Sept. 2, 1969 G. B. REMMEY 3,464,682

CONTINUOUS KILN FIRING SYSTEM

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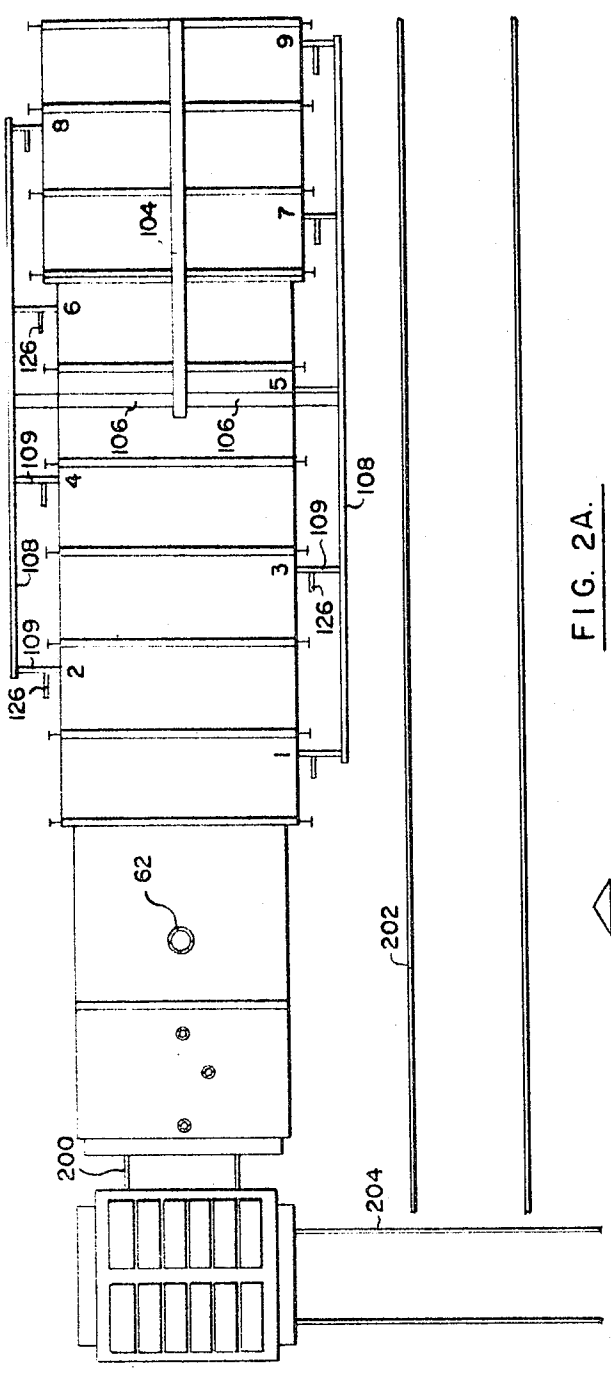


FIG. 2A.

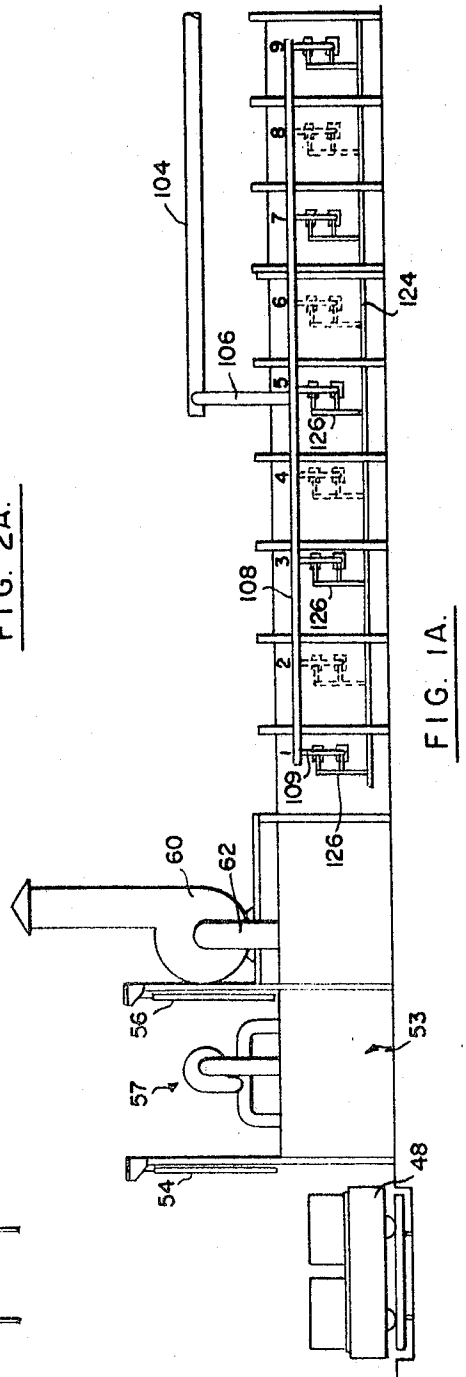


FIG. 1A.

INVENTOR
GEORGE BICKLEY REMMEY
BY
Busser, Smith & Harding
ATTORNEYS

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CONTINUOUS KILN FIRING SYSTEM

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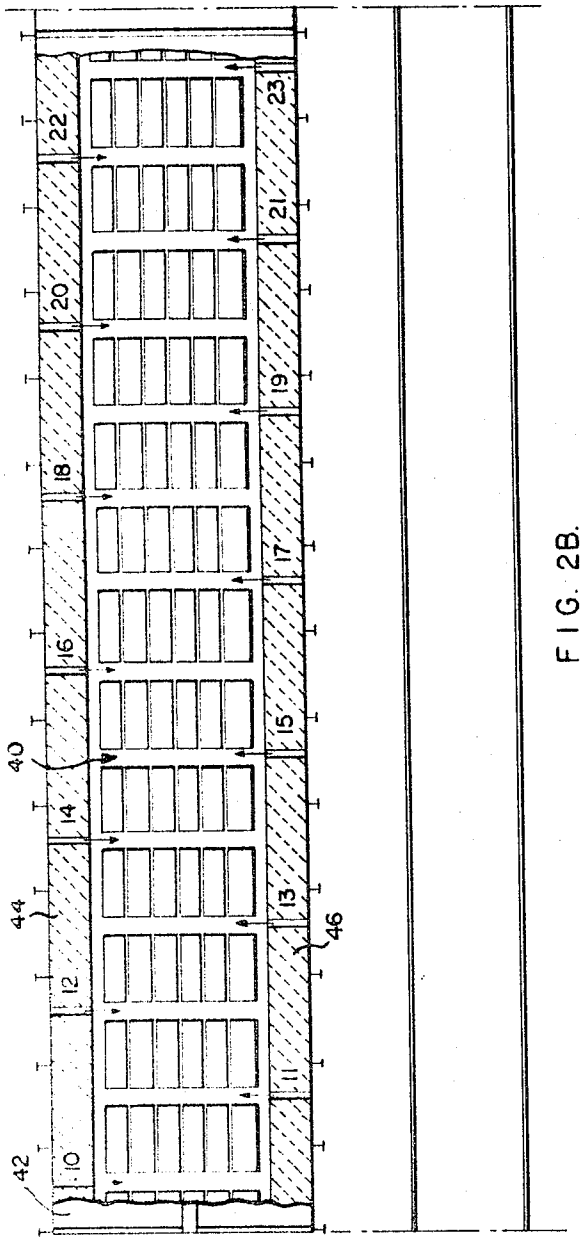


FIG. 2B.

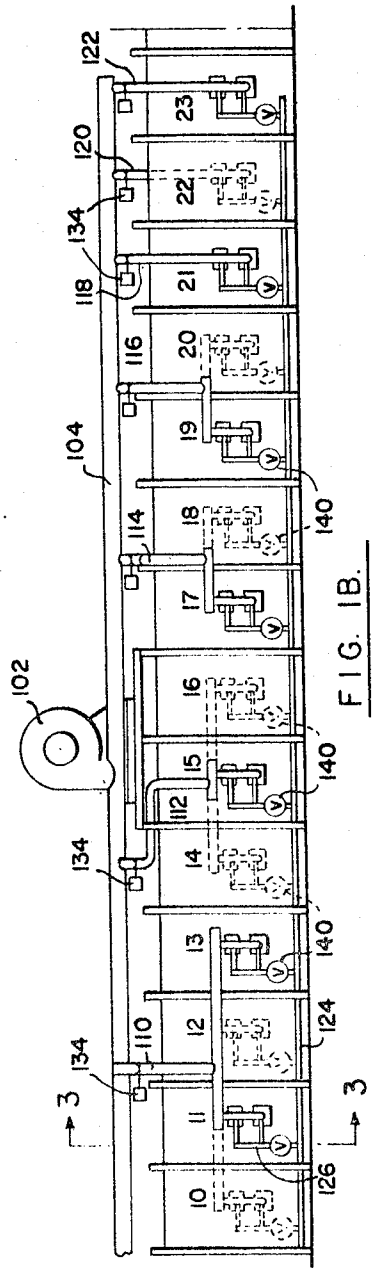


FIG. 1B.

