Nov. 4, 1969 HIROSHI SAIKI 3,476,368

HIGH TEMPERATURE KILN

Filed Nov. 28, 1967 3 Sheets-Sheet 1

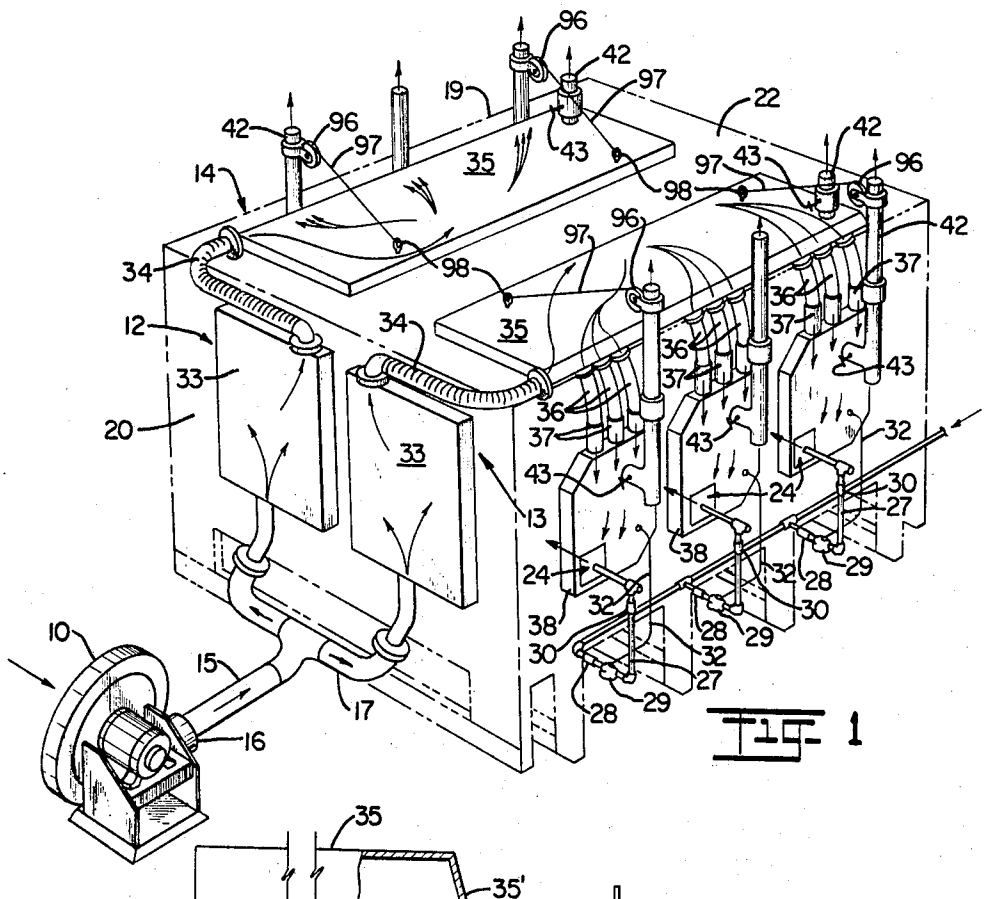

FIG. 1

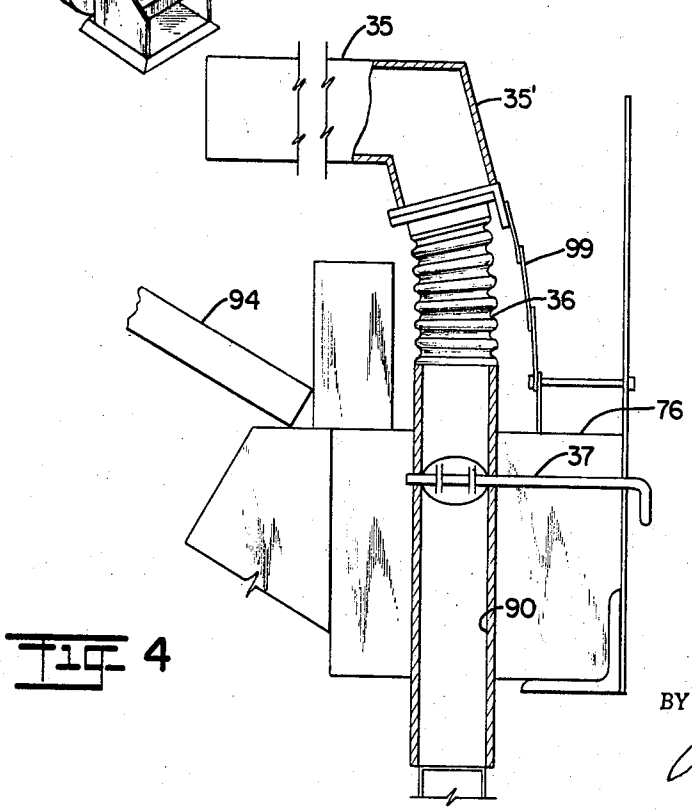

