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M. PARTIOT

3,291,188

DEEP COMBUSTION RADIANT ELEMENTS

Original Filed July 19, 1960

2 Sheets-Sheet 1

FIG. 1.

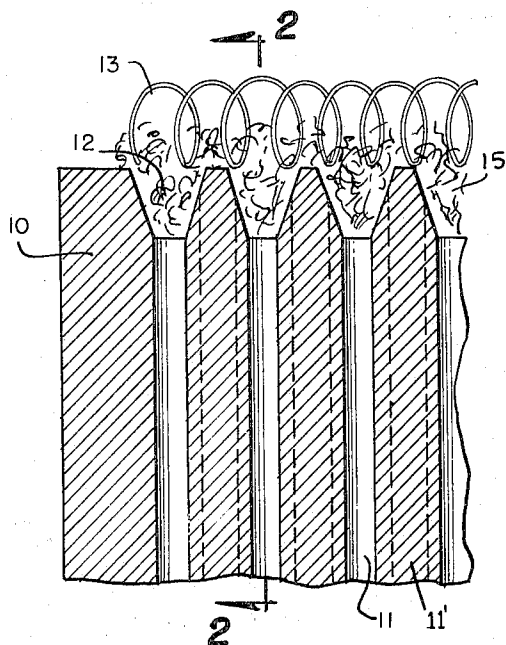


FIG. 2.

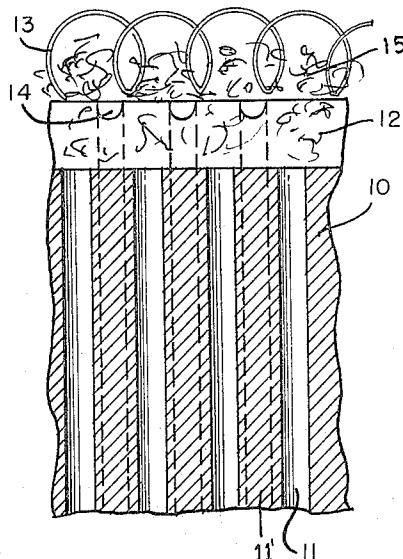
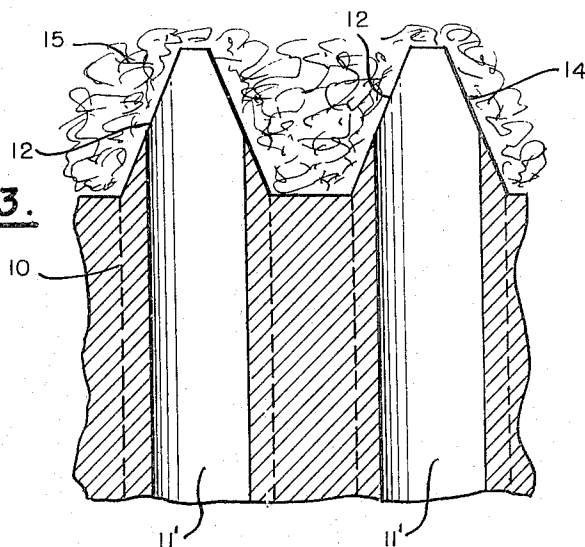


FIG. 3.



