Dec. 19, 1967 C. S. FLYNN 3,358,979

DYNAMIC FLOW OVEN

Filed Oct. 21, 1965 3 Sheets-Sheet 1

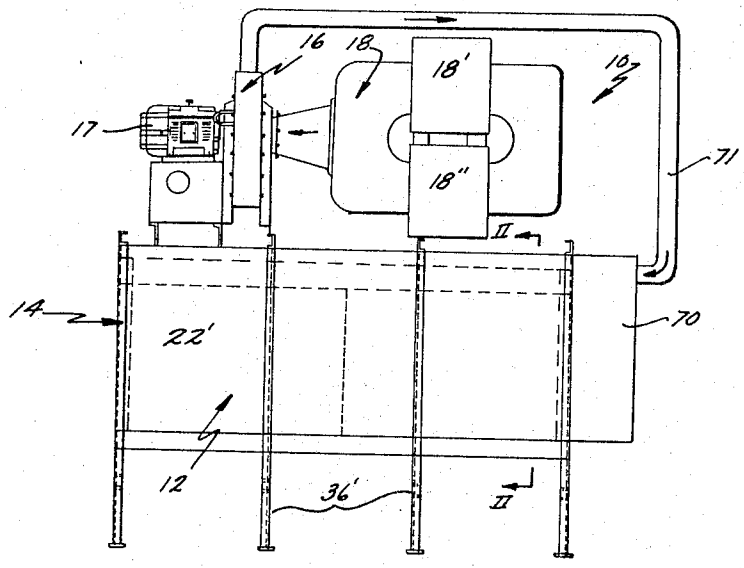


FIG. 1.

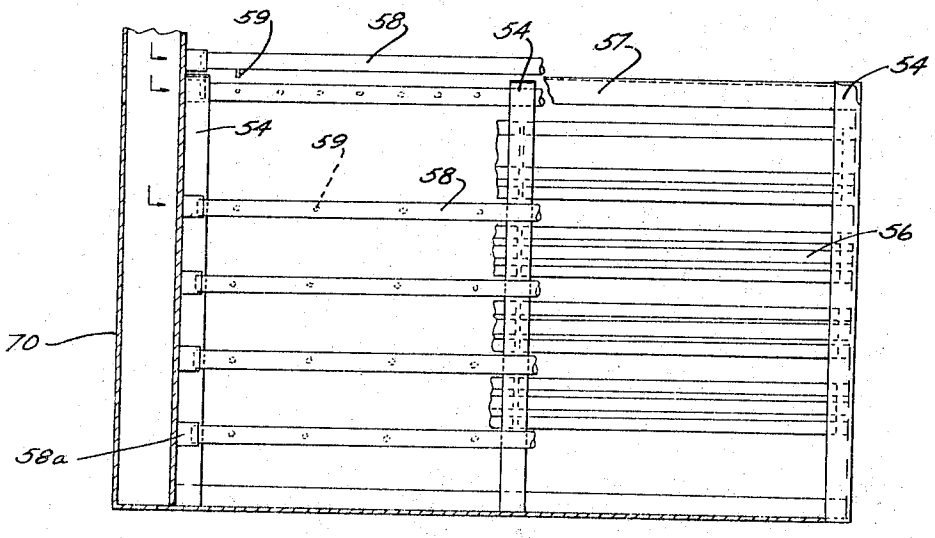


FIG. 3.