FIG. 4

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HIGH TEMPERATURE KILN

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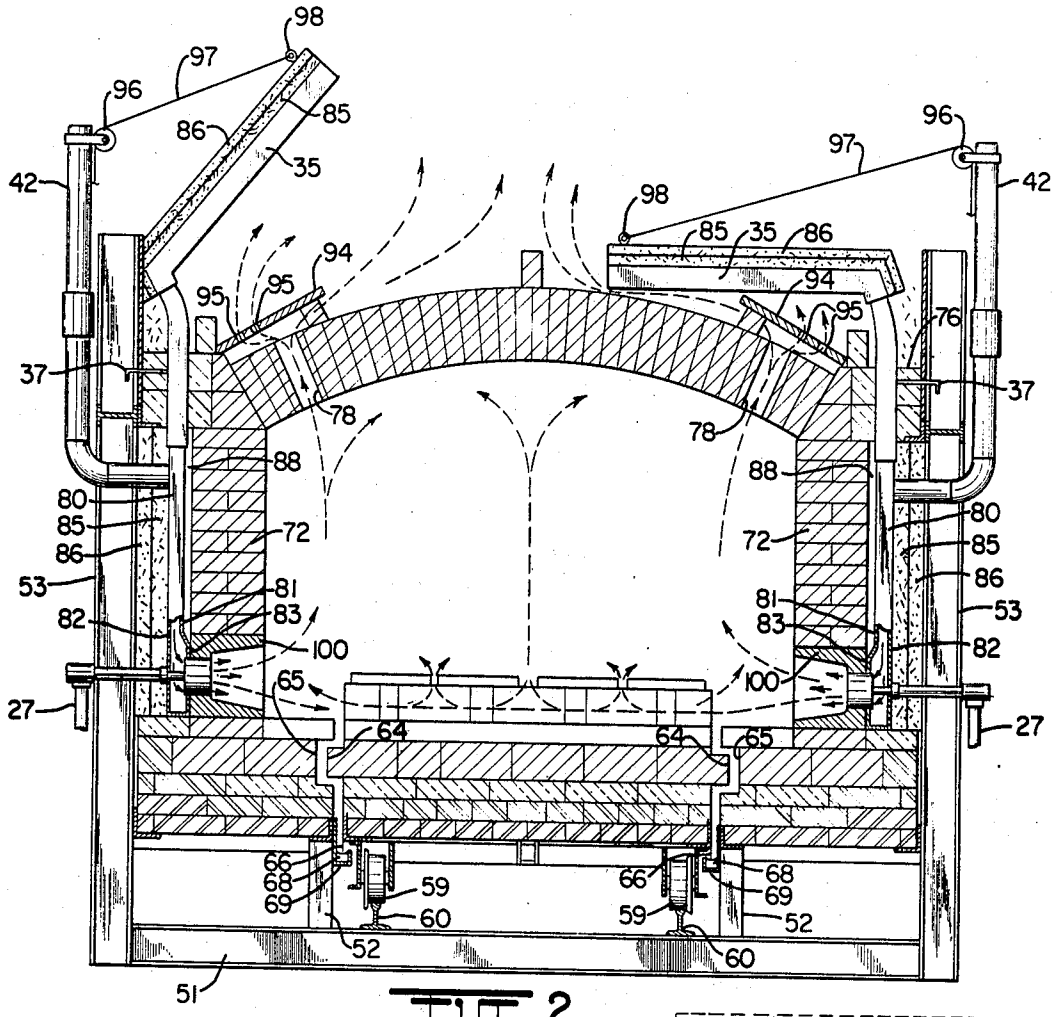

