

- [54] **INFRARED BURNERS AND HIGH EFFICIENCY RADIANT PLATES**
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Related U.S. Application Data

- [63] Continuation of Ser. No. 742,980, June 27, 1968, which is a continuation-in-part of Ser. No. 36,767, June 17, 1960, Pat. No. 3,179,155, and a continuation-in-part of Ser. No. 240,704, Nov. 28, 1962, Pat. No. 3,179,157, and a continuation-in-part of Ser. No. 440,465, June 17, 1960, and a continuation-in-part of Ser. No. 549,114, Feb. 2, 1965, and a continuation-in-part of Ser. No. 549,121, Dec. 31, 1963.

- [52] U.S. Cl. **264/156**, 431/328
- [51] Int. Cl. **B28b 1/48**
- [58] Field of Search 431/328, 329; 264/67, 156; 126/92 B

References Cited

UNITED STATES PATENTS

- | | | | |
|-----------|---------|-----------------|---------|
| 1,308,364 | 7/1909 | Lucke..... | 431/328 |
| 2,201,777 | 5/1940 | Kliesrath | 264/66 |
| 2,775,294 | 12/1956 | Schwank | 431/328 |

3,077,658	2/1963	Wharton.....	264/156 X
3,258,058	6/1966	Lherault et al.	431/329
3,302,689	2/1967	Milligan.....	431/328
3,312,268	4/1967	Milligan.....	431/328
3,321,000	5/1967	Partiot.....	431/328

FOREIGN PATENTS OR APPLICATIONS

551,940	11/1956	Belgium.....	431/328
558,007	6/1957	Belgium.....	431/328
1,056,454	10/1953	France.....	431/328
1,477,389	3/1967	France.....	431/328
741,660	12/1955	Great Britain.....	431/328

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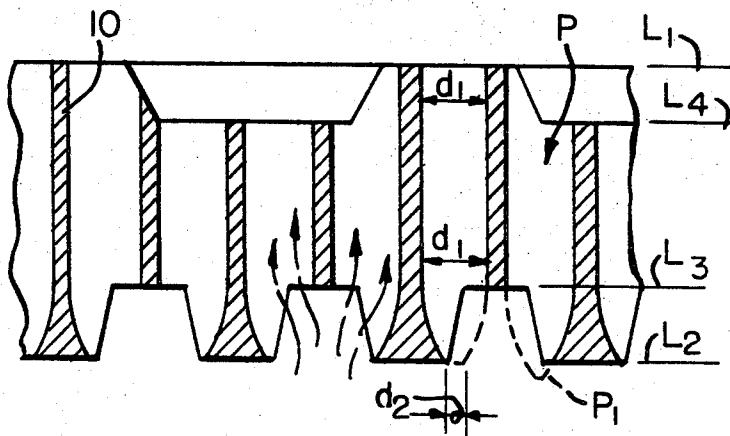
Assistant Examiner—Harry B. Ramey

