July 2, 1968 C. S. FLYNN 3,390,944

HIGH VELOCITY BURNER ASSEMBLY

Filed Oct. 21, 1965 2 Sheets-Sheet 1

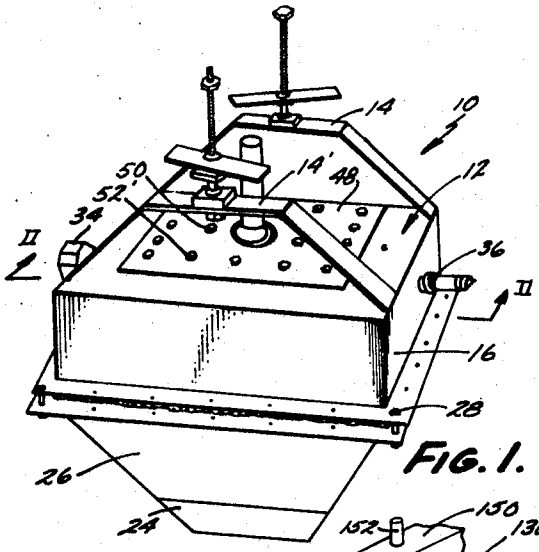


FIG. 1.

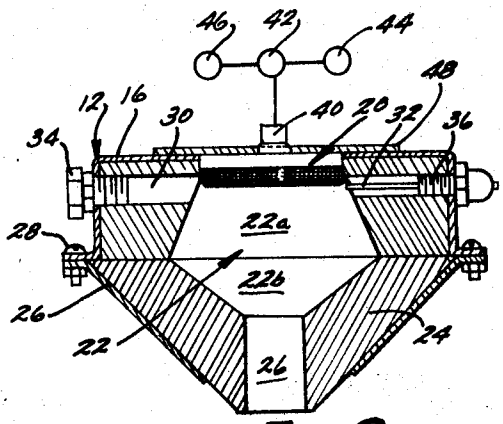


FIG. 2.

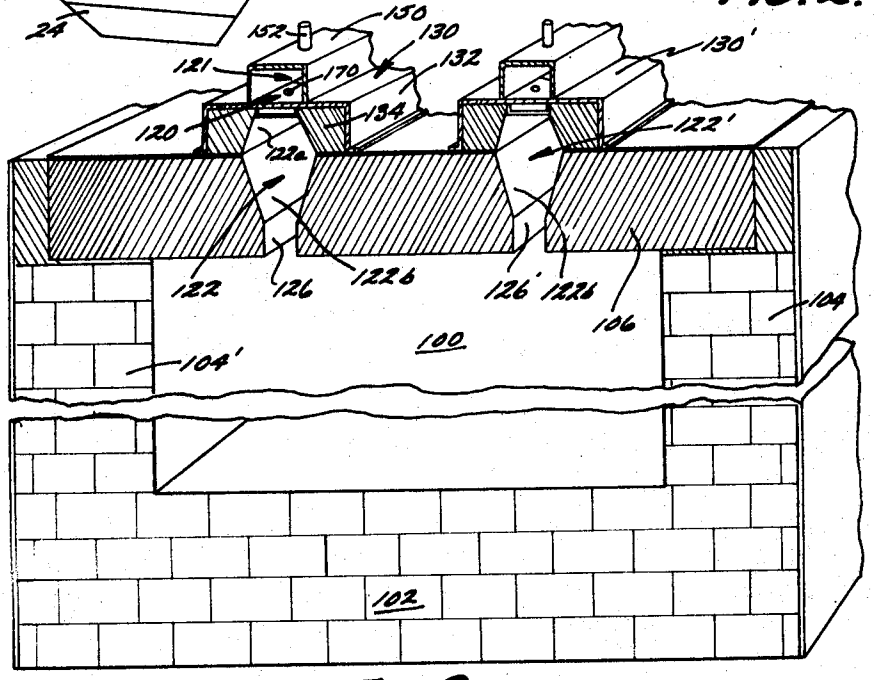


FIG. 3.