FIG. 2

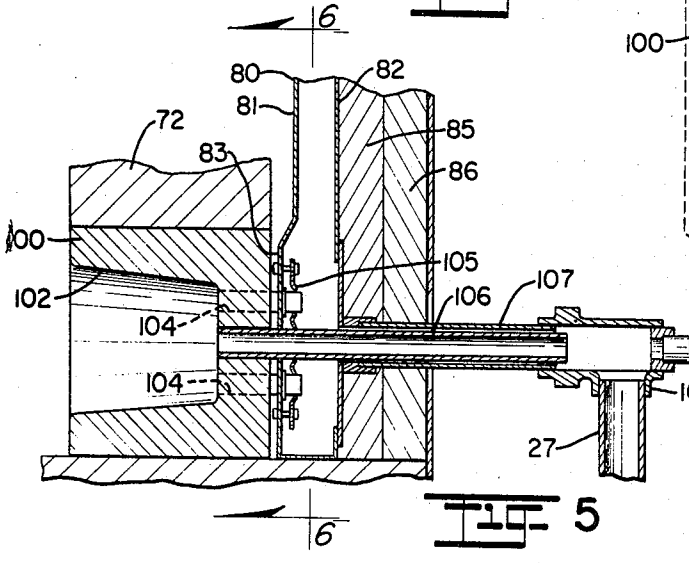

FIG. 5

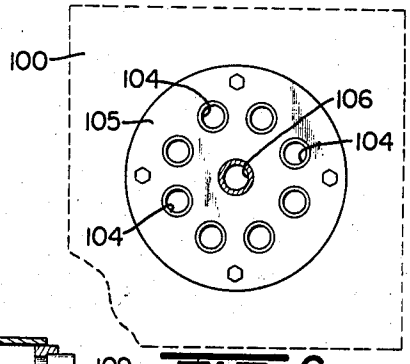

FIG. 6

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HIGH TEMPERATURE KILN

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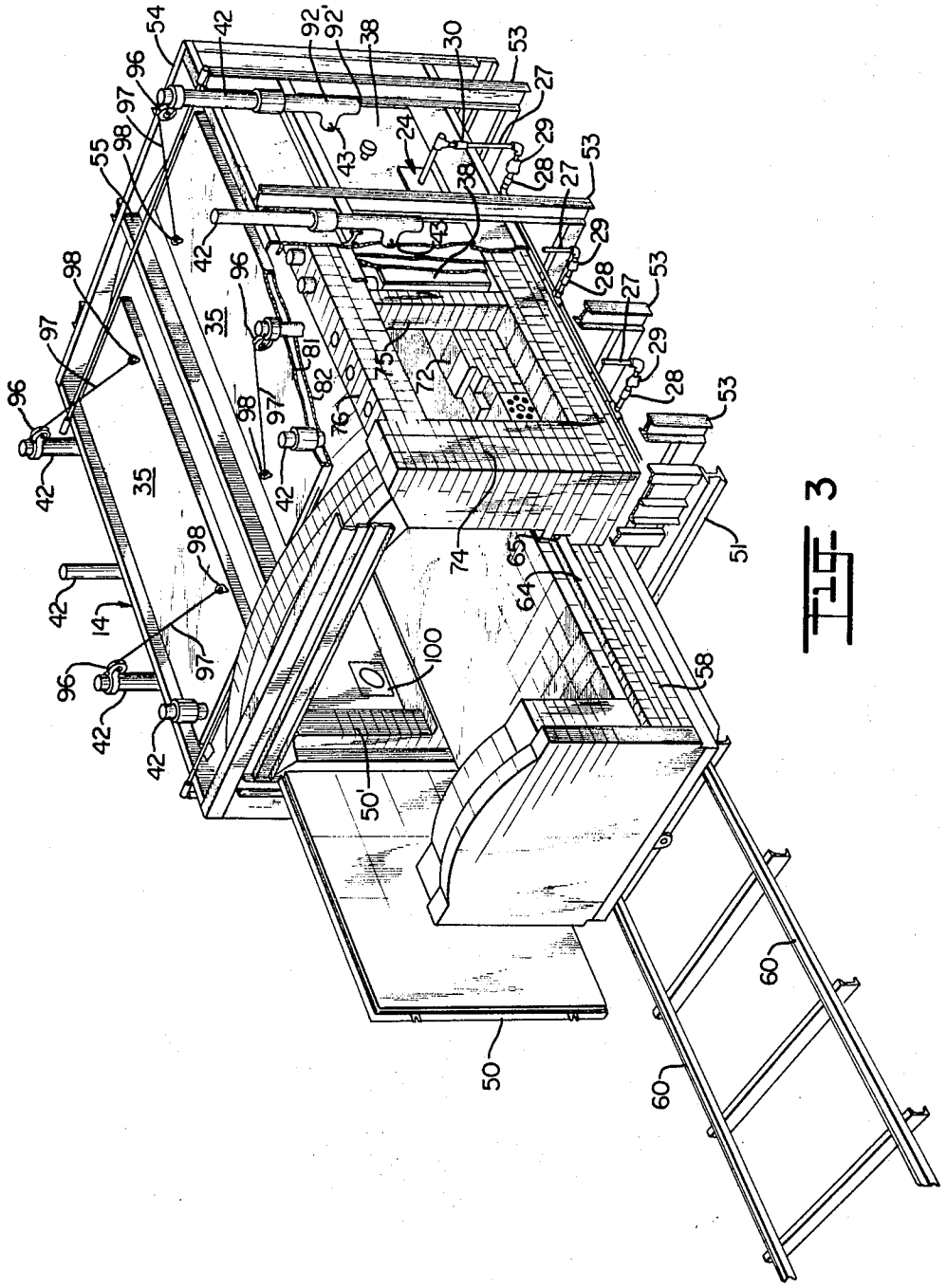

FIG. 3

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United States Patent Office 3,476,368
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3,476,368

HIGH TEMPERATURE KILN

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Int. Cl. F23l 15/04; F23c 5/08
U.S. Cl. 263—20 19 Claims

ABSTRACT OF THE DISCLOSURE

A temperature kiln has relatively lightweight, refractory wall and roof sections of reduced thickness which are substantially covered by relatively broad, flat plenums to circulate preheated combustion air into nozzle burner mix sections located in the refractory walls. The plenums are designed to closely control the air pressure and temperature of the combustion air.