INVENTOR

Maurice Partiot

BY

Moore & Hall

ATTORNEYS

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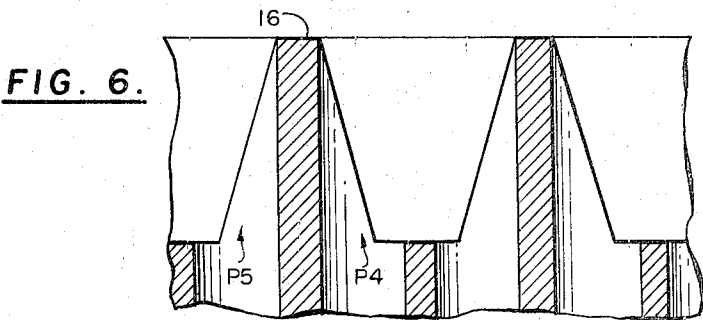
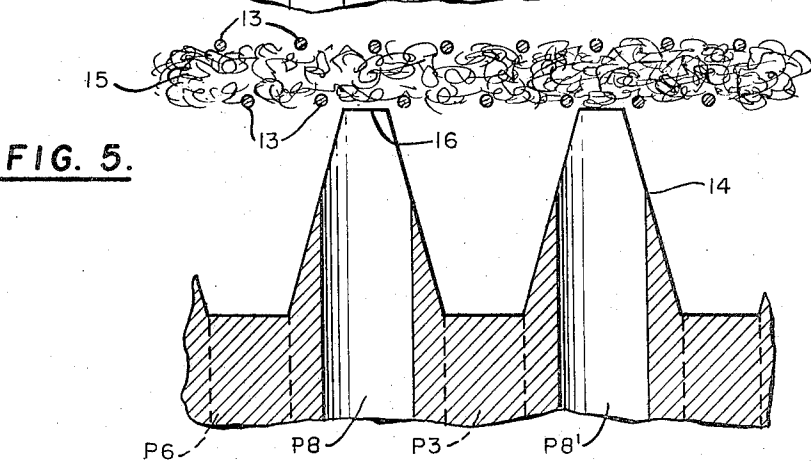
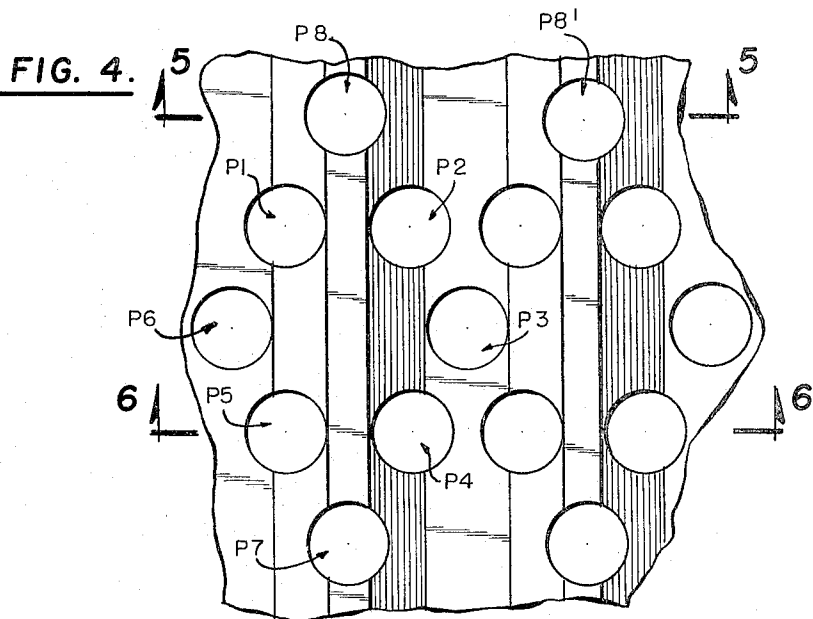
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INVENTOR

Maurice Partiot

BY *Hall, Pollock & Vande Sande*

ATTORNEYS

1

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DEEP COMBUSTION RADIANT ELEMENTS

Maurice Partiot, 12 Rue du Plateau Saint Antoine,

Le Chesnay, France

Continuation of application Ser. No. 43,803, July 19, 1960. This application Mar. 23, 1964, Ser. No. 354,508

7 Claims. (Cl. 158-116)

This application is a continuation of U.S. application, Serial No. 43,803 (now abandoned), which was in turn a continuation-in-part of my copending application, Serial No. 36,767, filed June 17, 1960, now Patent No. 3,179,155 for Deep Combustion Radiant Surfaces with Special Slotting.

The present invention concerns the design of radiant ceramic plates so that the flame produced by the combustion of flammable gas mixtures is caused to penetrate to a controlled depth in the combustion surface of the ceramic and provide a combustion region of predetermined thickness.

It is an object of this invention to provide means to achieve practically complete combustion of a gaseous mixture by reverberation of the radiant energy of combustion.

It is an object of the invention to raise the temperature of the radiant combustion face of a ceramic plate to maximize the rate and completeness of combustion of a gaseous mixture.

It is an object of the invention to provide a combustion region of controlled depth below the outer radiant surface of a ceramic plate.

