March 13, 1945. E. BLAHA 2,371,420

KILN AND METHOD OF OPERATION

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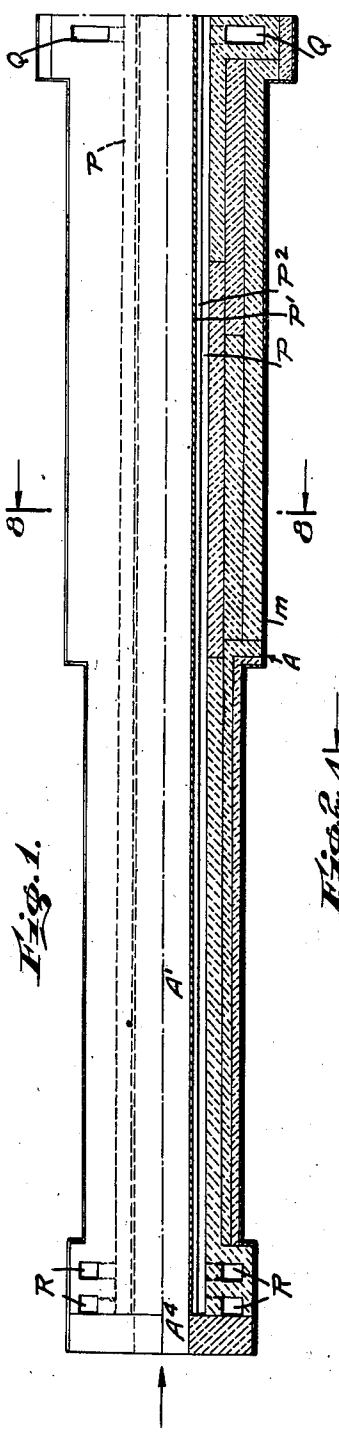


Fig. 1.

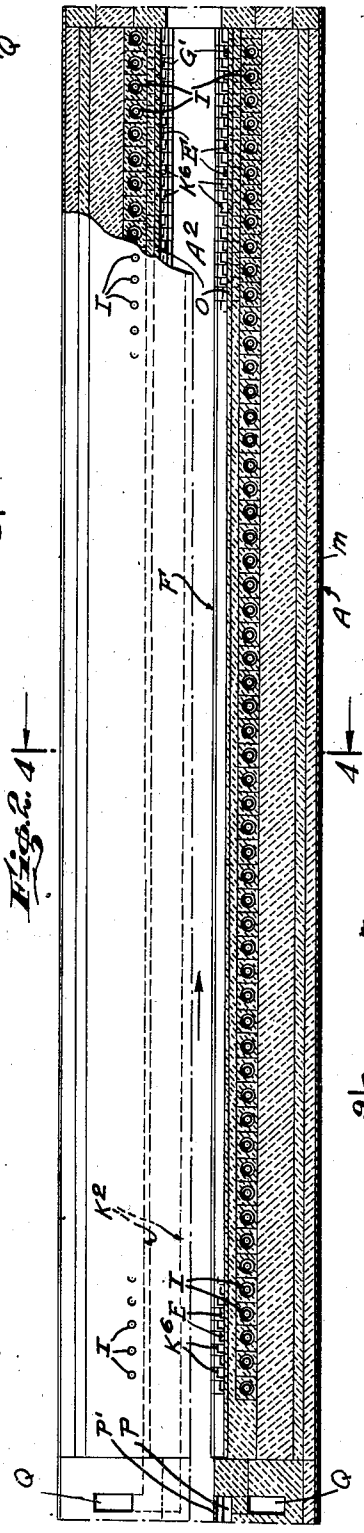


Fig. 2.

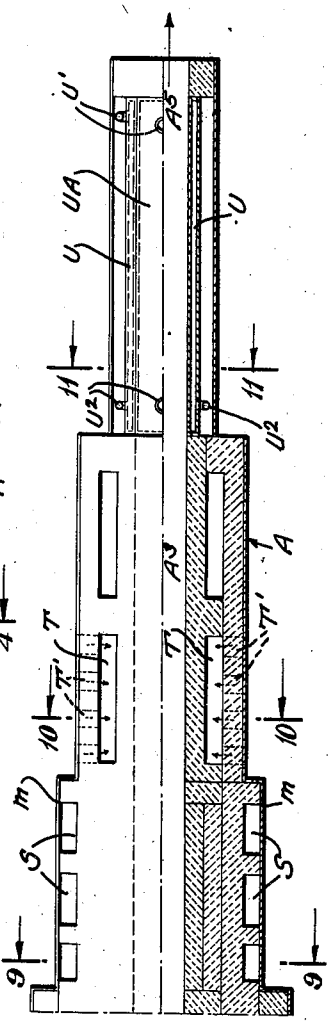


Fig. 3.

