

Aug. 14, 1934.

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1,970,320

TUNNEL KILN

Original Filed June 21, 1930 4 Sheets-Sheet 1

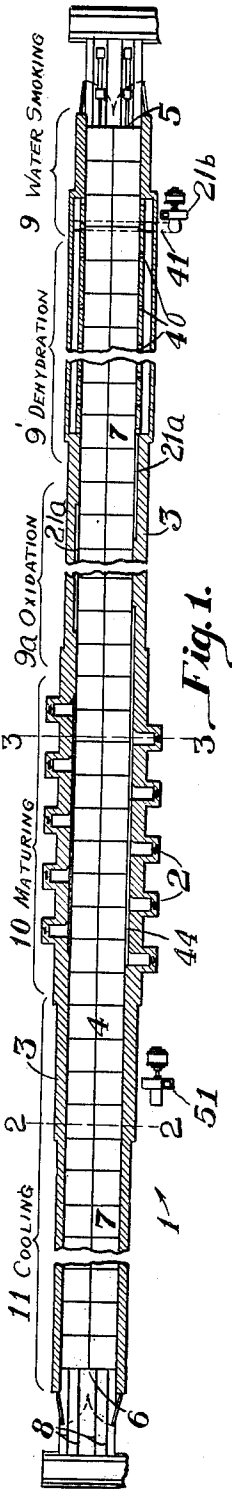


Fig. 1.

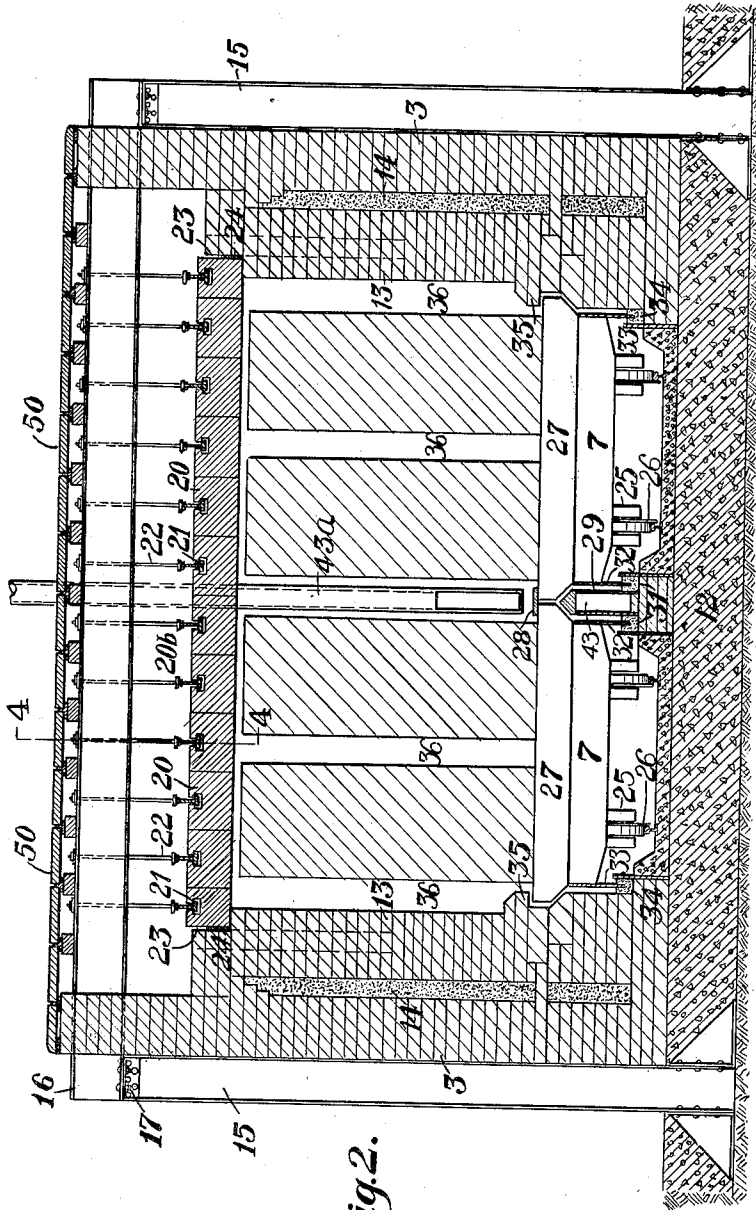


Fig. 2.

