March 7, 1967 T. N. STACK 3,307,612

CONVERGENT-STREAM GRID-TYPE GAS BURNER

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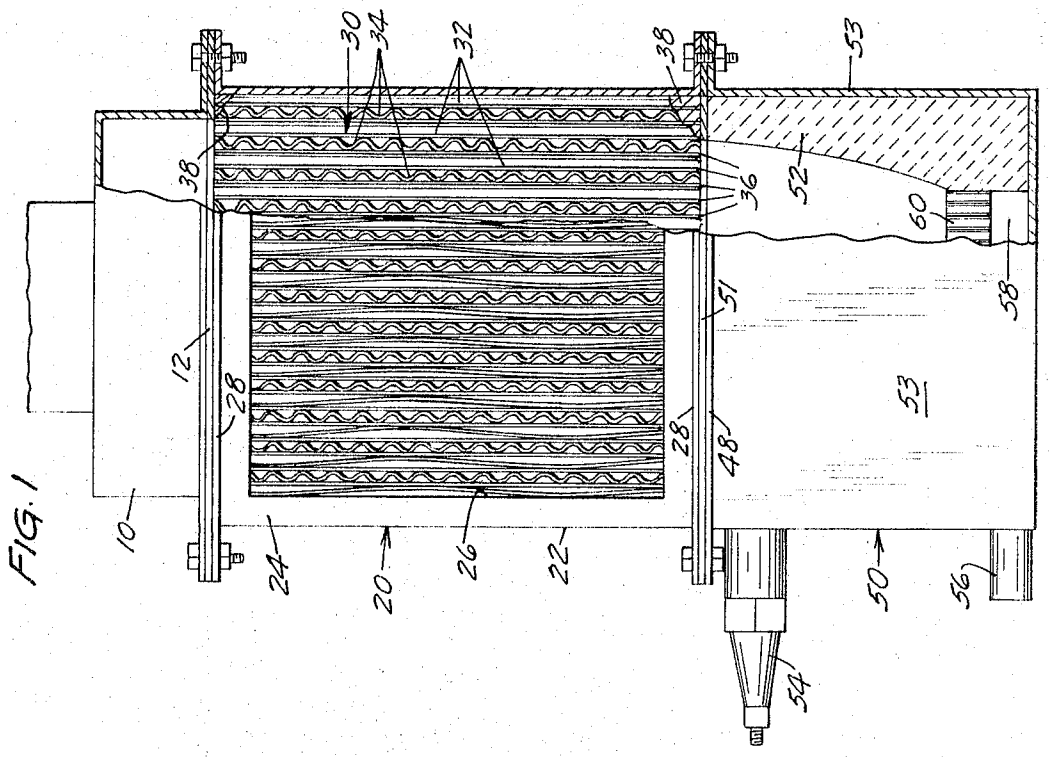