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KILN AND METHOD OF OPERATION

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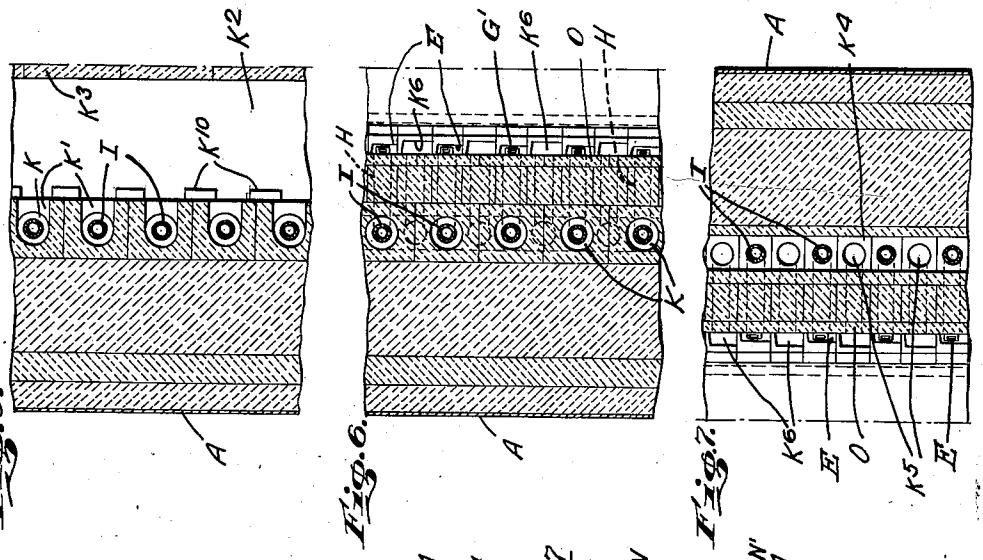


Fig. 5. Fig. 6. Fig. 7.

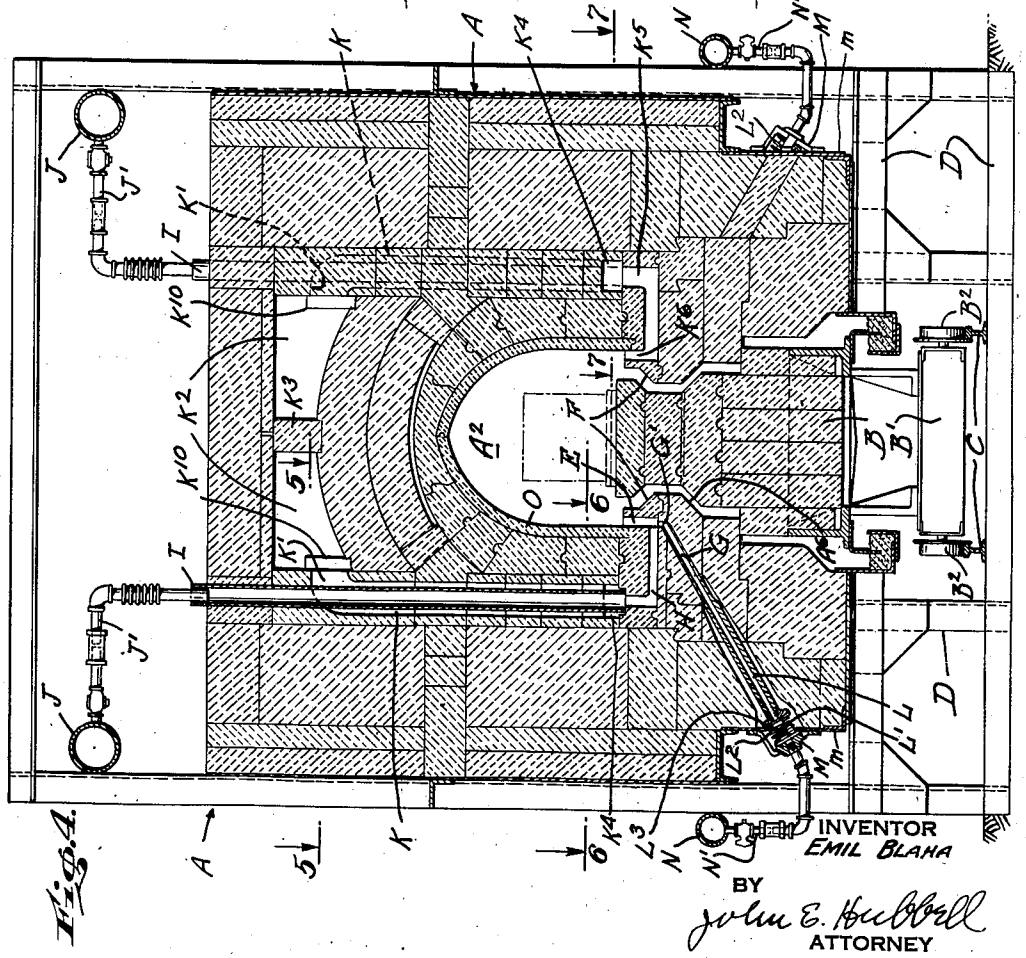


Fig. 4.

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KILN AND METHOD OF OPERATION

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Fig. 11.

