

May 21, 1929.

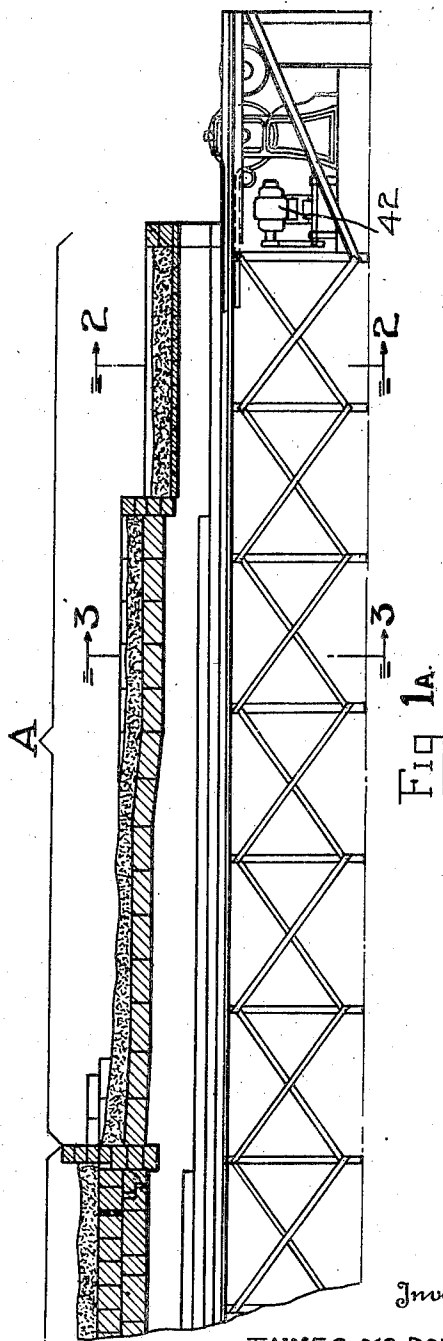
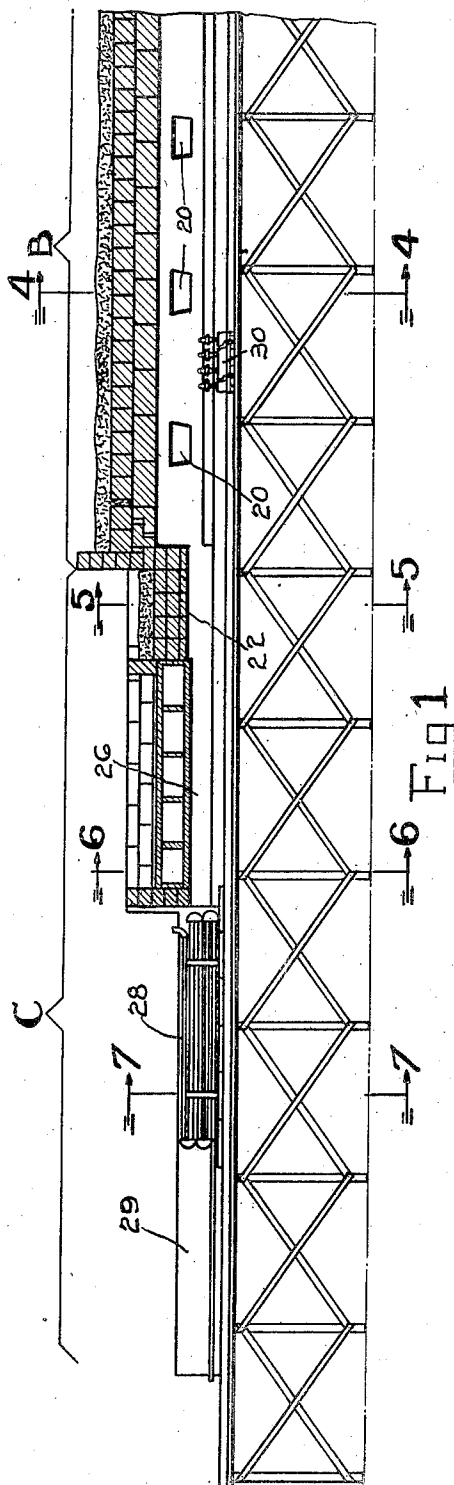
T. G. McDOUGAL

1,713,851

METHOD OF HEAT TREATMENT AND APPARATUS THEREFOR

Filed Dec. 12, 1925

3 Sheets-Sheet 1



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May 21, 1929.