FIG. 1

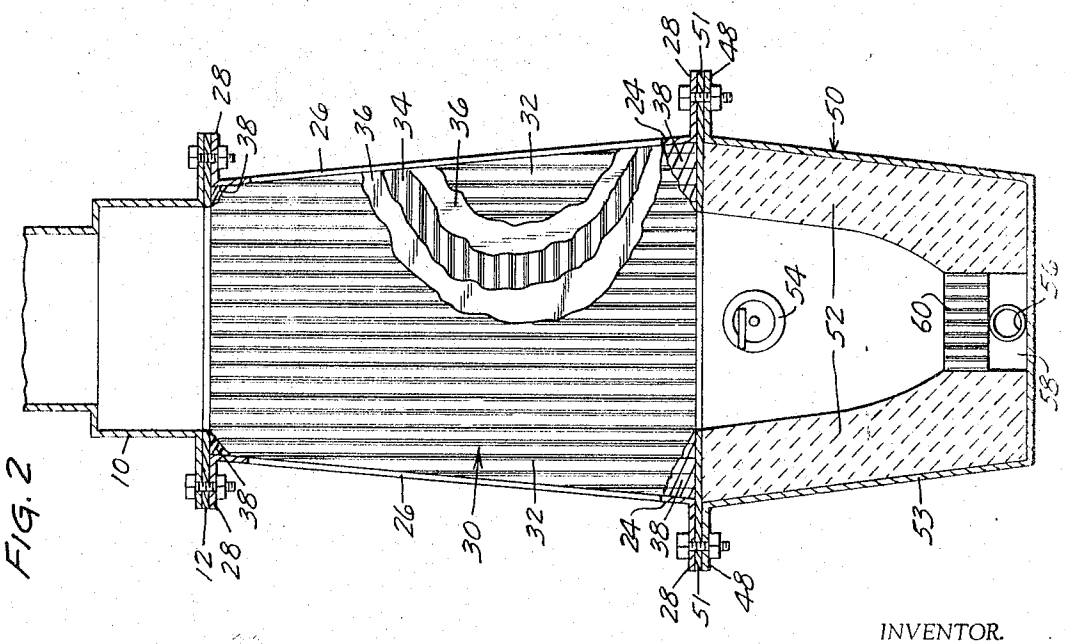


FIG. 2

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FIG. 3

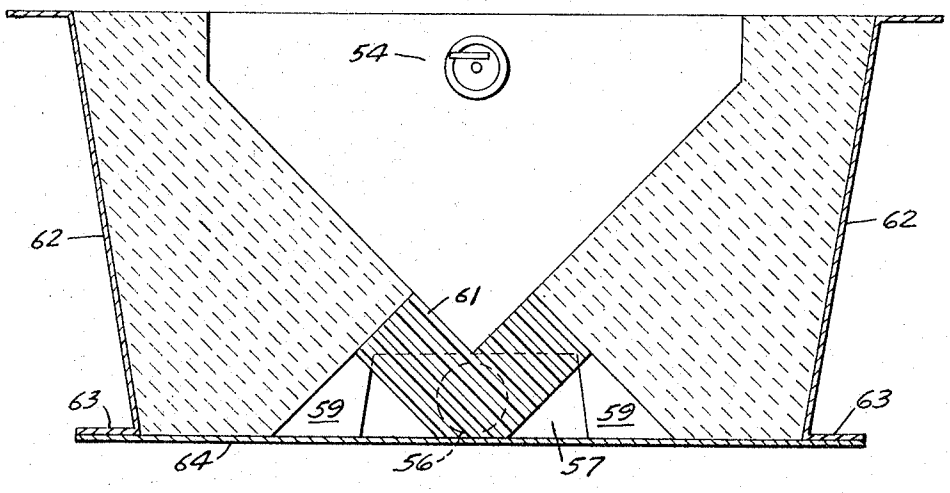


FIG. 4

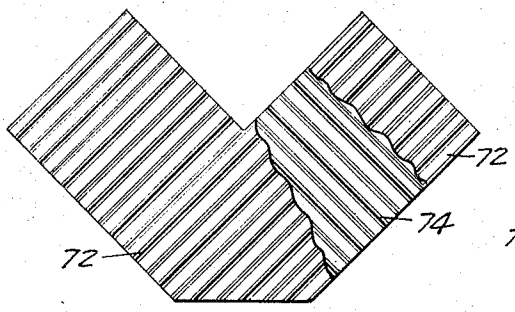


FIG. 5

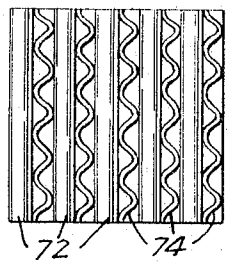


FIG. 7

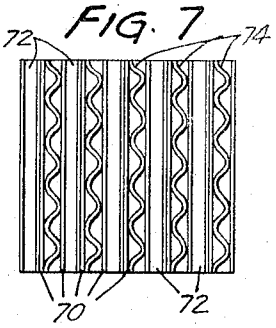
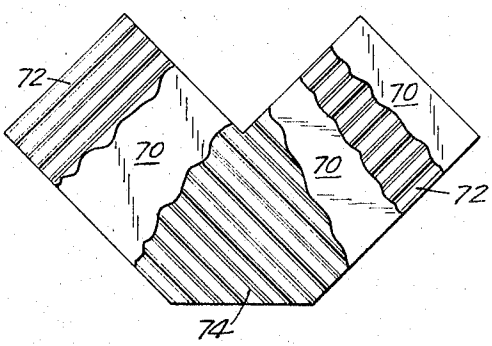