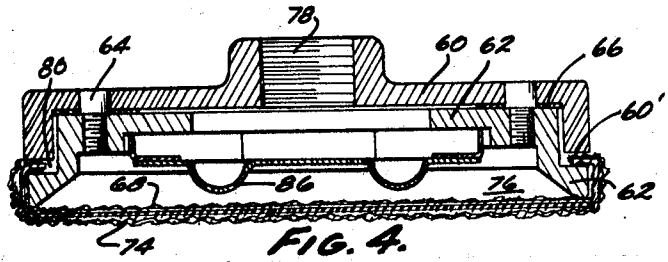


FIG. 4.

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HIGH VELOCITY BURNER ASSEMBLY

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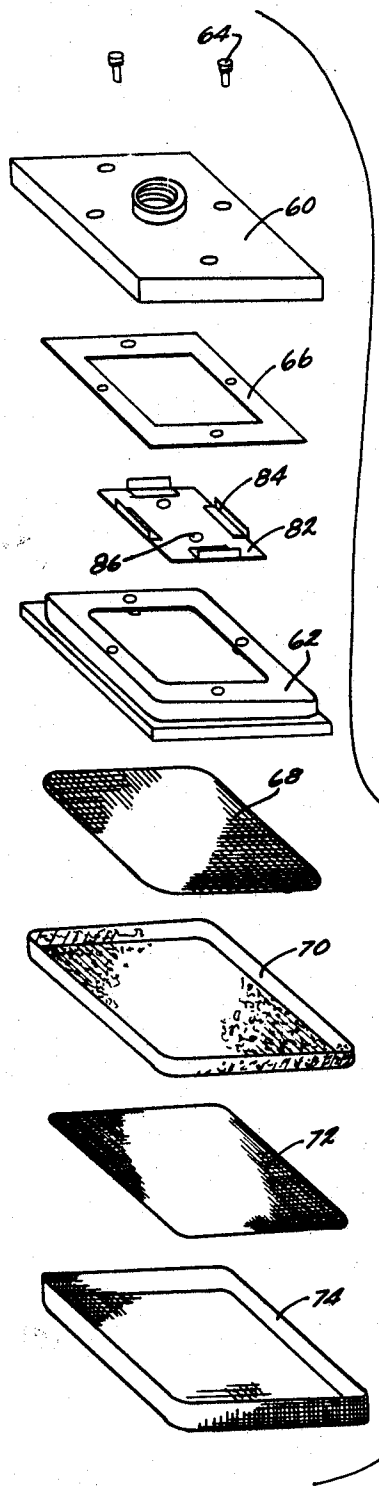


FIG. 5.

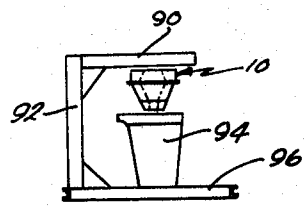


FIG. 6.

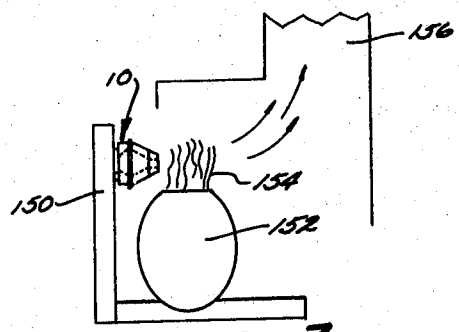


FIG. 7.

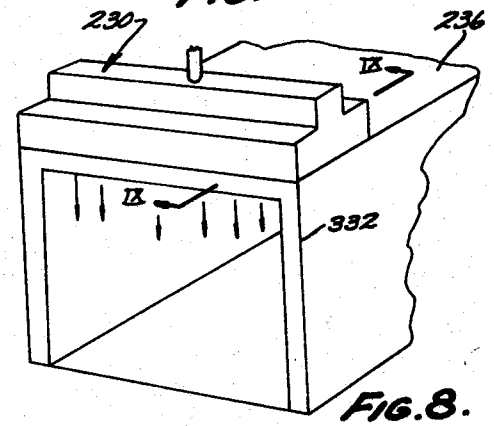


FIG. 8.

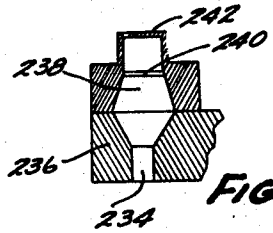


FIG. 9.