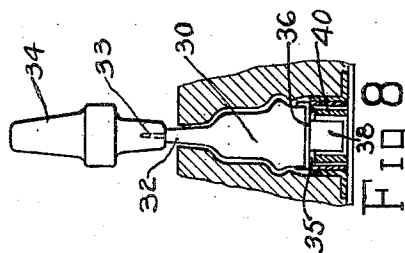
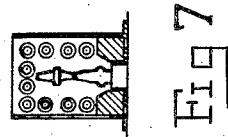
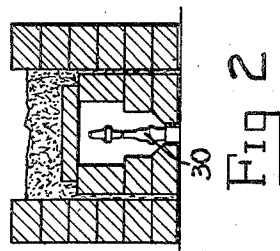
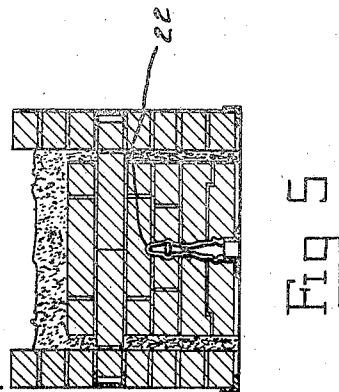
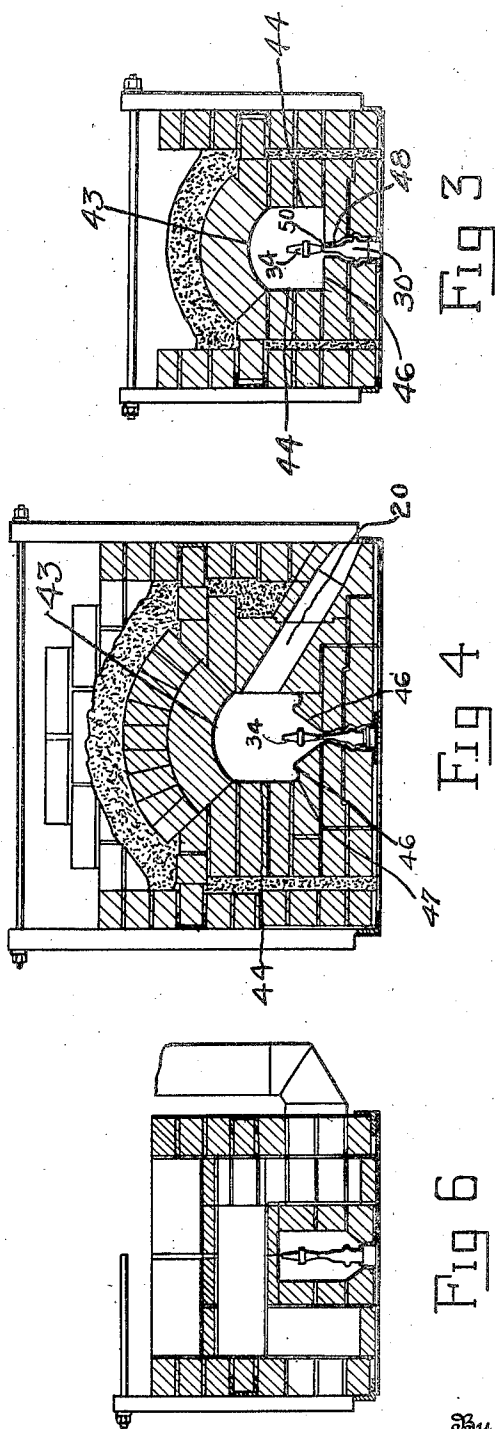
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METHOD OF HEAT TREATMENT AND APPARATUS THEREFOR