FIG. 6



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FIG. 9

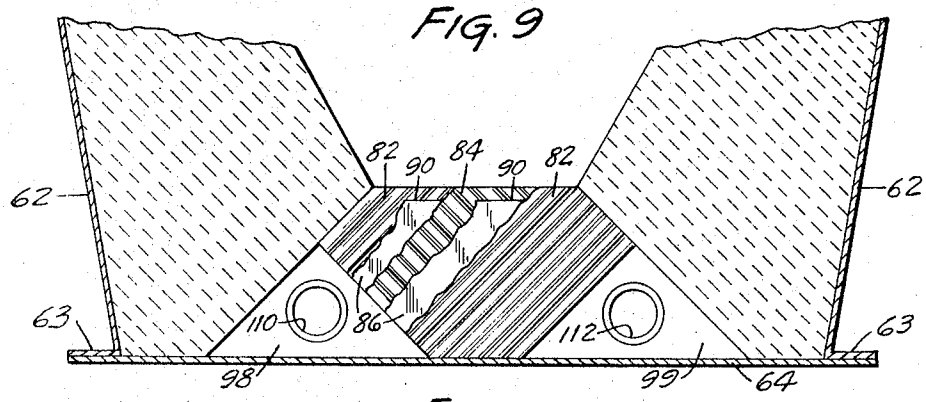


FIG. 10

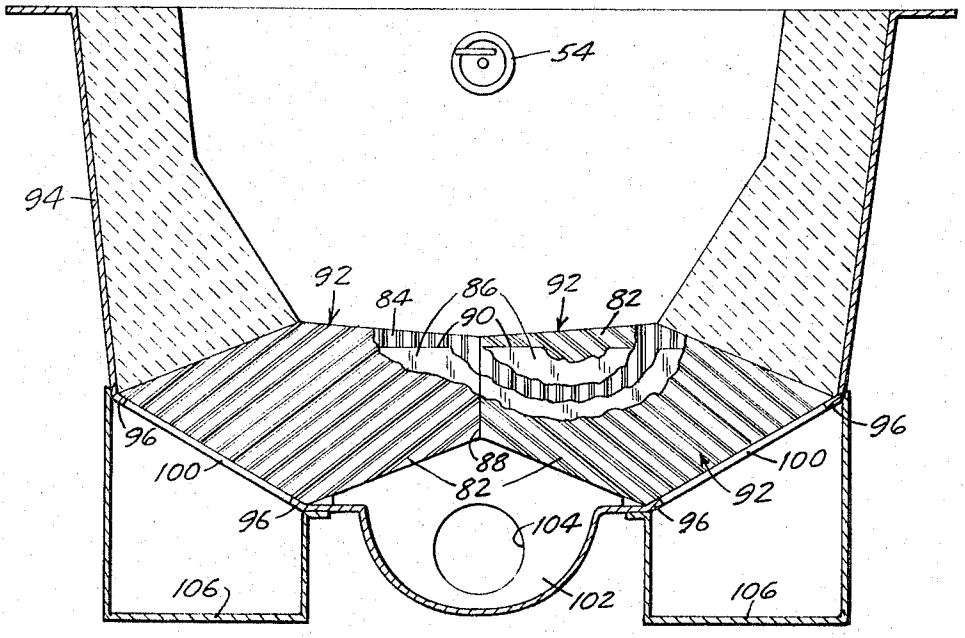
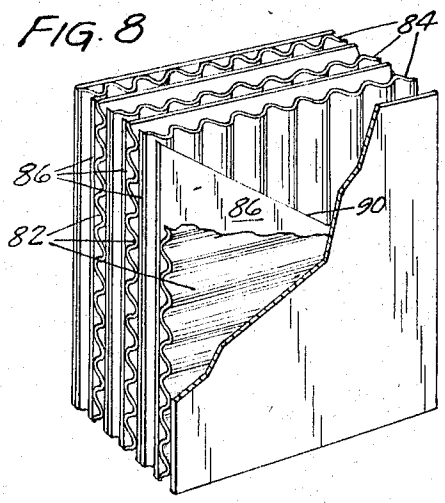