INVENTOR

GEORGE BICKLEY REMMEY

BY

Busser, Smith & Harding

ATTORNEYS

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CONTINUOUS KILN FIRING SYSTEM

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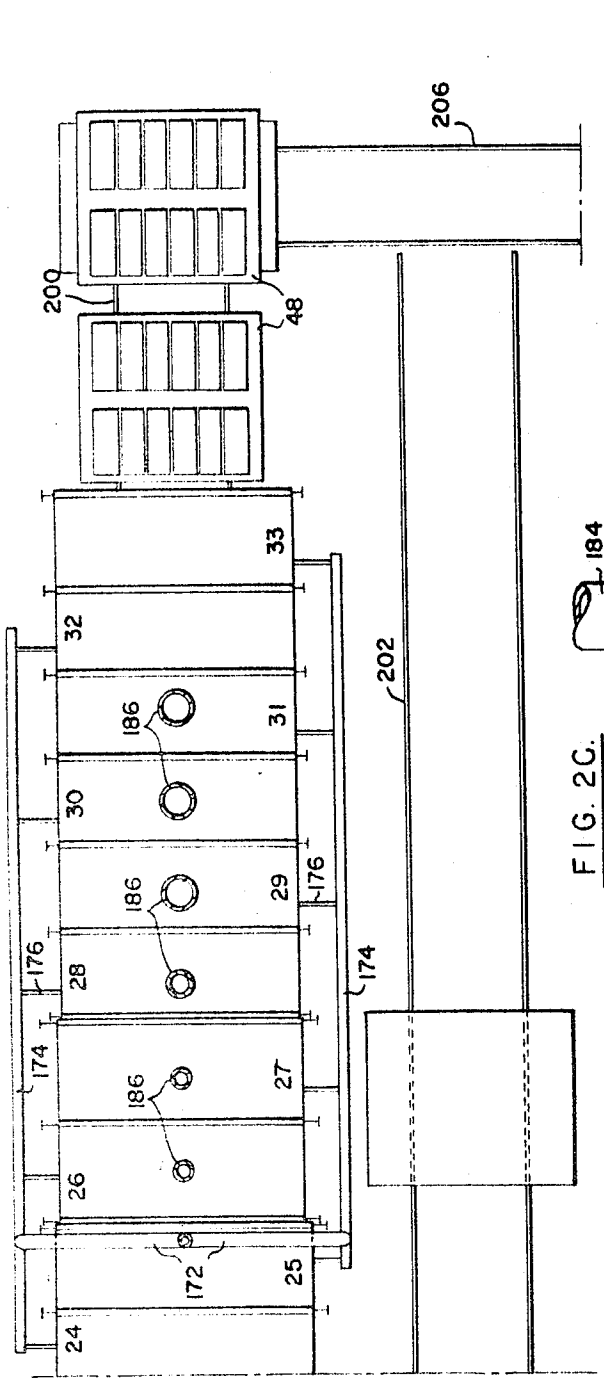


FIG. 2C.

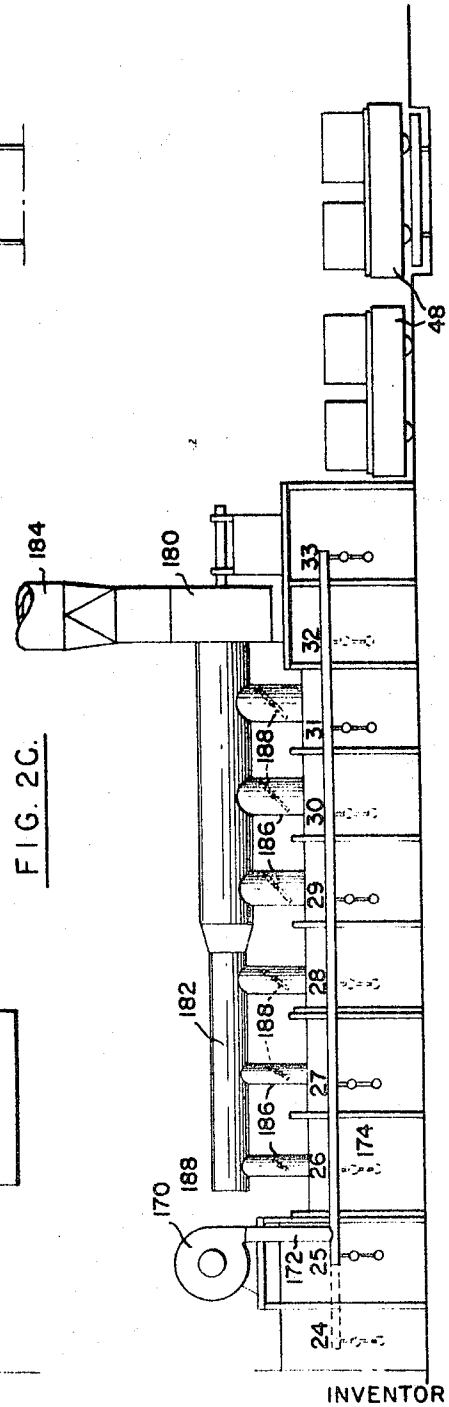


FIG. 1C.

INVENTOR
GEORGE BICKLEY REMMEY

BY
Bissell, Smith & Harding

ATTORNEYS

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CONTINUOUS KILN FIRING SYSTEM

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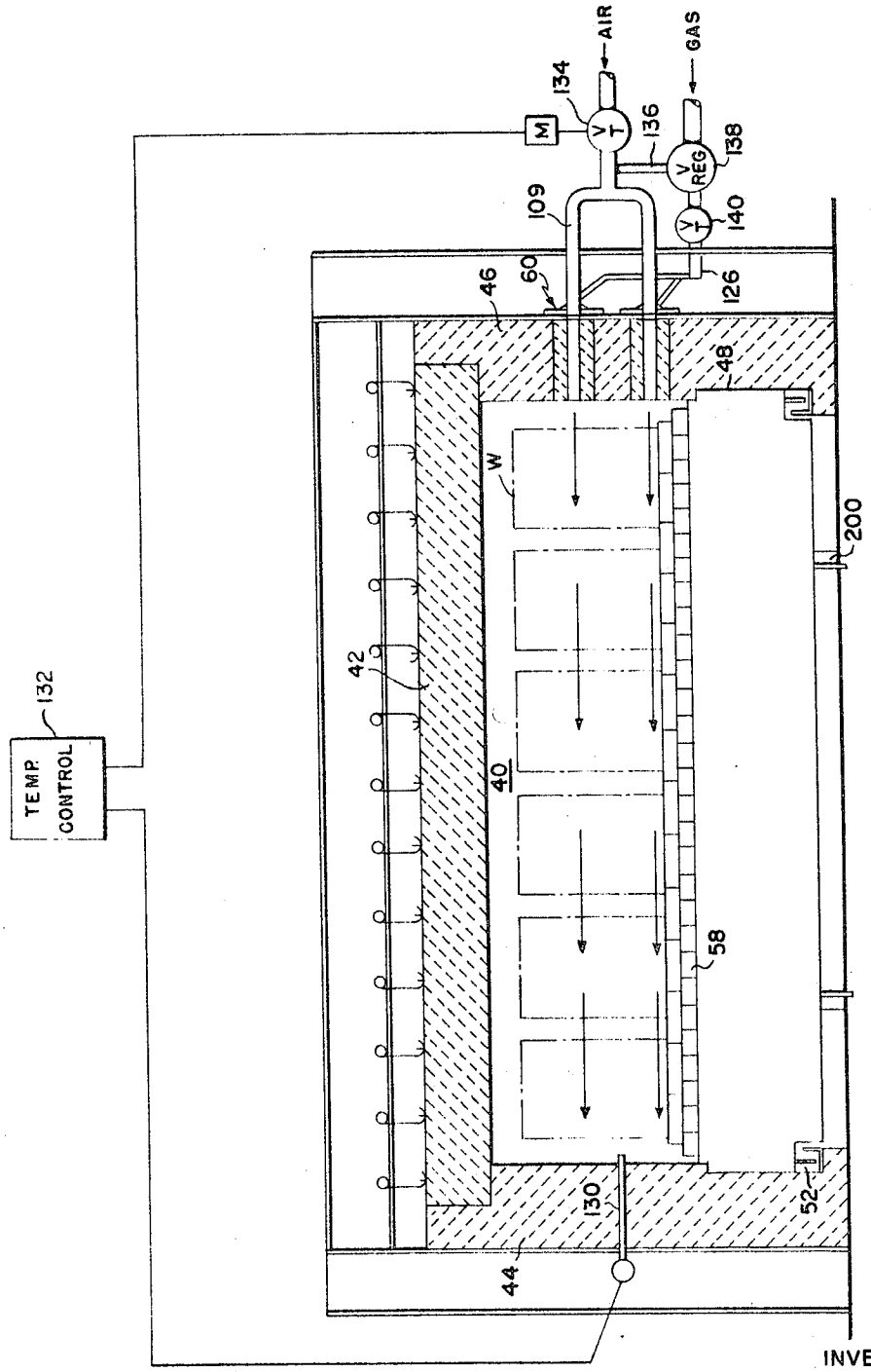


FIG. 3.