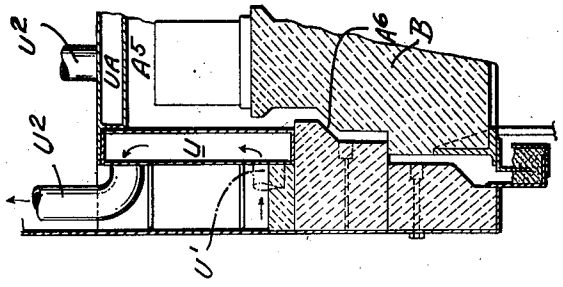


Fig. 10.

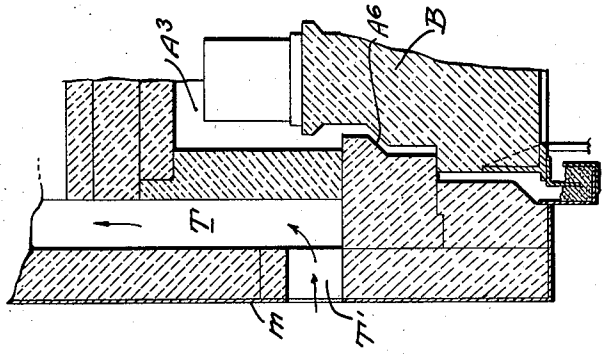


Fig. 9.

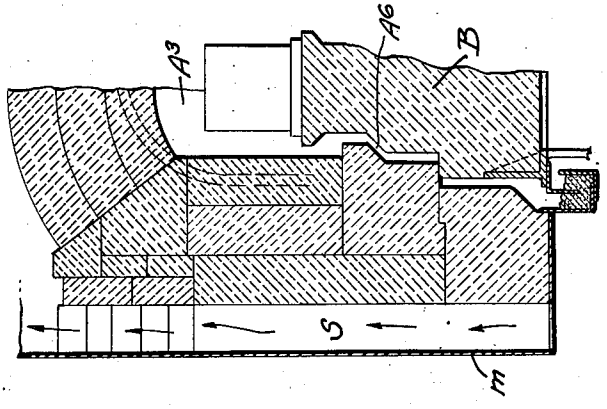
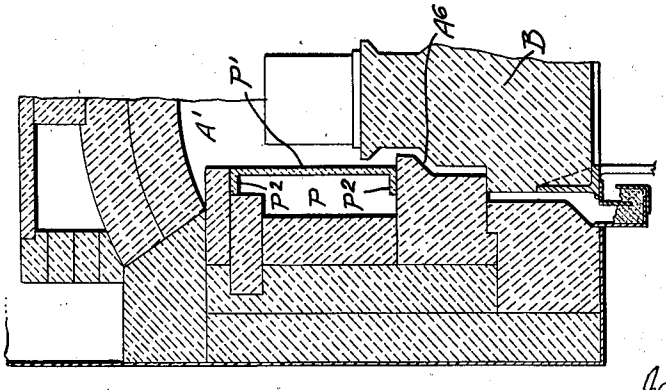


Fig. 8.



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UNITED STATES PATENT OFFICE

2,371,420

KILN AND METHOD OF OPERATION

Emil Blaha, Cheltenham, Pa., assignor to Selas Corporation of America, a corporation of Pennsylvania

Application July 29, 1942, Serial No. 452,761

19 Claims. (Cl. 25—142)

One general object of the present invention is to provide an improved method of heating the high temperature or firing zone of a kiln at temperatures higher than have heretofore been customarily produced, and another general object of the invention is to provide a simple and effective continuous tunnel kiln structure adapted for use in the practice of said kiln heating method.

A more specifically stated object of the invention is to provide a kiln with "open fire" heating provisions adapted to maintain firing zone temperatures of 3000°–3600° F., or even higher in some cases. A still more specific object of the present invention is to provide a kiln with novel provisions for the recuperative preheating of all, or a substantial portion, of the combustion supporting air.

My improved method of kiln heating is characterized by the introduction of upwardly directed burning streams or jets of combustible fuel and combustion supporting gas into a high temperature or firing zone of the kiln chamber, at closely spaced points distributed along the length of the kiln, and preferably with jet velocities high enough for the jets to form side by side streams which flow upward along the side walls of the kiln chamber and thence inward along the kiln chamber roof toward the longitudinal center line of the latter, and is characterized by the withdrawal of products of combustion from the kiln chamber at a multiplicity of points distributed along the length of and adjacent the lower edges of the side walls.

In a kiln chamber heated as described, all or practically all of the inner side wall and roof surface of the firing zone of the kiln is heated to incandescence and the work is largely heated by radiation from said surface and from the adjacent burning jets.

In the preferred form of the invention, the fuel gas and combustion air forming the burning jets are highly preheated, and my improved kiln is characterized by its preheating provisions. In the preferred construction illustrated, a portion of the available heat in the products of combustion withdrawn from the firing zone is utilized in recuperatively preheating streams of combustion air passing into the different burning jets and another portion of the available heat is utilized in a preheating zone of the kiln.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages, and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

Of the drawings:

Fig. 1 is a diagrammatic plan, partly in section, of the preheating zone portion of a continuous tunnel kiln;

Fig. 2 is a diagrammatic plan, partly in section, of the intermediate firing zone portion of the kiln;

Fig. 3 is a diagrammatic plan, partly in section, of the cooling zone portion of the kiln;

Fig. 4 is a vertical section on the line 4—4 of Fig. 2;

Figs. 5, 6 and 7 are partial plan sections on the lines 5—5, 6—6 and 7—7, respectively, of Fig. 4;

Fig. 8 is a partial vertical section on the line 8—8 of Fig. 1; and

Figs. 9, 10 and 11, are partial vertical sections on the lines 9—9, 10—10, and 11—11, respectively, of Fig. 3.