FIG. 8



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3,307,612

CONVERGENT-STREAM GRID-TYPE GAS BURNER

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Filed Apr. 6, 1964, Ser. No. 357,591
7 Claims. (Cl. 158—99)

The invention relates to a convergent-stream grid-type burner for use with a space heater of relatively compact size, employing wedge-shaped ceramic heat exchangers.

Another object of this invention is to provide burners for combustible mixtures of improved design. A further object of this invention is to provide burners of improved design in which fuel and oxidant are mixed immediately before combustion and which are flash-back-proof. A further object of this invention is to provide a milieu for the reaction of reactants in which mixing is provided immediately before reaction. Yet another object of this invention is to provide flash-back-proof radiant burners of novel construction. Other objects will become apparent from the reading of my present disclosure.

Further consideration of the invention will be more clearly understood by reference to the accompanying drawings wherein:

FIGURE 1 is a side elevation to reduced scale of a space heater of the invention partially broken away to a vertical section.

FIGURE 2 is a cross-section of a space heater of the invention along line **2—2** of FIGURE 1 and is also to a reduced scale.

FIGURE 3 is a convergent-stream burner adapted for use in a space heater of the invention.

FIGURE 4 is a grid without flat separator sheets for use in the burner of FIGURE 3.

FIGURE 5 is an end view of a portion of one leg of the grid of FIGURE 4.

FIGURE 6 is a grid with flat separator sheets for use in the burner of FIGURE 3.

FIGURE 7 is an end view of a portion of one leg of the grid of FIGURE 6.

FIGURE 8 is a broken away perspective view of mixing grid adaptable to use in burners of the invention.

FIGURE 9 is a flash-back-proof mixing burner of the invention adapted for use in the space heater of the invention shown in FIGURES 1 and 2 shown with the upper portion broken away.

FIGURE 10 is another flash-back-proof mixing burner of the invention adapted for use in the space heater of the invention shown in FIGURES 1 and 2.

Referring now to the details of the figures, wherein identical parts bear the same indicia, it will be seen that the space heater of FIGURES 1 and 2 consists of three parts, a flue gas manifold **10**, a heat exchanger assembly **20** and a burner assembly **50**. The flue gas manifold **10** may be of any convenient type for adaptation of the heat-exchanger assembly to suitable venting equipment (not shown) which desirably incorporates means such as a suction fan for overcoming back pressure from the heat-exchanger.

The heat-exchanger assembly **20** comprises an outer casing **22** having an opening at the top to the flue gas assembly, at the bottom to the burner and on the front and back faces. The ends are closed. The opening on the front face is seen in FIGURE 1 to be smaller in area than the surface of ceramic heat-exchanger **30** so that rim means, a relatively narrow engagement face **24**, is provided around the edge of opening **26** as is also to be noted in the cross-sectional view of FIGURE 2. At least one of the open faces of casing **22** tapers inward toward

the top at an angle of about 5° to 12° (both are shown thus tapered in FIGURE 2).

Heat-exchanger **30** is constructed of refractory materials, very suitably zircon-mullite, petalite-silica or the like, and is pressed into casing **22** with sufficient force that it frictionally engages with engagement face **24** around both faces. It will be evident that the inner surfaces of casing **22** must be finished to a sufficient degree to avoid irregularities such as welds, blisters, bumps, etc. which might prevent proper engagement or might gouge the faces of heat-exchanger **30**. Heat-exchanger **30** is constructed to be slightly oversize and the faces are then finished to the proper taper by sanding, or other procedure as will be evident to those skilled in the art, and the heat-exchanger is forced into casing **22** avoiding so much force as would crush the ceramic of the heat-exchanger. The upper and lower faces are then finished flush with the flanges **28** of casing **22**. Frictional engagement is sufficient to retain heat-exchanger **30** within the casing **22** and to maintain substantially gas-tight dihedral sealing at the angles between the faces and the top and bottom respectively throughout any operating cycle. A small amount of grouting may be employed around the edges if desired but is not necessary when the heat-exchanger assembly is carefully constructed in accordance with my teachings.