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HIGH VELOCITY BURNER ASSEMBLY

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11 Claims. (Cl. 431—158)

ABSTRACT OF THE DISCLOSURE

A convection heating assembly combination capable of high volume, high temperature, high velocity output with widely adjustable output variation without blowoff or flash back, formed of the combination of burner means and positive pressure chamber means with restricted outlet means, wherein the burner means has a housing with an open side covered by refractory fibrous felt and overlying screen means.

A method of forming a continuous stream of hot gas by forcing a mixture of combustion gases continuously through a uniform refractory fibrous felt layer, continuously combusting the gases as they emerge, enclosing the hot combustion gases temporarily in a pressure chamber, and continuously ejecting the hot combustion gases through restricted outlet means.

This invention relates to convection heat, combustion burner assemblies, and more particularly to a method and an apparatus for producing a continuous high temperature, high volume, high velocity stream of combustion gases, without flame output, yet employing a combustible mixture of gases for the heat source.

Combustion heaters for industrial and commercial uses vary from castable, ceramic, radiant heat, glow-burners, to flame torches, and to catalytic radiant glow-burners. Although some of such burners are capable of creating combustion gases of high temperature, or are capable of producing a glow surface having high radiant heat output, it has been found that these conventional burner assemblies require a relatively long time for many heating operations. This is particularly true where convection heat exchange is desirable, since convection heat exchange is normally quite small with present combustion burner assemblies. For example, it has been found that convection heat is the most effective mode of heat application when drying foundry ladles, or when drying articles having uneven surfaces. Further, sometimes it is desirable to have convection heat with a minimum of accompanying radiant heat.

Convection heating efficiency with highest heat transfer is greatly dependent upon dynamic flow conditions of the heated gases, as well as the temperature of the gases. However, conventional burners are not normally capable of providing all three desirable characteristics of high volume, high velocity, and high temperature dynamic flow of gases simultaneously. Specifically, castable ceramic burners, while providing a large heating area, have only a relatively slight combustion gas flow from the burner surface. The same is true of catalytic glow burners. Both of these are really basically radiant heat type burners with only slight convection action. Torch type burners have some convection action, but actual gas volume is relatively small, output velocity is not too significant, and the flame frequently is detrimental on the articles or surfaces heated.

In fact, about the only practical method of obtaining high volume, or high velocity flow with present type burner devices is to employ supplemental air propulsion means such as a fan or blower. However, these require supplemental air supply in order to obtain signfiicant

volume. The supplemental air lowers the gas temperature substantially. Therefore, in actual practice at least one of output temperature, output velocity, and output volume must be sacrificed for an increase in another.

It is an object of this invention to provide a high velocity, high volume, high temperature gas convection heating apparatus which has excellent convection heating characteristics many times greater than any present equipment.

Another object of this invention is to provide a high volume, high velocity, high temperature gas convection heating apparatus that does not require or employ any supplemental air propulsion means or any supplemental air supply means. It obtains a relatively high volume flow output of relatively high temperature gases at a relatively high velocity. The high velocity and high volume are obtained entirely from the hot combustion gases emerging from the burner itself.

Another object of this invention is to provide a high volume, high velocity ceramic face combustion burner that actually employs a back pressure chamber applying a back pressure directly on the exterior of the burner surface itself, in combination with a restricted outlet means from the chamber, to obtain high velocity of the combustion gases.

Another object of this invention is to provide a high volume, high velocity, high temperature gas combustion burner of the ceramic type that not only has excellent convection heating characteristics, but also has only minor radiant heat output. The assembly moreover has no exposed flame.

Another object of this invention is to provide a novel method of convection heating using only high temperature combustion gases themselves, yet with high velocity and high volume output without any supplemental air propulsion means or air supply means, with only minor radiant heat output, without exposed flame, and employing a premixed combustible mixture of gases.

Another object of this invention is to provide a novel method of convection heating to obtain a high temperature, high volume, high velocity flow of gases, by employing an actual back pressure on the output surface of a ceramic type burner, in combination with a restricted orifice outflow, yet without danger of the back pressure causing an explosion within the burner of an uncombusted combustible mixture of gases.