It is an object of the invention to provide a radiant ceramic plate having holes therethrough for the supply of a combustible gaseous mixture with outer radiant face slotted between holes to provide a combustion region of controlled depth.

It is an object of the invention to provide sufficient space within the combustion region to allow for the expansion of combustible gases without an increase in velocity which would drive them out of the combustion zone before they have finished burning and at the same time provide sufficient velocity to support the layer effect which causes the combustion gases to follow closely the surface of the ceramic plate around a bend.

It is an object of the invention to provide a resilient open matting of highly refractory metal close to the radiant surface of a ceramic plate to increase the depth of the combustion zone or region to increase the space available for the expansion of the burning gas, to increase the time the gas remains in the combustion zone and to cause said burned gases to stagnate within a thick layer adjacent said radiant surface. Reference is made to FIGURE 2 on page 217 of Van Nostrand's Scientific Encyclopedia, third edition, 1958.

Several arrangements are proposed, according to the purpose described, and are best adapted to meet variable gas mixture compositions under varied pressure feed at the gas injector nozzle.

One disposition consists in joining all the rows of holes at the radiant surface of the plate by a slot three to four millimeters deep. The flame will reach deeper into the holes joined by such a slot, and the wider the slot the deeper the flame will reach inside the slot, to heat the side of said slot and to cause said slot walls to reverberate heat to each other.

In the extreme width case, the flame reaches the bottom of the slot and burns at that level corresponding to its intersection with the unslotted part of the holes. The flames does not penetrate further into the plate because the design of the holes and the nature of the ceramic are planned to stop the flame from backfiring.

In another embodiment of the invention, the slots are

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only five-tenths of a millimeter wide and are terminated by an angle bevel about 60° from the outer surface. The slot totals between three and four millimeters deep, as compared to a hole diameter ranging from about one millimeter to one and a half millimeters, and the bevelled portion of the slot reaches about one to two millimeters below the outer surface.

The combustion takes place in a zone slightly below the bottom of the narrowed bevelled portion and is completed closely above the outer surface level of the radiant plate. The bevel serves the dual purpose of allowing the flame to enter substantially below the outer surface and of spilling the hot combustion gases over the outer surface between the slots. The walls of the slot and bevel opposing each other reverberate their radiation to each other and finally to outside space; the mutual reverberation serves to increase the temperature of the bevel surfaces and the rate of combustion of the mixture.

The temperature of the radiant plate with bevelled slots joining the holes is raised by as much as fifty to eighty degrees centigrade, as compared to the temperature of a ceramic plate which is flat, with all the holes being flush with the outside flat radiant unslotted surface of the plate.

It has been found that combustion in a radiant surface plate provided with holes, but unslotted, is confined to a region which begins about one thirty-second of an inch ($\frac{1}{32}$ ") to one sixteenth of an inch ($\frac{1}{16}$ ") below the radiant surface. As discussed above, this is not sufficient to provide the depth of combustion region needed to produce the full benefits of the invention. In order to obtain the desired increased temperature of the surface and the more complete oxidation of the gaseous mixture, a deeper combustion region about one-eighth inch ($\frac{1}{8}$ ") thick is provided. With holes of about one square millimeter in cross-section area, a slot of about 0.7 mm. to 0.8 mm. joining rows of holes permits combustion to occur at the bottom of the slot. As a result, an increased amount of heat is transferred to the material of the ceramic plate, increasing its temperature and both the rate and completeness of the combustion of the gaseous mixture.

The slots are preferably of the deep narrow designs described in my copending application, Serial No. 36,767, filed June 17, 1960, in which the combustion reaches the bottom of said slots and is practically complete when gases reach the outer surface of the ceramic plate and mutual reverberation occurs between the walls of said slots, which in turn cause the combustion to occur at a deep level in the non-slotted holes adjacent to said slots.

In the usual type of radiant surfaces for domestic purposes, the composition of the ceramic is the same throughout the whole thickness as well as in the slotted part and in the non-slotted part. However, when higher temperatures and higher heat outputs are contemplated, the outer surface composition is changed at a depth between one-eighth ($\frac{1}{8}$ ") of an inch and one quarter ($\frac{1}{4}$ ") of an inch. The usual vegetable fillers are replaced by more heat-resistant materials such as gypsum, zirconium oxide, and materials having high emissivity such as Carborundum or other refractory materials which stay black at higher temperatures and radiate as black bodies with a higher proportion of infra-red output. Although the clay binder is apt to melt and flow somewhat, the fibers or other oxide or carbide aggregates are sintered so as to provide a high durability at operating temperatures.