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3 Sheets-Sheet 2



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METHOD OF HEAT TREATMENT AND APPARATUS THEREFOR

Filed Dec. 12, 1925

3 Sheets-Sheet 3

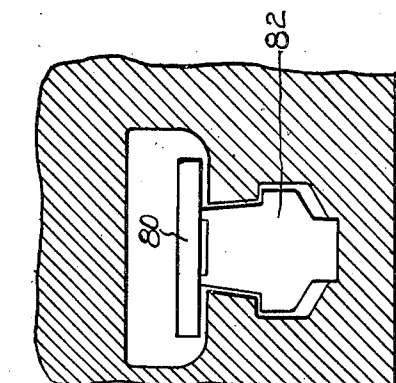


Fig 12

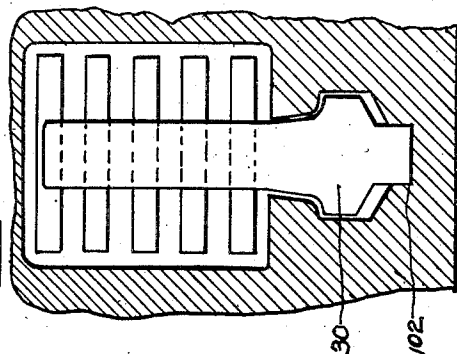


Fig 14

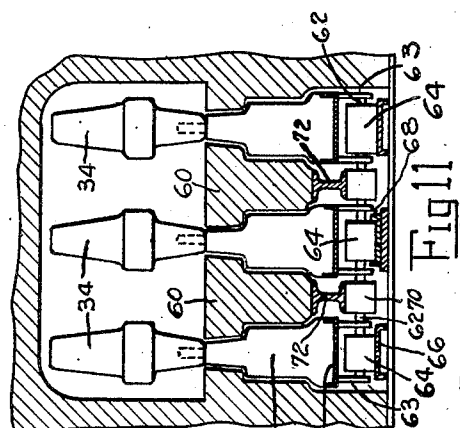


Fig 11

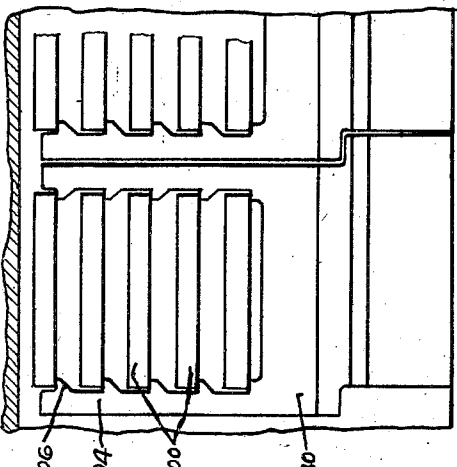


Fig 15

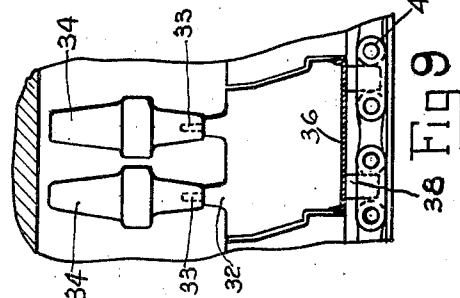


Fig 9

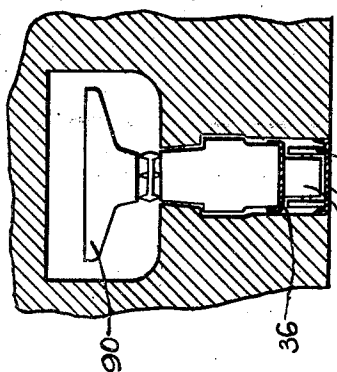


Fig 13

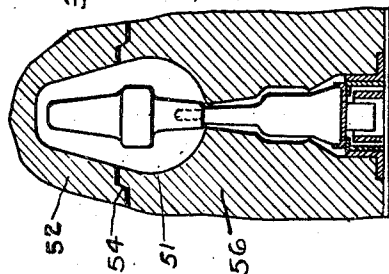


Fig 10

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1,713,851

UNITED STATES PATENT OFFICE.

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METHOD OF HEAT TREATMENT AND APPARATUS THEREFOR.

Application filed December 12, 1925. Serial No. 75,046.

The method of heat treatment disclosed in this application may be used wherever it is desired to subject an article to relatively high temperatures in any of the various industrial processes as in the baking of enameled articles, heat-treating of metals, and the like. However, the invention has been developed in connection with the treatment of ceramic articles and in order that the scope of the invention may be best understood a brief résumé is given of prior processes employed in the burning of ceramic wares. It is to be understood that these processes are fairly typical of the processes employed in heat-treating generally.