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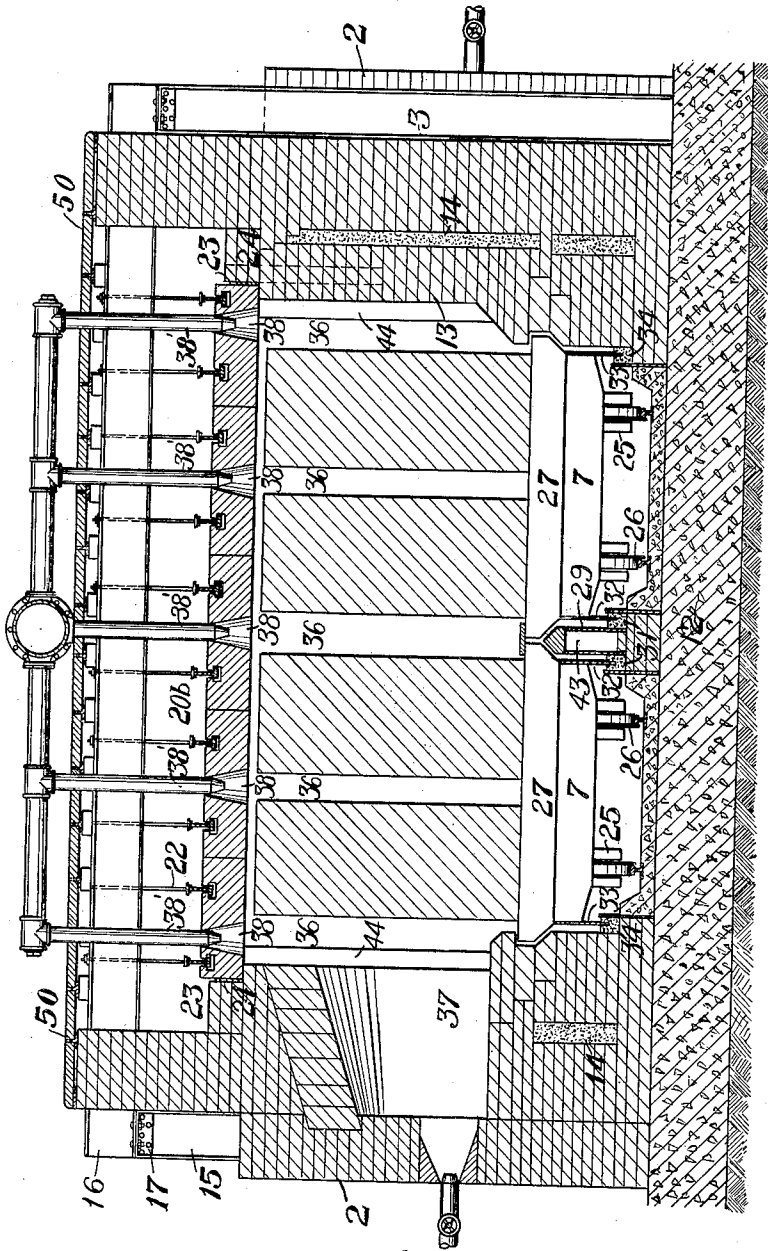


Fig. 3.

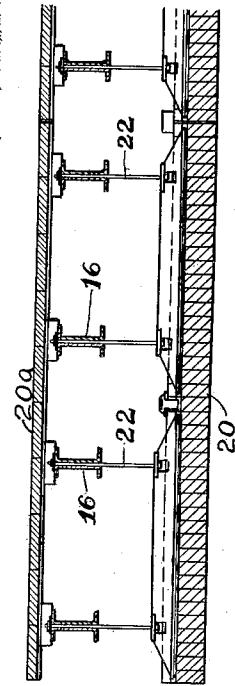


Fig. 4.

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TUNNEL KILN

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Fig. 5.

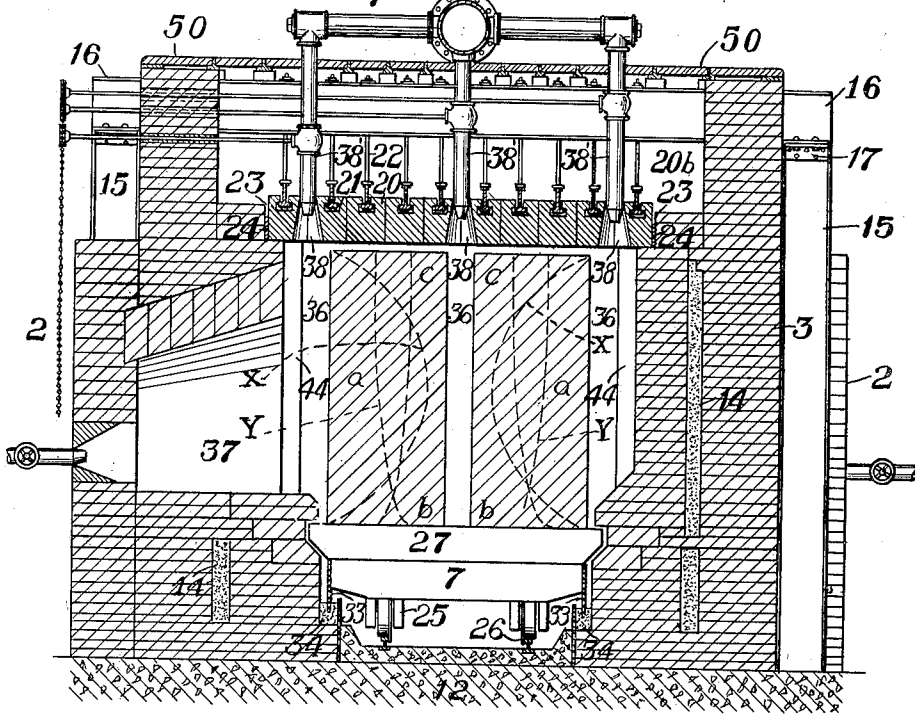
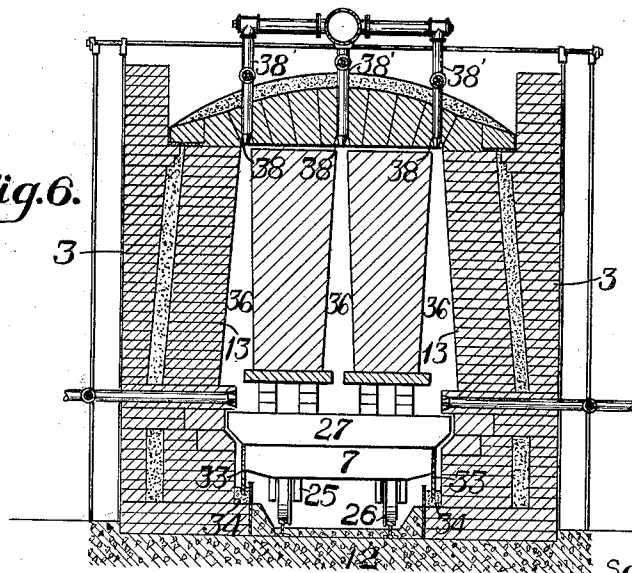


Fig. 6.