These and other objects of this invention will become apparent upon studying the following specification in conjunction with the drawing in which:

FIG. 1 is a perspective view of one form of the novel apparatus;

FIG. 2 is a cross sectional view of the apparatus in FIG. 1, taken on plane II—II;

FIG. 3 is a perspective fragmentary view of another form of the novel apparatus;

FIG. 4 is a cross sectional view of one of the individual combustion burner elements employed in either of the combinations in the previous figures;

FIG. 5 is an exploded perspective view of the burner assembly in FIG. 4;

FIG. 6 is a side elevational view of a combination of the assembly in FIG. 1 mounted to dry a foundry ladle;

FIG. 7 is a side elevational view showing the unit in FIGS. 1 and 2 in combination with a cupola to combust the smoke products therefrom;

FIG. 8 is a fragmentary perspective view of a third form of the novel assembly shown in combination with an open end oven or furnace; and

FIG. 9 is a sectional view taken on plane IX—IX of FIG. 8.

First form

Referring now specifically to the drawings, the assembly **10** illustrated in FIGS. 1 and 2 includes an enclosure means **12** having mounting bracket means **14** and **14'** attached to the back thereof. This enclosure means includes a metallic support casing **16** which retains a generally annular peripheral ceramic liner **18**. In this particular form of the construction, this liner is generally square in its configuration, extending around burner subassembly **20**. Ceramic block liner **18** defines an inner central cavity forming portion **22***a* of a positive back pressure chamber **22**, with the other portion **22***b* being formed by a peripheral supplemental ceramic block liner **24**. Portion **22***a* has a divergent configuration with respect to burner subassembly **20**, with portion **22***b* having a convergent configuration from portion **22***a* with its largest diameter fitting the large diameter portion of divergent portion **22***a*, and with its smallest diameter portion leading into outlet nozzle **26** in member **24** to form a restricted outlet means. Member **24** is supported in a metallic outer shell **26**. Shells **16** and **26** have adjacent outer peripheral flanges secured together by suitable means such as bolts **28**.

Member **18** includes an end opening aligned with chamber **22** and restricted outlet **26**, and receiving a burner subassembly **20**. The subassembly has its burner surface oriented toward passage **26**.

Preferably, a pair of transverse passages **30** and **32** are formed in ceramic block liner member **18**, aligned horizontally adjacent the surface of burner subassembly **20**. Passage **30** includes a lens fitting **34** to form an observation port. Passage **32** receives an igniter plug **36** for initially igniting the burner subassembly **20**.

Burner subassembly **20** employs a combustible mixture of gases including a gas such as a hydrocarbon gas, mixed with an oxygenating gas such as oxygen or air. This combustible mixture is conducted into the burner subassembly through a conduit **40**. This conduit is supplied (as shown schematically in FIG. 2), from a mixture means **42** which receives the combustible gas from a source **44** and an oxygenating gas from a source **46**. The gaseous mixture is thus introduced in its combustible state into the burner housing.

In this form of the apparatus, a single burner subassembly is employed. It is secured in position by a mounting plate **48** attached to burner subassembly **20** by bolts **50** and to the surrounding enclosure shell plate **16** by bolts **52** (FIG. 1).

The particular construction of each burner unit is important to the operation of the assembly. Each burner includes a generally square or rectangular burner housing formed of an outer shell member **60** and an inner generally annular, peripheral member **62**. These members are interconnected by suitable bolts **64**, with an annular gasket **66** therebetween. When assembled, the housing includes one open side (FIG. 4) covered by a coarse mesh support screen **68**, a fibrous gas dissipating refractory felt layer **70** on screen **68**, a relatively fine mesh retention screen **72** over the felt layer, and a generally coarse mesh outer retention screen **74** over the others. When assembled, these elements close the internal chamber **76** which receives a combustible mixture of gases through inlet **78** provided on the back closure face of housing member **60**.

Inner housing member **62** fits within outer housing member **60**, except for its outermost peripheral edge **62'** which is spaced axially slightly from the adjacent outer edge **60'** of member **60**, to form a peripheral outer groove **80** around the housing.