In prior constructions of radiant plates there has been a tendency to let a good part of the heat of combustion be carried away from the refractory plate which is intended to be heated to a maximum degree to convert as much of the heat of combustion into radiant heat as possible, leaving a maximum to be carried away by convection of the gases. With previous constructions the ex-

pansion of the gas during combustion imparts a relatively high velocity to the exhaust gas which is especially noticeable at the low gas feed pressures employed and the resulting low radiation output. One purpose of the invention is to provide enough space to permit expansion of the burning gas without substantial increase in velocity of flow, which rather stays the same or even decreases.

It is known that hot gases are more "viscous" or sticky than at normal temperatures. The matting or "shroud" is principally used as a means for holding the hot burnt gases close to the ceramic plate and to take away from them a portion of their residual heat for additional radiation before releasing them into the outer space in a pressureless leisurely flow.

The structure of the "matting" is wide open, so that practically the total amount of heat generated by the ceramic plate is radiated to the outer space, or re-transmitted from the fibers or wires which are in its way.

The actual volume of solid materials within the space outlined by the thick matting is only a small fraction of said space, thus allowing the free flow through it of burnt gases and of the radiations issued from the ceramic plate.

The slots in the ceramic plate are about two diameters deep and they join either selected rows or a limited number of passages in a regular pattern all over the area as shown in my copending application Serial No. 36,767. The slots can be either elongated through a row or be in the form of successive dashes with an interrupted recurring pattern.

In addition to the objects pointed out above, other objects will appear from the following description and from the drawings, in which like numerals refer to like parts throughout:

FIGURE 1 is a fragmentary sectional view of one form of radiant ceramic plate according to the invention.

FIGURE 2 is a fragmentary sectional view along line 2—2 of FIGURE 1.

FIGURE 3 is a fragmentary sectional view of a modified form of the invention.

FIGURE 4 is a top view of the plate of FIGURES 1 and 2.

FIGURE 5 is a cross-sectional view taken along line 5—5 of FIGURE 4.

FIGURE 6 is a cross-sectional view taken along the line 6—6 of FIGURE 4.

In FIGURE 1 a ceramic plate or slab 10 of low heat conductivity is provided with a large number of elongated passages or indentations 11 positioned as closely as possible together, preferably in a hexagonal pattern. The passages 11 and 11' are proportion and positioned to let through as large an amount of the hydrocarbon combustible gas mixture as possible. The passages 11 are short passages which open into the bottom portion of the slots 12, whereas the passages 11' are longer passages which extend to the outermost portion of the combustion surface of the plate. The passages along each row are connected by slots 12 about one-eighth ($\frac{1}{8}$ "') inch to one quarter ($\frac{1}{4}$ "') inch deep, providing a combustion chamber.

A resilient open matting 13 of highly refractory metal is supported by the ceramic slab 10 in contact with its radiant surface. Matting 13 may comprise intertwined pre-shaped strands which may be a woven open grid or a knitted and twisted refractory fabric, or coils comprising interknit chains of Nichrome or tungsten wire with beryllium and similar heat-resistant alloys. The wire of matting 13 may be covered or coated with radiant material comprising the rare earths, uranium oxide, metallic palladium, and similar radiant materials.

The matting 13 acts to increase the depth of the combustion region and retains a layer of hot combustion gases closely adjacent the radiant surface of slab 10 so as to raise the temperature of the surface and maximize combustion.

The slots 12 which may be V-shaped as shown, or straight-sided, so as to bring the combustion region well

below the outside radiant surface of the ceramic slab 10 to the bottom of the slots thus further increasing its depth so as to maximize combustion, raise the temperature of the radiant surface, and thereby the amount of heat radiated.