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TUNNEL KILN

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Fig. 7.

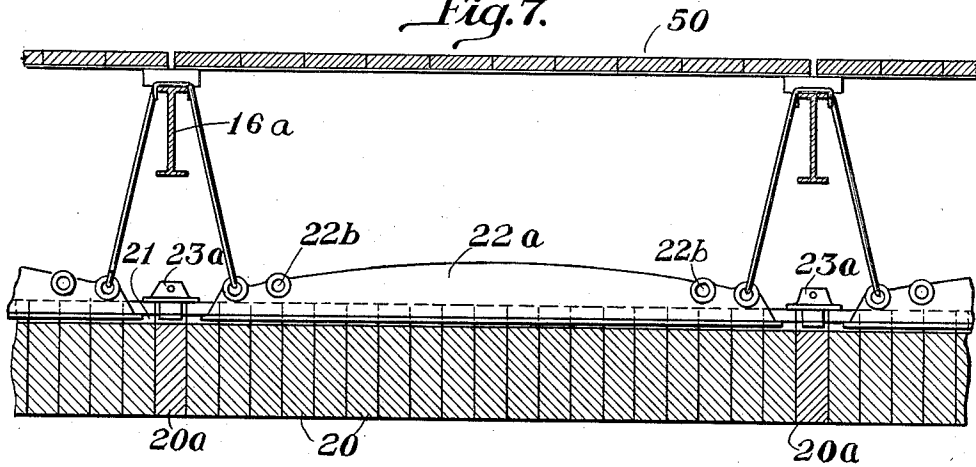
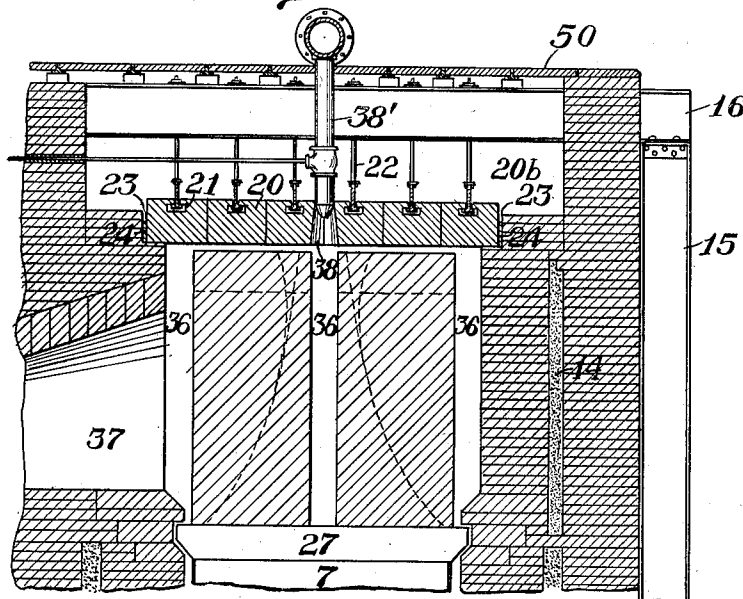


Fig. 8.



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UNITED STATES PATENT OFFICE

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TUNNEL KILN

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Application June 21, 1930, Serial No. 462,818
Renewed January 18, 1934

25 Claims. (Cl. 25—142)

This invention relates to continuous kilns of the type used in the burning or heat treating of clay ware. Kilns of this type are characterized by the provision of a wall and roof structure which forms a longitudinally extending passage or tunnel through which the ware, arranged on horizontally movable platforms, is advanced progressively, and wherein provision is made for developing desired operating temperatures within the tunnel in order to subject the ware to the desired degree of heat treatment during its passage through the tunnel.

The invention has for one object the provision of a tunnel kiln which is formed to comprise transversely spaced longitudinally extending side walls and a flat suspended roof having its lower surfaces, which define the top wall of the tunnel, arranged in a uniform substantially horizontal plane, whereby the ware may be disposed on the movable platforms in settings having a desired structure and stability and conforming closely to the roof plane and in uniform proximity thereto, to obtain uniform distribution of heated gases over the tops of the setting and longitudinally of the tunnel and also to obtain the maximum benefit of the radiant heat released from the refractory walls and roof of the tunnel.

Another object of the invention resides in the provision of a tunnel kiln constructed to permit of the passage of a large quantity of ware through the kiln on a plurality of cars arranged in two or more trains movable side-by-side through the tunnel but wherein the car units comprising the trains are interchangeable and may be conveniently separated and handled individually exteriorly of the tunnel, facilitating thereby the placing of the ware on the car units or the removal of the ware from such units; the installation affording large capacity and uniform burning effectiveness together with facility and ease in the matter of handling the products delivered to and removed therefrom.

In tunnel kilns now in use, designed to accommodate a single train of car sections, the tunnel is heated by the provision of heat generating devices associated with the side walls of the tunnel and on opposite sides of the ware-containing car sections. In a single track tunnel of limited width such heating arrangement is usually sufficient to effect a fairly uniform heat treatment of the ware, but in multi-track tunnels, or tunnels of extended width, of the type to which the present invention is particularly directed, the increased width of the tunnel

and ware setting necessitates the employment of additional heat generating appliances, in order that all portions of the ware comprising such settings will be subjected for the proper period of time to necessary temperatures for effecting the burning or complete maturing of such ware. Therefore, the present invention provides for the application and distribution of high burning or maturing temperatures not only along the sides of the settings, but particularly in the central and lower central regions thereof, and also the control of the heating in the upper central regions of the settings, this being accomplished by the introduction of heat generating and developing media through the roof of the kiln in a manner and under a control such that the location of the combustion zone with respect to the setting may be definitely predetermined and governed.

