously be made convex, the convexity of panel and grill being outwardly directed.
The passages provided in the ceramic plate advantageously have a diameter of between 0.40 and 0.70mm and may open into grooves over a wide operating range of the burner. Moreover, the heat transfer between the flame and the ceramic body is thus increased, as is the emissive power of the latter which tends to create an artificial black body because of the length to diameter ratio of each of the orifices.

Holes in panel allow the products of combustion to pass through the panel and the ratio between the solid and hollow parts is such that the panel provides a very small heat loss when compared with the emission plate. Grill as well as panel are not positively fixed in place so that they can expand freely and frame is advantageous because of refractory metal insulated from plate by a band of insulating material (not shown).

The operation of the burner is easy to understand. Combustion becomes localised in the area of the upper surface of emission plate, which radiates. This radiation, together with the smoke emitted by the flames, heats panel which is thus raised to a high temperature by the combined action of radiation and smoke.

Thus, as the radiant anti-convection grill limits heat losses by convection from panel to the outside, it enables the temperature of equilibrium of the latter, both faces of which can reach a temperature of equilibrium extremely close to that of ceramic plate, to be raised.

The very low thermal inertia of the burner, which enables normal operating temperature to be reached in a few minutes, added to the flexibility of operation permitted by the combination of plate, panel and grill, enables this burner to be adapted to groups of industrial processes requiring modulated or continuous emission of thermal energy.

A non-limiting example will be given below concerning the actual construction and operation of a burner as above described.

The emission plate 7 is approximately 200mm long by 135mm wide and the auxiliary emission plate 15 is 190mm by 125mm and 4mm thick; the holes drilled in plate are 6mm diameter, evenly distributed in such a way that the solid/hollow ratio is approximately 2. The distance of auxiliary emission plate from emission plate 7 is approximately 13mm round the periphery of emission plate 15 and approximately 20mm in the centre, and the distance between grill and auxiliary emission plate is approximately 8mm. Naturally these dimensions could be modified depending on various factors. Thus, the distances separating the auxiliary emission plate from the emission plate 7 on the one hand and from the grill on the other hand could vary within a margin of ±10 percent.

Tests carried out on burners according to the invention have shown that the temperatures of the emission plate and auxiliary emission plate, also the thermal output of the burner are dependent variably on the solid/hollow ratio of the auxiliary emission plate when all other ratios and dimensions remain the same.

Thus, four tests were carried out on the same radiant unit in which only the auxiliary emission plate was changed, the latter having the following characteristics for each of the tests:

- **1st test:** plate drilled with 5mm diameter holes, Solid/hollow ratio = 3.31
- **2nd test:** plate drilled with 5mm diameter holes, Solid/hollow ratio = 1.98
- **3rd test:** plate drilled with 7mm diameter holes, Solid/hollow ratio = 1.20
- **4th test:** plate drilled with 8mm diameter holes, Solid/hollow ratio = 0.73

The results of the tests are given on the graphs in FIGS. 4, 5 and 6.

The graph in FIG. 4 shows the temperature of the emission plate depends variably on the solid/hollow ratio of the auxiliary emission plate; that in FIG. 5 shows the temperature of the auxiliary emission plate depends variably on its solid/hollow ratio.

On these graphs, the abscissae are represented by burner power in mth/h (milliliter/hour) and the ordinates are represented by temperatures in degrees C.

The significance of the curves is as follows:

<table>
<thead>
<tr>
<th>FIG. 4</th>
<th>FIG. 5</th>
<th>Solid/hollow ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A'</td>
<td>3.31</td>
</tr>
<tr>
<td>B</td>
<td>B'</td>
<td>1.98</td>
</tr>
<tr>
<td>C</td>
<td>C'</td>
<td>1.20</td>
</tr>
<tr>
<td>D</td>
<td>D'</td>
<td>0.73</td>
</tr>
</tbody>
</table>

It is clear from these graphs that curves B and B' are those giving optimum values.

Furthermore exactly the same effect occurs as far as FIG. 6 is concerned, in which the curves A', B', C' and D' represent respectively the output expressed as percentage (shown as ordinates) variably depends on the burner output in mth/h (shown as abscissae) for a burner fitted with an auxiliary emission plate in which the solid/hollow ratio is:

- for A' is 3.31
- for B' is 1.98
- for C' is 1.20
- for D' is 0.73

Thus, it can be seen that the optimum operation of the burner will be obtained with an auxiliary emission plate in which the solid/hollow ratio is approximately 2.

There is thus provided a high temperature radiant burner possessing great flexibility of use and which is capable of reaching temperatures of over 1,200°C with a considerable radiation factor bordering on about 40 percent of the power provided.

This can possibly be explained by the fact that the auxiliary emission plate is located between two superimposed chambers inside which constant thermal exchanges take place between:

- the auxiliary emission plate and the main emission plate
- the auxiliary emission plate and the front screen, the latter acting as an anti-convection element reducing colorific losses to a minimum by convection on the other side of this same element.

As the auxiliary emission plate is not in direct contact with ambient air, both its sides are at practically the same temperature and there is thus a negligible loss.
of heat in relation to the lost heat from the emission plate.

The fact that the emission plate and the auxiliary plate are in thermal equilibrium makes it possible to consider that the burner's total radiant surface is considerably increased in comparison with conventional burners.

The burner may be operated with various types of combustion gas and liquid mixture and is easy to use industrially, e.g., in ovens, drying machines, etc.

I claim:

1. A radiant burner for a combustible gaseous mixture comprising:
   a box having an inlet for said gaseous mixture and constituting a mixing chamber;
   an emission plate opposite to said inlet and delimiting said mixing chamber, said emission plate being constituted by ceramic solid plates drilled of passages having a diameter of between 0.40 to 0.70 mm., said passage being adapted to permit flowing of the gaseous mixture therethrough;
   an auxiliary emission means made of a refractory metal drilled with holes of a larger diameter than the passages in said emission plate, said auxiliary emission means surmounting said emission plate and being spaced from the latter by a peripheral frame supported by said box;
   and an anti-convection screen spaced from said auxiliary emission means by said peripheral frame.

2. A radiant burner according to claim 1 wherein the diameter of the holes drilled in said auxiliary emission means is between 5 to 8 mm.

3. A radiant burner according to claim 1 wherein the diameter of the holes drilled in said auxiliary emission means is approximately 6 mm.

4. A radiant burner according to claim 1 wherein the solid/hollow ratio of the auxiliary emission plate is approximately 2.

5. A radiant burner according to claim 1 wherein the distance separating the emission plate from the auxiliary emission plate is approximately double the distance separating the latter from the screen.

6. A radiant burner according to claim 1 wherein said peripheral frame supporting said auxiliary emission means has an internal seating structure on which is freely seated said auxiliary emission plate so as to allow dilatation of the latter.

7. A burner according to claim 1 wherein the surface of the ceramic solid plate facing said auxiliary emission means are provided grooves, said passages in said ceramic plates opening in said grooves.

8. A burner according to claim 7 wherein said grooves are 1.5 to 2.5 mm. wide and 1 to 3 mm. deep.