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DYNAMIC FLOW OVEN

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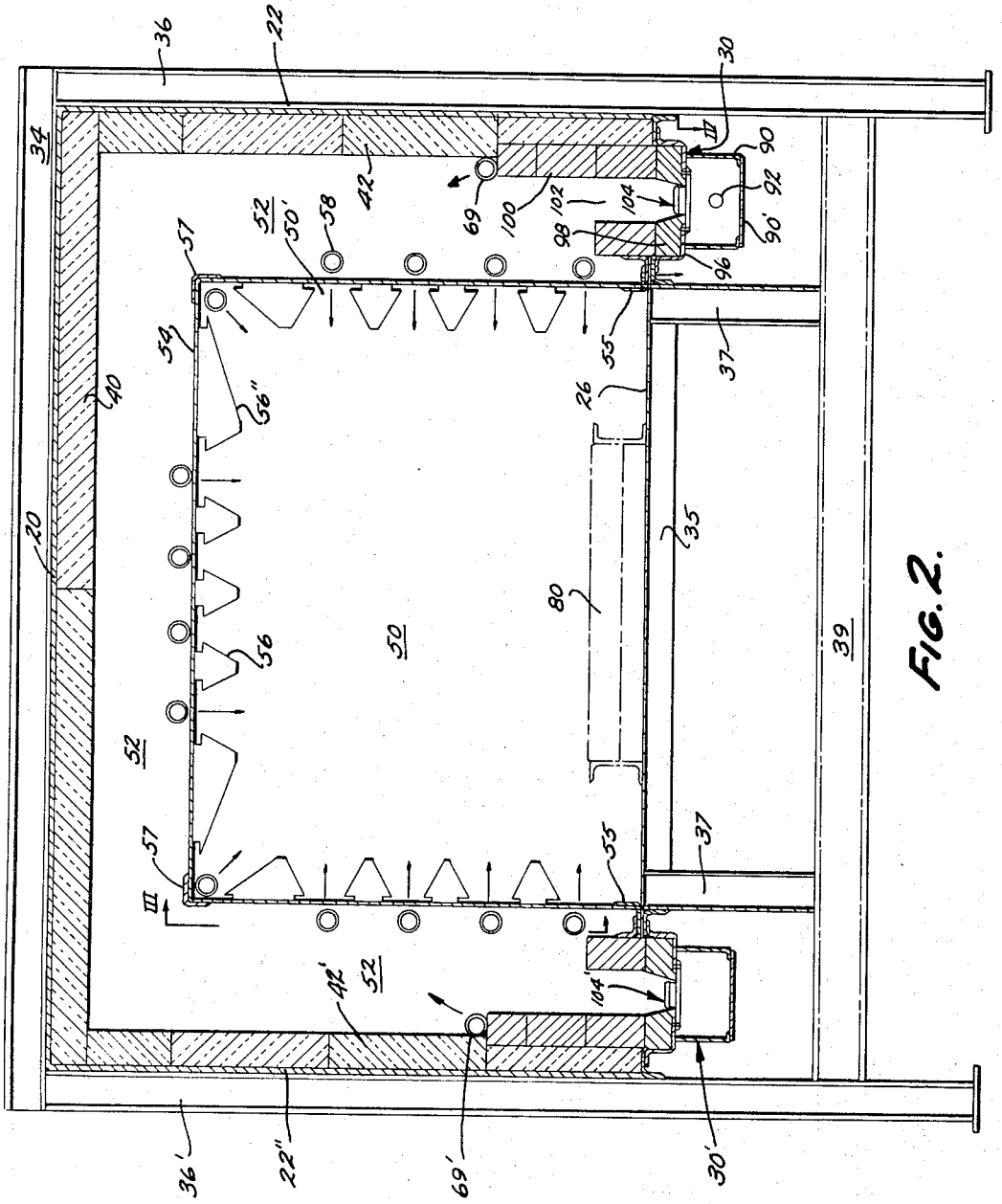


FIG. 2.