Support screen **68** is relatively rigid, and rests within the confines of flange **62'**. It may initially be adhered with an adhesive so as to hold its position during assembly. Felt layer **70** extends over screen **68** and around the periphery of flange or edge **62'**. It has its outermost edge deformed into groove **80**. It is held in this groove by the outer, relatively coarse mesh screen **74** which also has its peripheral edge extending around edge **62'** and deformed or crimped into groove **80** to press the felt layer tightly against edge **62'** and secure it and the other screens to the housing. Underlying outer screen **74** and overlying felt layer **70** is the relatively fine mesh screen **72**. It preferably is not extended around the housing since this is not necessary. Rather it is a flat screen member as shown in FIG. 5.

The fibrous felt is a self-supporting layer formed from short refractory fibers, preferably alumina and silica for example in a 50–50 ratio. The fibers are integrated into a unitary sheet body. The randomly dispersed fibers in the integrated structure are initially compressed to the desired thickness and density as by rolling. The felt has myriads of tiny passages, all with sufficient resistance to gaseous flow to cause uniform gaseous dissipation therethrough. The density of the felt may vary, depending upon the thickness used, the fiber diameter, the ratio of substances and the like. It may range for example from about 2 pounds per cubic foot to about 12 pounds per cubic foot for different applications and may be anywhere from 1/16 to ½ inch in thickness more or less, depending on the factors involved such as desired operating pressure, operating temperature, velocity of gases, and upon the width of the burner, the density of the material, the area of burner to be covered, and the desired flexibility of the felt body. Preferably it is normally quite thin, e.g. around 20 to 40 mils to flex and seal readily around the housing edge. The felt must be free from any gaseous leaks of pin hole size which would enable the gases to flow through in a stream with only slight resistance. These can be identified by the occurrence of flame pimples which visibly project from the surface of the felt during operation. The presence of these undesirable leaks can be readily ascertained by the presence of these flame pimples. The felt material has a substantial resistance to gaseous flow therethrough due to the fact that the gas must flow through millions of minute tortuous passages having a diameter in the low micron range. Therefore, the pressurized gaseous mixture is generally uniformly distributed over the entire back of the fibrous layer from inner pressure chamber **76**.

This distribution of gases is supplemented by a planar baffle plate **82** in chamber **76**. The baffle plate has a plurality of inwardly projecting, L-shaped, spacer flanges **84** on its periphery to abut the inner surface of housing member **62**. It also has a plurality of outward spacer projections **86** to abut the inner screen member **68**. The gases flowing in through central inlet **78** strike this baffle and are forced to travel out around the peripheral edge to be distributed relatively uniformly to the entire felt surface area.

The gases, when passing through the felt layer, do so in a finely dispersed uniformly distributed manner in the form of millions of tiny merging streamlets forming a continuous layer of gases over the combustion surface. They are ignited upon emergence from the felt layer. The blue combustion flame occurring on the surface of the felt layer is visible by peering across the surface as through the observation port shown in FIG. 2. Although the slight blue flame layer often projects a fraction of an inch from the surface, for higher firing rates (from 5,000 to 15,000 B.t.u.'s/sq. in.), the flame may be from ½" to 1" long.

The supporting screen **68** is relatively coarse, self-supporting, and quite rigid. A ten mesh screen (0.025 inch mesh diameter) of steel works excellently although the exact mesh may vary, providing the screen is kept relatively rigid.

The relatively fine mesh screen **72** has a mesh of about 40, for example (0.010 inch mesh diameter). Any individual fibers of the felt tending to protrude out of the burner surface under pressure are retained in position by this fine screen. It is desirable to keep the fine fibers from extending out from the surface in order to obtain

uniform flow and to prevent them from glowing to cause a spreading radiant heat glow over the surface.

The relatively stiff retention screen **74** serves the double purpose of retaining the felt and screen in position when crimped around the peripheral groove, and also retaining the fine screen, which may tend to bow when heated, in its planar condition.

Operation

In operation, a combustible mixture of gases is formed in external mixer **42** and conducted through conduit **40** and into the chamber of the burner subassembly **20**. The combustible mixture of gases is introduced under pressure into chamber **76** which remains cool. The combustible mixture of gases is then forced by the pressure through the fibrous felt layer, igniting at the outer surface of the felt layer to create a large volume of high temperature combustion gases. The particular volume and temperature of output can be regulated by varying the pressure and the gaseous mixture input to the burner. With this construction, the gaseous pressure applied can be varied over an extremely wide range, for example from a couple inches of water pressure up to 50 or more inches of water pressure without difficulty. The temperature can vary from a few hundred degrees Fahrenheit up to and over 2,700 degrees Fahrenheit, while the back of the housing construction of the burner subassembly remains cool enough to touch.