It is a further object of the invention to place the ware on the car platforms to produce a plurality of longitudinally extending passages between adjacent sections of the settings and between the side walls of the tunnel and said settings and wherein the burner devices operating through the roof serve to introduce a fuel for combustion in said passages in order that said burning of said fuel in the passages may directly deliver to the setting the required temperatures necessary to effect proper heat treatment of all portions of the ware, avoiding specifically lack of uniformity in heating of the entire mass of such settings.

A further object of the invention rests in the provision of a tunnel kiln provided with a suspended roof which consists of a plurality of refractories suspended from metallic cross members supported in conjunction with the side walls of the kiln, and wherein the mounting or suspension of said refractories is such as to permit various units thereof to be removed bodily from the kiln to provide convenient and immediate access to the interior of the tunnel through the roof, for the purpose of facilitating repairs or to relieve congestion due to the falling or shifting of the position of a setting on a car.

With these and other objects in view which will appear as the description proceeds, the invention consists in the novel features of constructions, combinations of elements and arrangements of parts, hereinafter fully described and pointed out in the appended claims.

In the accompanying drawings:

Figure 1 is a horizontal sectional view taken

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through a tunnel kiln constructed in accordance with the present invention,

Figure 2 is a similar view taken through the cooling zone of the kiln on the line 2—2 of Figure 1,

Figure 3 is a vertical cross-sectional view taken through the maturing zone of the tunnel on the plane indicated by the line 3—3 of Figure 1,

Figure 4 is a vertical longitudinal section of the roof structure of the kiln,

Figure 5 is a vertical transverse sectional view disclosing the single track kiln constructed in accordance with the present invention and formed with a suspended roof structure,

Figure 6 is a still further modification disclosing a single track-arch-roof kiln provided with roof burners disposed in accordance with the features of the present invention,

Figure 7 is a detail vertical sectional view illustrating the modified form of roof structure wherein the refractories are suspended from transverse supporting members, and

Figure 8 is a similar view taken through a kiln provided with a center row of roof burners and illustrating by broken lines the regions of the ware settings directly affected by the high temperatures produced by said burners.

Referring to the illustrative examples of structure shown in the drawings, the numeral 1 designates a tunnel kiln embodying the present invention. The kiln comprises an elongated masonry structure, the walls of which are formed of suitable heat resisting material. The construction is such as to provide an elongated tunnel or passageway which extends longitudinally through the kiln, the said tunnel being indicated by the numeral 4. The opposite ends of the kiln are open or provided with hinged doors, so that cars or other small portable carriers or conveyors may be moved into the kiln at one end, passed through the tunnel, and out of the other end thereof. The entrance end of the tunnel is indicated by the numeral 5 and the discharge end by the numeral 6. At a point approximately midway of its length the wall structure 3 of the kiln may be provided with a battery of furnaces, indicated at 2, which communicate with the tunnel and may be fired in any suitable manner partially to develop the requisite temperatures to properly fire the particular ceramic bodies passed through the kiln. The cars or other movable and portable carriers 7 which carry the ceramic wares to be fired, are moved progressively through the tunnel, in this instance along a plurality of trackways 8, and as the cars so advance through the tunnel from the entrance, the ware suitably piled thereon, encounters first water-smoking and dehydration zones 9 and 9' of progressively increasing temperature. During the passage of the cars through these zones moisture is driven from the ware and the latter is conditioned for the higher burning or oxidation temperatures prevailing in the zone 9a. Continued advance of the cars or carriers brings the ware into the high temperature or maturing zone 10, which is disposed approximately midway of the length of the tunnel or as determined by the location of the furnaces 2, and the rate of travel of the cars determines the period of time that the goods or ware are subjected to these high burning or firing temperatures. Further progressive advance of the cars removes the ware from the high temperature zone 10 into a cooling zone of progressively decreasing temperature, which cooling zone is indicated by the numeral 11, so

that by the time the ware is discharged from the end 6 of the tunnel its temperature has been reduced to a point such that it will not be adversely affected by the room temperature, and the burning ware may be removed from the cars or carriers. The latter may be advanced through the tunnel by suitable means either intermittently or continuously. Cold air is introduced adjacent the discharge end of the cooling zone and passed through the tunnel to expedite the cooling and to supply preheated air for use in combustion in the maturing zone.

With reference to the specific details of the kiln here shown for purpose of illustration, there is employed a concrete foundation or base 12. Upon this foundation is supported the wall structure 3 which includes a pair of spaced substantially vertical side walls 13—13, composed of brick, the inner portion being of fire brick, or other refractory material. The side walls are of suitable thickness to minimize heat loss through radiation or other escape to the atmosphere and, if desired, said side walls 13 may be provided with a lagging 14 of heat insulating material. Secured in the foundation 12 and ranged along the exterior planes of the walls 13 are vertically disposed structural members or buckstays 15, to the upper ends of which are secured transversely extending roof-supporting beams 16. The cross members 16 may rest on the side walls 3 and may be detachably bolted to brackets 17 on the upper portions of the buckstays 15. This construction is such that by disconnecting the cross members 16 from the buckstays, the said cross members, together with the portions of the roof structure suspended therefrom, may be elevated bodily over localized areas, providing thereby for convenient access to the interior of the tunnel through the roof of the kiln.