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DYNAMIC FLOW OVEN

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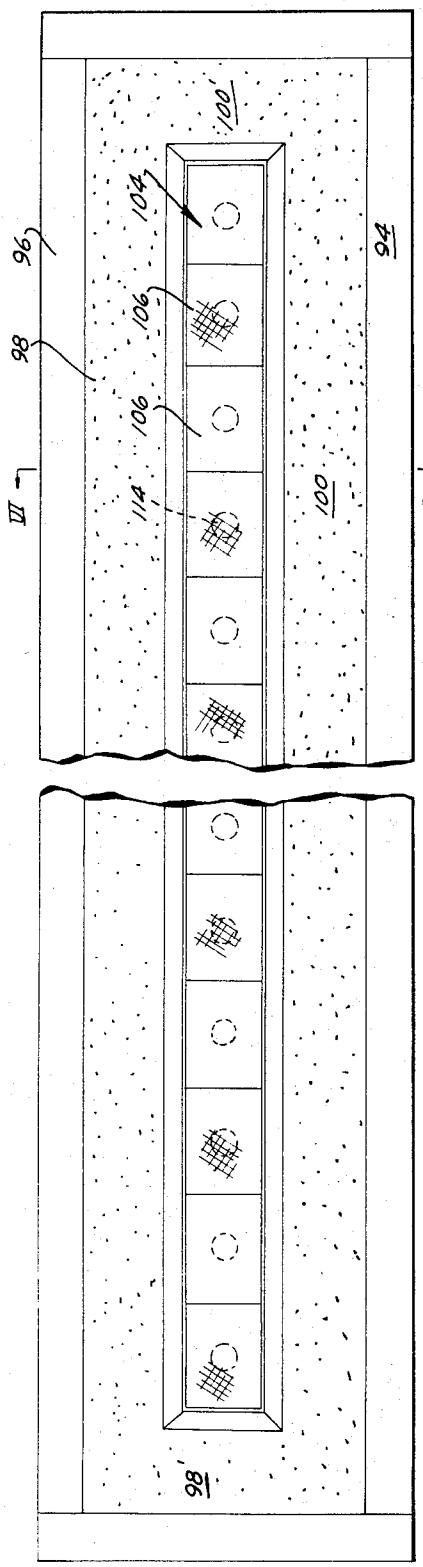


FIG. 4.

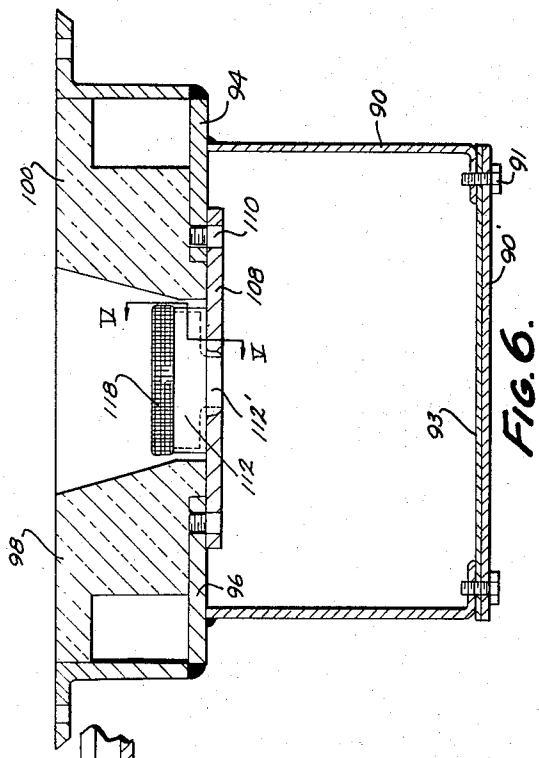


FIG. 6.

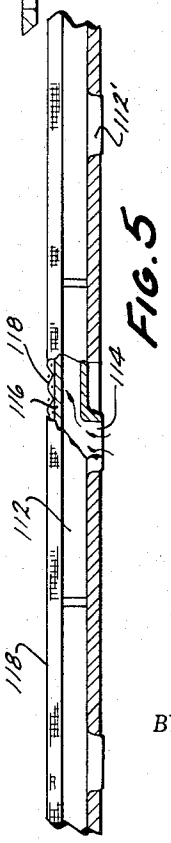


FIG. 5

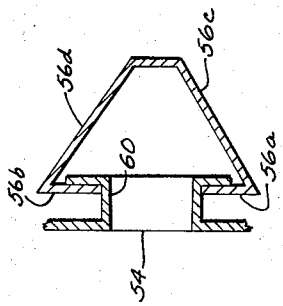


FIG. 7.

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3,358,979

DYNAMIC FLOW OVEN

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4 Claims. (Cl. 263—40)

ABSTRACT OF THE DISCLOSURE

A dynamic flow hot gas oven having an inner oven chamber and an outer plenum chamber into which a plurality of high volume individual burners having porous ceramic felt and screen retention mean faces eject combustion gases, with the high volume hot gases being projected into the oven chamber with special spaced baffles and cool air nozzles for obtaining dynamic Venturi action.

This invention relates to oven type heating equipment employing combustion burner heating units, and more particularly relates to a dynamic flow, convection heating oven.