Heat-exchanger assemblies of the invention may be constructed in which the length is up to about twice the height, say about one foot long, either by employing two heat-exchangers of the type shown in FIGURES 1 and 2 or one larger heat-exchanger constructed in accordance with my teachings. Greater lengths than that, i.e. having greater heat-exchange capacity are desirably achieved by using several smaller assemblies inasmuch as the longitudinal engagement faces (e.g. those at top and bottom) become so long as to be subject to some warpage in use and gas-tight sealing is no longer possible. This results in exacerbation of deterioration and warpage.

Heat-exchanger assemblies of the invention, which may be referred to conveniently as wedge-shaped or keystone heat-exchanger assemblies, are particularly useful with burners of the type disclosed which serve as means urging the heat-exchanger into engagement with the frame. Referring again to the FIGURES 1 and 2 where a suitable burner assembly **50** is shown, it will be seen that the liner **52** of the burner is relatively thick ceramic material overlapping the edges of heat-exchanger and in cooperation with ceramic gasket or packing **51** urges or retains heat-exchanger **30** in frame **22**. Burner assembly **50** will be seen to have a metal casing **53** with flange **48** and refractory ceramic liner **52**, ignition means **54**, port **56** for admission of combustible mixture into combustible mixture plenum **58** and burner grid **60** conveniently constructed of refractory ceramic with a multiplicity of vertical passageways and cemented in place. It will be evident that the liner **52** may be rabbeted to provide a seat for burner grid **60** if desired.

Heat-exchanger **30** is constructed of refractory materials show alternation of axes of corrugation (**32** vertically corrugated, **34** horizontally corrugated) and separation of successive corrugated sheets, i.e. **32** and **34**, by flat sheets **36**. In FIGURE 1 it will be seen that peripheral vertical passageways are cut by the inclined face. The upper and lower edges of heat-exchanger **30** are shown with at least these passages plugged by filling **38**. Other means effecting blockage of peripheral channels may be employed, thus it will be seen that these passages are blocked at the top by the widened flange of flue gas manifold **10** and gasket **12** and at the bottom by burner liner **52** and gasket **51**. Cross hatching lines on thin sheets shown in section are not shown in the drawings to avoid confusion.

Referring now to FIGURES 3 to 10 inclusive, FIGURES 3, 9, and 10 show burners having particular advantages for use in conjunction with the heat-exchanger assembly shown in FIGURES 1 and 2. In each of these figures the refractory liners are designated **52** and ignition means **54**.

The burner shown in FIGURE 4 possesses an advantage in producing very turbulent burning as a result of the quasi-convergent burner grid. It will be seen that for convenience in assembly in this burner, and that of FIGURE 9, the burner casing is constructed in two parts and has collar **64**, having flange **63** which is fastened to bottom of casing **62** suitably by bolts (not shown).

Two burner grid constructions, useful in the burner of FIGURE 3 are as shown in FIGURES 4 and 6 respectively and as further shown by partial end views of legs of the grids in FIGURES 5 and 7 respectively. The grid structure shown in FIGURES 6 and 7 will be seen to consist of corrugated sheets, separated by flat sheets **70**, with axes of corrugation successively at 90° angles. The corrugated sheets are designated **72** and **74** respectively. The grids of FIGURES 3, 4, 6, 9 and 10 are elongated structures having substantially the cross-section shown at all points. The structure of the grid of FIGURE 3 provides a flashback break point, i.e. is a flame arrestor, and assures equal area for admission and release of combustible mixture from the grid inasmuch as passageways which are not open at both ends are effectively closed.