According to the oldest of the methods employed in the firing of ceramic articles, the wares are placed in saggars or fire clay boxes that are stacked in the kiln, the charging entrance to which is then bricked up and the kiln fired. This process is necessarily slow in order to insure proper distribution of heat throughout the large mass of wares and saggars. Twenty four to one hundred forty four hours are required to complete a firing cycle. The process is also subject to loss of wares from over-firing and under-firing because of lack of uniformity in heat distribution throughout the large refractory mass; is expensive because of the necessity for maintaining a supply of saggars, these being subject to rapid deterioration in use; and is inefficient because of the amount of labor involved in handling the ware and also, from the standpoint of heat, because of the large amount of heat absorbed by the saggars and kiln and lost upon their subsequent cooling in the intervals between the periodical firing of units.

In an effort to overcome the deficiencies in the above process, a continuous process has been developed in which the ware is placed in fire clay saggars, piled high upon cars having refractory tops to protect the metallic running gear of the cars from the heat of the firing chamber. The cars thus loaded are passed through a long tunnel (from 220 to 400 feet in length) in which they are gradually heated to the required temperature followed by a gradual cooling. This method facilitates handling of the wares and reduces the time of firing somewhat, but even with this improvement the cycle requires not less than 24 hours for its completion. With this process there is also considerable loss

from over-firing and under-firing resulting from uneven heat distribution throughout the mass of wares and refractories,—and, while the kiln is continuously heated and consequently the heat loss in the kiln itself is much reduced as compared with the periodic type kiln, the saggars and the refractory car tops are subject to alternate heating and cooling and the heat lost through absorption by these large masses is very great.

In my prior Patent 1,416,726 granted May 23, 1922, I have disclosed an improvement in the continuous kiln process outlined in the preceding paragraph which consists, from one point of view, in exposing the wares to the intense heat of the top and sides of the kiln while arranged in a single tier only, upon the decks of cars, these decks being constituted, as usual, by a thick mass of refractory material in order to protect the running gear. By this improvement the time necessary for firing in the case of spark plugs is reduced to as low as 6 hours, or even less, and a more uniform product is secured. When this arrangement of articles is used the inner rows of wares, especially the lower portions farthest from the source of heat, are nevertheless partially shielded from direct radiation of heat from the top and vertical walls of the kiln and, when the shapes treated are spark plug porcelains, suspension type insulators, or the like, having portions intermediate between the source of heat and those other portions of the individual wares of greater width than the lower end portions, or are flat pieces such as tile or plates, the lower portions or undersides of the wares are more or less effectively shielded from direct radiation from the kiln walls by the upper portions. The arrangement of articles is also such as to interfere with the free circulation of hot gases about them. Consequently that portion of an article of such shape shielded from direct radiation and subject only to an impaired flow of hot gases must receive a large proportion of its heat by conduction from the hotter portions of the same article and by reradiation from adjoining articles. But not only is the flow of heat into the wares thus obstructed but the large supporting mass of refractories which enters the kiln cold and on which the wares rest affords an excellent path for the conduction of heat away from the wares. The heat thus absorbed by the refractory car deck is lost upon its subsequent cooling.

Heat is thus applied to each individual article alike, but with a lack of uniformity as between different parts of the same article, and where conduction of heat from the bottom portions of the wares is so great, considerable time is required for the passing of the wares through the kiln so that each part of each article may be brought up to the required temperature. At the same time the unequal heating of different portions of the same article sets up strains which may lead to fractures known to the art as "pre-burn cracks." The large quantity of heat lost by absorption by the car deck also results in a serious lowering in efficiency of the operation. Thus while the process of my prior patent constitutes a substantial improvement on previous practices in that variation in heat distribution between the individual articles is substantially eliminated, my present process constitutes a further improvement in that temperature variations between portions of the same article are minimized.

In carrying out my improved process heat is directly and effectively applied to the ware on substantially all sides including top and bottom causing a practically uniform rise in temperature throughout the article and reducing the firing time to a minimum, this latter effect permitting the thickness and consequently amount of refractory material or "kiln furniture" used in supporting the wares in their travel through the kiln to be greatly reduced so that the amount of heat lost by absorption by the wares-supporting refractories becomes a minimum.