Oven type equipment utilizing an enclosure and heat supply means thereto is presently used in a variety of industrial and commerical processes and manufacturing techniques. The hundreds of various uses include those of pre-heating, drying, baking, tempering, curing and others. Almost invariably, it is desirable to minimize retention time of articles in the oven, for maximum production output at minimum unit expense. The retention time necessary for a particular article in a particular oven varies greatly, of course, depending upon the characteristics of the article, the nature of the heating operation performed, the size of the oven, and so forth. One basic factor involved with all such heating operations, however, that greatly influences retention time, is the heat transfer rate. This in turn is dependent upon oven temperature, the effectiveness of hot gas contact and exchange with the article surfaces, radiant heat intensity, and when drying, the rate of vapor removal away from the article surfaces.

Of these factors, radiant heat is frequently undesirable because of potential damage or deterioration to the articles, e.g. color fading, article combustion, vapor explosion, etc. Also, temperatures are frequently limited because of the limited potential of known heat sources, and because of the potential heat damage to the articles. Therefore, it is oft times very important and usually desirable to maximize rate of contact of the hot gases in the oven with the article surfaces and to maximize vapor removal in drying operations, to maximize heat transfer and minimize retention time in the oven.

When heating articles having highly varied surface configurations such as dead end pockets, uniform heating becomes a problem. If such surfaces are being dried, the problems is even greater since the vapors of the solvent or moisture being evaporated become saturated in the stagnant pockets and prevent further effective evaporation from the surface. Therefore, the dynamic rate of exchange of the hot gases on the article surfaces is important to obtain optimum heat transfer and drying conditions. However, conventional oven equipment has only minor convection heat transfer potential, with little accurately directly dynamic flow.

It is an object of this invention to provide a novel oven apparatus that employs combustion heat supply means capable of actually reducing retention time of articles in the oven to a small fraction of that required for the same operation in presently available equipment, by a dynamic flow combination capable of directing hot

gases in a unique manner for optimum heat transfer. In fact, in all of many test operations performed in several months' time on the novel equipment, it has proven to reduce the necessary retention time in every case, over conventional equipment, by at least 90%, and usually more.

Another object of this invention is to provide a dynamic hot gas flow oven utilizing a venturi effect to drastically reduce retention time necessary to heat, bake, or cure articles, by greatly increasing the effective hot gas contact, flow, and exchange over all of the surfaces of the articles.

Another object of this invention is to provide an improved oven capable of drastically reducing the retention time necessary for drying operations, by greatly increasing the rate of vapor removal from around the article surfaces, even in dead end pockets, to prevent stagnant vapor saturation that inhibits drying.

Another object of this invention is to provide a high efficiency convection heating oven that achieves a greatly increased rate of heat transfer for articles, without employing radiant heat, so that even combustible or colored materials can be safely and rapidly heated without article damage or deterioration.

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

FIG. 1 is a side elevational view of the novel oven assembly;

FIG. 2 is a sectional view taken on plane II—II of FIG. 1;

FIG. 3 is a sectional view taken on plane III—III of FIG. 2;

FIG. 4 is a plan view of one of the combustion burner subassemblies taken on plane IV—IV in FIG. 2;

FIG. 5 is a sectional view taken on section lines V—V of FIG. 6;

FIG. 6 is an enlarged sectional end view of one of the burner subassemblies shown in FIG. 2; and

FIG. 7 is an enlarged sectional view of one of the control baffles shown in FIG. 2.

Referring now specifically to the drawings, the complete oven assembly **10** includes an oven enclosure housing **12** supported on framework **14** and cooperative with a dynamic blower subassembly **16** and filter subassembly **18**, both also mounted on framework **14** above enclosure housing **12**.

More specifically, the housing enclosure includes impervious top panel **20**, side panels **22** and **22'**, and central floor panel **26**. In the spacing between the elongated lateral edges of floor panel **26** and side panels **22** and **22'** is a pair of suspended burner subassemblies **30** and **30'** to be described in detail hereinafter. The housing and the mechanism contained therein is supported by the framework which includes a plurality of overhead, transverse, horizontal, parallel, spaced beams **34**, supported on their opposite ends by verticaly orienting, spaced, oven straddling columns **36** and **36'**. Connecting the lower ends of columns **36** and **36'** is a plurality of under girders **39**.

