

April 1, 1969

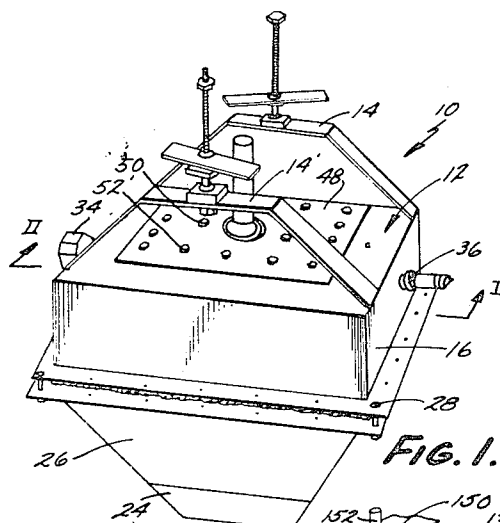
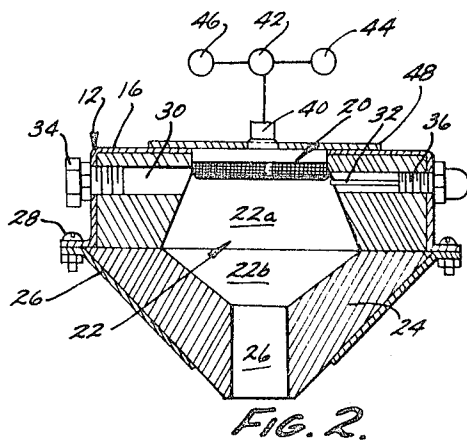
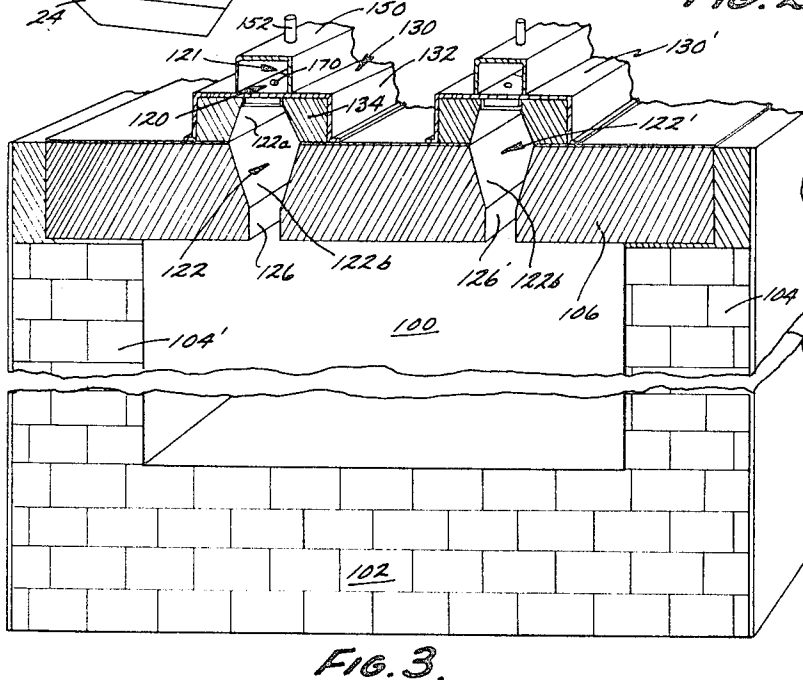
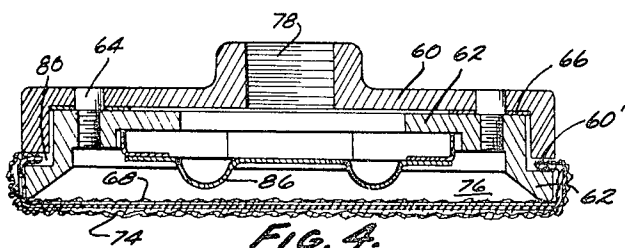
C. S. FLYNN