The grid structure shown in FIGURES 4 and 5 will be seen to consist of corrugated sheets **72** and **74** without interposed flat sheets. This structure also serves as a flame arrestor but additionally permits lateral movement of combustible mixture through the grid so that no passageways are blocked off and the outlet face (near which burning occurs) is smaller in area than the inlet face in the plenum. This results in somewhat greater gas velocities and greater burning turbulence.

It will be seen that in the burners illustrated by FIGURES 1 to 7 inclusive a combustible mixture is employed which is mixed before admission to the burner. In the burner of FIGURE 3 the admission port **56** is shown by broken lines. The liner portal **57**, which is an opening through the liner providing access to dual plenums **59**, is partially shown in broken lines. The exact shape of the liner portal is not important provided it does not permit direct access of combustible mixture to the burning space above the burner grid **61**.

The burners of FIGURES 9 and 10 are mixing burners which are completely proof against flash-back because the combustible mixture is only formed as it is about to be burned. These operate on the new principle which I have discovered which is explained by means of FIGURE 8. In FIGURE 8 it will be seen that courses of passageways are provided by corrugated sheets having the axes of corrugation inclined at angles to one another successively and separated by non-coextensive flat sheets having a leading edge intersecting the directions of all passageways in adjacent courses. These structures of the invention are termed generically "mixing grids." For purposes of illustration, the corrugated sheets forming parallel passageways in one direction of the mixing grid of FIGURE 8 are designated **80** and those forming passageways at an inclined angle (90° in FIGURE 8 for purposes of illustration) are designated **84**. The flat sheets are designated **86** and have a leading edge designated **90**. The structure shown in FIGURE 8 is employed for mixing fluids by providing suitable manifolding means so that one fluid enters at the bottom, and a second fluid enters at the front end. The blended mixture is removed from either or both of the top and back end of the structure as shown.

Although for purposes of illustration the simple structure shown in FIGURE 8 is approximately parallelopipedal with a portion broken away to show one diagonal i.e. leading edges, of a flat sheet, it will be understood

that I am describing a principle by which numerous small streams are brought together in intimate contact to effect blending of fluids. Expressed differently, two or more streams of fluid or flowable materials are each subdivided into multiplicities of smaller streams which are commingled and blended by turbulence of flow as the smaller streams of the respective materials merge. It will be understood that from this principle it is possible to employ courses of passageways in more than two directions so that three or more fluids may be mixed and blended. Proportioning is achieved by controlling rates of flow, sizes of passageways and by other methods which will be readily apparent to those skilled in the art. Although there appears to be no limit to the sizes of passageways which may be employed, it is generally preferable to employ relatively small passageways as provided by corrugated sheets having about 3 to about 20 corrugations per inch. These may be referred to as subinch passageways or corrugations. Viewed from another standpoint, the leading edge of the flat sheets may be considered as a foreshortened wall common to passageways running at an angle to one another in consecutive courses of passageways.

I describe a sheet such as the flat sheets which do not extend to the same forward edge as the corrugated sheets as being subextensive with the larger corrugated sheets. Other than for this outlet face of the mixing grid it will be seen that the flat sheets are coextensive with the corrugated sheets.

Structures employing this principle may be constructed of any desired material, preferably of inorganic materials such as ceramics, metals, vitreous materials and the like, and may further be made to any desired structure in accordance with the dictates of mechanical expediency.

Methods for the fabrication of sheets of ceramics as described in U.S. Patent 3,088,271 are quite suitable in the construction from ceramic of thin-sheet structures described herein including mixing grids, heat-exchangers, burner grids, etc. In forming mixing grids, the green structure may be compressed very slightly, if desired so that the forward edges of corrugated sheets make contact beyond the leading edge of the separating sheets.

It will be evident that passageways in different courses may be made of different cross-sectional areas if desired.