On the floor **26** of the oven may be mounted a conveying means **80**, if advisable for the particular type of heating operations to be performed. This conveying means as well as floor panel **26** are supported by transverse floor girders **35** supported on floor columns **37**, which in turn are supported on frame girders **39**.

Within housing enclosure **12** is a ceramic liner which may be formed of fire bricks extending up along the side walls i.e. **42** and **42'**, and over the top i.e. **40**.

If desired, the ends of the enclosed chamber can also be closed with suitable panels, and lined with ceramic

material. Alternatively, the ends may be left open for use of the structure as a continuous processing oven.

The housing forms an elongated enclosure which is divided into an inner oven chamber **50**, and an outer plenum chamber **52**. The plenum chamber extends up the sides of the oven chamber, and over the top, along the length of the oven. The means separating the plenum chamber from the inner oven chamber is formed of a plurality of longitudinally spaced, parallel, generally U-shaped vertical and peripheral support strips **54**, a plurality of special, elongated, horizontal, spaced, cooperative baffle elements **56**, and a plurality of elongated, horizontal, spaced, parallel orificed conduits **58** between adjacent baffle elements.

In the oven structure illustrated these elements extend up both sides and across the top, i.e. over side and top walls, for dynamic convection heating from three directions as explained hereinafter. More specifically, support strips **54** extend up the sides of the oven chamber, and across the top of it, at spaced intervals along the length of the oven to mount the hollow sheet metal baffle elements that form elongated nozzles. The lower ends of strips **54** are secured to the oven floor by angle iron braces **55** extending the length of the oven, and are reinforced on their upper corners by attachment to a pair of spaced angle iron braces **57** extending the length of the oven. These baffle elements are supported on the strips (FIG. 7) by pairs of oppositely extending brackets **60** on each strip for each element, slidably interfitting with a pair of opposite flanges **56***a* and **56***b* integral with remaining portions of the baffle elements. This mounting structure could be varied considerably.

The elongated opposite walls **56***c* and **56***d* of these elements converge toward each other toward the oven chamber. Normally these walls are of like width, but can be of different widths to provide a selected nozzle configuration between adjacent elements, as shown by baffle elements **56′** in the corner portions of the oven chamber.

The inwardly convergent relationship of the two elongated edges or walls of baffle elements **56** cause the elongated spaces between adjacent baffle elements to be divergent into the oven chamber from a restricted throat **50′**, to form an elongated nozzle for purposes to be described hereinafter.

Extending along each of the elongated nozzle spaces between each adjacent pair of baffle elements is an orificed conduit **58**. The orifices **59** in the conduits are at selected spaced intervals of several inches along the length of the conduit. These orifices may normally vary in diameter between about 1/16 inch to about 3/16 inch, depending upon the pressure of the blower used in combination therewith, the size of the oven, the stream velocity and volume desired, and other factors.

One end of these conduits is in flow communication through collars **58***a* with a common manifold **70** on one end of the assembly. The opposite end of these conduits is plugged or capped. Preferably, these conduits can be rotated on their axes in collars **58**, to direct the outlet orifices in a particular direction, to accommodate particular type and size articles heated, as explained more fully hereinafter.

Manifold **70** is supplied with pressurized air by blower **16** operated by electrical motor **17**, drawing air through filter subassembly **18** which preferably includes a pair of parallel filter flow lines **18′** and **18″**, and discharging air into conduit **71** that leads to manifold **70**.

The jetted air streams directed from orifices **59** through the elongated nozzle type passages between the baffle elements, draw hot gases from the plenum chamber by a Venturi effect. Hot gases are supplied to the outer plenum chamber from burner ensembles **104** and **104′** in subassemblies **30** and **30′**.

Each ensemble includes an elongated manifold **90** supplied with a pressurized combustible mixture of gases, e.g. natural gas and air, through a suitable inlet **92** communicating with conventional mixer means (not shown). The manifold is suspended by a pair of L-shaped brackets **94** and **96**. Cover plate **90′** is connected to manifold **90** by suitable bolts **91**, using a seal **93** to prevent leakage of gases from the manifold. This removable plate enables removal of an entire burner ensemble for repair and/or replacement of each burner unit. Secured by bolts to the underside of elements **94** and **96** is burner ensemble **104**. Each ensemble e.g. **104**, includes a plurality of adjacent cooperative, individual burner units **106**, together extending substantially along the length of the oven. All of these burners units are mounted to a common elongated support plate **108** secured by bolts **110** to members **94** and **96**. Each of the burner units is preferably of the construction shown in patent application Ser. No. 300,729 entitled Oven, filed Aug. 8, 1963, now U.S. Patent No. 3,232,593, by the applicant herein. Each includes a hollow metal support housing **112** having an inlet port **114** (FIG. 4) through an embossment **112′** on the back side, and having an open front covered by a thin porous ceramic felt layer **116** sealed and held over the open housing front by screen means **118**. The combustible mixture of gases is forced to pass generally uniformly out through the porous ceramic felt layer, to combust at its outer surface. If desired, a distribution baffle (not shown) may also be employed in the housing to supplement distribution of the gases from port **114** over the entire surface of the combustion area.

Brackets **94** and **96** support peripherally upstanding, ceramic channel walls **98**, **98′**, **100**, and **100′** (FIGS. 2, 4, and 6) forming a hot gas directing elongated outlet passage **102** (FIG. 2) therebetween discharging upwardly into the opposite sides of plenum chamber **52**. Positioned in the lower end of this passage **102** is ensemble **104**.

Preferably, the burner ensembles are employed only along the lower ends of the elongated side wall portions of the plenum chamber. In use, it has been found that it it quite important to have supplemental hot air propelling and directing means to distribute hot air to the top portion of the plenum chamber adjacent the top or ceiling wall of the oven. This is achieved with a pair of additional elongated conduits **69** and **69′** extending the length of the plenum chamber above the outlet passages from the burner ensembles and having a plurality of orifices directed diagonally upwardly and inwardly to propel the hot gases upwardly as indicated by the arrow in FIG. 2. One end of these conduits is plugged while the other ends are swivel mounted in communication with manifold **70** just like conduits **58**.

Operation

During operation of the apparatus, motor **17** constantly drives blower **16** to pull air through filter assembly **18** to conduit **71** and manifold **70**. This causes pressurized air to flow through elongated conduits **58** over the length of the oven, and out through spaced orifices **59** in high velocity streams. The streams are jetted through restricted throat areas **50′** of the elongated nozzles between special baffle elements **56**. The conduits **58** are rotated to selected positions so that the high velocity jets can be directed to accommodate the surface area or configuration of the articles heated in oven chamber **50**.

Simultaneously, burner ensembles **104** are continuously operated by introducing a combustible mixture of gases through inlet **92** into the manifolds, and from thence through the several ports **114** to the individual adjacent cooperative burner units **106**, with combustion occurring at the outer surface of the combined ceramic felt layer and screen retention means. The pressure applied to the burner ensembles can be varied greatly with this type of burner construction, to produce an output temperature which may vary for example from a few hundred degrees up to about 2700 degrees. The selected temperature will depend upon the nature of the articles to be heated, the

size of the oven, the particular type of heating or drying operation performed, and so forth. The hot combustion gases from these burners are ejected upwardly into plenum chamber **52**. Part of the gases are propelled upwardly by the pressure air jets from conduits **69** and **69'** for relatively uniform distribution. The hot gases filling the plenum chamber are drawn continuously at a substantial velocity into the oven chamber by the Venturi action resulting from the high pressure air jets from conduits **58** ejecting through restricted throat areas **58'** in the nozzles. The hot gases and relatively cool propulsion air mix as they flow into the oven chamber, thereby providing a high velocity, relatively high temperature, dynamic flow convection heating action on the surfaces of articles in oven chamber **50**.

It has been found with extensive experimentation on the novel construction that heat transfer characteristics are increased many times over that obtained with conventional, relatively stagnant air oven constructions. In fact, the heat transfer is so greatly increased that carefully run experimentation shows retention time to be reduced by 90% and more of that conventionally required. Moreover, excellent heat exchange occurs over uneven article surfaces, even in dead end pockets, because the dynamic hot gases are directed into such areas and flow constantly to obtain good gas contact and constant exchange of gas. Drying is also greatly improved and more rapidly and thoroughly achieved, due to this excellent contact and constant gas exchange to prevent vapor saturation and stagnation.