This invention relates to a novel and improved kiln, and more particularly relates to a high temperature kiln, such as, those for heating and firing ware.

In high temperature kilns presently designed for heating ceramic ware to temperatures in excess of 3000° F., it has been difficult to effect the controls necessary to uniformly heat the kiln and ceramic ware to the high temperature level within a reasonable time period, since the requirements and conditions for most efficient heating and insulation are materially different at the lower temperatures up to 2400° F. and intermediate temperatures from 2400° F. to 3000° F. than at the higher temperature level. For instance, in order to maintain a uniform temperature in shuttle kilns, relatively thick refractory walls have been utilized and have necessitated slow, gradual heating into the maximum range and excessively high fuel consumption in maintaining thermal equilibrium across the walls.

In heating the ware to the high temperatures required, it has been the practice in the past to preheat the combustion air or fuel/air mixture prior to introduction into the kiln. Definite limitations are imposed on the extent of preheating due to the danger of preignition; and the means devised for preheating the air has not afforded close accurate control over the degree of preheating desired. Thus preheating should be held to a minimum in the lower temperature ranges but rapidly increased to a maximum in the higher temperature ranges in order to increase the maximum temperature attainable while substantially reducing fuel consumption. At the same time it is desirable that the means employed for circulating and preheating the combustion air also function as lightweight insulative wall coverings in order to reduce the refractory wall thickness and enable the use of lighter refractory materials; and further, to so position the circulating means in relation to the refractory walls as to provide for maximum insulation therebetween in the lower and intermediate temperature ranges.

It is therefore an object of the present invention to provide a high temperature kiln in which combustion air is circulated externally of the kiln walls for closely controlled, adjustable preheating of the air over a wide temperature range in such a way as to minimize heat losses and fuel consumption as well as to accelerate the rate of heating and increase the maximum temperature level of the kiln; and in association therewith to provide relatively lightweight refractory walls of reduced thickness having a reduced heat storage factor thereby minimizing the time required to attain thermal equilibrium across the wall sections.

It is a further object of the present invention to provide in a kiln for novel and improved nozzle mix burner sections stationed at spaced intervals along the kiln walls being characterized by mixing preheated combustion air and fuel with close control of the fuel ignition point and sensitive temperature control from ambient to temperatures in excess of 3000° F., and wherein the nozzle mix burner sections are conformable for use with different selected fuel gases which may be preheated without danger of preignition and safely mixed with the preheated air upon introduction into the kiln.

It is a still further object of the present invention to provide for a novel and improved high temperature kiln in which the outer plenum chambers are so constructed and arranged externally of the kiln roof and wall sections as to effect close accurate control over the circulation and preheating of combustion air over a wide temperature range while reducing the heat storage factor in the kiln walls, and are operative to heat and cool the walls externally in order to further increase the heating and cooling rates of the wall sections.

The present invention contemplates the use of relatively broad flat plenum chambers in outer spaced relation to the refractory roof and wall sections of the kiln, the plenum chambers being controllable to accurately regulate the extent of preheating of the combustion air as the temperature is increased from the low to the high temperature ranges. The plenums are insulated and in cooperation with an insulating air space left between the plenums and the walls define relatively lightweight insulated wall sections which will permit substantial reduction in the refractory wall thickness. In this relation, the insulating space will afford improved insulation in the lower heat ranges against preheating of the air but which at the higher temperature ranges will have minimum insulating effect.

Nozzle mix burner sections are stationed at intervals along the lower portions of the walls which can be operated with preheated air in excess of stoichiometric requirements so as to reduce flame temperatures and hot spots, to increase the flame propagation rate, and to raise the maximum temperature level of the kiln in a rapid, dependable manner.

The above and other objects of the present invention will become more readily understood and appreciated from a consideration of the following detailed description when taken together with the accompanying drawings, in which:

FIGURE 1 is a somewhat schematic view in perspective and illustrating the relative disposition and arrangement between the plenum chambers and outer wall sections of the kiln.

FIGURE 2 is a cross-sectional view of the preferred form of invention shown in FIGURE 3.

FIGURE 3 is a perspective view with portions broken away to illustrate the kiln wall construction in a preferred form of the present invention.

FIGURE 4 is an enlarged view in detail of the upper side walls and roof sections of the preferred form.

FIGURE 5 is a fragmentary view in detail of one of the nozzle mix burner sections; and

FIGURE 6 is an end view of the nozzle mix burner section shown in FIGURE 5.