The high volume, high temperature gases are ejected directly from the burner surface into enclosure chamber **22** which creates a pressure chamber to the restricted outlet **25**. Obviously, it also creates a back pressure directly on the burner surface. This pressure creates a propelling force to eject the gases from nozzle opening **26** at a high velocity. The particular burner construction employed in combination has been proven to be free to any dangerous backfiring, even under a substantial back pressure. Even when a substantial back pressure of several inches of water pressure is formed in chamber **22**, the burner will not backfire to cause an explosion in its gas chamber **76** or back through the conduit system supplying the burner. Hence, this pressure on the surface of the burner can be employed to eject the gases at a high velocity. The output of the complete assembly, therefore, has all three of the desirable characteristics of high temperature, high volume, and high velocity at high values, i.e. without sacrificing one for the other as is normally necessary with presently known equipment.

The heat transfer rate effected with the novel combination and method is highly controllable and many times greater than conventional "still air" heating units. As just one example, with a temperature differential of 150° F. between the article to be heated and the burner output temperature, using only the burner component (and thus not the total combination) the heat transfer rate was 150 B.T.U.'s per square foot. This would be similar to present comparable equipment. However, with the combination, increase of the gas mass velocity (pounds per cubic foot per second times feet per second) occurs from the zero mass velocity of just the burner to a mass velocity of about 1.2 to approximately 3.0 (depending on the size of the unit) causing an increase heat transfer rate from 150 B.t.u.'s to 1175 B.t.u.'s per square foot—i.e. an increase of about 800%. Further, since the output temperature of the particular burner construction can be elevated up to about 2700° F., with accompanying increase in gas flow from the burner, the potential heat transfer rate is tremendous as has been proven by extensive experimentation.

Ladle drying

In operation, the high velocity system is shown to be extremely useful for many heat exchange applications. Referring to FIG. 6, the unit **10** is there shown to be mounted on a cantilever support **90** of an adjustable column **92** for use in drying a foundry ladle **94** resting on base **96**. It is oriented to eject the gases directly into the ladle mouth. Experimentation has shown that the novel unit requires only 24 minutes to dry a ladle which previously required 4 hours to dry by conventional torch flame techniques. A very substantial saving in fuel, time and other factors results.

As one example, in a test conducted by Chevrolet Motor Division of General Motors Corporation, the novel structure was tested against the conventional gas fired torch normally used. The test ladles were deep and normally very difficult to dry. Specifically, the ladles were 6 feet deep and 2 feet in diameter. Under like conditions the torch was fired at 5000 cubic feet of natural gas per hour and operated for 13½ hours to dry the ladles, while the novel unit, fired at 1000 cubic feet per hour, required only 2½ hours to dry the ladle, at which time the ladle shell temperature began to rise to several hundred degrees, indicating a thorough dryness. In fact, the torch never did elevate the ladle shell temperature over 200° F., meaning that the ladle never was completely dried.

Smoke combustion

The volume, velocity, and temperature of the gases from the assembly can be so high that it has been found that the structure can serve effectively as an after burner for a foundry cupola **152** (FIG. 7) by mounting unit **10** on a support **150**, so as to project the hot gases over the open mouth of the cupola. The partially combusted products forming the smoke **154** are heated sufficiently to complete the combustion, so that the usual billows of noxious smoke are consumed before passing up the stack **156** (shown schematically).