Returning again to the drawings, FIGURES 9 and 10 show burners employing mixing grids adapted for use as burner assemblies with the heat-exchanger assembly shown in FIGURES 1 and 2. The upper portion of FIGURE 9 may be identical to that of FIGURE 10 or may be modified as desired without departing from the scope of my invention. It will be seen that the sheets composing the mixing burner grids are designated by the same relative indicia as employed in the description of FIGURE 8 above. In FIGURE 10 it will be seen that a composite burner grid **92** is shown having left and right hand portions joining along line **88**. This line need not be an actual structural joint but provides a convenient reference line. This type of structure is readily constructed by the methods referred to hereinabove. The only feature in the construction of such a device that must be observed is that certain passageways in the courses connecting to the dual gas inlets **100** in casing **94** connect to plenum space **102** and these passageways must dead end (along joint line **88**) in passageways having the reverse inclination connected to the same plenum space. Expressed differently, passageways in one course ending beyond the leading edge of separator sheets must not connect to different plenums bearing different gas components. The vertical courses of passageways **84** in FIGURE 10 will be seen to be much smaller than the inclined passageways which connect to gas inlets **100** from manifolds **106**. The assembly is shown resting on manifolds **106** which form the legs of a horse-shoe having a common inlet. It will be apparent

that casing **94** may be attached to manifold **106** by welding or other means as desired.

The burners of FIGURES 9 and 10 may be employed independently of the heat-exchanger assemblies of FIGURES 1 and 2 as radiant burners, in which case retaining rims (not shown) are desirably attached to the upper flanges in place of the heat-exchanger assemblies as will be evident to those skilled in the art.

The burner of FIGURE 10, moreover, may be employed as a draft-producing radiant burner by omitting the manifold **106** and permitting the Venturi effect from gas passing through passageways **84** to draw in air for combustion through gas inlets **100**. It will be seen that casing **94** in FIGURE 10 is provided with retaining lips **96** around gas and defining inlets **100**. Grouting may be employed around these openings if desired, and, of course, modifications in the structure will occur readily to those skilled in the art for achieving efficient sealing where mixing burner grid **92** is in contact with casing **94**.

In the burner shown in FIGURE 9, two ports **110** and **112** admit different gases into plenums **98** and **99** respectively. Although a burner of this type may be employed in conjunction with a heat-exchanger assembly as described above for space-heating, it also possesses advantages for effecting controlled combustions or reactions between fluids which are not desirably transported in admixture. For example, the gases amployed can be acetylene and oxygen, or methane and a controlled amount of air for the synthesis of acetylene. Other such applications will readily become apparent. Suitable means for the recovery of reaction products will then be provided in the off-gas train which may include a heat-exchanger and flue gas venting system as in FIGURES 1 and 2.

Reverting yet again to space-heaters of the invention, as shown in FIGURES 1 and 2, and including such heaters employing alternative burner assemblies, these space-heaters possess certain unusual and remarkable features. Although one might expect such a device to operate very hot, and in fact in operation the interior of the heat-exchanger may indeed be very hot (of the order of 1500°) the dead spaces around the periphery of the heat-exchanger prevent excessive rise in temperature of the casing. This effect, which may be characterized as peripheral insulation, assists in maintaining compressive forces on the heat-exchanger under all operating conditions inasmuch as expansion of the casing does not exceed that of the heat-exchanger itself. The dihedral seals are thus retained intact so long as warpage of the frame is avoided. The efficiency of space heaters of the invention is such that large volumes of air are heated readily by small heaters.

Having thus broadly described my invention and several embodiments thereof so that the scope thereof will be apparent to those having skill in the art.

What is claimed is:

1. A burner assembly for the combustion of a gaseous combustible mixture comprising, in combination,

(A) a casing generally enclosing a chamber and having an inlet for gaseous combustible mixture;

(B) an elongated refractory convergent-stream burner grid, between said inlet and said chamber, having two diverging longitudinal legs giving a generally V-shaped cross-section and consisting essentially of corrugated sheets having the axes of corrugation of consecutive sheets respectively transverse of different legs of said grid; and

(C) means positioning said convergent-stream burner grid in said casing between said inlet and said chamber so that the gaseous combustible mixture has access to areas of said grid greater than the respective opposing inner areas of said legs, said means sealing around said grid so that the combustible mixture passes through said grid and converges into said chamber.