According to my improved process the wares are passed, preferably in single file, through a tunnel of special formation, this tunnel having top, bottom, and side walls which may, if desired, be blended into each other according to any preferred configuration. A slot is provided in one of the walls of the tunnel, preferably the bottom wall, the slot being substantially filled by the refractories upon which the wares are supported during their passage through the tunnel. The width of the tops of the refractory supports should be less than the greatest width of the wares so that portions of the wares overhang the bottom of the tunnel and are subject to radiation therefrom as well as from the lower portions of the sides of the tunnel. However, this last condition is not absolutely essential, although it is essential that stationary heat reflecting surfaces be provided closely adjacent the lower portions of the articles so as to effectively direct radiant heat upon the portions of the articles which, according to prior practices, were effectively shielded from direct radiation. In the embodiments of the invention herein disclosed these stationary heat reflecting surfaces are preferably constituted by portions of the bottom wall of the kiln.

With this arrangement each article is openly exposed on substantially all sides to direct radiation from the walls of the tunnel as well as bathed in the hot gases circulating freely about it. At the same time the heat lost by conduction from the article to the refractory support is small owing to the fact that because of the small area of the upper portion of the support which contacts with the wares and which is exposed to the heat of the kiln, as well as the small mass of the support, this small portion of the carrying refractory soon attains about the same temperature as the wares and the heat exchange between wares and support is very slight.

When wares are passed through a kiln constructed as above outlined all parts of the articles are quickly brought up to the required temperature. Only about two hours is required to complete a firing cycle in comparison with the six hours or more required according to the process disclosed in my prior patent, the twenty four hours or more required by previous tunnel kiln practices, and the twenty four to one hundred and forty four hours required by the periodic process. In this relatively short time (2 hours or slightly more) heat can penetrate but a small distance down through the thickness of refractory material of the character composing the travelling wares-supports so that the thickness of refractory required for the protection of the metallic running gear is greatly reduced. Thus whereas 18 inches of refractory protection, and in most cases more, was previously necessary to insulate and protect the metal running gear, I have found that about four and one-half inches is sufficient in carrying out my improved process. Reduction in the amount of heat absorbed by the travelling refractories, means increase in efficiency, for the heat thus absorbed is lost upon their subsequent cooling without having accomplished any productive result.

I have also found that firing by this process results in a very even application of heat by radiation and convection as distributed from top to bottom of the ceramic piece as it is disposed on the carrying means and as it advances toward the maximum temperature of the hot zone. The even heating of the piece eliminates strains which would otherwise be set up, and reduces liability of fractures. At the same time a more uniform glaze is obtained.

It is obvious that my process and the apparatus used for carrying it out may be variously modified. Thus the process is as applicable to muffle type kilns or electrically heated kilns as it is to those in which combustion takes place in the same chamber with the wares. It should also be noted that the process is not limited to cases in which but a single column or file of articles is advanced through the kiln, although this is to be pre-

ferred, but a plurality of columns spaced across the width of the tunnel and preferably separated by stationary heat reflecting portions of the bottom of the kiln may be passed through a single tunnel provided the condition is fulfilled that the individual rows of articles are subject to direct radiation and are thoroughly bathed in the hot gases during their passage through the kiln. It is also possible to arrange the articles in tiers provided they are so spaced as to permit direct application of heat by radiation and convection as before. In such event, however, for greatest efficiency the condition should be observed that the width of the supporting bodies should be considerably less than the greatest width of the pieces to be fired.

Reference is now made to the drawings in which several embodiments of my invention are disclosed.

In the drawings:

Figures 1 and 1^a are complementary longitudinal views of one form of my improved tunnel kiln, portions of the tunnel being shown in section. The figures show complementary halves of a complete kiln.

Figure 2 is a section on line 2—2 of Figure 1^a.

Figure 3 is a section on line 3—3 of Figure 1^a.

Figures 4, 5, 6, and 7 are views taken respectively on lines 4—4, 5—5, 6—6, and 7—7 of Figure 1.

Figures 8 and 9 are detail views showing the conveying means with articles mounted thereon.

Figure 10 is a cross section through the firing chamber of a kiln of slightly modified form.

Figure 11 is a cross section through a kiln which is constructed to treat a number of columns of wares.

Figure 12 shows a typical cross section of the preheating zone of a kiln used in firing flat pieces of ware, such as tile.