INVENTOR
GEORGE BICKLEY REMMEY

BY
Bussey, Smith + Harding

ATTORNEYS

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CONTINUOUS KILN FIRING SYSTEM

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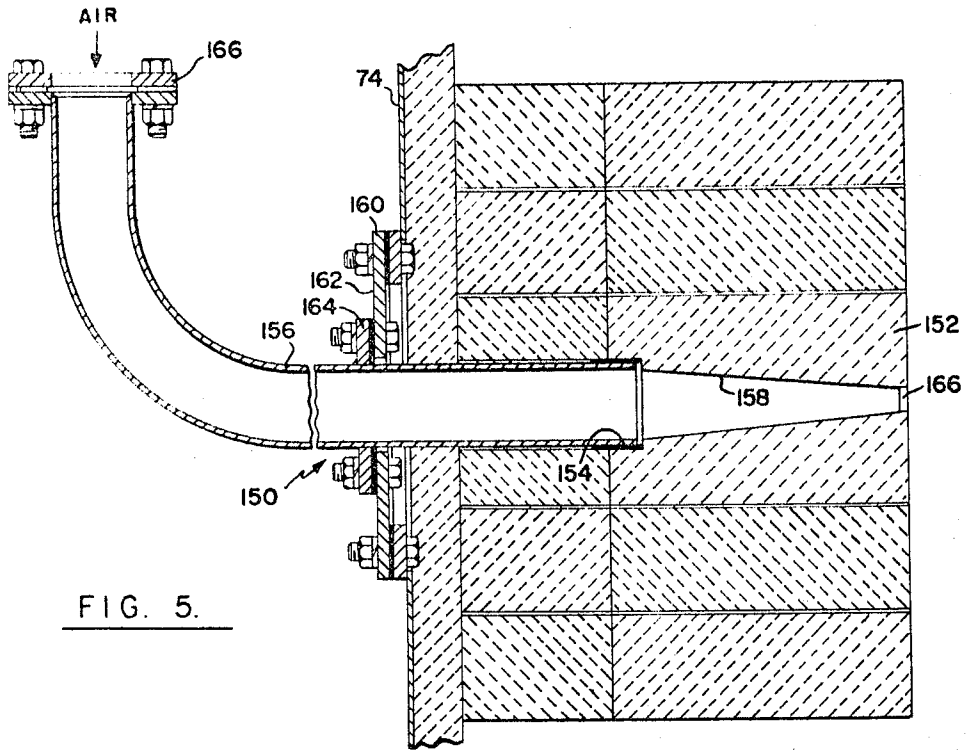


FIG. 5.

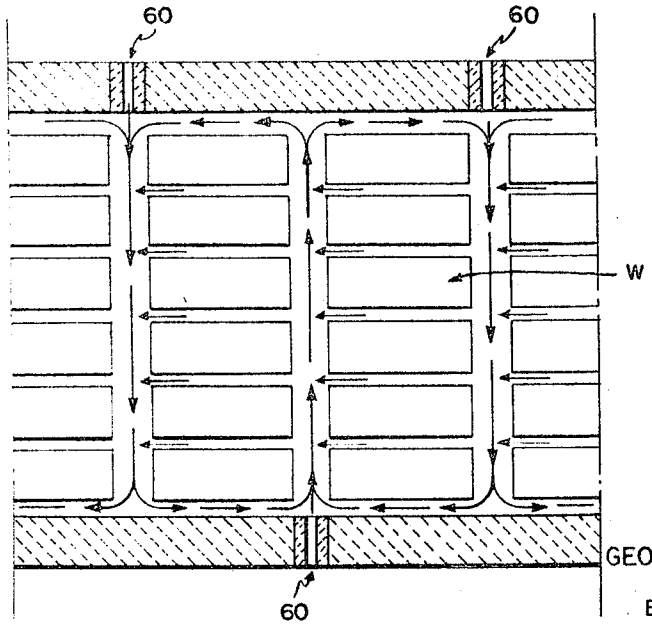


FIG. 4.

INVENTOR
GEORGE BICKLEY REMMEY
BY
Bussee, Smith + Harding
ATTORNEYS

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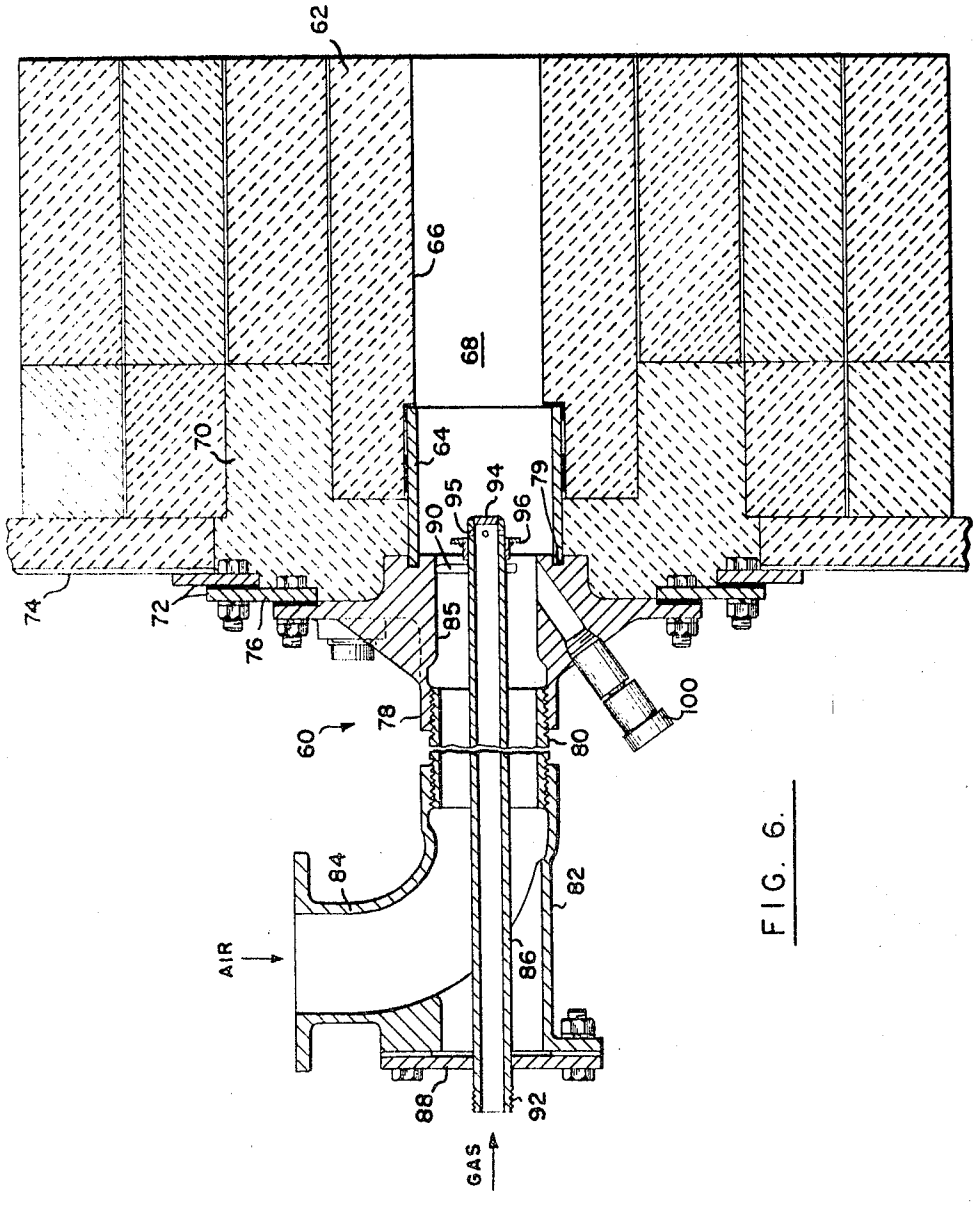


FIG. 6.