Second form

In the first form of the invention shown in FIGS. 1 and 2, the burner, pressure chamber, and restricted outlet, are shown as a single unit assembly. Sometimes it is desirable to have a multiple unit assembly as shown in one example in FIG. 3. In this instance, the hot gas discharge is projected into furnace chamber **100** defined by fire brick forming a bottom **102** and sides **104** and **104'**. The entire top of this chamber is enclosed by an assembly including a ceramic closure block **106** having an elongated restricted outlet nozzle **126**, elongated bottom portion **122***b* of chamber **122**, and a corresponding twin system of nozzle **126'**, and chamber portion **122'***b* of chamber **122'**. Mounted to the top of ceramic plate or block **106** are two removable subassemblies **130** and **130'**. Housing **130** includes a suitable metallic outer shell **132** containing a pair of spaced, elongated, ceramic, bar-shaped blocks **134** which form a divergent elongated chamber portion **122***a* between them. A plurality of burner subassemblies **120**, **121**, etc. are mounted end-to-end along the length of the housing unit **130** between the bars **134**. Each has its own gaseous inlet, e.g. inlet **178** for burner assembly **120**, to receive the combustible mixture of gases. All of the burners may be supplied from a common manifold housing **150** mounted in sealed manner on top of shell **132**. The manifold is supplied from a common inlet conduit **152**, which in turn is supplied from a mixer (not shown). Subassembly **130'** has similar components and therefore these are not described in detail.

In operation, the gas mixture is introduced into manifold **150**, passed down through passages **170** etc. into each of the burner subassemblies mounted end-to-end along subassembly **130**. All of these burners cooperatively form a continuous surface of high temperature, high volume output combustion product gases which are ejected into the positive pressure chamber **122**. The gases flow under this pressure out the elongated restricted orifice or slot nozzle means **126**, to form an elongated high velocity curtain of high temperature gases jetting downwardly in large volume into chamber **100**. It has been found that the actual convection heating occurring as a

result is many times more effective than heating techniques employed heretofore.

Slot orifices **126** and **126'** need not be oriented completely in line with the burner units, but can be at an acute angle to direct the hot gas jet or curtain, for example to suit a particular type of article being heated. This is shown by the phantom lines in FIG. 3.

Open end furnace

Since a curtain of the high temperature, high volume, high velocity gases can be formed in any particular direction or configuration desired, open end ovens or furnaces can be provided with a transverse high temperature gas curtain across the open end or ends to both retain heat within the oven rather than allowing it to flow out the open ends, and to add heat to the oven interior.

Referring to FIG. 8, an elongated assembly **230** like that illustrated at **130** in FIG. 3, is mounted transversely adjacent the open end of an oven or furnace **232**, so that elongated outlet nozzle **234** (FIG. 9) formed in the top **236** of the oven, is above and transverse to the open end, and cooperative with inner chamber **238**. Hot gases from the burner subassemblies **240** flow in a transverse downwardly jetting curtain (as indicated by the arrows in FIG. 8) across the mouth of the open end oven, to maintain the oven at an internal positive pressure. The curtain serves to largely prevent escape of the heat, while also supplying additional heat to the oven. The series of end-to-end burners may be provided with a combustible mixture of gases from manifold **242** which is supplied by conduit **241**.

In review, it will be realized that all of these variations in the construction employ the elements of one or more of the special burners that will not backfire under back pressure on the combustion surface, a positive pressure chamber adjacent the burner combustion surface, and a restricted hot gas outflow orifice or nozzle means from the chamber, generally opposite the burner, to produce a high velocity, high temperature, high volume output of gases, without flame, with minimal radiant heat, and without supplemental air propulsion means or air supply means.

The novel combination can be employed for other heating uses also, including several other foundry type applications, including heat treating furnaces, core wash and dip drying ovens, malleable iron preheat-for-coining furnaces, steel heat treat furnaces, stress relieving furnaces, aluminum reverberatory furnaces, and non ferrous crucible furnaces, to name only a few.

Typical of the enthusiasm with which the novel structure is being received is that exhibited in the article on pages 58 and 60 in the September issue of Modern Castings Magazine.

It is entirely conceivable that those familiar with the heating art, or with arts employing heat in various manners, will conceive of various structural modifications within the novel concept taught, to suit particular types of articles, enclosures, assembly operations, or the like, including variations in the specific outlet nozzle or restricted outlet means, variations in the number of units employed or their pattern and the like. Hence, this invention is intended to be limited only by the scope of the appended claims and the equivalents to that defined therein, rather than to the specific forms of the device illustrated.