Figure 13 is a cross section of the preheating zone of a kiln designed for the treatment of suspension insulators or other similarly shaped pieces of ware.

Figures 14 and 15 are respectively cross sections and longitudinal sections of portions of a kiln designed for the treatment of flat ceramic wares arranged for the glost burn.

I shall first describe the form of kiln illustrated in Figures 1 to 9. This kiln is of the type disclosed in my prior Patent 1,416,726, previously referred to, in that it consists of a preheating zone A, a high temperature zone B, and a cooling zone C. The kiln illustrated is of the direct fired type, although as previously stated an electrically heated kiln or a muffle type kiln might be employed if desired. In a direct-fired kiln properly mixed gaseous or liquid fuel and air enters the high temperature zone B through openings 20,

best shown in Figure 4, where it is burned in the same chamber with the wares, the gases then passing outwardly through the preheating zone A and serving to pre-heat the coming articles. Upon leaving the high temperature zone B, the wares pass through and under a baffle arch 22 into the cooling zone C where they are first subject to indirect air cooling in the portion 26 of the kiln followed by indirect water cooling in the portion 28 and finally, if desired, by direct air cooling in the portion 29. The details of the stages of heat treatment are set out more fully in my prior patent above referred to.

My present invention is characterized by the construction of the tunnel, particularly in the heating zones, and the cooperating conveying means.

In Figures 8 and 9 I have shown in detail the construction of the conveying means with the wares mounted thereon. Referring to these figures, 30 indicates a refractory mass for supporting the wares and corresponding to the car deck used in present practices. The support 30 is provided with integral upwardly extending projections 32 carrying pins 33 upon which are mounted the wares to be treated. While I have chosen to show the spark plug porcelains 34 undergoing heat treatment or "burning" it is obvious that my process is equally applicable in the heat treatment of various kinds of articles whether of ceramic character or not. It will be noted that the ends of adjacent supports 30 are of irregular interfitting configuration to prevent the direct passage of radiant heat outwardly to the metallic supporting structure. While it is quite feasible to merely slide the supports 30 directly along track 35, I have preferred to provide them with metallic shoes 36 to take the wear and pushing compression and to reduce friction. I have provided the shoes 36 with lugs 38 which are engaged by lugs or "dogs" on the chain 40 which is actuated by motor 42 through any suitable connections. If preferred, shoes 36 may be furnished with rollers or may travel over stationary rollers to reduce friction; and the tunnel may be inclined so that gravity alone will effect movement of the articles through the tunnel. The feature of gravity feed of wares through a tunnel kiln is described and claimed in my copending application, Serial No. 283,836, filed June 8, 1928. Sand seals may also be provided between the conveying means and the tunnel if desired. However, it is to be emphasized that no particular form of conveying means is essential to my invention.

The conveying devices with the wares mounted thereon travel through the tunnel from right to left as viewed in Figures 1 and 1^a.

In Figure 2 I have shown a section through a portion of the preheating zone near the

tunnel entrance. In this portion of the tunnel the ware is given a preliminary heating by the gases passing outwardly from the combustion chamber or high temperature zone B.

Figure 3 is a section through a hotter portion of the preheating zone and it will be noted that here the tunnel comprises a top portion 43, side portions 44, and a bottom portion 46 provided with a slot 48 which is substantially filled by the deck or support 30, the deck or support and the slot being of similar irregular configuration to prevent direct passage of radiant heat to the metallic conveying structure or to the bottom portion of the kiln walls. It will here be noted that the portion 50 of the support 30 which projects into the tunnel is of less width than the greatest width of the article, in this case the spark plug insulator 34, so that portions of the insulator project over the bottom 46 of the tunnel thereby subjecting the underside thereof to radiation from the bottom of the tunnel and the lower portions of the side walls. It will also be noted that the insulator is supported in the tunnel so as to be freely and openly exposed on practically all sides to the hot gases travelling through the tunnel. At the junction of the side portions 44 and the bottom 46 troughs 47 are provided. These troughs serve to intercept unburned particles of fuel and the like, preventing them from reaching the wares.