The continuous tunnel kiln A shown by way of example in the drawings, comprises preheating, high temperature and cooling zones or sections A′, A^2 and A^3, shown somewhat diagrammatically in Figs. 1, 2 and 3, respectively, through which the goods or wares treated are progressively moved from the inlet end A^4 to the exit end A^5 of the kiln chamber by suitable goods advancing means. The latter, in the conventional form shown, comprises a series of kiln cars B, having refractory body portions which extend vertically through a slot A^6 formed in the bottom wall of the kiln chamber, as shown most clearly in Fig. 4. The refractory body portion of each car is carried by a metallic car under structure B′, having wheels B^2 which run on track rails C extending longitudinally of the kiln chamber. As shown, the track rails are beneath the refractory body of the kiln which is supported above the kiln building floor level by a metallic framework D.

The cars B may be moved through the kiln chamber at the proper speed by mechanism which may be of one or another of various well known types and need not be illustrated or described herein. As shown in Fig. 4, the walls of the kiln chamber bottom wall slot A^6 and the sides of the refractory car bodies are relatively shaped to minimize air and gas leakage into and out of the kiln chamber through the bottom slot A^6, and to the same end the kiln is provided with

sand sealing means, but the leakage preventing expedients need not be further described herein as they are well known in the art and their particular form constitutes no part of the present invention.

The novel means provided to heat the kiln, comprise a series of vertical burner chambers or wells E arranged in two rows, one at each side of the kiln chamber and each extending along the full length of the firing zone kiln section A^2. Each burner chamber E is formed in a corresponding ledge or bench portion F of the refractory kiln structure. The two benches F at the opposite sides of the kiln chamber constitute the portions of the kiln chamber floor not formed by the refractory bodies of the kiln cars B.

In the preferred construction shown, each burner chamber E receives fluid fuel at its lower end through the outlet port G' of an individual upwardly inclined supply passage G, and receives combustion air through an individual transverse channel H. Each channel H opens at its inner end into the corresponding burner chamber E adjacent the lower end of the latter, and has its outer end connected to the lower end of a corresponding recuperator tube or pipe I of ceramic material which extends up from the bench level through the corresponding side wall of the kiln chamber and above the top of the refractory kiln structure. Each pipe I is connected to an individual valved branch J^1 from an air supply main J, at the same side and extending longitudinally of the kiln. Ordinarily, each of the two mains J is connected to a source (not shown) of air under a pressure somewhat above that of the atmosphere.

Each combustion air supply pipe I extends axially through an individual vertical recuperator channel K of larger diameter, and formed in the corresponding side wall of the kiln chamber. Each channel K extends upward to a level above the kiln chamber, but below the top of the kiln structure, and has a laterally bent upper end K^1 which opens into the adjacent one of two flues K^2 formed in the kiln roof structure at opposite sides of a division wall K^3. Each flue K^2 extends longitudinally of the kiln for the full length of a kiln firing zone A^2, and discharges partially cooled, but still hot, products of combustion into a corresponding preheating zone flue, as hereinafter described. Some, at least, of the channels K may be provided with individual slide brick outlet dampers K^{10}, as shown in Fig. 4, which may be adjusted to regulate the distribution of upflow through the channels.

The different channels K at each side of the kiln chamber open at their lower ends into a common longitudinal channel K^4 formed in the corresponding bench F and extending along the full length of the firing zone. Each channel K^4 receives hot products of combustion from the kiln chamber through a series of ports K^5. The ports K^5 and tubes I at each side of the kiln chamber alternate along the length of the firing zone. Each port K^5 forms the outlet end of a corresponding transverse channel formed in the bench and connected at its inner end to the kiln chamber through a corresponding inlet port K^6. The ports K^6 at each side of the kiln chamber alternate along the length of the firing zone with the burner wells E.

In the preferred construction illustrated, each channel G is the bore or axial passage of a suitable refractory ceramic tube L, which has an outer end portion which is of larger diameter than its inner end portion, and extends through an air or gas space in the kiln masonry. The tube L is mechanically connected at its outer end to the inner end of a corrugated metal tube L' which has its outer end connected through a metallic kiln armor member M to a corresponding valved branch N' from a supply main N extending longitudinally of the kiln along the corresponding side of the firing zone. As shown in Fig. 4, the part M is a metal casting connected to the metallic kiln casing *m*, and is formed with a passage into the outer end of which the end of the corresponding end pipe N' is threaded. At its inner side the member M is formed with a seat for the attachment of the corrugated tube L', and with a seat for a spring L^2 which acts against a metallic end member L^3 through which the pipe L is secured to the outer end of the tube L'.