The roof of the kiln additionally comprises a plurality of refractory blocks 20 which are preferably though not necessarily arranged in a horizontal plane and form, when assembled, a substantially flat roof. These blocks have their upper surfaces formed with T-shaped slots 21, which slots receive the flanged lower edges of cast iron arch bars 22 which are demountably suspended by hanger rods 22a from the cross members 16. The blocks 20 at the longitudinal edges of this roof structure overlap shoulders 23 provided on the upper portions of the side walls 13, the joints between the side walls and the blocks 20 being sealed with a compressible refractory or other suitable sealing material as indicated at 24. This allows for relative movement between the blocks comprising the roof structure and the vertical side walls in response to varying kiln temperatures and other conditions, and at the same time keeps these joints sealed to prevent leakage. The length of the arch bars 22 is less than the distance between the beams 16 from which they are suspended, and to close the space between the refractories 20 supported on aligned arch bars, similar refractories 20a are supported on flanged bridge castings 23, the heads of which rest on top of the refractories 20 on the adjacent arch bars. The bridge castings 23 and refractories 20a are disposed below the beams 16, and they may be withdrawn upwardly from the roof, so as to permit the roof sections carried on respective arch bars 22 to be elevated individually between the beams.

This flat suspended roof is in marked contrast with the usual arched masonry roof heretofore generally employed in kilns of this character, and

permits the tunnel 4 to be of any desired width. The use of the usual arched masonry roof imposes limitations on the width of the tunnel. Use of a suspended roof allows almost unlimited latitude in the width of the tunnel, so that as a result a single kiln constructed in accordance with the present invention may have the productive capacity of a plurality of kilns of conventional design. Moreover, this is accomplished without materially increasing constructional costs.

In Figure 1 of the drawings, the tunnel has been depicted as containing a pair of trackways 8, but it should be understood that this number may be varied if desired. Each of the cars or carriers 7 on which the ware is transported through the tunnel comprises a metallic frame 25 carried on track-engaging wheels 26. To protect the metallic frames 25 from the high temperatures prevailing in the kiln each car includes a floor or platform composed of a heat resistant insulating material, such as fire brick.

Between the trackways 8 there is provided a divisional wall 29 which, contiguous to its base, is formed with longitudinally extending troughs 31 in which sand or other sealing material is retained, and the car frames 25 are provided with depending plates 32 which have their lower edges dipping into the same to form a flexible seal against the passage of heat and gases from the heating areas of the tunnel into areas which it is desired to keep relatively cool. Similarly, the outer longitudinal edges of the car floors 27 are provided with depending plates 33, the lower edges of which are received within sand containing troughs 34 formed in conjunction with the lower inner portions of the walls 13. The latter walls are also formed with horizontally and longitudinally extending ledges 35 which overlap the floors 27 of the cars to baffle the passage of heat and gases from the tunnel 4 into the wheel areas. By this construction the metallic members of the cars or carriers 7 are protected against overheating.

The ware is piled on the platforms 27 of the cars, either with or without the use of saggars, in vertical order to produce spaced setting sections, as indicated at 36, which arrangement permits the heat of the kiln to pass freely and uniformly around the ware to procure a uniform burning or firing thereof. The hot combustion gases pass from the furnaces 2 directly into the tunnel 4 through openings 37 formed in the side walls 13-13. Also, fuel is injected through the burner ducts 38 formed in the roof structure of the setting. The ducts 38 are so placed that the discharge of the burners 38' is directed downwardly in the spaces between the setting sections carried on the cars and also, if desired, along the outer sides of the settings. By suitable adjustment of the force of the burner discharge, and the quantity of primary air and fuel fed, the zone of combustion from any burner may be adjusted or positioned vertically relative to the setting so as to apply the heat where desired and thereby, in conjunction with the heat from the lateral furnaces 37, obtain a uniform heating of the entire setting. In an ordinary tunnel kiln the heated gases of combustion enter the tunnel through openings formed in the side walls. However, when multiple tracks are used, and in certain instances single tracks, a more uniform firing action is secured by introducing the combustion producing fuels or gases at a plurality of points along the roof structure, and this is made feasible by the suspended type of flat roof here disclosed.

Above the cross members 16 and spaced from the lower row of blocks 20, there is provided a top closure formed of slabs 50 supported on angle bars which rest on spacing blocks laid on the beams 16. This top closure, in conjunction with the lower blocks 20, forms a roof duct or conduit closed at the side by the upper portions of the side walls. Air may be introduced into one end of this conduit by means of a blower 51 which may draw its supply from the external air, and operate to force the air longitudinally through said flue for preheating purposes and to limit the temperature of the refractory roof, and preventing overheating of the supporting beams. As the fuel feeding devices 38' pass through this air duct, the fuel and primary air introduced through them receives some preheating from the air in the duct. This preheated air is then introduced directly into the water-smoking zone 9 of the tunnel for heating and supplying oxygen to the ware in the zones 9, 9' and 9a. The blower 51, or an additional blower, may also introduce cooling air directly into the cooling zone 11 of the tunnel to expedite the cooling of the ware and to provide preheated air for admixture with the combustion gases and fuels present in the maturing zone 10 in order to effect regulated combustion in said maturing zone. The walls of the oxidation zone of the tunnel are provided with offsets indicated at 21a which are used to produce a tortuous path of travel of the gaseous products of combustion through the oxidation zone in a direction generally opposed to that of the direction of travel of the ware through the tunnel. A draft fan 21b communicates with the dehydration zone 9' to remove from the tunnel the gaseous products of combustion, which have been largely deprived of their effective heat.