Figure 4 is a section through a portion of the high temperature zone. As before stated pre-mixed fuel and air is projected into the tunnel through passages 20 raising the walls of the tunnel to a high temperature and bathing the insulator 34 in hot gases. This portion of the tunnel is also provided with a top wall 43, side walls 44, and bottom wall 46. As in Figure 3 portions of the insulator 34 overhang portions of the bottom, and I have preferably formed these portions 46' of the bottom of upwardly diverging configuration so as to more effectively subject the lower portions of the insulator to heat radiated therefrom. As before, the insulator is freely exposed to contact with the hot gases in the tunnel. It will be noted that the tunnel has an enlarged cross section at this point, this being required for combustion purposes with such fuel as oil.

Figure 5 is a section through the baffle which separates the high temperature zone from the cooling zone. As shown in this figure the tunnel opening is designed to rather closely conform to the shape of the article treated so as to prevent the passage of hot gases from the high temperature zone into the cooling zone.

Figure 6 is a sectional view through the indirect air cooling zone, both the insulator and a portion of the support being freely exposed to the cooling action.

Figure 7 is a similar view through the indirect water-cooled zone.

It will now be apparent that I have provided in the principal heating portions of the tunnel, means for heating the under portions of the treated articles which in prior constructions have been shielded by the upper or middle portions of the article and inefficiently heated by conduction through the upper portions of the wares and to some extent by convection and by reradiation from surrounding articles. This means consists, first, in the provision of radiating surfaces forming part of the walls of the tunnel so situated as to directly project heat upon the under portions of the wares. Specifically, I have so formed the support for the wares that the portions of the wares which are of greater diameter overhang portions of the bottom wall of the tunnel.

In the second place by supporting the individual insulators in an exposed position in the tunnel they are effectively bathed in the hot gases which impart to them a portion of their heat.

It is apparent that this heating means would be equally effective if the tunnel were of the muffler type. The rays of heat would be projected in the same manner from the heated walls of the tunnel and the articles would be subjected to the convection currents characteristic of this type of furnace.

While I have restricted the special configuration of kiln to the high temperature zone and a portion only of the preheating zone it is apparent that if desired it may be applied throughout the length of the latter zone. Also, if desired, the same idea may be made use of in any or all of the cooling zones to effect such variation in the rate of cooling of the different portions of the articles and support as may seem desirable.

In Figure 10 I have shown a section through the high temperature zone of a modified form of kiln. This differs from preceding forms in that the firing chamber conforms more closely in cross section to the shape of the article treated so that the heat radiated from the walls has but a short distance to travel to strike the article. A chamber of this size is permissible where the character of fuel is such that the volume of combustion products is small as in the case of oxy-acetylene fuel, or where an electrical source of heat is used.

It is well known that the high temperatures prevailing in the kiln have a tendency to form a melted glassy surface on the refractory forming the tunnel walls. This is especially so when glazed articles are fired because the glaze materials partially volatilize from the ware and are deposited on the said walls. With the walls thus provided with a smooth unbroken heat reflecting surface it is possible to direct the rays of heat where

desired by giving the walls of the tunnel the proper contour. Thus the lower portion of the walls of the firing chamber may be made of parabolic shape as shown at 51 in Figure 10 to focus the rays of heat upon the object.

The refractory block 52, constituting the top of the firing chamber is also shown offset as at 54 to cooperate with the correspondingly shaped block 56 forming the lower portion of the firing chamber so as to prevent shifting of the position of the blocks.

Figure 11 shows a further modification which may be employed where it is desired to run several lines of ware through a single tunnel. In this form plates 36 carry supports 30 upon which the ware 34 is mounted as before. Partitions 60, of refractory material, separate the lines of supports 30 and while these partitions may be fixed to the base of the kiln and the separate lines of ware driven from a common propelling means located at one end or the other of the kiln and operating upon chains or cams or the like having driving connection with the supports, I have preferred to illustrate in this figure a construction in which a transverse shaft 62 is journaled in arms 63 projecting downwardly from the plates 36, the shaft having rollers 64 thereon beneath the respective shoes and running upon tracks 66. I have shown the central track provided with flanges 68 to hold the parts in alignment. The shaft 62 also bears rollers 70 located beneath the partitions 60 and serving as a movable support for these partitions, an I-beam 72 preferably being interposed between the rollers and the partitions to take the bending strains. With this construction it will of course be necessary to provide means at the ends of the kiln for preventing endwise movement of the partitions 60 so that the upper surfaces of these partitions may serve as stationary heat reflecting surfaces to assist in directing radiant heat upon the lower portions of the wares. It will also probably be found to be desirable to provide sand seals at the ends of the plates 36 to further protect the moving parts from the heat of the furnace. This construction may be regarded as merely an amplification of the single file or line method of handling the wares shown in the preceding views, for each of the files or lines of wares is freely and openly exposed on all sides to the hot gases of the kiln and also, although to a slightly less degree, to direct radiation from the kiln walls.