The described connections between the supply mains N and the burner chambers E are designed to accommodate the very considerable relative expansion of the kiln structure and conduit parts due to temperature changes, and thus avoid leakage of the fluid fuel supplied by the mains N, even though the pressure in the mains may be several pounds above the pressure of the atmosphere.

In the preferred use now contemplated of the kiln shown in the drawings, the fluid fuel supplied by the mains N will ordinarily consist of a suitable available gas mixed with some of the air required for complete combustion of the gas. If the latter is a strong gas such as natural, city, or coke oven gas, it may well have mixed with it from 10 to 20% of the total air required for its combustion, the remaining 90% to 80% being supplied through the recuperator pipes I. The mixture of a significant portion of the combustion air with the fuel gas supplied to the burner chambers E, speeds up the rate of combustion in the burner chambers and eliminates the risk of objectionable deposits of carbon cracked out of the fuel gas in the channels G. The gas and air mixture passing through the channels G is subjected to a substantial preheatnig effect, but ordinarily the mixture temperature attained in the channels G will be appreciably lower than the temperature to which air is preheated in the pipes I. For the attainment of high kiln chamber temperatures with a weak fuel gas, such as producer gas supplied through the passages G', the gas should have little or no combustion air mixed with it.

Ordinarily, in the construction of my improved kiln, the customary practice will be followed of using highly refractory ceramic materials in the inner portions of the kiln chamber walls and of forming the outer portion of the kiln chambers walls of materials having good heat insulating properties but not adapted to withstand as high temperatures as the more refractory inner wall materials. For the extremely high firing zone temperatures required in some contemplated uses of the kiln, I line the kiln chamber with thin curved tiles O of some suitable high refractory material such as beryllium oxide. With temperatures somewhat lower, but still higher than are customary in tunnel kilns, I may form the tiles O of the refractory silicate known as sillimanite. Generally such tile materials have relatively little mechanical strength at high temperatures, and I advantageously construct the kiln chamber firing zone with a roof arch of Gothic form, as shown in Fig. 4, rather than of the more usual rounded form.

As the goods pass from the inlet end A^4 of the kiln to the firing zone, the goods temperature is progressively increased primarily as a result of the heating action of the flues P, one formed in and extending longitudinally of each side wall of the preheating section A' of the kiln chamber. The hot gases which the flues K^2 receive from the recuperator passages K, pass from the flues K^2 into the corresponding flues P through vertical passages Q formed in the portion of the corresponding side wall of the kiln chamber adjacent the junction of the preheating and firing sections A' and A^2, as best shown in Figs. 1 and 2. As shown in Figs. 1 and 8, each flue P is separated from the kiln chamber by a thin wall formed by refractory tiles P' arranged end to end along the length of said flue, and each extending from the top to the bottom of the flue. As shown the tiles P are provided at their upper and lower ends with inturned horizontal flanged portions P^2. The tiles P' may be formed of any suitable refractory material, but advantageously are of a material such as silicon carbide which has good heat conductivity at its normal operating temperatures. At the inlet end of the kiln, the flues P communicate with vertical passages R which are connected to a chimney or exhaust fan (not shown) for withdrawing products of combustion which have lost most of their original heat content before they reach the passages R.

In the construction of the cooling zone section of the kiln, use may be made of expedients commonly employed to secure a suitably rapid and suitably graduated reduction in the ware temperatures which may pass into the cooling zone from the firing zone at a temperature in excess of 3000° and which should be cooled down to a much lower temperature, which in some cases, is not higher than two or three hundred degrees F., before passing out of the exit end A^5 of the kiln.

As shown in Figs. 3 and 9, a short portion of the cooling zone of the kiln immediately adjacent the firing zone is formed with relatively thick side walls having adjacent their outer sides open ended vertical cooling channels S, the outer walls of which may be formed by corresponding portions of the metallic kiln casing *m*. The channels S are shown as open at their upper and lower ends and operate as chimneys to cause a continuous upflow through the channels of atmospheric air.

In an intermediate section of the cooling zone, the side walls of the kiln chamber are thinner than in the section previously described and are formed with vertical cooling channels T separated by ceramic material walls from the outer casing *m*, as shown most clearly in Fig. 10. The channels T open to the atmosphere at their upper ends and open to the atmosphere at their lower ends through lateral ports T', and act like chimneys.

In the exit end portion of the cooling section, as shown most clearly in Fig. 11, the top and side walls of the kiln chambers are formed by metallic conduits U and UA respectively, shown as rectangular in cross-section and each provided with inlet and outlet connection U' and U^2, which may be associated with suitable fan means for creating a forced circulation of air through the conduits U and UA.

In the normal contemplated operation of the kiln shown in the drawings and just described, combustion supporting air and a suitable mixture of air and gas are supplied by the mains J and N under pressures which may vary with operating conditions. Preferably said pressures are high enough under all normal operating conditions to cause the products of combustion and burning gases to issue from the upper ends of the burner chambers E in the form of jets each having a velocity high enough to maintain a continuous upflow along the side walls of the kiln chamber from the mouths of the burner chambers E to the apex of the kiln chamber roof arch, and to cause downflow of the heating gases from the apex of the kiln chamber roof to the outlet ports K^6 in streams which alternate with, but are not as sharply defined as the uprising streams or jets issuing from the burner chambers E.