3,436,065

METHOD OF DRYING A FOUNDRY LADLE

Original Filed Oct. 21, 1965

Sheet 1 of 2



INVENTOR
CHARLES S. FLYNN
BY *Price & Heneveld*
ATTORNEYS

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Sheet 2 of 2

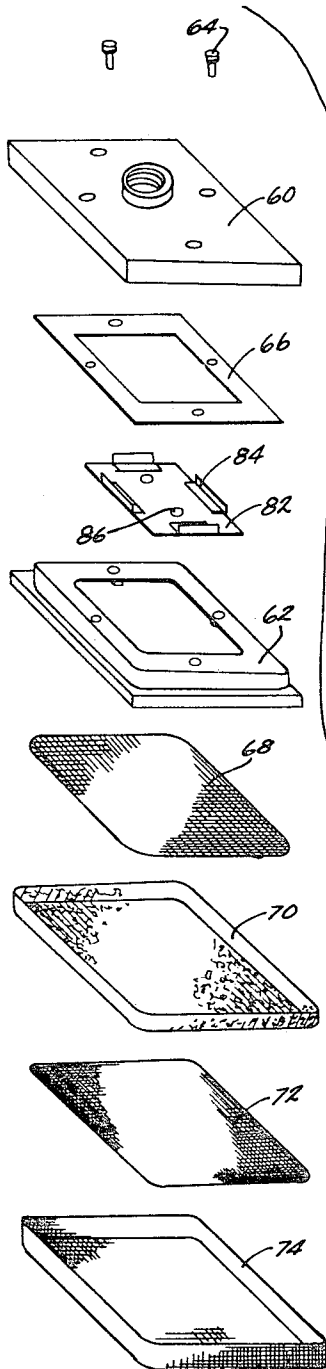


FIG. 5.

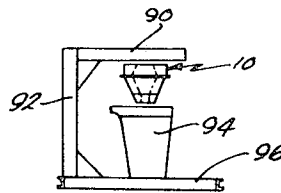


FIG. 6.

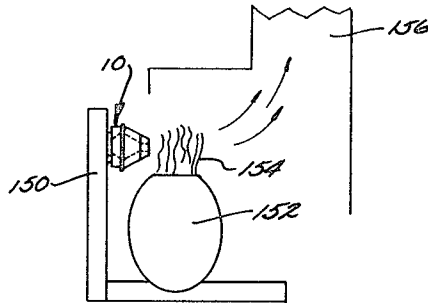


FIG. 7.

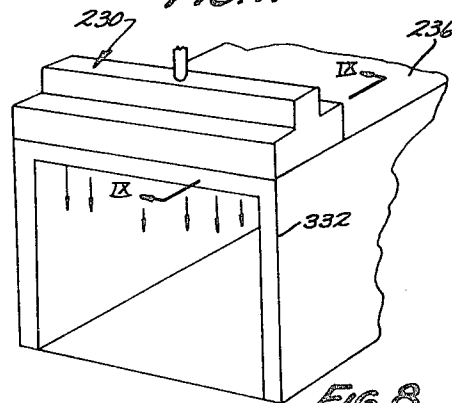


FIG. 8.

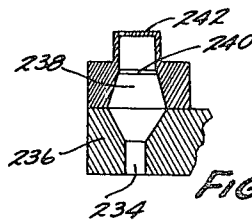


FIG. 9.

INVENTOR.
CHARLES S. FLYNN

BY *Price & Hennel*

ATTORNEYS

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3,436,065

METHOD OF DRYING A FOUNDRY LADLE

Charles S. Flynn, 2991 Sherwood Court,
Muskegon, Mich. 49441

Original application Oct. 21, 1965, Ser. No. 499,799, now
Patent No. 3,390,944, dated July 2, 1968. Divided and
this application Jan. 29, 1968, Ser. No. 721,909

Int. Cl. F26b 3/02

U.S. Cl. 263—52

1 Claim

ABSTRACT OF THE DISCLOSURE

A method of drying a foundry ladle by forming a continuous stream of hot gas by forcing a mixture of combustion gases continuously through a uniform refractory 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 directly into the ladle.

This application is a divisional application of the parent application entitled High Velocity Burner Assembly, filed Oct. 21, 1965, Ser. No. 499,799, now Patent No. 3,390,944, granted July 2, 1968, by Charles S. Flynn.

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 significant volume. The supplemental air lowers the gas temperature substantially. Therefore, in actual practice at least one

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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 surfaces 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 the 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 22a of a positive back pressure chamber 22, with the other portion 22b being formed by a peripheral supplemental ceramic block liner 24. Portion 22a has a divergent configuration with respect to burner subassembly 20, with portion 22b having a convergent configuration from portion 22a, with its largest diameter fitting the large diameter portion of divergent portion 22a, 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 certain 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. The 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 on 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, 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 there-through. 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 $\frac{1}{16}$ to $\frac{1}{2}$ 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 visably 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. This 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 $\frac{1}{2}$ " 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 screens 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 the 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 26. 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 affected 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 that 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 increases 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 252 (FIG. 7) by mounting unit 10 on a support 250, so as to project the hot gases over the open mouth of the cupola. The partially combusted products forming the smoke 254 are heated sufficiently to complete the combustion, so that the usual billows of noxious smoke are consumed before passing up the stack 256 (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 122b 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 forms a divergent elongated chamber portion 122a between them. A plurality of burner subassemblies 120, 121 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 mixtures 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, fur-

naces aluminum reverberatory furnaces, and non-ferrous crucible furnace, 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 issued 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 claim and the equivalents to that defined therein rather than to the specific forms of the device illustrated.

I claim:

1. A method of drying a foundry ladle 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; and projecting said gases directly in said ladle.

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KENNETH W. SPRAGUE, *Primary Examiner*.

U.S. Cl. X.R.

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