I claim:

1. A convection heat, combustion burner assembly comprising: enclosure means forming a hot gas pressure chamber; a restricted orifice outlet from said chamber to allow hot gaseous flow from said pressure chamber while retaining a positive pressure in said pressure chamber; at least one combustion burner having its burner surface in said enclosure means; said burner having a burner housing forming a cool gas chamber having an open side, combustible gas mixture inlet means into said cool gas chamber, a refractory fibrous felt tightly retained over said open side, and screen retention means retained over said felt; said felt forming a combustion surface for uniform combustion of a combustible mixture of gases emerging from said cool gas chamber into said hot gas pressure chamber; and said hot gas pressure chamber and restricted nozzle outlet causing high velocity flow of hot combustion gases in a jet stream from said outlet.

2. A convection heater assembly comprising: a burner subassembly and a restricted outlet positive pressure chamber means in combination therewith; said burner subassembly including at least one burner unit having a porous refractory felt layer forming a gas distributing means and combustion surface, said layer being formed of a great many randomly oriented refractory fibers forming many tiny gas passages and free of pinhole size gas leak openings; said chamber means including ceramic walls extending from the edges of said felt combustion surface and converging to a restricted outflow orifice means generally opposite said combustion surface; and gaseous mixture inlet means to said burner subassembly to enable combustion upon emergence from said felt layer, build up of pressure in said chamber, and emergence of a high velocity jet of hot combustion gases from said restricted orifice means.

3. The assembly in claim **2** wherein: said chamber means includes burner receiving means oriented toward said restricted orifice means, said chamber means converges to said restricted orifice means in a smooth tapered manner, said burner subassembly includes a housing having an open side oriented toward said orifice means, and said felt is retained over said housing open side by retention screen means.

4. The assembly in claim **3** wherein: said housing includes an outer peripheral groove; said retention screen means includes a relatively fine mesh screen immediately over said felt layer to prevent fiber extension out of said layer under operational pressure, and includes a relatively coarse mesh stiff screen over said fine mesh screen and crimped into said groove to retain the felt and screen means in position.

5. The assembly in claim **4** wherein: a screen mesh supports the inner surface of said felt layer opposite said screen means, said housing and felt form an inner pressure chamber, a distributor baffle extends across said inner pressure chamber and includes inwardly extending spacer projections to abut said housing and outwardly extending spacer projections to abut said screen mesh.

6. The assembly in claim **2** wherein: said burner subassembly comprises a single burner unit, and said restricted orifice means comprises a single nozzle outlet opposite said unit.

7. The assembly in claim **2** wherein: said burner subassembly comprises a plurality of burner units placed end-to-end, a common gaseous inlet manifold is operably associated with the mixture inlet means of said units; said chamber means is elongated along the length of said plurality of units, and said orifice means comprises elongated slot means from said chamber means, opposite said burner units.

8. An oven or furnace assembly comprising: walls forming a furnace space; at least one of said walls having combustion burner means thereon; said burner means including at least one burner unit having a porous refractory felt layer forming a gas distributing means and combustion surface, said layer being formed of many randomly positioned refractory fibers together forming many tiny tortuous passages and being free of pinhole size openings; hot gas passage means extending from said felt layer through said one wall and into said space, and comprising a positive pressure chamber adjacent said felt layer and restricted outlet means into said space.

9. The assembly in claim **8** wherein: said combustion burner means includes a plurality of end-to-end burner units, said chamber means is elongated along said burner

units, and said outlet means is a restricted flow slot along said chamber means.

10. The assembly in claim **9** wherein: said furnace has an open end, and said burner means, chamber means, and slot extend across said open end, with said slot oriented to project a hot gaseous curtain across said open end.

11. A method of continuously forming a high velocity, high volume stream of hot gases from a combustion burner, without exposed flame, comprising the steps of: forming a mixture of combustible gases; placing said combustible mixture under pressure and forcing it continuously through a uniform refractory felt layer having a myriad of minute pores; continuously combusting the combustible gas mixture as it emerges from said felt layer to form hot combustion gases; enclosing the hot combustion gases temporarily in a pressure chamber adjacent said felt layer, and continuously ejecting said combustion gases out of said pressure chamber through restricted gas outlet means to form a positive pressure in said chamber and a low pressure high velocity jet stream out of said restricted outlet means.

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