May 23, 1967 M. PARTIOT 3,321,000

DEEP COMBUSTION RADIANT SURFACES WITH SPECIAL SLOTTING

Original Filed June 17, 1960

FIG. 1.

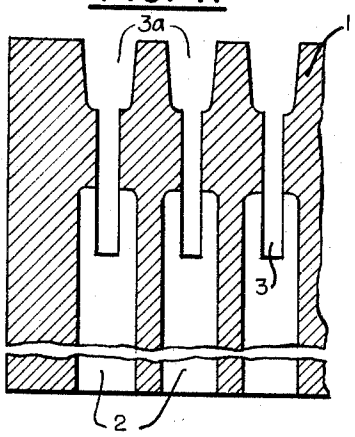


FIG. 2.

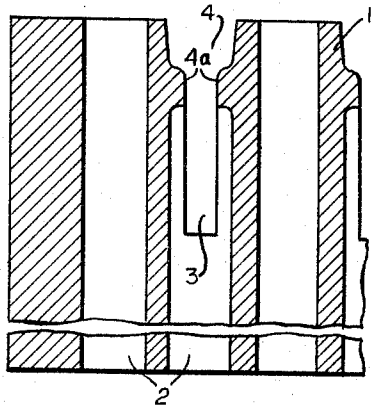


FIG. 3.

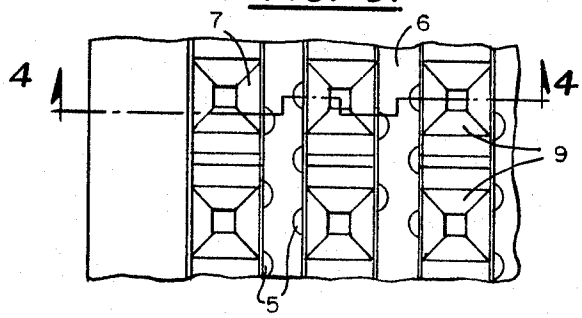
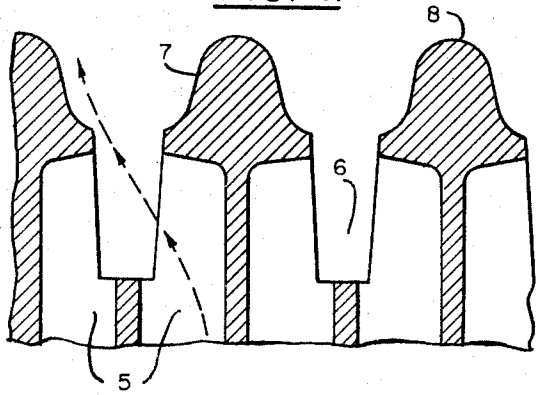


FIG. 4.



INVENTOR

Maurice Partiot

BY Hall, Pollock & Vande Sande

ATTORNEYS

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DEEP COMBUSTION RADIANT SURFACES WITH SPECIAL SLOTTING

Maurice Partiot, 12 Rue du Plateau Saint-Antoine, Le Chesnay, France

Original application June 17, 1960, Ser. No. 36,767, now Patent No. 3,179,155, dated Apr. 20, 1965. Divided and this application Mar. 17, 1965, Ser. No. 440,465
22 Claims. (Cl. 158—116)

This application is a division of my copending application Ser. No. 36,767, filed June 17, 1960, now Patent No. 3,179,155 and concerns the design of radiant ceramic plate 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 this 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 Coanda effect which causes the combustion gases to follow closely the surface of the ceramic plate around a bend.

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 (1/32") to one sixteenth of an inch (1/16") below the radiant surface. As discussed above, this is not quite 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 sixteenth of an inch to one quarter inch (1/4") thick is provided. With holes or passages of about one square millimeter in cross-sectional area, a slot of about 0.7 millimeter to one millimeter in width and 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.

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.

In general, in each of the several arrangements, the upper radiant surface defines a plurality of hollows, i.e. indentations, cavities or slots, which extend below the radiant surface a depth in excess of the minimum cross-sectional dimension of any passage and with a plurality of said passages opening into each hollow, the novel construction resulting in combustion deeply within the hollows to provide thereby a substantially hotter radiant surface.

One disposition consists in joining all the holes or passages in any of one or more rows of such passages at the radiant surface of the plate by a slot which may be three to four millimeters deep and from five-tenths to eight-tenths of a millimeter wide. 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 walls of said slots and to cause said 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 the unslotted part of the holes. The flame 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 this invention, each slot or cavity is so disposed as to join, at the bottom of the slot or cavity, passages which are respectively associated with different rows of such passages. More specificalliy, each of the generally opposing side walls forming a part of any one slot or cavity intersects one or more of the passages below the radiant surface of the grid and cuts away a portion of the passage-defining wall most deeply on that portion thereof which nears an opposing wall of the slot or cavity. This results in a tendency for the gas mixture passing through such intersected passage to be directed at least in part away from the axis of the passage and in a direction generally toward an opposing wall of the slot or cavity. Such a construction results in deep combustion within the slots or cavities and in a much higher radiant temperature of the walls of the slots or cavities because of the mutually radiant reverberation that takes place.