FIGURE 4 is a top view of the radiant ceramic grid of FIGURES 1 and 2 but with the matting or "shroud" removed to clarify the illustration. FIGURE 4 clearly shows the hexagonal arrangement of the through passages previously referred to (see passages P1—P6). As shown, some of these passages such as passages P7 and P8 extend, at least in part, to the topmost boundary surface 16 (see FIGURE 5) of the grid 10. Other passages open into the bottommost portion of each cavity such as the passages P3 and P6, while still other passages such as passages P1 and P2 open into the peripheral side walls 14 of the passages or indentations.

FIGURE 5 is a cross-sectional view taken along the cross-section line 5—5 of FIGURE 4, and this cross-sectional view shows both fine wire matting 15 and heavier wire matting 13 attached to the second, upper boundary surface of the grid 10.

FIGURE 6 is a cross-sectional view taken along the cross-section line 6—6 of FIGURE 4 and shows the slanted discharge openings that are provided for some of the passages. It will be recognized that such slanted discharge openings cause the issuing hot gas to be directed at an angle away from the axes of such passages and toward the opposing peripheral wall surface of the passages or indentations. Also, the deep V-shaped slots or passages form combustion chambers into which the hot gases spill sideways. This increased space permits expansion of the gas mixture and reduces its velocity so that it remains for a longer period in the combustion region to raise the temperature of the radiant surface and thereby maximize combustion which further raises the temperature.

A matting of fine wire 15 may be used alone, as shown in FIGURE 3, or may be used in combination with heavier wire matting 13, as shown in FIGURES 1 and 2. Fine matting 15 helps to retain the hot gases in contact with the radiant surfaces of ceramic slab 10 for a longer period for heat exchange and maximum combustion. As the fine wire 15 becomes incandescent and glows it provides increased areas of radiant emission surface and thereby increases efficiency. The more heat extracted from the hot gases of combustion and radiated in the direction desired the greater the efficiency of the construction. Radiation properties may be improved by coating the matting 13 or wire 15 with uranium oxide or metallic palladium which provide a high yield radiation in the infra-red range. These materials may also be incorporated in the radiating surface of the ceramic material comprising the slabs 10.

While there have been described above what are presently believed to be the preferred forms of the invention, variations thereof will be obvious to those skilled in the art and all such changes and variations which fall within the spirit of the invention are intended to be covered by the generic terms in the appended claims, which are variably worded to that end.

What I claim is:

1. A burner member comprising, a block of refractory material defining a multiplicity of small bore passages extending in generally parallel relation to one another from a first boundary surface of said block toward a second boundary surface thereof, said passages adapted to conduct a combustible gas mixture from said first boundary surface toward said second boundary surface for combustion adjacent to said second boundary surface, at least some of said passages opening into said second boundary surface, said second boundary surface defining therein a plurality of indentations each having a peripheral wall substantially longer than the bore diameter of

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any one of said passages, means for at least some of said passages for conducting at least some of said combustible gas mixture away from said passages at an angle to the axes of said passages and through said peripheral wall into an adjacent indentation, and a radiation and gas pervious metallic matting overlying at least a portion of said second boundary surface and extending outwardly from said second boundary surface beyond the region of burning of said gas mixture to thereby cause a layer of exhaust gases to stagnate in close proximity to said second boundary surface.

2. The combination as set forth in claim 1 wherein the side walls of each indentation form an angle relative to each other permitting mutual reflections of radiant energy therebetween.

3. The combination set forth in claim 1, said radiation and gas-pervious metallic matting comprising resilient spaced filaments of refractory metal.

4. The combination set forth in claim 1, and further including a coating on said radiation and gas-pervious metallic matting to improve its radiant properties

5. The combination of claim 1, wherein said radiation and gas-pervious metallic matting comprises a wire grid capable of becoming incandescent.

6. The combination in claim 1, each said indentation comprising a slot having a depth greater than twice the

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greatest cross-sectional dimension of any of said passages, said slots having opposing faces at divergent angles to reflect heat mutually to at least part of each other and to said matting.

7. A radiant heating element as defined in claim 1 in which said radiation and gas-pervious matting is sufficiently loose and open in texture as not to create any back pressure opposing the free flow of combustion gases from said second boundary surface.

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25 FREDERICK L. MATTESON, Jr., *Primary Examiner*,
JAMES W. WESTHAVER, *Examiner*.