Referring in detail to the drawings, there is schematically shown in FIGURE 1 the method and means for circulating combustion air from a blower **10** into separate preheat plenum systems **12** and **13** which are located at the back and along either side of a kiln **14**. The air is delivered by the blower **10** through a main duct **15** having a butterfly blast valve **16** to regulate the flow of air through an air header **17** into the plenum systems. As a preliminary to describing in detail the preferred form of kiln construction, the construction and operation of the

combustion air-circulating system shown in FIGURE 1 will be briefly described. The kiln **14** may be comprised of side and back refractory walls **19** and **20**, respectively, with an upper or top refractory wall section **22** forming a generally rectangular enclosure for the introduction of ceramic ware through a door or other opening in the front end, not shown, of the kiln. A series of burner sections **24** are located at spaced intervals along the lower part of the sidewall sections **19**, each burner section being supplied with fuel from a common supply line **26** through a gas line **27**, the latter being suitably provided with a stop cock **28**, gas regulator **29** and limiting orifice valve **30** leading into each burner section. Also shown is an impulse line **32** running from the gas regulator **29** to the plenum supply chamber, to be hereinafter described, leading into each burner section.

In the schematic showing of FIGURE 1, each of the plenum systems **12** and **13** is correspondingly formed with a relatively broad flat plenum **33** along the back wall of the kiln communicating through a metallic flexible hose **34** with an upper adjustable crown plenum **35** which traverses the substantial length of the top wall section **22**. Each crown plenum distributes the air downwardly through metallic flexible hoses **36** provided with flow regulating butterfly valves **37** into the upper end of relatively broad flat plenums **38** where the air flows into the burner section for combustion as the air mixes with the gas at this point. The combustion gases pass under the ware in the kiln, upwardly along the sides and through the ware, then are exhausted through flues located at spaced intervals along the roof section.

In a manner to be shown and described in detail with reference to the preferred form of invention the plenums **33**, **35** and **38** are positioned in outer spaced relation to the external surfaces of the kiln whereby to form a space therebetween which has insulative value below radiant temperatures but which decreases as the main mode of heat transfer shifts from convection to radiation. As a result, insulation is provided at lower temperatures where air preheat is unnecessary and decreases as the requirement for air preheat increases in the higher temperature ranges. In this same connection, the upper crown plenums **35** are adjustably mounted for swinging movement toward and away from the roof section; thus, at the lower kiln temperatures and under conditions of low temperature control the crown plenums may be raised away from the exhaust gas stream in order to minimize air preheating. Under increasing temperatures the crown plenums may be lowered into the path of the exhaust gas stream through the roof section. Further, each of the crown and sidewall plenums is provided with a stack **42** having a butterfly valve **43** to adjustably control the pressure and temperature of air supplied through each crown and sidewall plenum to the burner section.

In heating ceramic ware, air is directed by the combustion blower **10** through the main duct **15** into each of the preheat plenum systems **12** and **13** where the pressurized air is caused to flow upwardly through the back wall plenum **33** into the end of the crown plenum **35** and downwardly through the sidewall plenum **38** into the burner section. In heating the ceramic ware at low kiln temperatures, the crown plenums **35** are raised to eliminate preheating of the combustion air so that in the lower temperature range the plenums act merely as passageways for the air and as lightweight insulation for the kiln. As stated, the air space between the plenums and outer surfaces of the kiln will serve as added insulative value in the lower kiln temperature ranges.

At higher kiln temperatures, the crown plenums **35** are lowered into the path of the exhaust gas stream flowing upwardly from the kiln through openings in the roof section. The broad flat configuration of the plenums will permit rapid preheating of the air prior to its downward passage through the sidewall plenums **38**, and in turn the sidewall plenums as they are heated will transfer heat to the outer faces of the refractory walls as well as to the other outer insulative layers protecting the skin. The pressure and temperature of the air can be closely controlled by regulating the disposition of the crown plenums in the exhaust stream as well as by individually regulating the side stacks **52** communicating with the sidewall plenums.

Now considering in more detail the preferred form of invention as shown in FIGURES 2 to 6 and with particular reference to FIGURES 2 and 3, the kiln **14** takes the form of a shuttle kiln having a hinged door member **50** which serves as a closure for the opening **50'** in the front end wall of the kiln. The kiln is reinforced and supported by a steel frame including horizontally extending I-shaped beam members **51** and standards **52** beneath the floor section of the kiln. Vertical beam members **53** are arranged at spaced intervals along opposite sides of the kiln outwardly of the plenum sections together with an upper rectangular beam structure **54**, and a refractory baffle **55** extends the length of the kiln between the upper crown plenums.

The ware to be heated may be placed upon a ware-supporting car **58** having flanged wheels **59** movable along guide rails or tracks **60** running longitudinally of the kiln through the central opening in the floor section. In a conventional manner, opposite sides of the ware-supporting car **58** may be provided with laterally projecting ribs **65** complimentary to channels or grooves **65** in the floor section along the sides of the opening. Additionally, the lower side edges of the car each have a downwardly projecting flange **66** which extends into a sand seal **68** positioned in a trough **69**, a pair of troughs being provided in inwardly spaced relation at the upper ends of the standards **52** on opposite sides of the floor sections. An air seal, not shown, may be positioned above the sand seal to prevent the flow or circulation of hot gases from the kiln into the space above the sand seal.