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 a deep combustion radiant slotted plate having blind holes opened by slots.

FIGURE 2 is a fragmentary sectional view of a deep combustion radiant slotted plate having slotted blind holes and open holes in alternate rows.

FIGURE 3 is a fragmentary plan view of a plate according to the invention with blind holes and cross bevels to increase heat exchange or reverberation.

FIGURE 4 is a section taken along line 1—1 of FIGURE 3.

FIGURE 1 shows in a ceramic plate 1 the use of partly blind holes 2 that are aligned in rows and which are cut open and joined by slots 3. Blind holes that are cut open by a slot create turbulence and aid in locating the combustion region at a predetermined depth. Slots 3 connect with the outer surface of plate 1 through an outer wider slot 4 providing space for expansion of the heated gases. Said slots can have a beveled opening and be of a non continuous design.

In FIGURE 2 the use of slotted blind holes is employed in alternate rows with intermediate rows of straight bore open holes.

FIGURES 3 and 4 show two adjacent rows of blind holes 5 joined by wider slot 6 with a beveled opening 7. The surface of the plate 8 may preferably be formed with cross bevels 9 to increase heat exchange and also allow for heated gas expansion without substantial velocity increase thus reducing any tendency of the hot gases to drive themselves away from the radiant surface.

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, leav-

ing a minimum to be carried away by convection of the gas. With previous constructions the expansion of the gas during combustion imparts away from the plate 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 decreases. To that effect, the velocity of exhaust gases is preferably adjusted to follow closely the surface of the ceramic around the bend, or profiles of the indentations, slots of cavities below the outer boundary surface of the plate. In the embodiment in FIGURES 3 and 4, the resultant deflection of gases through a side-cut slot causes the combustion gases to slow down and follow closely the profile of the opposite slot wall, thus enhancing the heat exchange and radiant performance of the plate.

In the embodiment of FIGURES 3 and 4, the shoulders 31 increase the turbulence of the gas mixture within the combustion region and help assure completeness of the combustion. Similarly, in the embodiments of FIGURES 1 and 2, a restriction or obturation is provided in the path of the gas stream prior to its issuance into the outer wider slots provided at the combustion surface. For example, in FIGURE 1, the narrow slots 3 provide an obturation encountered by the gas mixture passing upwardly through each blind hole 2 and prior to its emergence into the wider outer slot 3*a*. In FIGURE 2, the use of a narrow slot 3 intersecting the passages 2 of alternate rows provides a restriction 4*a* encountered by each streamlet of the gas mixture just prior to its emergence into the wider slot 4 at the combustion surface. In each case, such an obturation forming a restriction in the flow path of the gas mixture prior to its emergence into the associated indentation increases the velocity of the gas mixture at least near the outlet of such restriction and thereby increases substantially its turbulence in the expanded space adjacent the outlet end of the restriction.

While there have been described above what are presently believed to be the preferred form 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.

I claim:

1. A radiant grid element for a gas burner comprising, a unitary block of refractory heat insulating material having a myriad of continuous, straight minute-bore passages which extend from an inlet end at a first boundary surface of said block toward the opposite surface of said block for conducting from said first surface a myriad of streams of a combustible gas mixture for combustion adjacent said opposite surface, said block having formed in its said opposite surface a repeat pattern of indentations each of which intersects at least two of said passages, each said intersected passage together with the respective intersecting indentation forming a restriction in the flow path of said gas mixture prior to its emergence into the associated indentation to thereby increase the velocity of said gas mixture in said restriction and impart to said gas mixture a turbulence adjacent the outlet end of said restriction, the arrangement of said passages and their dimensions together with the shape and size of said indentations comprising a means which is jointly operable to cause at least some of the gas mixture to burn at substantially the outlet ends of the respective restrictions, the thickness of said block at its minimum within said indentations and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first surface from reaching the ignition temperature of said gas mixture, and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating therethrough to said first surface.

2. The radiant grid element of claim **1** in which each said indentation comprises an elongate slot.

3. The radiant grid element of claim **2** in which each slot has a width less than the major cross-sectional dimension of each said minute-bore passage.

4. The radiant grid element of claim **2** in which each said slot has a width at the level of its intersection with the associated passages which is less than the maximum cross-sectional dimension of the intersected passages but but has a substantially greater width at said opposite surface.