The present invention is adapted for use in kilns employed for a wide variety of high temperature operations, and when so used may include various expedients which experience has shown to be necessary or desirable in the operation of a continuous tunnel kiln for such purposes. For example, in the use of my improved kiln for firing ceramic products giving off substantial volumes of vapor or "smoke" as they are preheated, the preheating zone of the kiln may be provided with smoke discharging means. Furthermore, kilns constructed in accordance with the present invention may in some cases, advantageously include provisions of known form for regulating kiln atmosphere circulation.

As will be understood, also, the relative amounts of fuel gas and combustion supporting air supplied to the kiln burners may be regulated to maintain a neutral, reducing or oxidizing kiln atmosphere, as conditions make desirable. It is to be noted, however, that with the relatively large number of burners E, the accurate regulation of the amounts of fuel and air supplied to each burner and the high combustion temperatures characteristic of my improved kiln, combustion is so rapid and complete that to maintain a neutral kiln chamber atmosphere, the ratio of combustion supporting air to gas supplied must be almost precisely that theoretically required for complete combustion.

In the normal contemplated operation of any particular kiln of the type disclosed, the goods are progressively advanced through the kiln chamber at a rate determined by the conditions of operation, and the relative amounts of gas and combustion supporting air supplied to the different burner chambers E distributed along the length of the firing section of the kiln are regulated as required to maintain the temperature curve, or temperature gradation along the length of the kiln, considered desirable for the particular use to which the kiln is being put.

In general, the rates at which gas and combustion supporting air are supplied to the different burners E, and the rate of goods movement through the kilns, should be so related that the goods temperature will progressively increase, but not necessarily at a uniform rate, as the goods move to a point which is intermediate the ends of the kiln firing zone and which is usually nearer the exit end than the inlet end of that zone, and so related that a fairly constant goods temperature will be maintained as the goods move from said point to the exit end of the firing zone of the kiln.

The particular kiln shown in the drawings was devised for use in firing steatite parts, used in radio receivers and for other purposes, to a temperature of 3200° F. by the combustion of city gas of about 530 B. t. u. per cubic foot and with

the amount of combustion supporting air supplied slightly less than that required for complete combustion, so that the kiln chamber atmosphere is reducing in character. The particular kiln design shown in the drawings is well adapted, however, for uses in which goods are heated to a temperature of or above 3600° F., and can be used, of course, in heating goods to maximum temperatures lower than 3200° F.

The passage of the burning and highly heated gases from the burner wells E in jets or streams flowing upward along and in proximity to the side walls of the combustion chamber and thence inward along and in proximity to the kiln chamber roof to the center line of the latter, contributes to the maintenance of high temperatures and good heat distribution. With the burning and highly heated gases moving in relatively thin streams along the side and roof walls of the kiln chamber, all or practically all of the inner wall surface of the high temperature zone of the kiln chamber is heated to incandescence, and the major portion of the heat absorbed by the goods passing through the high temperature zone of the kiln is transmitted to the goods by radiation from said wall surface and from the burning and highly heated gases immediately adjacent said surface.

The preheating of the combustible constituents passing to the burner E through the channels G and through the pipes I and channels H, is substantial, and contributes to the maintenance of desirable combustion conditions and to the attainment of high temperatures.

It is usually desirable to decrease the percentage of air in the mixture supplied to the wells E through the channels G as the B. t. u. value of the gas diminishes, and when a fuel gas as weak as ordinary producer gas is used to produce relatively high temperatures, little or no air should be mixed with the gas supplied through the channels G. With rich gas, however, it is ordinarily practically feasible to maintain the desired temperature conditions with considerable variations in the relative amounts of combustion supporting air supplied through the channels G and H.

By suitable regulation of the air-fuel ratio in the mixture supplied through the channels G and of the relative rates of flow through the channels G and H, it is possible to significantly vary the longitudinal temperature gradients of the jets discharged into the kiln chamber from the burner wells E. Such regulation of the jet temperature gradients contributes to the maintenance of desirably related temperatures at different levels. The temperature drop along the length of the firing zone, may be regulated by adjustment of the valves in the different supply branches J' and N', desirably accompanied in some cases by related adjustments of the slide brick dampers K^{10} in the roof flues K^2.

For the particular use for which the kiln shown in the drawings was devised, under maximum load conditions the air in the supply main J may be under a pressure of about 1 pound per square inch above atmospheric pressure, and the pressure in the air and gas mixture supply main N may be about 3 pounds per square inch above atmospheric pressure, and said mixture may include about 50% of the combustion supporting air required. Under such conditions the gauge pressure of the kiln chamber atmosphere in the high temperature zone in the kiln at the bench level may be positive and from about two-tenths of an inch to about one-half of an inch of water.

As will be understood, the operational data just given is given merely to illustrate the suitable operating conditions for one particular use of a kiln of one particular design and size.