In the construction of the sidewalls **19** of the kiln, as best seen from FIGURE 2, each comprises an inner brick wall section **72** composed of a lightweight refractory material, which extends continuously along either side of the kiln with double brick wall sections **75** at each corner of the kiln and outer brick wall sections **75** extending vertically at spaced intervals along either side from the outer edge of the floor section to the outer wall section **76** to reinforcing opposite sides of the roof section **22**. Here the roof section **22** is in the form of an arch composed of lightweight refractory brick and provided with flue openings **78**, and the upper wall sections **76** are similarly composed of lightweight brick which span the length of the kiln between the corner sections **74**. Although not shown, the back wall **20** of the plenum similarly includes an outer wall section **75** centrally located between the back wall plenums **33**.

Each of the back and sidewall plenums **33** and **38** is correspondingly comprised of a generally rectangular, thin-walled metallic shell which is dimensioned to occupy the entire space formed intermediately between the outer sidewall sections **75** and between a section **75** and a corner section **74**. Specifically, each plenum includes relatively narrow side and end walls **80** joined by rectangular inner and outer panels **81** and **82**, respectively, the inner panel including an inwardly directed offset portion **83** at its lower end **24** in order to increase the cross-sectional area of the plenum at the burner section. The outer panel **82** of each plenum is covered with a lightweight insulating material, such as, mulitple layers **85** and **86** of rigid fiber insulation. Preferably, each plenum chamber is mounted to leave a clearance space **88** between the inner panel and the outer hot face lining or skin of the inner wall section **72** which as stated defines an insulating space at lower temperature ranges. Here, each plenum is mounted in place between the outer wall sections with a series of ducts **90** extending upwardly

through openings in the wall sections **76** for connection to the flexible hoses **36** leading from the upper crown plenums. In turn, each exhaust stack **42** has a lower horizontal duct portion extending horizontally through the thickness of the outer insulating layers **85** and **86** into a T-shaped fitting **92**, the lower open end **92'** of the fitting being adapted to draw relatively cool air into the exhaust stack for mixture with the relatively hot air discharged from the plenum when the butterfly valve **43** is open.

The upper crown plenums **35** are each formed in the same manner as the back and sidewall plenums, except that the crown plenums are dimensioned to cover each side of the upper roof span and to extend the length of the kiln. Further, the side of each crown plenum has an outwardly and downwardly inclined extension **35'** provided with openings therein to receive the upper ends of the flexible hoses **36**. In the space between the upper crown plenums and the roof section, angularly extending flame deflector plates **94** are positioned in spaced relation above the flue openings **78**, and limited openings **95** are provided in each deflector plate to permit the hot exhaust gas stream to pass upwardly therethrough into contact with the inner wall panel of the crown plenum. After passing across the inner wall of the crown plenums **35** the gases are free to escape around the inner edges, in the direction of the arrows as shown in FIGURE 2.

Each of the crown plenums is adjustsable toward and away from the roof section **18** about the lower ends of the flexible hose connections into the sidewall plenums between the elevated position shown on the left and the lowered position shown on the right in FIGURE 2. This adjustment may be suitably accomplished by means of a winch, not shown, having pulleys and cable lines **97** and connected to eyes **98** at the inner free ends of the plenums. If desired, slidably adjustable supporting plates **99** may be positioned outwardly of each of the flexible hoses to loosely retain insulating material in place along the outsides of the hoses.

The air passing downwardly into each of the sidewall plenums is introduced into the burner section **24**. Each burner section includes a burner block **100** mounted in the inner refractory wall sections **72**, and the burner block is provided with an inwardly divergent, conical recess **102** communicating with a series of orifices **104**. The orifices **104** are defined by ceramic tubes concentrically mounted in a burner plate **105** for introduction of air from the plenum into the kiln. A ceramic fuel supply tube **106** extends through the burner plate centrally of the air supply orifices **104** to introduce fuel into the cavity **102** for mixture and ignition with the air supplied through the orifices **104**. The gas supply tube extends rearwardly through an outer concentric pipe member **107**, the latter being mounted in the side plenum and having at its outer end an elbow-shaped fitting **108** provided with an observation port **109**. As described in connection with FIGURE 1, gas is supplied from the main fuel line **26** through each individual gas supply line **27**, each line being connected to the fittings **108** leading into the burner sections. Fuel supply may be closely regulated in relation to the amount of air supplied through the side plenums to provide optimum ignition and flame conditions at each burner section. Of particular importance is that the nozzle mix burner enables close accurate control of the combustion process in the low temperature range, and the burners may further be operated with a supply of air directed through the concentrically arranged orifices in excess of stoichiometric requirements in order to reduce the flame temperature and localized heating in the vicinity of the burner sections.

In operation, pressurized combustion air is directed upwardly through the back wall plenums to enter the rear ends of the crown plenums through the flexible hose members **34**. The crown plenums distribute the air to the sidewall plenums **38**, the air flow being regulated by adjustment of the butterfly valves **37** in the hose connectors **36** between the crown and sidewall plenums. In passing downwardly into the sidewall plenums the air is directed into the nozzle mix burner blocks through the concentrically arranged orifices **104**. The gas is introduced through the central fuel supply tube **102**, combustion occurring in the burner block and beyond as the air mixes with gas at this point. The combustion gases pass under and through the ware in the ware-supporting section and pass upwardly along the kiln walls to exhaust through the flues in the roof section.

In the lower temperature ranges, the upper crown plenums are raised, as shown on the lefthand side of FIGURE 2, to avoid preheating of the air, and in this relation the crown plenums merely act as passageways for the combustion air. Further, in the lower temperature range the air space between the plenums and hot face linings of the refractory wall sections serve as insulating spaces below radiant temperatures; however the insulative value of the spaces will decrease as the heat transfer shifts from convection to radiation in the higher temperature range. For high temperatures or accelerated heating, the crown plenums are lowered into the hot exhaust gas streams passing upwardly through the flues to preheat the air prior to passage into the sidewall plenums. The heated combustion air will enable higher flame temperatures and proportionately decrease the fuel consumption. In turn, the higher flame temperatures will result in higher kiln temperatures and accelerated heating rates, and can produce oxidizing flames by providing excess air through the burner sections to more rapidly reach kiln temperatures in excess of 3000° F. In this connection, the high temperature combustion air is safely handled in the burner sections which are entirely of refractory material, and the gas and air are mixed in the burner nozzles where ignition temperatures and flame propogation rates are of minor significance. Moreover, the flame propagation rate is materialy increased by mixing the air and gas in this manner, the effect being to shorten flame length particularly by use of excess air.

As the kiln is heated into the high temperature range and the insulative value of the air space between the plenums and kiln walls decreases, the air is preheated further by radiant heat tranfer from the hot face linings of the kiln walls through the side and back wall plenums. At the same time, the plenums function as lightweight insulating mediums along the kiln walls and is of particular value in reducing the outer skin temperature without adding appreciable weight in the form of thicker refractory walls. Moreover, the plenum system materially reduces the heat storage factor by reducing the static mass and results in substantially less time in reaching thermal equilibrium both in heating and cooling of the kiln, since the preheat temperature of air in the plenum system can be closely regulated. Thus, heat may be added by preheating the combustion air in the crown plenums and the hot sidewall plenums will then transfer heat to the outside of the inner refractory wall sections, or hot face lining, as well as to the outer insulative layer protecting the plenums. The converse is true when cooling is desired since the crown plenums may be elevated away from the exhaust gas streams and the cooler air circulated through the plenums will operate to more rapidly reduce the temperature along the outer surfaces of the kiln walls.

It will be appreciated that the pressure and temperature of the air can be regulated for the system as awhole through the butterfly blast valve at the outlet of the blower. The pressure and temperature is also controlled by the degree of immersion of the crown plenums in the exhaust gas stream and further by the air bleedoff stacks provided for each of the sidewall and crown plenums.

Summarizing the many advantages and features of the high temperature kiln of the present invention, closely controllable preheat air temperatures and pressures are obtained through the utilization of the crown plenums

which can be adjusted to intercept the flow of exhaust gases from the kiln to regulate the preheat temperature in cooperation with flow regulating means for the system and for each individual plenum chamber to regulate the pressure and temperature of the air supplied to each burner section. The plenum system materially reduces the thickness of the refractory walls and permits utilization of lighter refractory materials thereby reducing the heat storage factor and permitting faster heating and cooling rates of the kiln walls. The plenums function to heat and cool the outer refractory wall surfaces to permit accelerated heating and cooling rates, and the air spaces between the kiln walls and plenums insulate the plenums from the kiln walls in the lower temperature ranges. Moreover the nozzle mix burner sections permit closer regulation and control of the flame characteristics and heating of the kiln throughout the entire temperature range. Low temperature control is afforded by employing excess air for flame quenching and high temperature control is afforded through the use of burner blocks composed of refractory material which serve to contain the high temperature combustion process. The system devised therefore results in a recuperative cycle in which waste heat from the exhaust gas is employed to preheat the air, the preheated air permitting higher flame temperatures to be generated and the higher exhaust gas temperatures accelerating the rate of preheating which in turn further increases the flame temperature elevation rate.

While there has been described a preferred form of the present invention it is to be understood that the plenum system and burner section described may be utilized independently or in cooperation with one another in kilns other than that described in the preferred form, and for example, in the manner broadly described with reference to the kiln construction shown in FIGURE 1. It is further to be understood that various modifications and changes may be made in the specific construction and arrangement of elements comprising the present invention as well as the specific kiln construction without departing from the spirit and scope thereof as defined by the appended claims.

What is claimed is:

1. In a kiln having refractory roof and wall sections defining an enclosure for heating and firing ware, the combination comprising:

relatively broad plenum sections substantially covering the roof and wall sections of said kiln,

burner sections disposed at spaced intervals in communication with the lower ends of the wall plenums,

means for circulating air through the roof plenums and downwardly through the wall plenums into said burner sections for admixture and combustion with fuel introduced into said burner sections, and

means associated with each of said plenum sections to adjustably control the pressure and temperature of air flowing through each plenum section.