The walls of the dehydration and water-smoking zones are provided with ports as at 40 which lead to a transverse exhaust duct 41 with which communicates a draft fan 21b for maintaining a forced passage of the heated gases of combustion through the kiln and the removal of such gases after the desired heat transfer with the ware has taken place. If desired, the ware may be set or placed on a perforate foundation disposed on the platforms of the cars so that the heated gases discharged from the side wall burners may enter such foundation and pass upwardly through the ware disposed thereon. In this manner the ware is heated from the bottom as well as from the top and sides during its passage through the tunnel. It is, of course, within the scope of this invention to apply these features of construction to a single track tunnel as well as to a multiple track installation, and to arched as well as flat types of roofs. The divisional wall separating the tracks in the multiple track tunnel may be provided with a conduit 43a through which air may be forced to cool the surface of said divisional wall and, if desired, said wall in the entrance end of the kiln may be perforated to assist in withdrawing gases from the tunnel.

The multiple car trains, as previously stated, are particularly advantageous in the handling of the ware. Considerations of convenience and efficient handling outside the kiln impose limitations on the size of the cars. By the multiple track arrangement, the present invention provides, for purposes of kiln capacity, a ware supporting platform approximating the full width of a kiln of extra width, and makes it possible for convenience and efficiency in handling, loading and drawing outside of the kiln to employ small

cars of a width which is only a fraction of that of the tunnel. For example, in tunnels possessing a width of 12 feet, 18 feet, 24 feet, etc., cars of 6 foot width may be used. The respective trains can be run either at the same speed, or at different speeds to provide different time cycles of tunnel occupancy of adjacent trains, since it may be desirable to load one train of cars with brick and the companion train with other materials requiring either longer or lesser exposure to the tunnel temperatures. Preferably, the fuel is injected into the vertical passages formed between the setting sections with such velocity and mixture that active combustion thereof takes place contiguous to the lower portions of the settings. As indicated generally by the dotted curves X in Figure 5, the wall burners heat quite adequately the sides of the setting, and while the upper portions of the settings are effectively heated from the roof radiation and the high temperatures in the upper portion of the tunnel, in many instances difficulty is involved in thoroughly heating or burning that portion of the ware located adjacent to the center and lower parts of the setting. By proper regulation of the roof burners, their zones of combustion may be definitely located at an elevation or position with respect to the setting sections which is appropriate to supply the requisite heat in areas which would be inadequately heated from the wall burners alone. Thus a zone of maximum heating from the roof burners may be maintained, for example, as illustrated generally by the dotted curves Y in Figure 5, the heating of the entire setting being thus equalized. Thus the heating zones indicated at *a* in Figure 5, are heated conjointly by the side wall and the outermost of the roof burners, while the zones *b* and *c*, which include the central portions of the ware settings, are heated more directly by the central roof burners. It will be understood that these zones more or less overlap to secure the desired uniformity of heating throughout all parts of the ware settings.

From the foregoing it will be appreciated that the combination of the flat suspended roof with the other elements of the structure accomplishes several highly advantageous and desirable results. It completely obviates the limitations as to width of the tunnel which are the necessary sequela of the use of a sprung arch. The use of the flat suspended roof, accordingly, not only permits the per-hour capacity of the kiln to be doubled or tripled, but permits all of the setting sections to be made of uniform height and size and to be subjected to uniform temperature conditions. The latter effect results in part from the fact that it permits sections of uniform height to occupy uniform relationship with respect to the roof, and thus to obtain uniform gas circulation and uniform backfeed through the tunnel or secondary combustion air. Moreover, it permits the roof duct to be made of uniform cross section and as a result thereof obtains uniform cooling effect on the refractory roof from the air passed through the roof duct. This is of importance in obtaining uniform temperatures across the tops of all the setting sections, in which portion of the tunnel the temperatures are most likely to build up and are most difficult to limit without resulting in undesirable limitation of temperatures in the lower portions of the setting.

The quick demountability of localized portions of the roof is of great importance. It takes a considerable period of time to heat up a kiln of the tunnel type preliminary to the introduction

of the ware, and the proper treatment of the ware depends on the maintenance of proper temperatures in the kiln. Under the drying and heating influences to which the ware is subjected during its passage through the kiln, it is subject at different stages to expansion and shrinkage. Consequently, the stacks or sections of the setting, where the pieces of ware are piled one upon another, as in the burning of fire bricks, may get out of plumb, and in instances where some of the pieces fracture or fall, a portion of a setting may topple over. Due to the close proximity of the setting sections to the side walls, such happenings may result in jams which will prevent the progressive movement of the cars. In such a contingency the removal of the cars of partly finished ware would involve a great loss of heat and possible injury to the ware, and the cooling down of the kiln would require a long time and a very great heat loss. By having the suspended roof sectionally supported, and respective sections individually removable, the roof may be opened directly over where the jam occurs, and the dislodged portions of the ware quickly removed and the roof sections quickly replaced, without material loss of heat and without detrimental effect on the other portions of the kiln charge. It will be obvious that in the construction herein shown the roof sections carried on respective arch bars *22a* may be quickly lifted out of the roof by comparatively light tackle engaged in the hoisting eyes *22b*, after preliminary removal of the refractories *20a* at the ends of such sections. When the sections are replaced and their hanger rods *22a* engage with their supporting beams, the sections will be automatically positioned with their lower surfaces in the proper association with the tops of the settings already in the kiln, thus eliminating any necessity for truing of the replaced sections preliminary to resuming movement of the train. The free joints between the marginal roof sections and the walls permit first the removal of a marginal section or sections with facility, after which one or more sections in the same transverse tier may be as readily removed, until an opening of sufficient size is made to permit the rapid extraction of the dislodged ware from the kiln by means of tongs. The construction of the top closure is such as to permit its being opened quickly in areas of any desired extent, to afford access to the suspended roof sections.