It will be realized that the particular orientation of the burner ensembles can be varied to suit the type and configuration of plenum chamber. Also, the particular details of the dividing means formed by the baffle elements and cooperative air jet devices can be varied within the broad concept presented, to suit the particular type of oven structure, articles, etc. to be accommodated. For example, the baffle elements and conduits can be vertically oriented as well as horizontally oriented. Also, the nozzle type inlets to the oven chamber from the plenum chamber could be of spaced short length type rather than elongated.

Experimentation has shown that, even though the cool air is being jetted into the apparatus to mix with the hot combustion gases, temperatures ranging anywhere from 150° to 1200° F. can be readily maintained within oven chamber **50**. Furthermore, with the dynamic convection flow effects obtained, the oven can be heated up almost instantly, and will cool off almost instantly.

Those familiar with this general technology will probably realize several additional advantages to those specifically noted. It is also conceivable that the details of construction may be modified in several different ways, a few of which are suggested above, to suit the particular application involved. Hence, it is intended that the invention is to be limited only by the scope of the appended claims, and the reasonably equivalent structures to those defined therein.

I claim:

1. A dynamic flow, hot gas, convection heating apparatus, comprising: a plurality of peripheral wall means forming a heating chamber; at least one of said wall means including an outer closure wall, and inner baffle means spaced from said outer wall to form a plenum therebetween; hot gas burner means in said plenum to eject hot gases into said plenum comprising high volume individual burners arranged in row fashion and each formed of a housing with gas inlet means thereto and with an open side covered by porous ceramic felt and screen retention means to form a combustion surface; said baffle means including a plurality of elongated spaced baffle elements forming elongated restricted slots therebetween; pressurized air manifold means including a plurality of elongated conduits aligned with and along said slots, said conduits having outlet orifice means oriented to eject pressurized air through said slots into said chamber, and thereby cause dynamic hot gas flow into said chamber by drawing the high volume of hot gases from said plenum into said heating chamber by Venturi action.

2. A dynamic flow, hot gas, convection heating oven, comprising: a plurality of peripheral wall means forming an outer closure wall, and inner baffle means spaced from said outer wall to form an inner oven chamber and a plenum between said baffle means and said outer wall; hot gas burner means in said plenum to eject hot gases into said plenum; said burner means comprising at least one burner ensemble formed of a plurality of individual adjacent burner units; each unit having a housing with a combustible gas mixture inlet and an open side, and having a porous ceramic felt and screen retention means over said open side to form a combustion surface; and a common manifold to said plurality of units; said baffle means including a plurality of elongated spaced baffle elements forming elongated restricted slots therebetween; the individual ones of said baffles having convergent walls from said plenum to said oven chamber to cause said slots to have divergent walls effecting elongated nozzles; pressurized air manifold means including a plurality of elongated conduits along said slots, said conduits having outlet orifice means oriented to eject pressurized air through said slots into said oven chamber, and thereby cause dynamic hot gas flow into said oven chamber from said plenum.

3. The oven in claim **2** wherein said baffle means extend up sides and over the top of said oven chamber, said hot gas burner means are located along said sides, and including a plurality of hot gas distribution, orificed conduits in said plenum chamber adjacent said side walls and communicant with said manifold to propel hot burner gases by air jets up to said top.

4. A dynamic flow, hot gas, convection heating oven, comprising: a plurality of peripheral wall means forming an outer closure wall, and inner baffle means spaced from said outer wall to form an inner oven chamber and a plenum between said baffle means and said outer wall; hot gas burner means in said plenum to eject hot gases into said plenum; comprising at least one burner ensemble formed of a plurality of individual adjacent burner units; each unit having a housing with a combustible gas mixture inlet and an open side, and having porous ceramic means over said open side to form a combustion surface; and a common manifold to said plurality of units; said baffle means including a plurality of elongated spaced baffle elements forming elongated restricted slots therebetween; the individual ones of said baffles having convergent walls from said plenum to said oven chamber to cause said slots to have divergent walls effecting elongated nozzles; pressurized air manifold means including a plurality of elongated conduits along said slots, said conduits having outlet orifice means oriented to eject pressurized air through said slots into said oven chamber, and thereby cause dynamic hot gas flow into said oven chamber from said plenum.

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