2. In a kiln according to claim 1, said plenum sections being disposed in outer spaced relation to the roof and wall sections of said kiln.

3. In a kiln according to claim 1, each of said plenum sections being provided with an outer lightweight insulating layer of a composition other than the composition of said refractory wall and roof sections.

4. In a kiln according to claim 1, further including means adjustably supporting said roof plenum sections for movement toward and away from heat transfer relation to the roof section of said kiln.

5. In a kiln according to claim 1, the roof plenum sections being defined by a pair of plenums extending lengthwise of the roof section in side-by-side relation, and means adjustably mounting each of said roof plenum sections for movement toward and away from heat transfer relation to said roof section.

6. In a kiln according to claim 5, wherein flue openings are provided in the roof section of said kiln beneath said plenum sections, and flame deflector plates are interposed between the flue openings and the inner surfaces of said roof plenum sections.

7. In a kiln according to claim 1, said wall plenum sections being disposed in external recess portions along the refractory walls of said kiln, each of said wall plenums being in the form of a generally rectangular thin-walled shell having an insulating layer along the external surface of said shell, and

flexible air ducts interconnecting said roof plenum sections and said wall plenum sections.

8. In a kiln according to claim 7, said means for adjustably controlling the pressure and temperature in said roof and wall plenums being defined by exhaust stacks each including a valve member being adjustable to regulate the flow of air from each plenum section through each respective stack.

9. In a kiln according to claim 8, each of said exhaust stacks being further characterized by having a relatively cool air inlet communicating with the vent to cool the combustion air withdrawn from the wall plenums.

10. In a kiln according to claim 1, said burner sections each having a refractory burner block disposed in the refractory wall of said kiln, a fuel supply line extending through each burner block and air supply orifices communicating with the plenum wall sections and being concentrically disposed about said fuel supply line.

11. In a kiln according to claim 10, said burner sections each being characterized by having a conical-shaped recessed portion diverging inwardly from the inner ends of said fuel supply line and fuel supply orifices for mixing and combustion of said fuel and air.

12. In a kiln having refractory roof and wall sections defining an enclosure for heating and firing ware with a combustible mixture of fuel and air supplied through burner sections located at spaced intervals along the walls of the kiln, and flue openings in the roof section of the kiln for discharging the gaseous products of combustion,

a plenum system for supplying preheated combustion air to each of said burner sections, said plenum system comprising relatively broad, thin-walled plenum sections being disposed in side-by-side relation to substantially cover the refractory roof section of the kiln, and

means for adjustably supporting said roof plenum sections for movement toward and away from the path of the gaseous products of combustion discharged through the flue openings in the roof section of the kiln.

13. In a kiln according to claim 12, each of said plenum sections being provided with an outer lightweight insulating layer, and

means for circulating combustion air through said roof plenum sections including flexible hose connections leading into and away from one side of each of said plenum sections.

14. In a kiln according to claim 12, said roof plenum sections being defined by a pair of plenums extending lengthwise of the roof section in side-by-side relation, said flexible hose connections being disposed along the outsides of each of said plenum section and said adjustable supporting means being operative to angularly raise and lower each of said plenum sections about said flexible hose connections.

15. In a kiln according to claim 14, said roof plenum sections being further characterized by having adjustable exhaust stacks to regulate the pressure and temperature of preheated air in each of said plenum sections.

16. In a kiln according to claim 14, further including plenum sections disposed along the sidewalls of the kiln in communication with said burner sections, and said flexible hose connections leading away from said roof plenum sections being connected to each of said wall plenum sections for circulation of preheated combustion

air from said roof plenum sections into said burner sections.

17. In a kiln according to claim 14, further including flame deflector plates being interposed in spaced relation between the flue openings in said roof sections and the inner surfaces of said roof plenum sections.

18. In a kiln having refractory floor, roof and wall sections dfining a common enclosure for heating and firing ware,

a series of burner sections being located at spaced intervals in the walls of said kiln above said floor section,

each of said burner sections having a burner block composed of refractory material mounted in the wall of said kiln, a fuel supply line extending centrally through each burner block, air supply means providing a source of combustion air for each of said burner sections including ceramic tubes defining air supply orifices being concentrically arranged about said fuel supply line in each burner block with a conical-shaped recessed portion in each burner block diverging inwardly from the inner ends of said fuel supply line and air supply orifices, and

said air supply means including plenum sections disposed along the external surfaces of said kiln for preheating the combustion air delivered into each of said burner sections, and means associated with each plenum section to adjustably control the pressure and temperature of preheated air supplied to said burner sections.

19. In a kiln according to claim 18, said plenum sections including sidewall plenums inserted in recessed portions in the sides and back of said kiln, upper crown plenums in outer spaced relation to the roof section of said kiln, and flexible hoses interconnecting the crown plenums and adjacent sidewall plenums.

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EDWARD G. FAVORS, Primary Examiner

U.S. Cl. X.R.

431—178