5. The radiant grid element of claim **2** in which the opposing walls of said slot are substantially planar.

6. The radiant grid element of claim **1** in which at least some of said indentations have opposing peripheral wall surfaces which are substantially parallel in the area adjacent to the intersection of said indentation with said passages but thereafter diverge in the region adjacent the furthest reaches of said opposite surface.

7. The radiant grid element of claim **1** in which each said intersected passage comprises a blind hole and each intersecting indentation extends from said opposite surface downwardly below the level of said restriction.

8. The ceramic block of claim **7** in which said passages which are intersected by said indentation are blind passages which communicate with said one surface only through the associated intersecting indentation.

9. A unitary two-sided flat ceramic block for emission of infra-red rays by heating one side of said block by the combustion at said side of a gas mixture flowing from the other side through a great many continuous elongated passages each of which is straight over at least most of its length all having substantially the same cross-sectional area at least at their inlet ends adjacent said second side of said block and being substantially evenly distributed over the area of said block, said ceramic block at its one side having a repeat pattern of indentations extending below the outer surface of said one side, each of said indentations intersecting the ends of at least two of said passages to gather the outflow of at least two of said passages, at least some of said passages being partly obturated along their axial length by the ceramic material of said block to thereby increase the velocity of said gas mixture in said restriction and to impart to said gas mixture a turbulence adjacent the outlet end of said restriction, the arrangement of said passages and their dimensions together with the shape and size of said indentations comprising a means which is jointly operable to cause at least some of the gas mixture to burn at least in part at substantially the outlets of said obturation, the thickness of said block at its minimum within said indentations and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first surface from reaching the ignition temperature of said gas mixture, and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating therethrough to said first surface.

10. The invention as described in claim **9** in which the repeat pattern of indentations comprises a plurality of parallel slots in said one side of said block, said cuts intersecting said passages at or near their axis.

11. The invention as described in claim **9**, in which said first-named side comprises alterations of straight bored passages lined in rows and said indentations comprise slots joining several passages in alternate rows.

12. The ceramic block of claim **10** in which said partial passage obturation occurs along the axial length of each said passage at a point between said one surface and the bottom of the intersecting slot.

13. The ceramic block of claim **12** in which each said slot is formed over the deepest part of its depth of substantially parallel planar surfaces each said slot having

opposing surfaces at its upper portion adjacent said one surface which are significantly wider spaced than at the point of intersection of said slot with said passages.

14. A radiant grid element for a gas burner comprising,

a unitary block of refractory heat insulating material having a myriad of minute-bore passages which extend from an inlet end at a first boundary surface of said block toward the opposite surface of said block for conducting from said first surface a myriad of streams of a combustible gas mixture for combustion adjacent said opposite surface, said block having formed in said opposite surface a repeat pattern of indentations each of which intersects at least two of said passages,

each said indentation having opposing peripheral walls whose spacing at the bottom of said indentation is less than the maximum cross-sectional dimension of an intersected passage but whose spacing adjacent said opposite surface is greater than said maximum cross-sectional dimension, said change in spacing of said opposing peripheral walls being discontinuous to thereby form a step which increases the turbulence of the burning gas mixture adjacent said opposite surface, the thickness of said block at its minimum within said cavities and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first surface from reaching the ignition temperature of said gas mixture, and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating therethrough to said first surface.

15. The radiant grid element of claim 14 in which at least some of said indentations have opposing peripheral wall surfaces which are substantially parallel in the area adjacent to the intersection of said indentation with said passages but thereafter diverge in the region adjacent the furthest reaches of said opposite surface.

16. A radiant grid element for a gas burner comprising,

a unitary block of refractory heat insulating material having a myriad of minute-bore passages which extend from an inlet end at a first boundary surface of said block toward the opposite surface of said block for conducting from said first surface a myriad of streams of a combustible gas mixture for combustion adjacent said opposite surface, said block having formed in said opposite surface a great many discrete protuberances which are substantially uniformly spaced both longitudinally and transversely over said opposite surface, each said protuberance being formed at least in part by upstanding walls which extend upwardly and inwardly above a lower portion of said opposite surface, at least some of said passages opening at least in part into said lower portion and others of said passages opening at least in part into said upstanding walls,

the arrangement of said passages and their dimensions together with the shape and size of said discrete protuberances comprising a means which is jointly operable to cause at least some of the gas mixture to burn at substantially said lower portion of said opposite surface,

said upstanding walls of said discrete protuberances being contacted by the flames of the burning gas mixture,

the thickness of said block at its minimum and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first surface from reaching the ignition temperature of said gas mixture, and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating therethrough to said first surface.

17. The radiant grid element of claim 16 in which adjacent of said protuberances have side walls which generally face each other, said side walls being heated substantially to incandescence by said flames of the burning gas mixture and thereby providing mutually reverberating infra-red radiating surfaces which aid in the complete combustion of said gas mixture.