2. A burner assembly according to claim **1** wherein the corrugated sheets of the convergent-stream burner grid are separated by and adhered to coextensive flat sheets.

3. A burner assembly according to claim **1** wherein the corrugated sheets of the convergent-stream burner grid are consecutively in contact and are adhered at points of intersection of ridges.

4. A mixing grid consisting essentially of an assemblage of bonded alternating flat and corrugated sheets defining courses of passageways, each course being directionally defined by the axis of corrugation of the corrugated sheet forming walls common to adjacent passageways in the same course and all courses having like direction opening at one end in one manifoldable face of said assemblage defined by geometrical edges of all successive sheets, consecutive courses having axes of corrugation of differing inclination and having common flat walls over a major portion but less than all of their area, formed by said flat sheets and said flat sheets having substantially parallel leading edges inclined to the axes of corrugation of all said corrugated sheets and being subextensive with said corrugated sheets along said leading edges and otherwise being coextensive therewith.

5. A reactor comprising in combination

(A) a casing having at least two inlets for at least two fluid reactants and manifolding means for each said reactant,

(B) a mixing grid consisting essentially of an assemblage of bonded alternating flat and corrugated sheets defining courses of passageways, each course being directionally defined by the axis of corrugation of the corrugated sheet forming walls common to adjacent passageways in the same course and all courses having like direction opening at one end in one manifoldable face of said assemblage defined by geometrical edges of all successive sheets, consecutive courses having axes of corrugation of differing inclination and having common flat walls over a major portion but less than all of their area, formed by said flat sheets and said flat sheets having substantially parallel leading edges inclined to the axes of corrugation of all said corrugated sheets and being subextensive with said corrugated sheets along said leading edges and otherwise being coextensive therewith,

(C) means positioning said mixing grid in said casing so that all courses having like direction are open to only one of said manifolding means,

(D) means sealing around said grid so that all said reactants pass through said grid, and

(E) means for removing reaction products from said reactor.

6. A radiant burner comprising in combination

(A) a casing having at least one inlet for combustible fuel and at least one inlet for oxidant for said fuel and manifolding means connected with each said inlet,

(B) a mixing grid consisting essentially of an assemblage of bonded alternating flat and corrugated sheets defining courses of passageways, each course being directionally defined by the axis of corrugation of the corrugated sheet forming walls common to adjacent passageways in the same course and all courses having like direction opening at one end in one manifoldable face of said assemblage defined by geometrical edges of all successive sheets, consecutive courses having axes of corrugation of differing inclination and having common flat walls over a major portion but less than all of their area, formed by said flat sheets and said flat sheets having substantially parallel leading edges inclined to the axes of corrugation of all said corrugated sheets

and being subextensive with said corrugated sheets along said leading edges and otherwise being coextensive therewith,

(C) means positioning said mixing grid in said casing so that all courses having like direction are open to only one of said manifolding means,

(D) means around said grid so that all of said fuel and said oxidant pass through said grid.

7. A radiant burner comprising in combination

(A) a casing having at least one inlet for combustible fuel and manifolding means connected with each said inlet and further having at least one opening to the atmosphere for admission of air,

(B) a mixing grid consisting essentially of an assemblage of bonded alternating flat and corrugated sheets defining courses of passageways, each course being directionally defined by the axis of corrugation of the corrugated sheet forming walls common to adjacent passageways in the same course and all courses having like direction opening at one end in one manifoldable face of said assemblage defined by geometrical edges of all successive sheets, consecutive courses having axes of corrugation of differing inclination and having common flat walls over a major portion but less than all of their area, formed by said flat sheets and said flat sheets having substantially parallel leading edges inclined to the axes of corrugation of all said corrugated sheets and

being subextensive with said corrugated sheets along said leading edges and otherwise being coextensive therewith,

(C) means positioning said mixing grid in said casing so that all courses having one direction connect to said manifolding means and courses having other directions and passing through said grid connect to said openings to the atmosphere and

(D) means sealing around said grid so that by pass therearound is prevented.

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