What is claimed is:

1. In a tunnel kiln, a wall structure provided with spaced vertical side walls, cross members resting upon the upper edges of said side walls and arranged horizontally between said walls, a plurality of refractory block units arranged in a horizontal plane and suspended from said cross members to form the roof of said tunnel, and a covering carried by said cross members spaced horizontally from said block units to produce a longitudinally extending flue in said wall structure above said block units.

2. In a tunnel kiln, a wall structure formed to provide a longitudinally extending tunnel, spaced track-ways arranged in the base of said tunnel, portable carriers movable longitudinally through said tunnel over said track-ways, a divisional wall situated in the base of said tunnel between said track-ways and terminating below the plane of the platforms of said carriers, and means for circulating a gaseous fluid through the divisional wall.

3. In a tunnel kiln, the combination with side walls and a progressively movable ware support-

ing platform therebetween, of a flat refractory roof extending parallel with the ware supporting platform and conjoining the walls, and a top closure spaced above the refractory roof to afford therebetween an air duct of uniform height across the roof.

4. A tunnel kiln structure as specified in claim 3 and wherein supporting members for the refractory roof are exposed to air in said air duct.

5. In a tunnel kiln, a heat confining structure comprising spaced side walls and a roof cooperatively related to form a tunnel which extends longitudinally through the kiln from one end thereof to the other, spaced parallel longitudinally movable conveyors arranged in the base of the tunnel and upon which conveyors the ware to be heat-treated is positioned for advancement through the tunnel, said ware being disposed in vertical settings to produce therebetween vertical longitudinally extending passages, and burner means mounted in conjunction with both the side walls and roof of the kiln for introducing fuel in a state of active combustion into the vertical passages formed between adjoining settings of the ware and between the side walls of said kiln, whereby said combustion gases contact directly with the ware.

6. In a continuous kiln, a heat confining structure formed to include spaced side and roof walls forming a longitudinally extending tunnel, spaced parallel trains of ware carriers movable simultaneously through said tunnel, and burner means arranged intermediately of the length of said heat confining structure for delivering fuel in a state of active combustion into said tunnel for uniform distribution around and in direct contact with the ware positioned on said carriers, said burner means being mounted in connection with both the side and roof walls of the heat confining structure.

7. In a tunnel kiln, a heat confining structure formed to include spaced vertical side walls, transverse members and a roof structure suspended from said transverse members whereby to provide a longitudinally extending tunnel passing through the kiln from one end thereof to the other, a plurality of spaced longitudinally extending ways formed in the base of said tunnel, carriers movable simultaneously in the same direction through said tunnel along said ways, said carriers being adapted to have positioned thereon the ceramic ware to be heat-treated in the kiln, and means arranged intermediately of the length of the tunnel for delivering a combustible fuel into said tunnel for direct contact with the ware through both the side and roof walls thereof.

8. In a tunnel kiln, a heat confining structure of a refractory material consisting of spaced side walls and a roof which conjointly produce a longitudinally extending tunnel, the base of said tunnel being provided with a plurality of spaced longitudinally extending ways, ware-receiving carriers movable longitudinally along said ways, and a plurality of burners arranged adjacent to said roof and side walls for delivering a heated gas of combustion directly into said tunnel intermediate of the length thereof for direct contact with the ware on said carriers.

9. A kiln comprising a longitudinally extending tunnel formed with spaced vertical side walls and an overlying roof structure, said tunnel substantially midway of its length being formed with a high-temperature heating zone, means for advancing ware to be heat-treated longitudinally through the tunnel, a plurality of burner units

provided in the side walls of said high-temperature zone, and a plurality of complementary burner units provided in the roof structure of said high-temperature zone, said latter units being disposed to initially direct the combustion producing materials discharged therefrom downwardly along the sides and central portion of the tunnel into direct contact with the ware passing through said zone.

10. In a tunnel kiln, spaced vertical side walls and an overlying roof structure forming conjointly an enclosed longitudinally extending tunnel, transversely spaced longitudinally extending carriers movable longitudinally through said tunnel, said carriers being adapted for the reception of ware to be heat-treated in the tunnel, and a hollow flue-forming divisional wall arranged between said carriers substantially below the ware positioned thereon and extending longitudinally of the tunnel.

11. In a tunnel kiln, spaced vertical side walls and an overlying roof structure forming conjointly an enclosed longitudinally extending tunnel, transversely spaced longitudinally extending carriers movable longitudinally through said tunnel, said carriers being adapted for the reception of ware to be heat-treated in the tunnel, and a hollow divisional wall arranged in the lower part of said tunnel between said carriers and extending longitudinally of the tunnel substantially below the ware supported on said carriers, said divisional wall being provided with ports establishing communication between a flue formed interiorly of said divisional wall and the interior of said tunnel.

12. In a kiln, a wall structure formed to provide a longitudinally extending tunnel passing through the kiln from one end thereof to the other, conveying means movable longitudinally through the tunnel and upon which the ware to be heat-treated in the tunnel is positioned, the ware being disposed in spaced settings producing longitudinally extending passages between the adjacent vertical walls of the settings and the outer vertical walls of the settings and the corresponding inner walls of the tunnel, and means for delivering combustible materials downwardly and vertically into each of said passages for combustion adjacent to the lower portions of said passages.

13. In a kiln, a wall structure formed to provide a longitudinally extending tunnel passing through the kiln from one end thereof to the other, conveying means movable longitudinally through the tunnel and upon which the ware to be heat-treated in the tunnel is positioned, the ware being disposed in spaced settings producing longitudinally extending passages between the adjacent vertical walls of the settings and the outer vertical walls of the settings and the corresponding inner walls of the tunnel, and independently controlled means for delivering combustible materials downwardly and vertically into each of said passages for combustion adjacent to the lower portions of said passages.