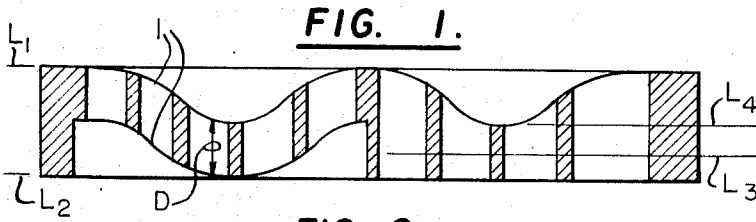
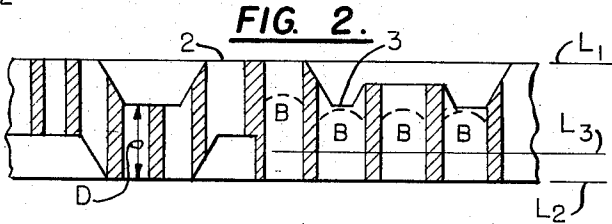
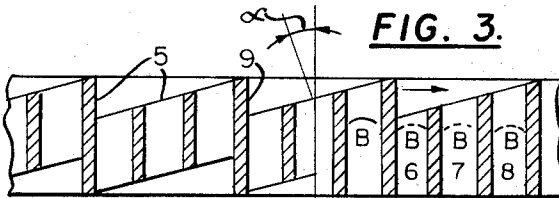
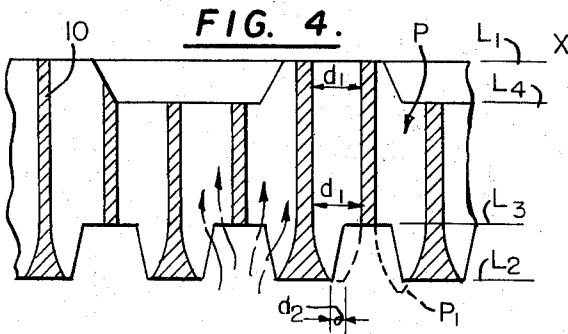
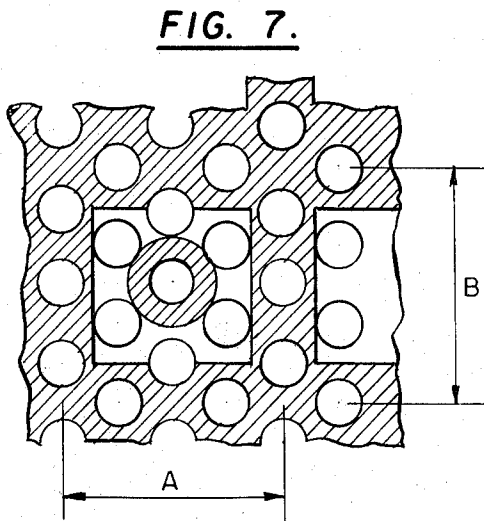
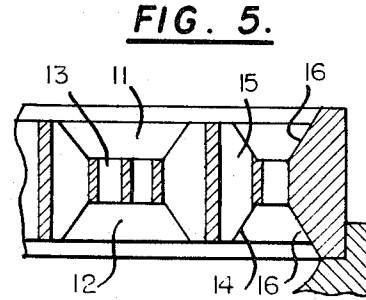
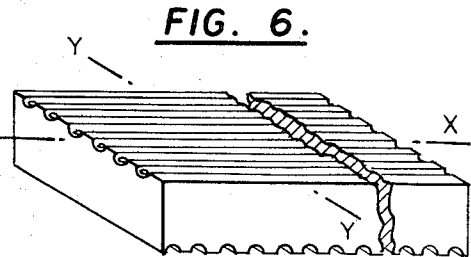
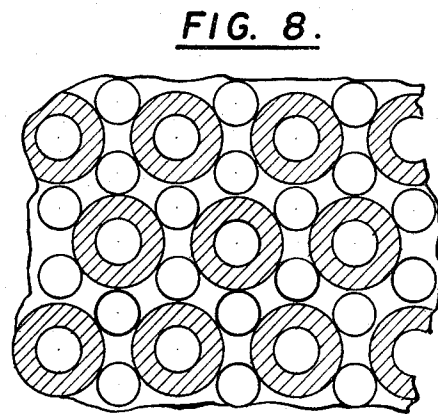
Attorney—Hall, Pollock & Vande Sande

[57] ABSTRACT

The disclosure relates to radiant ceramic plates for gas burners having a multiplicity of passages therethrough for conducting a combustible gas mixture from one surface of the plate to an opposite surface adjacent which combustion of the gas takes place. Both surfaces of the plate are provided with a repetitive pattern of indentation and the patterns of the two surfaces may be the same or different, thereby enabling the plates to be used with either side facing outwardly in the direction of desired infrared radiation.

1 Claim, 9 Drawing Figures





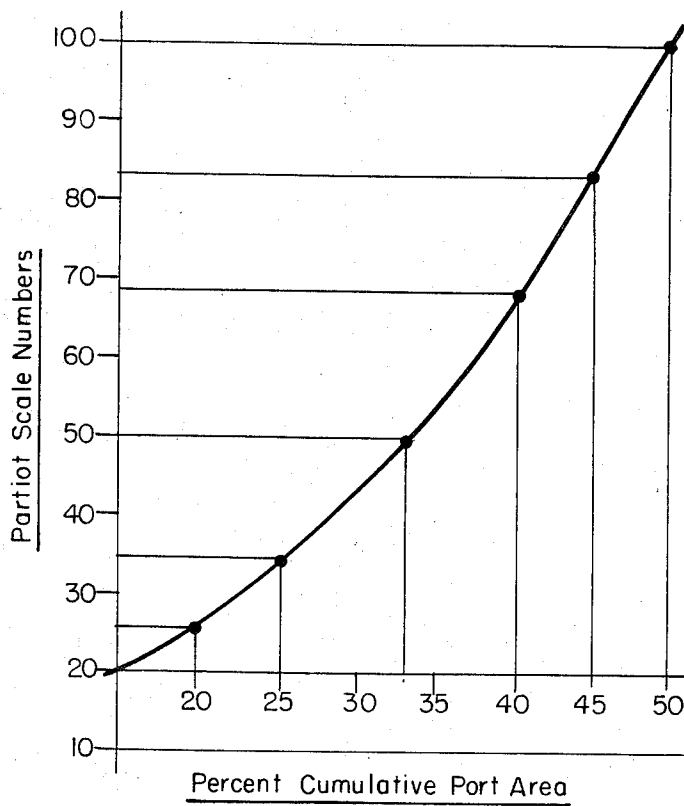
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FIG. 9.



INFRARED BURNERS AND HIGH EFFICIENCY RADIANT PLATES

This application is a continuation of my application Ser. No. 742,980, filed June 27, 1968, which is a continuation in part of my application Ser. No. 36,767, filed June 17, 1960, now U.S. Pat. No. 3,179,155 and my application Ser. No. 240,704, filed Nov. 28, 1962, now U.S. Pat. No. 3,179,157, of my copending application Ser. No. 440,465, filed June 17, 1960, of my copending burner application Ser. No. 549,114, filed Feb. 2, 1965, and of my copending application Ser. No. 549,121, filed Dec. 31, 1963.

It is intended in the present patent application to disclose further alternates of the prior inventions as well as to describe improvements in the burner and plate combination, the invention referring more especially to the plates as a coactive improved element of the previously described burners.

The present invention refers principally to improved plates for use in my perfected burners to produce a more closely integrated combination of the plates, the burners and the associated reflectors. The present invention however does not exclude the use of the improved plates in conventional burners, except that the combination of the plates with standard burners is of a substantially lesser usefulness than when used to burners especially adapted to my plates.

One purpose of the invention is to provide a diversity of superficial shapes for enhancing the radiant emission of said plate and for anchoring the flame within the outlets of the shorter passages, and for providing for said anchorage a shelter against cross plate drafts.

Another purpose of the invention is to maintain at a substantially constant level from one plate to another in a large plate lot, the aggregate flow per square inch, in spite of the wear of the punch-pressing equipment, provided said wear does not exceed reasonable limits.

The commonly accepted manufacturing practice consists in locating the stripper plate die which bears the reverse or negative form of the design for the combustion surface of the finished plate at the base ends of the pins, and then subsequently grinding away the flat side of the plate where pin wear occurs at the ends of the pins. However, this practice often results in plates that become excessively thin as pin wear increases and extends farther up the length of the pins. One of the purposes of the invention is to make plates by a method which is directly contrary to the foregoing, generally accepted practice by producing plates which, without any grinding, provide for compensation of the pin wear. This is accomplished by providing relatively deep indentations in that side of the plate which is opposite to that into which the pins are inserted in the plate molding step. This results in a considerable saving in the expensive replacement of a myriad of pins, and the importance of this factor increases with the size of the plates being made. Moreover, it also then becomes possible to provide a design on what would ordinarily be the bottom or back side of the plate which may be the same or quite different from that which is provided on the upper radiant surface, thereby making possible a reversible plate whose different patterns of indentations and intervening raised areas provide different radiation patterns depending upon the manner of assembly of the plate into a burner.

A further purpose of the invention is to provide plates of which the passages adjacent to the supporting edges receive an unobstructed flow of gas mix near the area of contact with the supporting burner body.

Still an alternate purpose of the invention is to provide multiple purpose plates that are of a reversible design on opposite sides of said plates. The plates may also be designed to have on at least one face thereof, and over at least a portion of such face, a flat surface not having any indentations.

The reversible plates having two indented faces on at least a portion of their respective surfaces make it possible to provide plates having a substantially constant gas mix flow. Moreover, it is possible to provide plates which are reversible and which are provided, on their respective surfaces, with designs of indentations and intervening raised areas which are entirely asymmetrical, not only as to pitch, but also as to depth of pattern, or direction and form of the pattern so as to provide a spaced distribution radiation pattern per unit area of plate which is distinctly different dependent upon which surface of the plate is used as the radiant surface.

Another purpose of the invention is to provide plates in which the length of the passages from one face to the opposite face of the plate is substantially constant.

Another purpose of the plate is to provide passages in which the heating of one face is controlled locally by the length of the passages at that point.

Still a further purpose of the plate is to provide discrete areas in which the individual diameter of the passages is different from the diameter of passages in another discrete area adjacent to said first named one.

Another purpose of the invention is to provide plates in which a repeat pattern of discrete areas comprising relatively short passages is surrounded by a substantially thicker web of supporting ceramics reaching to the edges of the plates to increase their heat thruput and still to retain material strength.

Still a further purpose of the invention is to provide a diversity of reversible oblong plates having on opposite sides different plate designs having a combination on opposite sides of designs diffusing radiations substantially evenly in all directions, or with predetermined patterns having a major cross plate component along one preferred axis of symmetry of the plate, out of the long axis or the short one of the oblong plate.

A further purpose of the invention is to provide a plate in which the aggregate porting area within discrete portions of the plate is different from the porting area immediately adjacent portions to said first named ones.

Still a further purpose of the invention is to provide less expensive, more serviceable and more efficient plates and radiant burners.

Another purpose of the invention is to provide reversible plates whose opposite faces are the seat of radiations of different wave lengths to be used for distinct infrared applications.

The manufacture of high output ceramic plates for radiant purposes generally involves the press molding and subsequent firing of a ceramic mix whose final specific gravity is determined by provisions to increase the natural porosity of the ceramic as compared to that of a pure ceramic pressed at the same pressure.

This process in which the porosity and specific gravity of the plates are closely linked in an inverse ratio has been well known for a half century and consists either in allowing the ceramic mix under lower molding pressures and lower firing temperatures to retain a controlled proportion of spaces between the individual grains, or to intimately include in the mix various combustible products which burn during the firing phase and cause the ceramic to contain a definite proportion of gas cells, or to include in the mix a predetermined proportion of non-combustible products of relatively low heat conductivity or of high porosity, that are ground very fine and which are intimately dispersed throughout the ceramic mix, or any combination of the three above mentioned means.

The manufacture of ceramic plates involves the use of dies having a high multiplicity of needle punches of minute diameters generally comprised between 0.030 and 0.080, which punches at the time the final pressure is applied on the mix caged within the die, are generally guided at both ends.

The punches that are thoroughly ground and hardened in depth or in surface, are submitted to the intense abrasive action of the ceramic powders and inclusions, a small part of which seep into the very fine spaces between said needle punches and said guiding and forming die plates (which oppositely to each other shape the opposite faces of the molded plate) have a degree of wear which is limited only in part by harder die parts and punches.

This factor of variation is the more unwelcome as the proportion of aggregate passage areas versus the remaining ceramic increases. The ceramic walls between adjacent passages are thin when the aggregate porting area rises above 30 percent of the overall plate area.

When in the hotter and more perfected plates in which the porting area is comprised between 40 and 50 percent, the intervening walls are substantially thinner, and the die equipment must be built with far greater skill and precision, consequently, the variations in wear from one needle punch to the other, and the general wear in said punches during the manufacture of a plate lot exceeding five or ten thousand plates, is of such a comparative magnitude that the plates at the end of a run are definitely not comparable to the plates at the beginning of the run.

Variations in the passage diameters cause multiplied variations in the temperature of the plate surface, and since the radiation total output varies at the fourth power of the temperature above zero absolute (minus 273° C), the loss in radiant output is far more considerable than is a nearly imperceptible loss in passage diameter, and said losses variable in spots are "seen" quite readily through inspection by instruments using infrared radiation filters.

It has been found necessary to establish a scale of comparison that is more sensitive to manufacturing variations than the mere punch diameters and I have therefore established a scale, with numbers between 25 and 100, which I believe is properly indicative of the comparative heat flow values of various plates, for each elemental volume of heated ceramic.

The Partiot number in the Partiot scale as shown in FIG. 9 is obtained by dividing the percentage number

of the aggregate porting area by the remaining percentage of ceramic area. It can be expressed by the formula $100 F/S$, F being the flow of gas mixed with the amount of air needed for its full combustion and is measured by the aggregate porting area, and S is the percentage of aggregate porous ceramic walls separating the gas flow passages.

For instance, the Partiot number of 25 would correspond to a 20 percent aggregate porting area; the Partiot number of 50 corresponds to an aggregate porting area of one-third of the plate surface; a Partiot number of 67 roughly corresponds to a 40 percent porting area; a number of 83 corresponds to a 45 percent aggregate porting area, and a number of 100 to a 50 percent porting area, which calculations show to be a practical ceiling for the manufacture of die-punched plates so far as their usefulness and durability are concerned, avoiding excessive production of light.

It is to be noticed that as the porting area and the corresponding plate temperatures increase, the Partiot scale is far more sensitive to manufacturing variations in the 70 to 100 range than it is in the lower range, since the relation curve is of the second degree. See FIG. 9.

Assuming that for each Partiot increased scale number, the combustion of the gases is proportionately transformed into radiant heat by the ceramic, which is most difficult to achieve, the increments or variations in infrared radiation output are highly sensitive to wear variations of the punch dies.

The sharply rising curve of the Partiot scale in the higher ranges illustrates the point and the invention discloses a partial remedy against the most troublesome wearing point, that is the pin diameter at its extremity where it engages the guiding counterplate in the presence of highly abrasive ceramics, said guiding being most required to be accurate as the ceramic walls are made thinner by required increases in the aggregate porting area percentages for hotter plate operation.

At the free extremity of the needle punches, the wear whittles the pin in an elliptic form, and one remedy generally consists in grinding the plates thinner and thinner as the wear spreads away from said extremity. The immediate practical result is that plates of a single lot are not comparable except with substantial differences to each other, nor to the originally submitted samples; or in order to make the plates fairly even, all plates are ground at the back face in an excessive amount.

One aspect of the invention is to provide at once an automatic compensation for the wear of the extreme end of the pin, and to provide plates that are substantially comparable in gas output and Partiot numbers during a longer run of manufacture of said plates.

Further aspects and benefits of other parts of the invention refer to plates that have on both faces a design that may or may not be the same, so that by reversing the plate in its holder, the distribution pattern of the infrared radiation may be different and better adapted to the purpose and scope of the radiation. The surface temperature is also controlled to vary as variable areas of ceramic are located in the path of the flame issued from the passages; inasmuch as the wavelength of the radiations is shorter as the surface temperature increases, the invention provides plates in which the

wavelengths of the infrared radiation are not the same on both sides of the plates, and can be so controlled on each side accordingly in intensity, direction and other characteristics.

A proper combination of passage lengths, diameters, surface indentations or prominent areas on one or on both sides of the plate provides the means for complete control of the infrared radiations emitted from the combustion side of the plate.

An important further purpose of the invention is to provide an accurate scale for the comparative evaluation of foraminous plate bodies that is more highly sensitive, in radiant plates of higher output per square inch, to variations in sizes of the through passages.

FIGS. 1 to 5 are sections of plates.

FIG. 6 is a perspective view.

FIGS. 7 and 8 are repeat surface patterns emitting non-directional radiations.

FIG. 1 is an exemplification of two forms of one aspect of the invention, with a long wave radiant surface 1, the left side of the plate shows passages having substantially all the same diameter and length. The right side shows a long wave design on one side of an oblong plate and an optional cross slot repeat pattern extending at right angles from the first pattern, said cross slots being intersected by through plate passages at a level at or between L2 and L3.

FIG. 2 shows on the left a plate 2 of which the top pattern is matched in the rear by a similar pattern synchronized with the first one so that the length of the passages is about the same. The right side of the figure shows a combination of a four-row repeat pattern on surface L1 with a cavity at the center of which is disposed a raised single central passage which contributes to the afterburning of the gas burnt at the bottom of the indentations 3. In longer passages such as 4, the level of the combustion is lowered by the overheating of the inner walls of said passages by conduction of the heat of the combustion taking place at a level slightly below the outlet of passage 3, as is shown by dotted lines B, B, etc.

FIG. 3 shows at the left a saw-tooth pattern 5 especially useful in all the burners described in my V-burner copending application Ser. No. 549,114 and particularly when plates are assembled so that side radiations R4 are used both for overheating the immediate adjacent area and the opposite angle plate turned around so that radiation R4 bearing surfaces of one plate face similar radiation-bearing surfaces of the other, for mutual activation. The right hand of the plate of FIG. 3 shows a plate in which only one side carries a saw-tooth pattern, the axes of the passages being gradually longer, but the pattern being intensely radiant, the combustion taking place substantially at a depth below the surface gradually lower as shown in B, B, etc., in passages 6, 7 and 8, the heat flow in 6 being the greatest since the friction losses with the shorter passage walls are lower; at the same time, the overheating of wall 9 in the path of the flame issued from the shorter passages forces the combustion of the mix at a greater distance from the surface.

FIG. 4 shows a plate 10 having a distinct pattern on each face. On face L1 and to the depth L4 there are either enclosed cavities, or separated pyramids of which the repeat pattern encompass each at least three

rows of passages in more than one cross plate direction. On face L2 and to depth L3, there are parallel slots encompassing two rows of passages.

At the right of FIG. 4 there is described with great cross scale amplification the condition of the punches at the end of a run of 5,000 to over 10,000 plates.

At the beginning of the run, samples are furnished from nearly new needle punches which, except for the small end cones, are substantially cylindrical. As a result the holes at level L2 have very substantially the same diameter as $d1$ at level L1. Since the needle punches in the ceramic mass have a tendency to bend, their interpenetration in the guiding counter-plate to set them straight causes a substantial side effort against the sides of the hardened die plate guiding holes and this occurring in the presence of abrasive media, gives to the extremity of the punch needle an olive end form which is accentuated to give a profile somewhat like P1.

As a result, when the face at the level L1 is a flat straight one, the visible diameter is not any more $d1$ but it is restricted to $d2$ with a depleted gas flow. The drastic fall evidenced in the Partiot scale is still more evident in the compounded effect on temperatures at the outlets of such passages made by worn pins while all pins are not wearing out evenly.

The established remedy consists in grinding the backface of the plate by removing various layers from L2 to L3, a procedure which again gives plates of uneven thickness and flow in the same lot. The wear from diameter $d1$ is considered as relatively unimportant between L1 and L3, except in lots reaching over forty thousand plates.

My invention consists in providing a side entry to the incoming gas mixture by providing a side cut or a slotting, centered, or not centered as shown in FIG. 4 by which the gas mixture is allowed to reach substantially in unrestricted flow the level L3 at which the passage diameter $d2$ is practically nearly the same as at level L1. Conversely, the gas mixture can also be fed through the plate so that the combustion outlet is at the die pin worn end of the plate.

As a result, the fundamental necessities of a proper maintenance of the heat flow and thruput in a large lot of radiant plates will impose that the portion of the needle punch that is wearing the fastest, meaning the tip end of it, should preferably be guided not by a flat counter plate, but by one bearing a surface design whose indentations reach farther than the normal zone of accelerated wear of said needle punch.

Therefore, in the manufacture of the plate, regardless of whether the face at level L1 is flat or indented, the face at level L2 L3 should be indented to provide additional free passage to the flow of gas mix, up to the L3 level within the plate.

As a further optional angle to the invention, and contrary to the generally accepted practice, the flow of gas in any plate flat on one side only should be preferably in the direction of the penetration of the guided punch. In this fashion, the indentations at level L2 L3 are the indentations whose intervening raised surfaces carry a more evenly distributed radiation of a more constantly regular radiation temperature and output, and face L2 L3 is turned up in the burner, the opposite side facing the inside of the burner plenum.

Examples of surface patterns are shown in FIGS. 7 and 8; the patterns are provided to radiate evenly in all directions around normal to the plate and are described as diffusing plates.

FIG. 5 is a griddlecake type of plate in which the locus of the indentations in one face coincide with indentations 12 on the opposite face, so resulting in small dimensioned thin plates 13 offering but small resistance to the gas flow.

The thin plates are supported by a parallel, hexagonal, or criss-cross, web of ribs 14 which may or may not be perforated throughout. Passages 15 are shown in the ribs of FIG. 5 and said passages being longer than in the plate 13 are preferably of a larger diameter, while smaller diameter passages are recommended for the thinner sections of the overall plate. Ribs 16 surround the plate at least in part, so that the passages at close proximity to the burner body receive a free flow.

FIG. 6 shows the perspective of an oblong reversible plate having a multiplicity of through passages from the front to the rear and with the opposite faces bearing the indented imprints in parallel grooves following on the one face the direction of the axis of symmetry XX, while the parallel grooves on the opposite face follow the direction of the cross axis of symmetry YY. Such plates are called directional, since the side wall radiations are polarized at their maximum in planes generally perpendicular to the direction of the rows at the expense of radiations in planes parallel to said rows.

The so-called directional plates are preferred in the case where a maximum of the radiations are required to be sent in a beam, as is described in my V-burner patent. In particular, the saw tooth non symmetrical directional design is preferred in burners described in my former application Ser. No. 430,129, refiled under Ser. No. 549,114.

Reversible plates can be made with a directional pattern on one face, and a diffusing design on the opposite face, or with the same pattern on both faces, without any obligation that the location of the two patterns be the same in the same plate, the common requirements to all of the described plates being that the narrowing part of the punch profile intersects for at least a portion of the passage perimenter the bottom of one or the other design for a large plurality of the passages.

FIGS. 7 and 8 show shaded surface patterns in which respectively one-half and two-thirds of the passages correspond to this requirement and the bottom line level H runs in both FIG. 7 and 8 as hexagons. The opposite non-radiant face needs not have a pattern so long as the radiant face design shows passages interspersed by shorter passages immediately adjacent to them.

In FIGS. 7 and 8, the shaded parts are at a level below the outermost upper plate surface thereby corresponding to level L2 of FIG. 1 L2 while the bottom lines H run at a still lower level of the plate similarly corresponding to level L3 of FIG. 1. The immediate proximity of several deep cut passages adjacent to the ones reaching the outer surface makes less perceptible

the apparent loss of flow in the passages ending in the shaded parts.

Regarding FIG. 9, it must be said that the Partiot scale runs true for predetermined percentages of aggregate porting areas, the diameter and length of the passages, the gravity, nature, pressure and temperature of the gas mix, and the condition of the inner passage wall surfaces remaining the same.

The plate designs can be further devised so as to obtain by various means a selective directional effect for different infrared wavelengths by a combination of local heat control, and by appropriate coatings in preselected areas which can for instance change a part of the radiant emission of radiations from a short wavelength to contain a greater amount of longer wavelengths.

By applying such coatings, the useless emission of visible rays can be limited to a certain extent.

The invention applies to all types of plates having at least on one of its faces a repeat pattern of indentations and raised areas whether in line, circular, square, oblong, hexagonal or any other form and shape and as a combination of one or more of these patterns, the indentations being from about one-half millimeter to about 3 millimeters deep, or more for a griddlecake or a pyramidal or cone surface pattern. It also includes all forms of slots, cavities or indentations described, suggested or claimed in any one of my prior patents and patent applications.

While there have been described above what are now believed to be 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.

I therefore claim :

1. A method of manufacture of a ceramic plate for use in an infrared gas heater, said plate having an oblong shape and being formed of an abrasive ceramic material and having a multiplicity of through passages for conducting a combustible gas mixture between its opposite faces for combustion at a radiant face thereof, said method comprising in combination the steps of, molding said plate in said oblong shape from said abrasive ceramic material, forcing a multiplicity of pins through said material from one of said faces toward and through the opposite face, guiding the tips of said pins adjacent said opposite face into respective apertures of a die plate and forming in said opposite surface of said plate a plurality of indentations which intersect at least some of said through passages at an acute angle to their axes and to a depth greater than the depth of wear of the said pins adjacent their tips to thereby cut away a portion of the ends of said through passages which may be formed by the abraded ends of said pin so as to form an effective increase in the opening of said passages which at least partially compensates for the partial obturation resulting from pin wear.

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