With a kiln chamber shaped to provide uprising side walls which merge into inwardly inclined roof sections intersecting at an angle, use in the high temperature zone is advantageously made of wall lining tiles O which extend, as shown in Fig. 4, from the bottom of the kiln chamber to the apex of the vaulted roof. Such tiles may be formed of beryllium oxide or other material having little mechanical strength, but which is substantially more refractory than the load carrying kiln chamber walls which they line and shield against the high kiln chamber temperatures.

While in accordance with the provisions of the statutes, I have illustrated and described the best from of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention, as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of heating an elongated high temperature zone of a continuous tunnel kiln having kiln chamber side and roof walls of refractory material, which comprises upwardly directing burning jets of preheated fuel gas and combustion supporting air into the kiln chamber at closely spaced points distributed along the length of said zone and adjacent the lower edges of its side walls, and withdrawing products of combustion from said zone at a multiplicity of closely spaced points distributed along the length of said zone and adjacent the lower edges of said side walls.

2. The method of heating an elongated high temperature zone of a continuous tunnel kiln having kiln chamber side and roof walls of refractory material, which comprises upwardly directing burning jets of preheated fluid fuel and combustion supporting gas into the kiln chamber at closely spaced points distributed along the length of said zone and adjacent the lower edges of said side walls, and forming each jet by combining, immediately adjacent said points, two separately preheated supply streams, one of which includes the fluid fuel and a portion of the combustion supporting gas and the other of which includes the remainder of the combustion supporting gas.

3. The method of heating an elongated high temperature zone of a continuous tunnel kiln having kiln chamber side and roof walls of refractory material, which comprises passing preheated fluid fuel and combustion supporting gas into the kiln chamber at closely spaced points distributed along the length of said zone adjacent the lower edges of its side walls, and forming burning streams of the fluid fuel and combustion supporting gas which flow side by side and upward from said points along said side walls approximately parallel to vertical planes transverse to the side walls of and thence along the roof wall toward the longitudinal center line of the latter.

4. A continuous tunnel kiln having a kiln

chamber comprising an elongated firing zone with uprising side walls and having a multiplicity of burners distributed at short intervals along the length of said zone and opening into the kiln chamber adjacent the lower edge of each of said side walls and each adapted to discharge an upwardly directed burning jet alongside the adjacent side wall, and means for supplying preheated fluid fuel and preheated combustion supporting air to each burner at separately regulable rates.

5. A continuous tunnel kiln having a kiln chamber comprising an elongated firing zone with uprising side walls and having a multiplicity of burners distributed at short intervals along the length of said zone adjacent the lower edge of each of said side walls and each adapted to discharge an upwardly directed burning jet alongside the adjacent side wall, means for supplying fuel gas and combustion supporting air to each of said burners, and means for withdrawing products of combustion from said zone at a multiplicity of points distributed along the length of said zone and adjacent the lower edges of said walls.

6. A continuous tunnel kiln having a kiln chamber comprising an elongated firing zone with uprising side walls and having a multiplicity of burners distributed at short intervals along the length of said zone and opening into the kiln chamber adjacent the lower edge of each of said side walls, and having a plurality of outlet ports distributed at short intervals along the length of said zone and opening to the kiln chamber adjacent the lower edge of each of said side walls, and means for supplying fuel gas and preheated combustion supporting air to each of said burners.

7. A continuous tunnel kiln structure having a multiplicity of closely spaced burners distributed along the lower portion of a high temperature kiln chamber zone adjacent each side of the latter and having walls at the sides of the kiln chamber and recuperators therein comprising a separate downflow combustion supporting air supply channel for each of said burners and in communication at its lower end with the latter and upflow channels respectively adjacent the different downflow channels and in communication at their lower ends with respectively adjacent lower portions of the kiln chamber, and means for supplying fuel gas to the different burners comprising a separate supply channel for each burner.

8. A continuous tunnel kiln structure having a multiplicity of closely spaced burners distributed along the lower portion of a high temperature kiln chamber zone adjacent each side of the latter and having walls at the sides of the kiln chamber and recuperators therein comprising a separate downflow combustion supporting air supply channel for each of said burners and in communication at its lower end with the latter and upflow channels respectively adjacent the different downflow channels and in communication at their lower ends with respectively adjacent lower portions of the kiln chamber, and means for supplying fuel gas to the different burners comprising a separate supply channel for each burner, the last mentioned channel having a wall of ceramic material and extending through and absorbing heat from a heated portion of the kiln structure.

9. A continuous tunnel kiln structure having a multiplicity of closely spaced burners distributed along the lower portion of a high temperature kiln chamber zone adjacent each side of the latter, and having kiln chamber side walls and recuperators therein comprising a separate downflow combustion supporting gas supply channel for each burner and in communication at its lower end with the latter and upflow channels respectively adjacent the different downflow channels, and having a flue in the lower portion of each side wall extending along the length of said zone to which the lower ends of the said upflow channels in the same side wall are connected, each of said flues being in communication at points distributed along its length with respectively adjacent portions of the kiln chamber, and means for supplying fluid fuel to the different burners.