INVENTOR
GEORGE BICKLEY REMMEY
BY
Busser, Smith & Harding
ATTORNEYS

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CONTINUOUS KILN FIRING SYSTEM

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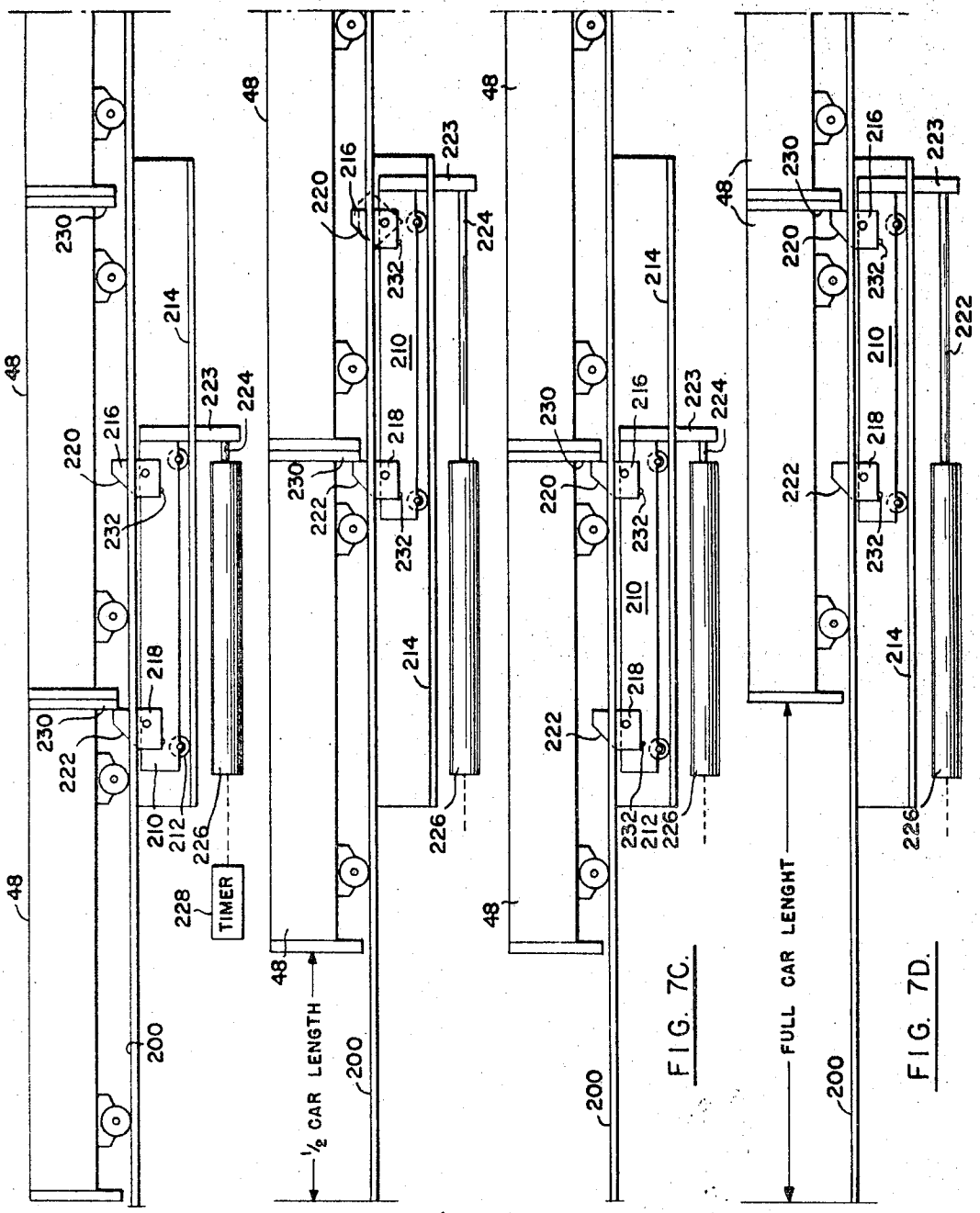


FIG. 7A.

FIG. 7B.

FIG. 7C.

FIG. 7D.

INVENTOR
GEORGE BICKLEY REMMEY

BY
Busser, Smith + Harding

ATTORNEYS

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CONTINUOUS KILN FIRING SYSTEM

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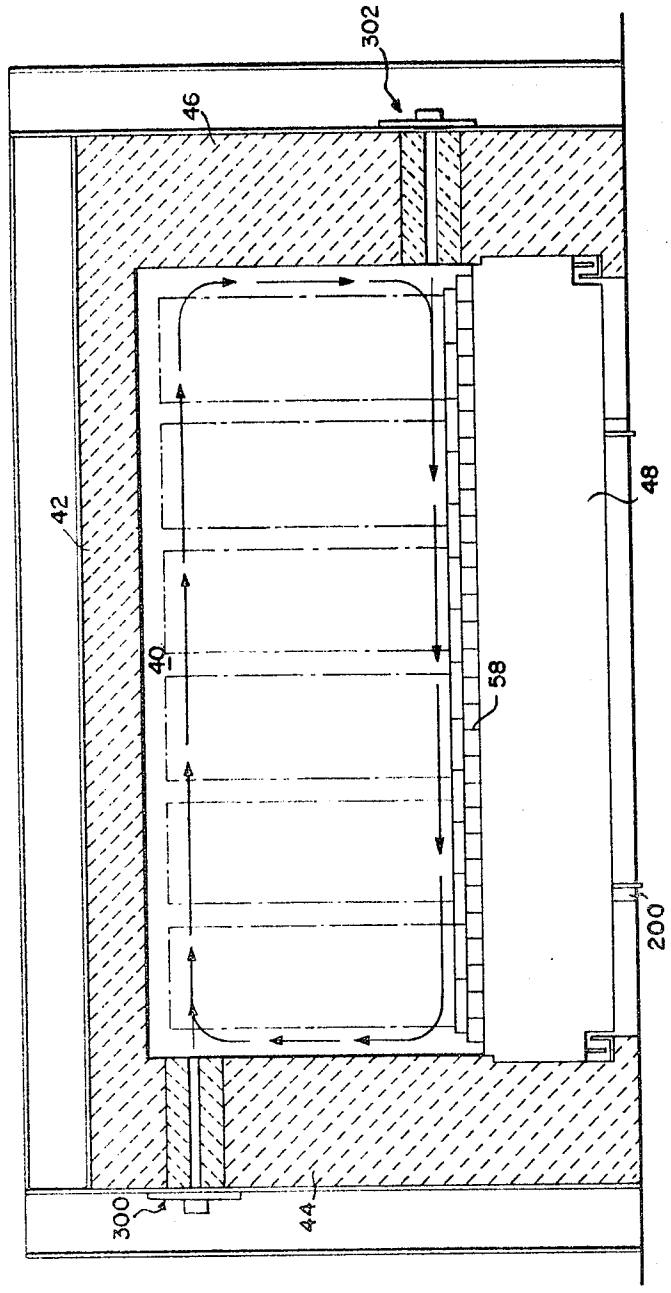


FIG. 8.

INVENTOR
GEORGE BICKLEY REMMEY

BY
Bussey, Smith + Harding

ATTORNEYS

United States Patent Office 3,464,682
Patented Sept. 2, 1969

3,464,682

CONTINUOUS KILN FIRING SYSTEM

George Bickley Remmey, Jenkintown, Pa., assignor to Bickley Furnaces Incorporated, Bensalem Township, Bucks County, Pa., a corporation of Pennsylvania

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Int. Cl. F27b 9/36; F27d 3/12
U.S. Cl. 263—28 15 Claims

ABSTRACT OF THE DISCLOSURE

A firing system for a continuous kiln in which the heating and cooling gases are introduced into the kiln at locations throughout the length of the kiln in the form of high velocity gas streams. The high velocity gas streams are directed transversely into the kiln along fire lanes formed between the ware settings to cause the gases within the kiln to flow in a desired circulating type of pattern across the fire lanes at high velocities.

BACKGROUND OF THE INVENTION

The invention relates to a firing system for a continuous kiln of the type known in the art as a tunnel kiln.

The state of the prior art is illustrated, to an extent, by U.S. Patents Nos. 1,499,354 and 3,172,747, the latter being applicant's own patent. Thus, there have been provided continuous kilns in which the heating gases are introduced into the kiln chamber at locations along the length of the kiln.

SUMMARY OF THE INVENTION

The continuous kiln firing system in accordance with the invention involves the generation of a more efficient gas circulating pattern in a continuous kiln by the use and arrangement of high velocity gas streams. Briefly stated, the firing system involves the introduction of high velocity gas streams into the kiln chamber at spaced locations throughout the length of the continuous kiln. The gases are introduced into the kiln chamber so as to flow at a high velocity through fire lanes formed by the arrangement of the ware within the kiln chamber. The gas streams are adjusted to have a sufficient velocity to flow across the kiln chamber and the high velocity gas streams function to induce circulation to the gases within the kiln to cause the gases to flow in a desired pattern across the fire lane. By reason of the gas flow pattern produced by the high velocity gas streams, there is achieved a very efficient, convection heat transfer between the gases and the ware and, perhaps more importantly, there is achieved a uniform heating of the ware.

There is also provided means for exhausting the gases from the heating portion of the kiln so that there is a secondary flow of gas in an axial direction toward the entrance end of the kiln where the ware in introduced. In other words, this secondary flow is counter to the movement of the ware through the kiln. The high velocity gas streams flow transversely relative to this secondary gas flow to entrain the same and rejuvenate the heating capacity thereof.

Various other advantages result from the firing system in accordance with the invention.

One advantage is that the firing system in accordance with the invention permits a kiln construction involving only a simple wall and roof construction since it does not require any of the complicated flue arrangements commonly used in conventional kilns.

Also, because of the great efficiency the high velocity gas streams have for developing velocity even in high temperatures, it is possible to build continuous kilns much wider than previously. This is an important advantage

since a much shorter kiln could be used for a given output. The shorter kiln will require less wall area to thereby decrease the heat losses and the initial construction cost. There are many other obvious advantages resulting from a shorter kiln construction.

Another advantage is that the type of gas circulation produced by the firing system in accordance with the invention avoids the problem of heat stratification resulting from the hottest gases gravitating to the top of the kiln and moving along the upper part of the kiln chamber only. This results in obtaining uniform temperatures across extremely wide kilns as well as from top to bottom along with very efficient heat transfer between the gases and the ware.

Another advantage of the firing system in accordance with the invention is that it is easily adapted so that the amount of heat being introduced at each fire lane can be controlled to thereby make it possible to develop more efficient heating rates on the ware moving through the kiln. At certain temperatures the ware can be heated easily at relatively fast rates, while at other temperatures the ware would be harmed if a low heat rate is not maintained.

Another important advantage of the use of high velocity gas streams over the conventional practice of using fans for controlling the flow of gases through the kiln, is that fans lose static pressure and their effectiveness diminishes rapidly at higher temperatures. Furthermore, the reduced strength of materials at high temperatures greatly limits the speed of the fan.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURES 1A, 1B and 1C are side elevations views of adjacent sections of a continuous kiln in accordance with the invention;

FIGURES 2A, 2B and 2C are plan views corresponding to FIGURES 1A, 1B and 1C, respectively with various portions broken away and various parts eliminated for the sake of clarity of illustration;

FIGURE 3 is a section taken generally at line 3—3 of FIGURE 1B;

FIGURE 4 is a fragmentary sectional view illustrating the gas flow pattern;

FIGURES 5 and 6 are detailed views of means for introducing high velocity gas streams into the kiln;

FIGURES 7A, 7B, 7C and 7D are schematic views illustrating the sequential conditions of operation of the means for moving the kiln cars through the kiln; and

FIGURE 8 is a sectional view illustrating another arrangement of the gas stream introducing means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The continuous kiln in accordance with the invention comprises a horizontally extending structure defining a longitudinal tunnel or kiln chamber **40** defined by a lining of suitable refractory material. The kiln structure comprises a roof **42** supported on vertical side walls **44** and **46**. The roof **42** may take various forms at various locations along the kiln and is of a suspended arch construction or a sprung arch construction as is well known in the art. The type and size of the refractory materials at various locations along the length of the kiln are chosen in accordance with the particular associated temperature condition as is well known in the art. The refractory walls are supported in steel plate casings with welded structural steel reinforcements in accordance with well known practices. As is apparent, the structural aspects of the kiln will be apparent to those skilled in the art.

The bottom wall of the kiln is formed by refractory walls supported on the usual kiln cars **48** which ride on conventional rails. The kiln cars **48** are provided with

conventional sand ceiling means **52** for closing the kiln chamber **40** at the bottom thereof (see FIGURE 3).

At the inlet into the kiln there is provided a conventional vestibule **53** including a pair of vertically sliding doors **54** and **56** arranged to move vertically to close the inlet end of the kiln when desired. The purpose of the vestibule arrangement is to prevent air from being drawn into the kiln through the inlet end when the kiln cars are introduced into the kiln. The vestibule may be provided with a recirculating air system **57** as is conventional.

The kiln cars **48** are moved through the kiln by way of a hydraulic pusher mechanism beneath the vestibule arrangement. The operation and details of the pusher mechanism and the vestibule arrangement will be described fully hereafter.

The cars **48** are provided with a horizontal platform **58** for supporting the ware indicated at W. As shown in the drawings, the ware is arranged specially on the platform **58** in order to provide fire lanes extending transversely across the kiln chamber for a purpose to be described more fully hereafter.

There are provided along the length of the kiln a plurality of individual firing sections **1** to **33**, these sections being equally spaced longitudinally. Means are provided to introduce either heating or cooling gases, into the kiln at each firing section. More specifically, the gases are introduced into the kiln in the form of high velocity gas streams as will be described more fully hereafter.

Each of the firing sections is adapted to provide a desired heating or cooling condition within the kiln chamber in the region of the location thereof, various firing sections cooperating to provide the heat-up, soak and cooling zones, for example. The number of individual firing sections comprised in each of the zones may be varied in accordance with the particular kiln firing application.

Firing sections **1** to **23** are provided with burners capable of introducing high velocity gas streams of heating gases into the kiln chamber. Firing sections **24** to **33** are provided with air jets capable of introducing high velocity gas streams of cooling air into the kiln chamber. Suitable burner means and air jet means are illustrated in FIGURES 6 and 5, respectively, and the details of the construction thereof will be described more fully hereafter with reference to said figures.

It will be noted from a consideration of the drawings that at each firing section there is provided two gas introducing means spaced vertically and arranged to direct gas streams horizontally across the transverse extent of the kiln chamber. It will also be noted that the arrangement of the gas introducing means is such that adjacent firing sections direct gases in opposite directions. More specifically, each of the odd numbered firing sections directs gases in one direction while each of the even numbered firing sections directs gases in the opposite direction transversely across the kiln. This results in a flow pattern best illustrated in FIGURES 3 and 4 wherein the arrows illustrate the flow of gases transversely across the kiln from the point of introduction to the opposing wall of the kiln whereat they are turned to flow longitudinally in either direction to the adjacent gas stream and then back across the kiln in the opposite direction. As was discussed previously, the function of the high velocity gas streams is to induce the gases from the kiln to flow in the circulating pattern generated thereby. It is this circulating pattern involving the gases moving at a relatively high velocity which results in the superior uniform heating of the ware. As will be described more fully hereafter, the flow pattern illustrated in FIGURES 3 and 4 will occur throughout the length of the kiln in both the heating and the cooling zones of the kiln.

Moreover, by reason of the exhaust system provided, there is an overall or secondary flow of gas axially along the kiln from the region of firing section **23** to the entrance end of the kiln. This flow is illustrated in FIGURE 4 by the axially extending arrows. The exhaust system to achieve this overall flow comprises an exhaust fan **60** connected by its inlet duct **62** to the kiln chamber **44** at a location near the entrance end of the kiln and between firing section **1** and the kiln entrance. Since this is the only exhaust provided in the portion of the kiln comprising sections **1** to **23**, the gases will flow counter to the ware movement as was discussed above and there will be an overall gas flow axially from the region firing section **23** to the exhaust duct **62**.

Thus, as the gases within the kiln flow axially toward the entrance end, they will mix with the high velocity heating gases directed into the fire lanes and these gases will be entrained with the transverse flow and be rejuvenated to the desired temperature condition at each particular firing section. Since the ware is stacked in an arrangement, as shown in FIGURE 4, there will be gas flow axially through the ware and this flow will be joined with the high velocity gas streams flowing through the fire lanes to achieve the above discussed temperature rejuvenation.

While in accordance with the broadest aspects of the invention, various high velocity gas introducing means may be used, illustrative of one suitable burner for use in the heating firing sections **1** to **23** is shown in detail in FIGURE 6.

Referring now particularly to FIGURE 6, the burner assembly is indicated generally at **60** and is mounted in the kiln vertical wall which is provided with suitable layers of refractory blocks as is shown in FIGURE 6. A rectangular burner block **62** is mounted in a suitable opening provided by the refractory blocks forming the furnace wall. The block **62** has a recess in the outer end adapted to receive the downstream end of a tubular nozzle adapter **64**. The block **62** is provided with a longitudinally extending cylindrical bore **66** which extends inwardly from the downstream end of the nozzle adapter **64**. The nozzle adapter and the bore **66** cooperate to define a cylindrical combustion chamber **68**, the downstream end of which communicates with the interior of the kiln.

The upstream end of the burner block **62** is enclosed by a suitable ramming mix **70**. A rectangular burner mounting plate assembly **72** is secured to the outer lining **74** of the kiln and comprises a front plate **76**. A burner body portion **78** is mounted on the front plate **76** by suitable mounting bolts as shown in FIGURE 6 with an annular recess **79** therein receiving the upstream end of nozzle adapter **64**. A pipe **80** is connected in threaded engagement with the burner body portion **78** and another burner body portion **82** and serves to mount these body portions together. The burner body portion **82** has a conduit **84** formed thereon and adapted to receive air from a suitable supply. By the arrangement shown, air is conducted to flow through the air conduit **84**, pipe **80** and a communicating cylindrical bore **85** formed within body portion **78** into the combustion chamber **68**.

A gas pipe **86** extends axially through the cylindrical passage provided by pipe **80** and bore **85**, the gas pipe **86** being mounted at its upstream end in a plate **88** secured to the body portion **82** and at its forward end by means of three radial centering pins **90**. The upstream end of gas pipe **86** is threaded at **92** to receive a suitable fitting connected to the gas supply. The gas pipe **86** is mounted so that it extends centrally within the air flow passage provided by pipe **80** and cylindrical bore **85**. The downstream terminal portion of the gas pipe **86** extends beyond the downstream end of the bore **85** and is closed by a disc **94**. A plurality of outlet ports **95** are provided in the gas pipe **86** adjacent the disc **94**. Ports **95** extend transversely through the gas pipe **86**, are circumferentially spaced thereabout and are located downstream of the end of bore **85** to provide communication between the gas pipe **86**

and the upstream end of the combustion chamber **68**, which end may be termed a mixing chamber since in this region the air and gas are intermixed initially.

A flame retaining disc **96** is mounted on the gas pipe **86** at a location immediately upstream of the gas outlet ports **95**. The flame retaining disc provides an annular surface extending circumferentially around the gas pipe **86** at the location indicated.

There is provided the usual pilot connection **100** which, in accordance with conventional practice, serves to ignite the fuel mixture flowing to the combustion chamber **68**.

In the operation of the burner assembly **60** illustrated in FIGURE 6, air is supplied to conduit **84** under pressure from a suitable air supply and a gaseous fuel is supplied to the gas pipe **86** under pressure from a suitable gas supply. The air under pressure flows through a conduit **84**, pipe **80** and bore **85** into the upstream end of combustion chamber **68** through an annular orifice provided between the exterior of the gas pipe **86** and the bore **85**. It will be apparent that the air flow is directed along the longitudinal axis of the burner. The fuel gas under pressure flows through gas pipe **86** and is directed from the outlet ports **85** into the upstream end of chamber **68** in a direction transversely to the air flow. This achieves a very effective mixing of the fuel gas and the combustion air in the upstream end of chamber **68**. The gas-air mixture then passes into the combustion chamber **68** where it is ignited. The products of combustion leave the combustion chamber **68** and pass into the furnace chamber within the kiln at a high velocity. It will be obvious that the velocity of the gases directed into the kiln can be adjusted by varying the pressure conditions and the fuel-air mixture in accordance with well-known burner practices.

Means are provided for supplying the combustion air and fuel to the individual burner assemblies **60** located at firing sections **1** to **23**. The air supply comprises a combustion air blower **102** mounted on the top of the kiln in the region of firing section **15** (FIGURE 1B). The discharge of the blower **102** is connected to an air distributing pipe **104** extending along the top of the kiln. The air for firing sections **1** to **9** is supplied by a branch pipe **106**. The branch pipe **106** is connected to manifold lines **108** to which burner inlet connections are connected by conduits **109** to supply air to the air connection, such as **84** in FIGURE 6, for each burner assembly. As shown in FIGURE 1B, a similar supply arrangement is provided for the firing sections **10** to **13**, the branch line being indicated at **110**. There is also provided branch lines **112**, **114**, **116**, **118**, **120** and **122** which supply air to various groups of burner assemblies as is shown in FIGURE 1B. It will be noted that each of the branch pipes **110** to **120** is provided with an automatic temperature control valve **134** for a purpose which will be described more fully hereinafter.

The means for supplying the fuel gas to the individual burner assemblies **60** comprises a pair of manifold lines **124**, one extending along each side of the kiln, and a delivery connection **126** extending from a manifold line **124** for connection with the gas pipe **86** for each burner assembly. The details of the connection are best illustrated in FIGURES 1A and 2A. As will be described more fully hereafter, means are provided for regulating the gas flow in correspondence with temperature control conditions within various desired regions of the kiln. Such means are illustrated generally by the valves **138** in FIGURE 1B, the details of the controls being deleted in this figure for the sake of clarity of illustration.

In FIGURE 3, there is illustrated a control means for maintaining automatically a desired temperature in one zone of the kiln. It will be apparent that a similar control means may be used at each zone where temperature control is desired. Such means comprises a pyrometer **30** constructed and arranged to sense the temperature in the zone to be controlled, and to actuate a suitable temperature control **132**. The temperature control **132** controls a motor operated throttle valve indicated at **134** and located in the air supply branch to control the supply of air to the burners **60** for the particular zone to be controlled. A control line **136** is connected from the downstream side of the air supply to a suitable pressure regulating valve **138** connected in the supply branch for the fuel gas. The gas supply also contains a throttle valve **140** which is set manually to achieve the desired fuel to air ratios. This ratio adjusting valve **140** is set at the start of operation to originally establish the desired fuel to air ratio. In operation, if the pyrometer senses a drop below the desired temperature for the zone, the controller **132** is actuated to adjust the valve **134** to effect an increase in the flow of combustion air to the burners. This increase in air flow is accompanied by an increase in pressure and the air pressure is transmitted through the air control line **136** to the pressure regulating valve to actuate the same to open and increase the downstream pressure in proportion to the increase in combustion air pressure. This will result in a proportionate increase in the flow of fuel gas, and, of course, an increase burner heating rate. It will be apparent that if the temperature in the zone should exceed the desired temperature a reverse action will occur. Moverover, the specific details of the control means are in accordance with techniques well known in the control art and will be readily apparent to those skilled in the art.

The cooling zone of the kiln is located in the region of the firing sections **24** to **33**. The gas introducing means at each of the firing sections **24** to **33** comprises what may be termed an air jet assembly which is constructed to direct high velocity air streams into the furnace chamber as will be described more fully hereafter. While various forms of air introducing means may be used, illustrative of one suitable air jet assembly for use in the firing sections **24** to **33** is the arrangement shown in detail in FIGURE 5.

Referring now particularly to FIGURE 5, the air jet assembly is indicated generally at **150** and is mounted in the kiln vertical wall within a layer of the refractory blocks thereof. A rectangular air jet block **152** is mounted in a suitable opening provided by the refractory blocks forming the furnace wall. The block **152** has an annular recess **154** formed in its outer end and adapted to receive the downstream end of an air supply pipe **156**. The block **152** is provided with a longitudinally extending tapered bore **158** which extends inwardly toward the furnace from the downstream of air pipe **156**. The bore **158** converges in the direction toward the kiln chamber and forms a chamber which serves to accelerate the velocity of the air to the desired velocity for flowing into the furnace chamber as will be described hereafter.

An air jet mounting plate assembly **160** is secured to the outer lining **74** of the kiln and comprises a front plate **162** to which an annular mounting bracket **164** is secured by means of mounting bolts as shown in FIGURE 5. The annular mounting bracket **164** is secured to the outer wall of the air pipe **156**, as by welding.

As shown in FIGURE 5, the air pipe **156** has a straight portion extending axially outwardly from the conical bore **158** to the exterior of the kiln and has a curved portion extending upstream from said straight portion. At the upstream end of the air pipe **156**, there is provided an assembly flange **166** which is adapted to be connected to a pipe which delivers air under pressure to the air pipe **156**.

In the operation of the air jet assembly **150** illustrated in FIGURE 5, air is supplied to the upstream end of air pipe **156** under pressure from a suitable air supply. The air under pressure flows through the air pipe **156** and is delivered into the upstream end of the tapered bore **158**. The air then flows through the tapered bore **158** which converges in the direction of flow so that the air velocity is increased to a desired point at the discharge

port **166** formed at the downstream end of the bore **158**. The air leaves the port **156** and passes into the furnace chamber within the kiln at a high velocity. It will be obvious that the velocity of the air can be adjusted by varying the supply pressure conditions in accordance with well-known practices.

Means are provided for supplying the cooling air to the individual air jet assemblies **150** located at firing sections **24** to **33**. Such air supplying means comprises an air fan **170** mounted on top of the kiln. The discharge of the fan **170** is connected by a pair of pipes **172** to a pair of manifold lines **174** extending along the sides of the kiln in the cooling zone region. A plurality of branch pipes **176**, one of which is associated with each of the firing sections **24** to **33**, are provided to supply the air to the upstream end of the air pipes **156** for each of the air jet assemblies **150**.

There is provided an exhaust system for controlling the exhaust of the gases from the cooling zone of the kiln. Such means comprises a cooling exhaust fan **180** mounted on top of the kiln and having its suction end connected to a longitudinally extending exhaust manifold **182**. The discharge of the fan **180** is connected to a discharge conduit indicated at **184**. A plurality of vertically extending exhaust ducts **186** provide communication between the exhaust manifold **182** and the top of the kiln at spaced locations throughout the cooling zone as is illustrated in FIGURES 1C and 2C. Each of the pipes **186** is provided with a manually adjustable control or damper valve **188**.

The exhaust system is set by adjusting the setting of the damper valves **188** in the conduit **156** to create an overall or secondary flow of air, i.e., as opposed to the high velocity flow provided by the air jet assemblies, from the discharge end of the kiln, which is opened to atmosphere, toward the entrance end counter to the movement of the kiln car. This secondary flow will move from the entrance end to the region between the firing sections **23** and **24**. As was discussed above, there is also a secondary flow of air from the region of the firing section **23** to the entrance end of the kiln under the control of the exhaust fan **60** at the entrance of the kiln.

If desired, the exhaust systems may be adjusted and controlled so that there is a minimum of longitudinal movement of the gases across the region between the firing sections **23** and **24**. Briefly stated, this will be achieved by the provision of a pair of pressure control units for maintaining the same pressure on either side of a transverse plane between the firing sections **23** and **24**, the pressure controllers being operative to control the exhausting action of the two exhaust fans **60** and **180**.

There is provided a track system for a kiln car comprising a track **200** running axially through the kiln, a return track **202** running along the side of the kiln, an transverse track **204** extending between the track **200** and **202** at the entrance end of the kiln and a tarnsverse track **206** extending between the tracks **200** and **202** at the exit end of the kiln. Each of the tracks comprises a pair of parallel rails in accordance with conventional rail constructions, the rails being adapted to receive and guide the wheels of the kiln cars. It will be evident that by reason of the rectangular track arrangement, kiln cars may be moved through the kiln and along the return track back to the entrance of the kiln.

Means are provided for moving the kiln cars **48** through the kiln in a manner such that after a predetermined dwell cycle in a first position, the ware is moved forwardly relatively rapidly a distance equal to the spacing between adjacent firing lanes so as to place an adjacent fire lane in alignment with the next adjacent firing section in a forward direction. Such means comprises a car pusher mechanism which is located in a pit in the floor of a kiln in the region of the entrance vestibule.

The pusher mechanism is shown in FIGURES 7A to 7D and comprises a pusher dolly **210** having four wheels **212** which ride on dolly rails **214** extending longitudinally along the kiln and beneath and within the kiln rail track **200**. The pusher dolly **210** carries a pair of front pusher dogs **216** and a pair of rear pusher dogs **218**. The dogs **216** and **218** are pivotally monuted on the body of the dolly **210** so as to pivot from an upstanding position shown in full lines in the drawings to a downward position illustrated by the dotted line position in FIGURE 7B. Each of the pusher dogs **216** and **218** has an inclined cam surface **221** and **222**, respectively, facing the rearward portion thereof for a purpose to be described more fully hereafter. The pusher dolly **210** is connected by a member **223** to the outer end of the actuating arm **224** of a hydraulic cylinder **226** which is shown in the retracted position in FIGURE 7A. When the hydraulic cylinder **220** is actuated, it will cause the arm **224** to move outwardly to an extended position shown in FIGURE 7B. There will be corresponding movement of the pusher dolly **210** from the position of FIGURE 7A to the position of FIGURE 7B. The hydraulic cylinder **224** is controlled by a timer **228** which, after a predetermined dwell time, causes actuation of the hydraulic cylinder through a pushing movement in which it moves arm **224** forwardly to an extended position and then rearwardly to the retracted position. The timer control **228** may be set for various desired dwell times in accordance with the nature ware being treated by the kiln.

The sequence of operation of the kiln car advancing mechanism will be described with particular reference to FIGURES 7A to 7D which illustrate sequential operating position of the parts. When a kiln car **48** has been loaded with a ware setting and is ready to be passed through the kiln it is moved either manually or by a suitable power-operated mechanism into the vestibule to a position shown in FIGURE 7A with a dog engageable portion **230** of the car frame being placed in engagement with the rear pusher dogs **218**. At the appropriate time, the timer control **228** actuates the hydraulic cylinder **226** through an indexing movement during which the pusher dolly is moved a distance of approximately one half a car length to the position shown in FIGURE 7B. Accordingly, the kiln car has been moved forward a half car length as is indicated at FIGURE 7B. During the return stroke of the hydraulic cylinder, the pusher dolly **210** is moved rearwardly to a position in which the forward pusher dogs **216** are now in engagement with the kiln car frame portion **230**. It will be apparent that during this return movement, the forward pusher dogs **216** contact the kiln car along their cam surfaces **22** and are pivoted downwardly as they move rearwardly therepast. It is noted that there is provided suitable means, such as springs (not shown), for returning the dogs to their upright position determined by stops **232** on the dolly frame. The pusher mechanism is now in the position shown in FIGURE 7C and is ready for a second advancing movement.

After the dwell time set on the timer control, the timer **228** again actuates the hydraulic cylinder **226** through an indexing movement, during which movement the kiln car is indexed another half a car length to the position shown in FIGURE 7D. It will be apparent that during this movement it is the forward pusher dogs **216** which are in engagement with the frame portion **230** of the car to effect the advancing movement of the kiln car. During the return stroke of a hydraulic cylinder, the pusher dolly will again be retracted to the position shown in FIGURE 7A and is now ready to be engaged with another kiln car. Of course, the kiln cars are all positioned adjacent one another along the length of the kiln and as the kiln car in engagement with the pusher mechanism is moved forwardly, all the cars in the train are moved along therewith.

The vestibule entry arrangement which serves to prevent air from being drawn into the kiln through the inlet end during the charging of a kiln car is operated in

conjunction with the kiln car advancing or pusher mechanism discussed above. Thus, referring to FIGURE 1A, after the advancing mechanism has moved a kiln car its full length, this car will be positioned within the kiln so that its rear end is to the right of the plane of the door **56**. It will be noted that during the advancing operation of this kiln car the outer door **54** will have been in the closed position. However, now that the car has been advanced to the position discussed above, the inner door **56** will be closed. The outer door **54** will then be raised to an open position to permit the movement of a car into the vestibule chamber in which position the rear end of the newly inserted car will be to the right of the plane of the outer door **54**. The outer door **54** is then closed and the inner door **56** is raised to an open position. It will be noted that during this entire car charging operation, the entrance end of the kiln is always closed off to the flow of air into the kiln from the room. It will also be noted that entire car charging operation will be effected during a dwell time of the car advancing mechanism.