14. In a kiln, a wall structure comprising vertical side walls, vertical buckstays arranged exteriorly of the side walls, horizontally extending cross-members resting upon the upper surfaces of said side walls and connected with the upper portions of said buckstays, a roof for said wall structure composed of a plurality of refractory block units independently suspended from said cross-members and having the lower surfaces thereof arranged in substantially a horizontal

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- plane, and a conveyor passing longitudinally through the kiln for the reception of ware settings to be heat-treated, said ware settings being shaped to closely conform to the substantially rectangular configuration of the kiln.
- 15 15. In a tunnel kiln, a wall structure including vertical side walls, vertical buckstays arranged exteriorly of said side walls, horizontally extending cross-members supported by the upper edges of the side walls and removably connected at their ends with said buckstays, a roof for said wall structure consisting of a plurality of refractory block units suspended from said cross-members, said units being removably bodily for cooperation with said side walls, said block units having their lower surfaces arranged in a substantially horizontal plane, and a ware carrier movable longitudinally through said kiln between said side walls and below said roof structure.
- 20 16. In a tunnel kiln, a wall structure including spaced vertical side walls, a substantially flat roof structure formed in units composed of a plurality of refractory blocks, cross-members arranged over said side walls, means for suspending said units from said cross-members, and a ware carrier movable longitudinally through said kiln between said side walls and below said roof units.
- 25 17. In a tunnel kiln, a wall structure comprising a pair of spaced vertical side walls, a roof for the kiln comprising a plurality of suspended refractory blocks arranged in a substantially horizontal plane, a conveyor movable longitudinally through the kiln and having ware placed thereon in substantially rectangular settings conforming to the cross-sectional configuration of the kiln, said ware settings being substantially uniformly spaced from the interior walls of the kiln to receive uniformly radiant heat energy released from the side and roof walls of the kiln, and means for introducing combustible gases into the spaces of the kiln formed between said ware settings and the internal kiln walls.
- 30 35 40 45 50 55 18. In a tunnel kiln, a wall structure comprising a pair of spaced vertical side walls, a plurality of horizontal cross-members carried by the upper portions of said side walls, refractory block units suspended from said cross-members and forming a horizontal roof for the kiln, said side walls and roof serving to define conjointly a tunnel extending longitudinally through the kiln, said tunnel being of substantially rectangular cross-sectional configuration, a ware carrier movable through the tunnel and having ware settings arranged thereon substantially uniformly spaced from the walls of said tunnel, and joints of compressible heat-insulated material provided between the adjoining portions of the block units of said roof and side walls of the tunnel.
- 60 65 70 75 19. In a tunnel kiln, spaced side walls and a roof structure forming a tunnel which extends longitudinally through the kiln from end to end thereof, a carrier movable longitudinally through the tunnel and upon which the ware to be heat-treated is positioned in a manner to form vertical longitudinally extending flue passages between said side walls and roof, burners mounted in connection with the roof structure for delivering combustible materials downwardly into said passages, burners provided in conjunction with the side walls of the kiln for delivering combustible gases into said spaces and passages, and means for controlling the operation of said burners to localize the high-temperatures produced thereby in any desired region throughout the height of the setting.
20. In a tunnel kiln, spaced side walls and a roof structure forming a tunnel which extends longitudinally through the kiln from end to end thereof, carriers movable longitudinally through the tunnel and upon which the ware to be heat-treated is positioned to form vertical longitudinally extending flue-passages, burners mounted in connection with the roof of the setting for delivering combustible materials to said passages, means for controlling the operation of said burners to regulate the zones of combustion of said materials in said passages, whereby to localize the high temperatures produced by the combustion of said materials at any desired region throughout the height of the setting, and means for regulating the longitudinal travel of the high temperature gases in said flue passages.
- 80 85 90 95 100 21. In a tunnel kiln, the combination with side walls and a movable ware supporting platform therebetween, cross-members extending transversely of the upper portions of said side walls, of a flat refractory roof disposed between the walls, and suspension means uniting said cross-members and roof with the lower surface of the latter parallel to that of the ware supporting platform.
- 105 22. A tunnel kiln comprising: the combination with side walls, of a refractory roof extending between the side walls, a top closure spaced above the refractory roof to form an intervening air duct, fuel feeding devices extending through the duct and discharging combustion gases downwardly through the refractory roof, and complementary combustion devices extending through said side walls.
- 110 115 120 125 23. In a tunnel kiln, the combination of an elongated heat confining structure having side walls and a roof arranged to form a tunnel, means for moving ware progressively through the tunnel, combustion devices projecting through said side walls and arranged to discharge combustible materials into the tunnel in direct contact with the ware, complementary combustion devices arranged to discharge combustible materials into the tunnel and in direct contact with the ware and extending through the roof of the tunnel, and means for regulating the last-mentioned combustion device to govern vertically the zones of combustion.
- 130 135 140 145 24. In a tunnel kiln, the combination with side and cooperatively spaced tracks disposed between said walls, of supporting members spanning the space between the walls, refractory roof sections suspended from said supporting members with their lower surfaces in a common plane to form a roof extending continuously across the tracks and parallel thereto, ware supporting platforms movable progressively in parallel relationship with the roof, burner devices arranged to discharge combustible materials into the tunnel formed by said walls and roof sections.
- 150 25. In a tunnel kiln, the combination with side and cooperatively spaced tracks disposed between said walls, of supporting members spanning the space between the walls, refractory roof sections suspended from said supporting members with their lower surfaces in a common plane to form a roof extending continuously across the tracks and parallel thereto, ware supporting platforms movable progressively in parallel relationship with the roof, burner devices arranged to discharge combustible materials into the tunnel formed by said walls and roof sections, and combustion devices arranged to discharge downwardly through the roof sections combustible materials.

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