10. A continuous tunnel kiln structure comprising side walls at the opposite sides of an elongated firing zone section of the kiln chamber and benches respectively adjacent and at the inner sides of the lower portions of said side walls and having a series of closely spaced burner wells formed in each bench and each open at its upper end to the kiln chamber, a separate combustion supporting gas supply conduit connection to each well, each such connection comprising a downflow channel in the adjacent side wall and a regulable supply pipe connection to the upper end of said channel, upflow channels in said side walls respectively adjacent the different downflow channels and in communication at their lower ends with respectively adjacent portions of the kiln chamber, and a separate regulable fluid fuel supply conduit connection to each of the different burner wells.

11. A continuous tunnel kiln including aligned preheating and high temperature kiln chamber zones and having a multiplicity of closely spaced burners distributed along the lower portion of said high temperature zone adjacent each side of the latter, and having a roof formed with a flue space over the high temperature zone and having side walls and recuperators therein at the sides of the high temperature zone comprising a separate downflow combustion supporting gas supply channel for each of said burners and in communication at its lower end with the latter and upflow channels respectively adjacent the different downflow channels which are in communication at their lower ends with respectively adjacent lower portions of the kiln chamber and in communication at their upper ends with said flue space, preheating zone heating means in communication with and receiving heating gases from said flue space, and means for supplying fluid fuel to the different burners.

12. A continuous tunnel kiln as specified in claim 11, including dampers for regulating communication between said upflow channels and flue space.

13. A continuous tunnel kiln structure comprising side walls at the opposite sides of an elongated firing zone section of the kiln chamber and benches respectively adjacent and at the inner sides of the lower portions of said side walls and having a series of closely spaced burner wells formed in each bench and each open at its upper end to the kiln chamber, a separate combustion supporting gas supply conduit connection to each well, each such connection comprising a downflow channel in the adjacent side wall and a transverse channel connecting the lower end of the downflow channel to the corresponding

burner well, upflow channels in said side walls annular in cross section and each surrounding a corresponding one of said downflow passages, a longitudinal flue in the lower portion of each side wall to which the lower ends of the annular upflow channels in said wall are connected, and transverse connections from said flues to the kiln chamber distributed along the length of the firing zone section.

14. In the method specified in claim 1, the further step which comprises transferring heat from the products of combustion withdrawn from the kiln chamber at each of the last-mentioned points and passing upwardly therefrom, to combustion supporting air passing downward and thence into the kiln at a closely adjacent one of the first-mentioned points.

15. In the art of heating a zone of a kiln having a chamber formed by opposed side and roof walls of refractory material, the improvement which comprises directing upwardly burning streams of combustible fuel and combustion supporting gas in the chamber at spaced regions distributed along the zone adjacent to the lower edge portions of the side walls, and withdrawing products of combustion from the chamber at a number of spaced regions distributed along the zone adjacent to the lower edge portions of the side walls.

16. In the art of heating a zone of a kiln having a chamber formed by opposed side and roof walls of refractory material, the improvement which comprises flowing combustible fuel and combustion supporting gas to a plurality of spaced regions distributed along the zone adjacent to the lower edge portions of the side walls, directing burning streams of the combustible fuel and combustion supporting gas upwardly from said regions alongside the side walls, withdrawing products of combustion from the chamber at a number of spaced regions distributed along the zone adjacent to the lower edge portions of the side walls, and passing the products of combustion withdrawn from the chamber in heat exchange relation with the combustion supporting gas flowing to the first-mentioned regions.

17. A kiln comprising a chamber providing a firing zone having opposed vertically disposed walls, a number of burners distributed at intervals along the zone adjacent to the lower edge portions of said walls, means for supplying combustible fuel and combustion supporting gas to the burners, said burners being formed and disposed so that burning streams of the combustible fuel and combustion supporting gas may be discharged upwardly therefrom alongside the walls, and means whereby products of combustion are withdrawn from the chamber at a number of regions distributed along the zone adjacent to the lower edge portions of the walls.

18. Kiln structure comprising refractory material forming a chamber providing a firing zone having opposed vertically extending walls, a number of burners distributed at intervals along the zone adjacent to the lower edge portions of said walls, heat exchangers having first and second passages, the heat exchangers being embedded in the refractory material, means for supplying combustible fuel to the burners, means including the first passages of the heat exchangers for supplying combustion supporting gas to the burners, said burners being formed and disposed so that burning streams of the combustible fuel and combustion supporting gas may be discharged upwardly therefrom alongside the walls, and means including the second passages of the heat exchangers for withdrawing products of combustion from the chamber at a number of regions distributed along the zone adjacent to the lower edge portions of the walls.

19. A kiln comprising a chamber providing a firing zone having opposed side and roof walls formed of refractory material and constituting the load carrying walls of the kiln, a number of burners distributed at intervals along the zone adjacent to the lower edge portions of the side walls, means for supplying combustible fuel and combustion supporting gas to the burners, said burners being formed and disposed so that burning streams of the combustible fuel and combustion supporting gas may be discharged upwardly therefrom alongside the side walls, means whereby products of combustion are withdrawn from the chamber at a number of regions distributed along the zone adjacent to the lower edge portions of the side walls, and wall lining tiles at the inner surfaces of said side and roof walls, the wall lining tiles being formed of material of less mechanical strength and more refractory than the refractory material forming the load carrying walls of the kiln.

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