18. A radiant grid element for a gas burner comprising,

a unitary block of refractory heat insulating material having a myriad of substantially straight minute-bore passages which extend from an inlet end at a first boundary surface of said block toward the opposite surface of said block for conducting from said first surface a myriad of streams of a combustible gas mixture for combustion adjacent said opposite surface,

said opposite surface being formed in part by a repetitive pattern of mutually intersecting elongated longitudinal and transverse indentations at least some of which have a plurality of said passages opening at least in part into their bottom portions.

said indentations being at least for the most part substantially uniformly spaced in both the longitudial and transverse directions over the opposite surface of said block,

the arrangement of said passages and their dimensions together with the shape and size of said intersecting indentations comprising a means which is jointly operable to cause at least some of the gas mixture to burn at substantially the bottoms of the respective indentations,

said intersecting indentations having side walls which slope upwardly and outwardly over at least a portion of their length at an acute angle to the longitudinal axes of said passages to form in said opposite surface a plurality of raised portions joined with the remainder of said opposite surface by upstanding surfaces which are heated to incandescence by the flames of combustion of said gas mixture,

adjacent of said discrete raised portions having respectively opposing sloping surfaces to enhance mutual infra-red radiation therebetween.

the thickness of said block at its minimum within said indentations and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first surface from reaching the ignition temperature of said gas mixture,

and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating therethrough to said first surface.

19. A radiant grid element for a gas burner comprising, a unitary block of refractory heat insulating material having a myriad of minute-bore passages which extend from an inlet end at a first boundary surface of said block toward the opposite surface of said block for conducting from said first surface a myriad of streams of a combustible gas mixture for combustion adjacent said opposite surface, said opposite surface being defined by a repetitive pattern of elemental portions which are raised relative to depressed portions of said opposite surface and in part extend to the outermost reaches of said opposite surface, said raised portions and said depressed portions being joined by upstanding surfaces, some of said passages opening at least in part into said raised elemental areas at their said outermost portions and defining a line of intersection with the respective raised elemental portion which for at least most of its length lies in the same plane and others of said passages opening at least in part into said depressed portions each of said passages which opens into one of said raised portions being surrounded at least in part by at least one of said depressed portions into which at least one of said passages opens, said passages which open into said depressed portions

providing combustion flames and hot gases which pass over said upstanding surfaces to increase their temperature markedly and thereby facilitate the combustion of said gas mixture at a deep level within said passages which open into said raised areas, the arrangement of said passages and their dimensions causing at least some of the gas mixture to burn at substantially the point of emergence of said passages into said depressed portions, the thickness of said block at its minimum within said cavity and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first boundary surface from reaching the ignition temperature of said gas mixture, and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating through to said first surface.

20. A radiant grid element for a gas burner as defined in claim 14 in which said indentations alternate with raised areas which extend to the outermost reaches of said opposite surface and with at least some of said raised areas having passages opening thereinto.

21. A radiant grid element for a gas burner as defined in claim 19 in which at least some of said upstanding surfaces generally face each other and are generally parallel to the axes of said passages.

22. A gas burner having a radiant grid element comprising, a unitary block of refractory heat insulating material having a myriad of minute-bore passages which extend from an inlet end at a first boundary surface of said block toward the opposite surface of said block for conducting from said first surface a myriad of streams of a combustible gas mixture for combustion adjacent said opposite surface, said opposite surface being defined by a repetitive pattern of elemental portions which are raised relative to depressed portions of said opposite surface and in part extend to the outermost reaches of said opposite surface, said raised portions and said depressed portions being joined by upstanding surfaces which are substantially parallel to the axes of said passages, some of said passages intersecting said depressed portions over only a part of their cross-section and others of said passages opening at least in part into said raised portions, said passages which open into said depressed portions providing combustion flames and hot gases which pass over said upstanding surfaces to increase their temperature markedly and thereby facilitate the combustion of said gas mixture at a deep level within said passages which open into said raised areas, the arrangement of said passages and their dimensions causing at least some of the gas mixture to burn at substantially the point of emergence of said passages into said depressed portions, the thickness of said block at its minimum within said cavity and the nature of the refractory material of said block comprising a means which is jointly operable to prevent said first boundary surface from reaching the ignition temperature of said gas mixture, and each said passage being many times longer than its width and sufficiently narrow to prevent the flame from back-propagating through to said first surface.

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FREDERICK L. MATTESON, JR., *Primary Examiner.*

JAMES W. WESTHAVER, *Examiner.*

H. B. RAMEY, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,321,000 May 23, 1967

Maurice Partiot

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 26, "cavities" should read -- indentations --. Column 7, line 9, "cavity" should read -- depressed portions --. Column 8, line 12, "cavity" should read -- depressed portions --.

Signed and sealed this 2nd day of September 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents