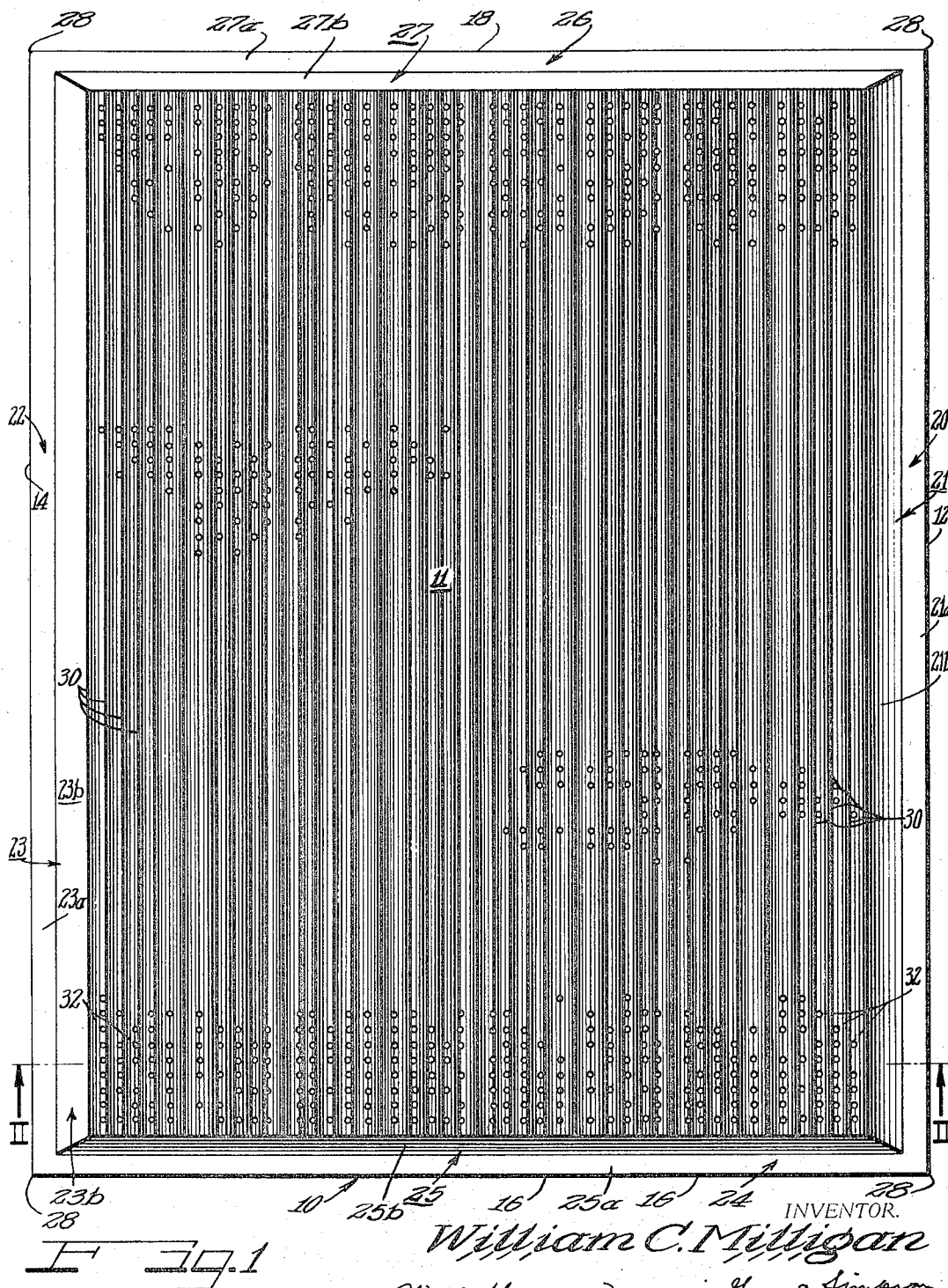


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ATTORNEYS

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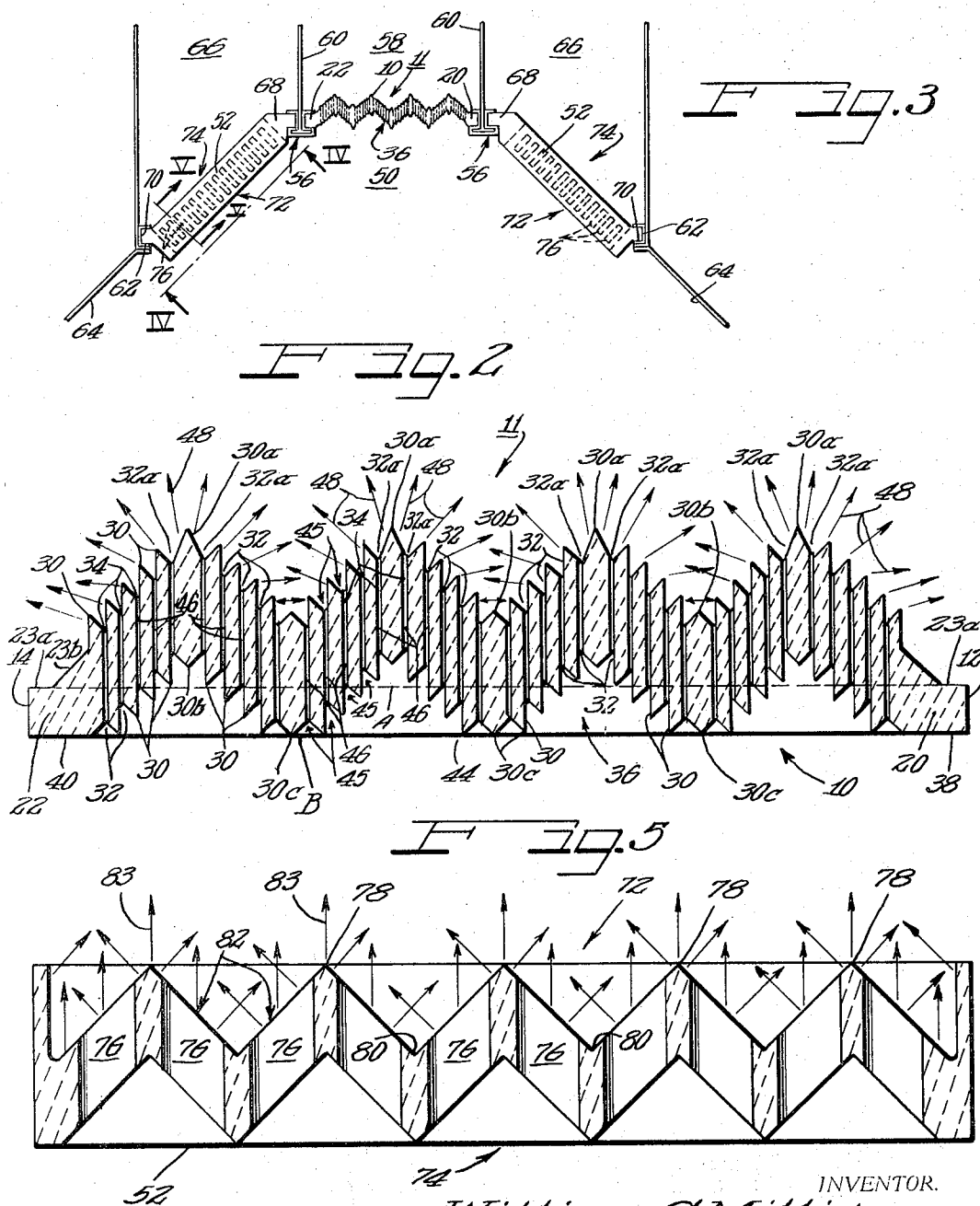
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BURNER ELEMENTS

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3 Sheets-Sheet 2



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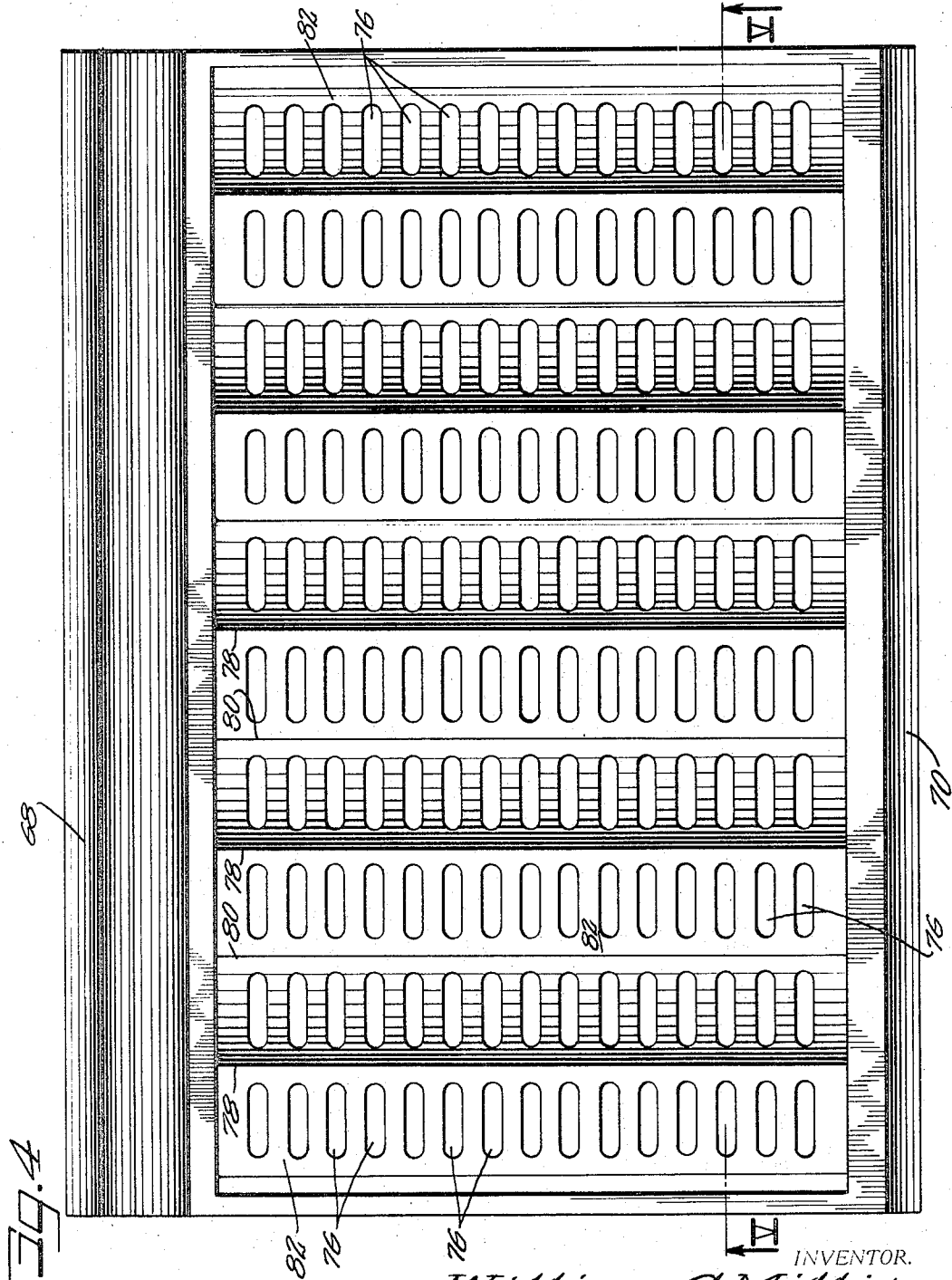
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BURNER ELEMENTS

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BURNER ELEMENTS

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The present invention relates to novel and efficient infrared radiant burner elements for use in gaseous fueled combustion heaters and is specifically related to unitary ceramic infrared burner elements of a novel and advantageous configuration.

Many attempts have been made by manufacturers and users of radiant heating burner elements to increase the total radiant output of these elements. Some heating elements have employed metallic screens or grids, positioned before the burning surfaces of the radiant heating elements to increase the radiant energy output. These metallic elements are relatively expensive and, because they deteriorate quickly under the required high temperature conditions, limit the burner element service life.

Conventional ceramic heating elements have limitations on the surface temperature at which they may operate. For fixed dimensions of gas passage holes, the burning surface may not exceed a certain temperature without causing "flash-back," a propagation of combustion back through the element into the plenum chamber. As this chamber contains a quantity of fuel and oxygen under pressure and in combustible proportions, a dangerous explosion can result from the "flash-back." Furthermore, the operating temperature of the burner element surfaces in contact with the plenum cannot reach the kindling temperature without likewise causing an undesirable burning or explosion within the plenum. Similarly, if the temperature adjacent to the gaseous fuel passages or holes in the element passing from the plenum to the burning surface of the element becomes too high, the fuel passing through will tend to either burn inefficiently within the passageway and possibly lead to "flash-back," or will expand unduly, causing increased back pressure. In this latter case, either the plenum chamber pressure must be raised or the hole or passage size increased. Either alternative is undesirable; the first requires additional equipment, increases the requirements for proper sealing of the plenum chamber against leakage and increases the danger and occurrences of crack-leaks in the element; and the second increases the danger of "flash-back" and results in excessive combustion during the starting and warmup period of the element. As is well known, in infrared heating, it is desirable to obtain as high a surface temperature as possible for generating a maximum of radiant heat with as small a heater as possible.

It is an object of the invention to provide a radiant heater burner element which allows higher radiating surface temperatures with less danger of "flash-back."

It is also an object of the invention to provide such an element with lower plenum pressure requirements.

It is another object of the invention to provide a radiant heating burner element which eliminates the necessity of a supplementary radiating metallic grid or other surface.

It is a primary object of the invention to provide a new and improved radiant heating burner element which can provide very large radiating surface in relation to its size and operate at exceptionally high temperatures.

It is an object of the invention to provide a radiant heating burner element which can attain high surface temperatures for a given fuel-air input and which may employ a small plenum chamber.

It is an object of the invention to provide a radiant heating element which has exceptionally high radiating efficiency in respect to a given gaseous fuel-air input.

It is an object of the invention to provide radiant heat-

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ing burner elements which can radiate heat over a very wide angle and in a uniform radiant energy pattern.

It is another object of the invention to provide a simple, compact and inexpensive radiant heating burner element.

An infrared heating burner element constructed in accordance with the invention comprises a unitary structure of ceramic material having an input surface and output surface of a sawtooth shape and is constructed from ceramic material which is gas permeable between the input surface and the output surface of the element.

The organization and manner of operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which an exemplification of the invention is illustrated.

FIG. 1 is a plan view of the burning surface side of a radiant heating burner element incorporating the principles of the present invention;

FIG. 2 is a sectional side elevational view of the burner element of FIG. 1 as seen from the line II—II of that figure;

FIG. 3 is an end view of an overhead radiant space heater assembly incorporating the burner element of FIGS. 1 and 2, and further incorporating a second embodiment of the invention;

FIG. 4 is a plan view of the second heater element embodying the invention as seen from line IV—IV in FIG. 3; and

FIG. 5 is a side end view, partly in section, of the heater element of FIGS. 3 and 4 as seen from line V—V of FIGS. 3 and 4.

Referring to FIG. 1, there is depicted as a catalytic ceramic infrared heating burner element constructed in accordance with the invention and generally indicated by the numeral 10. The element 10 is of generally rectangular shape and the major portion of the upper surface area of the element 10 comprises a burning surface 11 of unique design. The outer perimeter of the element 10 is formed by a pair of longitudinal edge walls 12 and 14 and a second pair of transverse edge walls 16 and 18. The longitudinal edge walls 12 and 14 form respectively the outermost edges of a pair of supporting edge flanges 20 and 22 having bi-planar upper surfaces 21 and 23 extending from the burning surface 11 to the edge walls 12 and 14. Likewise, the transverse edge walls 16 and 18 bound the outermost extension of a pair of flanges 24 and 26, respectively having a bi-planar upper surfaces 25, 27 extending from the surface 11. Each of the upper surfaces 21, 23, 25 and 27 of the flanges 20, 22, 24, 26, comprises a flat outer planar surfaces 21a, 23a, 25a, 27a juxtaposed along the respective edge walls 12, 14, 16, 18 and an inner planar surfaces 21b, 23b, 25b, 27b adjacent but canted upward from the respective outer surfaces 21a, 23a, 25a, 27a to the burning surface 11 of the element 10. The flanges 20, 22, 24, 26 join at the corners 28 of the ceramic element 10 and have their outer upper surfaces 21a, 23a, 25a, 27a lying within the same plane to form a rectangular brim-like extension about the firing surface 11 of the element 10. The firing surface 11 comprises a plurality of elongated longitudinal ridges 30 parallel to the longitudinal edge walls 12 and 14. Furthermore, the surface 11 comprises a plurality of longitudinal valleys 32 between the ridges 30 likewise parallel to the edge walls 12 and 14 of the element 10.

As may best be seen in FIG. 2, the height of the various ridges 30 and valleys 32 above the plane formed by the outer upper surfaces 21a, 23a, 25a and 27a, generally indicated by the letter A, varies transversely across the element 10. The ridges 30 and valleys 32 rise and fall in

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periodic succession to give burning surface 11 an overall generally serrated sawtooth shape. In the particular depicted burner element 10, a succession of four equally sized ridges 30 and valleys 32, each rising an equal amount above the preceding ridge 30 and valley 32, has the highest ridge 30 of the four followed by a wider valley 32a and an equally acute but broader and larger particular ridge 30a which rises above the other ridges 30. Across this highest ridge 30a is another wide valley 32a of the same elevation above the plane A as its twin across the ridge 30a. This valley 32a is followed by four descending ridges 30 and valleys 32. Immediately adjacent to the lowermost valley 32 of each set is a twin valley 32 which is part of a second set of rising vales and ridges 32, 30. Separating the pair of adjacent lower valleys 32 is a relatively thick and less acute ridge 30b. In the illustrated embodiment, the rising and falling sets of ridges 30 and valleys 32 repeats four times transversely across the burning surface 11 to provide four equally spaced parallel major ridges 30a and three minor ridges 30b equidistant between the adjacent ridges 30a. The outermost major ridges 30a, nearest the flanges 20 and 22, have a set of five ridges 30, with four valleys 32 between, dropping downward toward the plane A. The outermost of the ridges 30 meet, respectively, the rising canted portions 21b, 23b of the upper surfaces 21, 23 of the longitudinal supporting flanges 20, 22.

In the illustrative element 10, the surface 11 has an overall configuration of regular serrations which rise and fall such that the lowest points or lines 34 of a rising set of valleys 32 between the ridges 30 define planes canted to reference plane A at an angle of approximately 45° and to the intersecting planes of an adjacent set of valleys 32 at an angle of approximately 90°. The canted flange surfaces 21b and 23b also rise at an angle of approximately 45° to the plane A to merge with and meet contiguously with the plane defined by the lowest points 34 of the respective sets of valleys 32 descending to meet the flange surfaces 21 and 23.

The underside of the element 10 comprises an input surface 36 which is preferably constructed to be somewhat complementary in shape, but displaced below, the burning surface 11. The under flange surfaces 38, 40 of the longitudinal supporting flanges 20, 22 and the under surface 44 of the transverse supporting flanges 24, 26 join at the corners 28 and lie in a common plane, generally designated B, which is parallel to and spaced below the plane A.

The input surface 36 may be made generally sawtooth shaped and complementary to the overall shape of the surface 11, but without longitudinal valleys and ridges. However, for greater versatility and interchangeability, the element 10 is constructed with the surface 36 having a plurality of such ridges and valleys again designated, respectively, 30 and 32. The surface 36 differs from that of the surface 11 in that its ridges 30 point in and its valleys 32 open to the opposite direction; in that the peaks or downward pointing tips of the ridges 30 are all equal to or above the elevation of the plane B; and in that the ridge 30c between the lowermost valleys 32 of the descending sets of four ridges 30 and valleys 32 is less acute than the ridges 30 and descends only to the same level as does its adjacent ridges 30. The highest ridge of the surface 36, corresponding to the lowest ridge 30b of the surface 11 is equally acute and broad and has been therefore also labeled 30b.

Passing between an opening or port 45 of each of the inverted valleys 32 of the input surface 36 to another port 45 at the valleys 32 of the burning surface 11 is a plurality of small passageways 46. These passages or channels 46 render the element 10 porous in that they allow the passage of a flammable gaseous fuel between the surface 36 when the element 10 is in use. A series of such fuel channels 46 extends the length of each of the valleys 32. The gaseous fuel is normally burned at the burning sur-

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face 11 of the element 10 to heat, primarily via infrared radiation, the area in front of the surface 11. The radiation generated by combustion of a gaseous fuel with the element 10 is schematically indicated by the arrows 48 radiating from the surface 11.

Referring now to FIG. 3, there is depicted one application of the burner element of the present invention, an overhead gas fueled radiant space heater 50 incorporating the ceramic burner element 10 and a second ceramic burner element 52 which is also constructed in accordance with the present invention. The burner element 10 is mounted in the heater 50 with its surface 36, designated the "input" surface above, serving as the surface for burning the gaseous fuel and its surface 11, designated above as the "burning" surface, serving as the fuel supply or input surface. This reversibility is an advantage of the preferred element 10 which allows for an increased service life and selectivity in radiation patterns.

The burner element 10 is secured in a horizontal plane by a set of surrounding fixed flange support braces generally indicated at 56. The braces 56 may be of entirely conventional construction and preferably embrace in sealing contact the element 10 completely about its periphery. The details of the construction of the braces 56 will not be further described as they are not necessary for a proper understanding of the present invention. The braces 56 are affixed to the brim or supporting flanges 20, 22, 24, 26 of the element 10 and serve to seal the burning surface 36 from contact with a plenum or pressurized gaseous fuel chamber 58 formed above the element 10 by an enclosure including sheet metal walls 60.

Also partly supported by the braces 56 is a pair of exhaust burner elements 52 constructed in accordance with the invention. The elements 52 flank the element 10 on opposite longitudinal edges and extend outward and downward from the element 10 in a manner not unlike a picture box frame. At the longitudinal sides away from and below the braces 56, the exhaust elements 52 are supported by another set of longitudinal braces 62 which may also be entirely conventional. Also affixed to the braces 62 is the conventional reflector shield 64 which continues away from the exhaust elements 52 in approximately the same plane as the elements 52.

Above each of the exhaust burner elements 52 is a duct or chamber 66 for conducting spent exhaust gas away from the elements 52. The duct 66 may be exposed to the local environment or preferably, especially when the heater 50 is installed in an enclosure, vented away.

The burner elements 52 have a pair of longitudinal edge flanges 68 and 70, not unlike the longitudinal edge flanges 20 and 22 of the element 10. The longitudinal edge flanges 68 and 70 are seated for support, respectively, within the braces 56 and 62. The element 52 has a generally sawtooth-shape exhaust gas input surface 72 and oppositely disposed exhaust gas output surface 74 which is preferably also of a generally sawtooth shape. Between the input surface 72 and the output surface 74 are provided a plurality of exhaust gas passages or slits 76 which are shown in dashed outline in FIG. 3.

The general shape of the input surface 72 and exhaust gas slits 76 is best shown in FIG. 4. Referring to that figure, it can be seen that the passages or slits 76 extend parallel to the longitudinal edge flanges 68 and 70 and also perpendicular to and between transverse ridge lines 78 and valley lines 80. The passages 76 are located at spaced intervals along sloped planar surfaces 82 between the ridge and valley lines 78 and 80 of the surface 76.

As may best be seen in FIG. 5, the oppositely disposed output surface 74 is also of a generally sawtooth configuration and is somewhat complementary to the input surface 72.

The exhaust burner element 52 serves to raise the heating efficiency of the burner space heater 50 by extracting additional radiant heat energy from the hot ex-

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haust gases that result from the combustion upon the surface 36 of the element 10. The radiant heat from the element 52 is schematically represented by the arrows 83 in FIG. 5.

The burner elements 10 and 52 should preferably be constructed from ceramic materials as taught in the present inventor's co-pending application entitled "Catalytic Infrared Heating Device," Ser. No. 246,761, filed Dec. 24, 1962 and now abandoned, in which case much less active catalytic material can be used for the heater elements than has heretofore been considered necessary. In fact, the principal constituent of the ceramic catalytic unit of the invention can be composed of inexpensive materials such as clays of the kaolin, ball or talc type. These clays can be used in various combinations to obtain easy workability, plasticity, and strength without affecting the catalytic properties desired. Also, they may be fired at various temperatures to obtain suitable strength properties. In order to minimize the amount of vitrification which would occur on firing, it may be desirable to add stabilizers such as alumina or zirconia to the clay material before firing.

When used in cooperation with a suitable fuel supply chamber, such as chamber 58 of the burner 50, to supply fuel through the gas passages or channels 46, it has been found that the surface used for burning will very quickly reach, after ignition, an exceptionally high temperature for the input ratio of fuel to air and will exhibit radiating patterns as shown by the individual arrows 48 of FIG. 2. The output radiation obtained will cover a wide area with a very nearly uniform radiation pattern. This multiple ridged design will supply a substantial quantity of radiation between the oppositely disposed sets of ridges 30 between the adjacent high ridges 30a and the low ridge 30b. Since the ridges 30 are very close to each other, the multiple feedback between them and the rising sets of ridges provide very high radiating surface temperatures. It will accomplish this end without increase in the possibility of "flash-back" of the flame from the burning surface 11 to the gas chamber.

The multiple ridge arrangement of the burning surface 11 is a simple, inexpensive and effective method of obtaining substantially high radiant energy output for a given fuel input. When desired, the elements may include only a single narrow strip comprising only a V-shaped section of the element 10. This construction is economical and simple to achieve and is very useful for providing burner elements for strip heaters which are used for heating nearby areas at a relatively low height. The construction has the advantage of providing the desired heat while not overheating nearby objects. Even the single V arrangement has been found to provide both a wide radiation pattern and high ridged surface temperatures with efficient fuel-air ratio inputs.

The small ridges 30 on the radiating surface 11 may have other configurations than that shown, but are preferably made of a thin longitudinal planar surface at approximately a 90° angle to the reference plane A adjacent to a second such surface set at a 45° angle to plane A. The ridges 30 may be semi-circular or even flat between the gas channels 46. However, a considerable reduction in total surface area will occur if the ridges 30 are eliminated and the total peak temperature obtainable without danger of "flash-back" will be substantially reduced. The construction described reduces the radiation reaching into the ports 45 and the gas channels 46 and therefore materially decreases the possibility of overheating and the resultant "flash-back" of flame to the chamber 58. Such a "flash-back" can be extremely dangerous and can result in an explosion, destroying the heater 50—or worse. Although the ridges 30 can be eliminated on the input surface 36 without appreciable effects on the performance, they also assist the entrance of the fuel-air mixture into the gas channels and reduce the back pressure effect at the input surface of the ceramic

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element 10 to a negligible amount. However, for reasons of simplicity in molding or grinding the surfaces involved, the ridges 30 on the input surface 36 may be eliminated without any serious effect on the overall performance of the radiating surfaces or excessive back pressure effects on the fuel-air mixture. But in this case, the interchangeability of the surfaces (as when used in the arrangement of FIG. 3) and the consequential choice of radiating patterns is eliminated.

A compound ridged burner element 10 of the type shown in FIGS. 1 and 2 was constructed having dimensions of 10 inches along its longitudinal edges 12, 14 by 6½ inches along its transverse edges 16, 18 and had the following dimensions. The burning surface 11 was constructed with 41 ridges, 40 rows of holes, and with 100 holes per row, with a resulting surface area of 179.37 square inch or 1.247 square feet. The planar surfaces comprising the ordinary ridges 30 had a transverse dimension of 0.2500 inch and 0.2187 inch. The transverse dimensions of the planar surfaces forming the ridge 30a were 0.3125 inch and the same dimension for the planar surfaces of the ridge 30b were 0.1875 inch. Furthermore, with holes 0.064 inch in diameter spaced ⅓ inch apart from center hole to center hole, the element contained 4000 holes with a total hole area of 12.88 square inches. The percent of hole area to the combustion area is 6.68%.

A standard conventional burner element may have 200 holes per square inch with each hole being 0.050 inch in diameter. Such an element of comparable dimensions and occupying the same space of 10 inches x 6½ inches or 65 square inches has a hole or passage area for its 13,000 holes of 25.5 square inches. The resulting total radiating area is 39.5 square inches, as compared to 179.37 square inches of a similarly sized element constructed in accordance with the present invention.

The sawtooth exhaust burner element 52 is constructed without the ridges 30 and with larger passages 72. The ridges 30 are not as desirable in an element used for extracting heat from the hot exhaust gases as the possibility of "flash-back" does not, normally, exist. The size of the passages 72 is considerably larger and forms a greater part of the surface area of the element 52 than was the case of the passages 46 of the element 10 because of the greater volume of gas to be handled by the exhaust units. The exhaust gases are of a considerably greater volume, of course, than the gaseous fuel because of their higher temperature resulting from the combustion at the burning surface of the element 10.

The use of the surface segments 82 set at an angle of approximately 90° to adjacent segment 82 has the effect of materially raising the temperature of the entire surface 72 because of inter-facial irradiation.

The higher surface temperature at the exhaust gas exit passages 72 increases the efficiency of the heater 50 by the extraction of additional energy from the hot exhaust gases by absorption and by causing combustion of any unburned fuel carried with the exhaust gases. The exhaust elements 52 when embodied in a heater such as the heater 50 will normally obtain, in operation, a temperature of only 100° to 200° F. below that of the combustion surface of the burner element 10 and can increase the useful thermal energy output of such a heater by as much as 30%.

As is now apparent there have been described two embodiments of a novel and improved burner element which is simple, compact and inexpensive to manufacture. The described burner element when used as a combustion or firing element, is capable of operation at high temperatures without the use of supplemental radiating grilles or the occurrence of flash-back. The described burner elements provide exceptionally high radiating efficiency with respect to the gaseous fuel-air input and allow for the direction of radiant heat over a wide angle with an even energy pattern.

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It will be understood that various modifications may be suggested by the embodiment disclosed, but I desire to claim within the scope of the patent warranted hereon all such modifications as come within the scope of my invention.

I claim as my invention:

1. An infrared radiant heating burner element for use in a gas fueled space heater comprising a rectangularly shaped unitary catalytic ceramic structure having an outer rectangular perimeter defined by a support flange having an outer edge wall and two oppositely disposed upper and lower flange surfaces, at least part of one said flange surfaces defining a reference plane generally parallel to said rectangularly shaped structure, said structure including a firing surface comprising a transverse succession of juxtaposed longitudinal ridges each of which is defined by a pair of angularly related generally rectangular planar ridge surfaces, one of said pair of ridge surfaces defining with one of the pair of ridge surfaces of the juxtaposed successive longitudinal ridge one of a succession of inter-disposed longitudinal valleys, said successive ridges and said valleys being defined in first groups of successively rising elevation relative to said reference plane, followed by second groups of successively falling elevation relative to said reference plane to obtain a serrated sawtooth cross-sectional shape, a rectangular gas input surface oppositely disposed to said firing surface and generally of a sawtooth cross-section shaped similarly to said firing surface, spaced gas inlet means extending into said valleys for de-

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livering gaseous fuel to said firing surface, and means for supplying gaseous fuel to said spaced gas inlet means.

2. An infrared radiant heating burner element in accordance with claim 1 in which said input surface is similarly composed of a succession of ridges, is of a serrated sawtooth cross-sectional shape and is shaped similarly to said firing surface.

3. An infrared radiant heating element in accordance with claim 2 in which said succession of ridges and valleys is periodic transversely across said surfaces.

4. An infrared heating element in accordance with claim 3 in which said periodic succession of ridges defines a general sawtooth cross-section in which each group of successive ridges rises or falls at approximately an angle of 45° to the reference plane and in which the majority of said ridge surfaces are at angles of approximately 90° and 45° to said reference plane.

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