During the operation of the kiln, the various gas supply means provide combustion air and fuel gas to the firing sections **1** to **23** as was discussed above. Also, cooling air is supplied by the air jet fan **170** to the air jet assemblies provided at firing sections **24** to **33**. The kiln car advancing mechanism is operative to position the fire lanes provided by the ware setting in alignment with the firing sections. Accordingly, high velocity gas streams are directed into the kiln chamber **40** through fire lanes formed by the ware to provide the flow pattern illustrated in detail in FIGURES 3 and 4. As was discussed above, the high velocity gas streams flow in a substantially straight line across the width of the kiln. At the same time, the exhaust system for the heating zone (firing sections **1** to **23**) and the exhaust system for the cooling zone (firing sections **24** to **33**) are operative to create the secondary gas flow counter the ware movement as was discussed in detail above. Briefly stated, gases are directed to flow from the region between the firing sections **23** and **24** longitudinally through the kiln toward the entrance end whereat they are exhausted by the exhaust fan **60**. Also, in the cooling zone the secondary flow of gases is from the open entrance end longitudinally through the kiln to the region of firing section **24**. The manner in which the high velocity gas streams entrain the secondary gas flow and rejuvenate the heating effect thereof was described above.

It will be noted that automatic temperature control means may be provided at various zones along the length of the kiln. As is best shown in FIGURE 1B, a typical temperature control may involve the provision of automatic temperature control in the zone of firing sections **10** to **13**, in the zone of firing sections **14** to **16**, the zone of firing sections **17** and **18**, in the zone of firing sections **19** and **20**, in the zone of firing section **21**, in the zone of firing section **22**, and in the zone of firing section **23**. Each of these automatic temperature control means may be like the one disclosed in detail with reference to FIGURE 3.

During operation, the kiln car advancing mechanism is operative to move the ware through the kiln at predetermined spaced intervals of dwell time. In other words, after a predetermined dwell time, the kiln car advancing mechanism is actuated to move a kiln car forwardly a distance approximating the spacing between the fire lanes or the spacing between adjacent firing sections. The ware setting is arranged on the kiln car to provide these fire lanes as was discussed above. Thus, each fire lane is successively positioned in alignment with each of the firing sections **1** to **33**.

In FIGURE 8, there is disclosed an alternate form of arrangement of the gas introducing means at each fire lane. Instead of providing a pair of gas introducing means on one side of the kiln to direct the gas stream in one direction across the fire lane, the form of the invention shown in FIGURE 8 comprises a gas introducing means on each side of the kiln for directing a high velocity gas stream into a fire lane within the kiln in opposite directions. More specifically, a gas introducing means **300** is located at one side of the kiln and arranged to direct a high velocity gas stream horizontally across the upper portion of the fire lane and a gas introducing means **302** on the other side of the kiln is arranged to direct its high velocity gas stream horizontally across the lower portion of the fire lane.

By this arrangement in which the gas streams are directed in lines opposite to and nonaligned with each other, there is achieved a flow pattern in which the gas stream from each gas introducing means supplements the flow of the other to cause a vertical circulating flow pattern within the fire lane as is illustrated by the arrows in FIGURE 7. First, the gases which are directed across the kiln from the upper gas introducing means **300** flow across the kiln and turn downwardly to be joined with and to supplement with the gases being introduced by the lower gas introducing means **302**. In a like manner, the gases which are directed into the furnace from the lower gas introducing means **302** flow across the kiln to the opposite side thereof and upwardly to be joined with and supplement the flow from the upper gas introducing means **300**.

The gas introducing means **300** and **302** may be constructed the same as the burner assemblies **60** or the air jet assemblies **150** described above.

It will be understood that the arrangement shown in FIGURE 8 in which the gas streams from oppositely positioned gas introducing means supplement each other may be oriented in various arrangements. For example, the gas stream introducing means may be arranged to direct their gas stream at an angle relative to the horizontal and still achieve a supplementing action. Also, one of the opposite gas stream introducing means may be arranged to direct gas streams downwardly from the top of the kiln and another may be arranged to be directed upwardly from a lower portion of the kiln. It is considered that these variations of the supplementing gas flow concept are to be included within the broadest scope of the invention.

It will also be apparent that changes may be made in the construction and arrangement of parts without departing from the scope of the invention.

I claim:

1. A continuous kiln comprising wall means defining a horizontally extending kiln chamber, means for conveying the ware to be treated longitudinally through said kiln chamber, said ware being arranged to provide fire lanes which extend transversely across the kiln, there being provided a plurality of equally spaced fire lanes provided throughout the length of the kiln, and means for introducing high velocity gas streams into said fire lanes transversely across the kiln chamber to cause the gases in the kiln chamber to circulate through said fire lanes, there being provided a plurality of said gas stream introducing means spaced substantially throughout the major ware treating zones along the length of the kiln, the gas stream introducing means being spaced the same amount as the spacing between the fire lanes, said conveying means including spacing means operative after a predetermined dwell cycle to move the ware forwardly through the kiln chamber a distance equal to the spacing between adjacent gas introducing means.

2. A continuous kiln according to claim **1** including means for exhausting gases from the kiln so as to cause a flow of gases in the kiln longitudinally toward the entrance end of the kiln counter to the movement through the ware of the kiln.

3. A continuous kiln according to claim **1** wherein said gas stream introducing means are arranged so that in each fire lane the gases are introduced in a transverse direction opposite to that of an adjacent firing lane.

4. A continuous kiln according to claim 3 wherein in each fire lane there are provided two vertically spaced gas introducing means.

5. A continuous kiln according to cliam 1 including means for controlling various selected gas introducing means to maintain a desired temperature condition within selected zones of the kiln chamber.

6. A continuous kiln according to claim 2 wherein there is provided a heating zone including a plurality of said firing sections and a cooling zone adjacent said heating zone including a plurality of said firing sections, and including a first exhaust means for withdrawing gases from the kiln chamber near the entrance end thereof to cause gases to flow through said heating zone in the direction toward the entrance end of the kiln, and a second exhaust means having its suction communicating with the cooling zone to cause a flow of gases through the cooling zone in a direction from the kiln exit toward the entrance end of the kiln.

7. A continuous kiln comprising wall means defining a horizontally extending kiln chamber, means for conveying the ware to be treated longitudinally through said kiln chamber, said ware being arranged to provide fire lanes which extend transversely across the kiln, there being provided a plurality of equally spaced fire lanes provided throughout the length of the kiln, means for introducing high velocity gas streams into said fire lanes, said gas stream introducing means including at least two gas introducing assemblies located at opposite locations with respect to a corresponding fire lane, each gas introducing assembly being arranged to direct its gas stream in a line opposite to and nonaligned with the other gas introducing assembly so that the gas stream from each supplements the flow of the other to cause a circulating flow pattern within the fire lane associated therewith, there being provided a plurality of said gas stream introducing means longitudinally spaced along the kiln the same amount as the spacing between the fire lanes, said conveying means including spacing means operative after a predetermined dwell cycle to move the ware forwardly relatively rapidly a distance equal to the spacing between adjacent gas introducing means.

8. A continuous kiln according to claim 7 wherein at each firing section one of said gas introducing means is located on one side of the kiln and the other of said gas introducing means is located on the opposite side of the kiln.

9. A continuous kiln according to claim 8 wherein at each firing section one of said gas introducing means is arranged to direct its gas stream across an upper region of the fire lane and the other is arranged to direct its gas stream across a lower region of the fire lane.

10. A continuous kiln according to claim 7 including means for exhausting gases from the kiln so as to cause an overall flow of gases in the kiln longitudinally toward the entrance of the kiln end counter to the movement through the ware of the kiln.

11. A continuous kiln according to claim 7 including means for controlling various selected gas introducing means to maintain a desired temperature condition within selected zones of the kiln chamber.

12. A continuous kiln according to claim 10 wherein there is provided a heating zone including a plurality of said firing sections and a cooling zone adjacent said heating zone including a plurality of said firing sections, and including a first exhaust means for withdrawing gases from the kiln chamber near the entrance end thereof to cause gases to flow through said heating zone in the direction toward the entrance end of the kiln, and a second exhaust means having its suction communicating with the cooling zone to cause a flow of gases through the cooling zone in a direction toward the entrance end of the kiln.

13. A continuous kiln according to claim 7 wherein said gas stream introducing means are located along substantial portions of the major ware treating zones of the kiln.

14. A continuous kiln according to claim 12 wherein the ware treating zones of the kiln include a preheat zone, a heating zone, and a cooling zone extending along the kiln, and said gas stream introducing means are provided throughout the entire length of the kiln at each of said fire lanes.

15. A continuous kiln according to claim 1 wherein the ware treating zones of the kiln include a preheat zone, a heating zone, and a cooling zone extending along the kiln, and said gas stream introducing means are provided throughout the entire length of the kiln at each of said fire lanes.

References Cited

UNITED STATES PATENTS

2,991,535	7/1961	Hanley.	
3,390,870	7/1968	Yacura	263—28

JOHN J. CAMBY, Primary Examiner