Figure 12 shows a typical cross section in a preheating zone such as would be used in firing flat pieces of ware, such as tile, a piece of which is indicated at 80. The width of the top of the travelling conveyor 82 will depend upon the strength of the individual pieces of ware in resisting the cantilever forces arising from the over-hanging parts

of the piece. Flat pieces of ware may be burned in this way either for bisque or glost firing. The carrying means or conveyor 82 is shown as merely sliding through on the more or less refractory bottom of the kiln. The refractory carrying device or "car" introduced at the charging end of the kiln may be propelled by some suitable means and in turn force the line or train of cars ahead of it through the kiln.

Figure 13 is a cross section through the preheating zone of a kiln designed for the treatment of suspension type insulators, or the like, one of which is shown at 90. The shoe 36 in this case carries a steel block or member 92 provided with wheels 94 which run upon a track 96.

The construction shown in Figure 13 may also be used as an enamelling oven, articles, such as kitchen-ware, taking the place of the insulator shown at 90.

Figures 14 and 15 are fragmentary views showing the arrangement of flat ceramic wares which may be resorted to for the glost burn. In this case the supports 30' slide in guideways 102 and are provided at their upper portions with standards 104 having a plurality of vertically spaced supporting lugs 106 arranged to support a plurality of wares 100 in superposed relation. This manner of supporting the wares is permissible for the glost burn as the wares have already been subjected in the bisque firing process to a higher temperature and the lower glost temperature is not high enough to cause re-softening and thus permit deformation of the unsupported portions.

Where I have used the term "air" in the specification and claims I have used it in a general sense as a supporter of combustion and it is to be understood that the phrase "pre-mixed fuel and air" should be construed to cover such combustible mixtures as oxy-acetylene or the like, wherein the chief active ingredient of air is used for supporting combustion.

I claim:

1. The method of burning ceramic wares which consists in mounting the article to be treated in a kiln in position to be exposed on substantially all sides to direct radiation from the walls of the kiln and applying heat to the said walls.

2. The method of burning ceramic wares which consists in mounting the article to be treated in a kiln in position to be freely exposed on substantially all sides to the direct action of hot gases as well as to direct radiation from the walls of the kiln and applying heat to the kiln by burning premixed air and fuel in said kiln in direct contact with said article.

3. The method of burning ceramic wares which consists in applying heat to a tunnel kiln by burning pre-mixed fuel and air there-

in, thus effectively heating the walls thereof and causing a circulation of hot gases therein, and passing wares in single file there-through while openly exposed on substantially all sides to direct radiation from the said walls as well as to the action of the hot gases.

4. That improvement in the art of burning ceramic wares which consists in passing the wares in single file through a tunnel in the course of which the wares are subjected to graduated heat treatment, the walls of said tunnel substantially completely enveloping the wares so as to cause heat to be reflected directly from said walls to substantially all portions of the surface of the wares.

5. A tunnel kiln having a heating zone constructed with top, bottom, and side walls, one of the walls of said kiln being provided with a slot therein, conveying means for transporting wares through said tunnel, said conveying means including refractory portions extending into said slot and substantially closing the latter, and wares carried by said conveying means and having portions projecting over the said slotted wall.

6. A tunnel kiln, the heating zone of which is in the form of a substantially closed tube, said tube being provided with a narrow longitudinal slot, and a refractory support for wares substantially closing said slot and arranged to travel through said tunnel, the mass of said support being small compared with the mass of the walls of said tunnel so as to reduce the amount of heat absorbed by said travelling support.

7. The combination of a tunnel kiln, means for heating the kiln, supporting devices upon which the wares are mounted, said supporting devices being adapted to move through the kiln and including refractory portions exposed to the heat of the kiln and metallic supporting parts remote therefrom, the width of the tops of said supporting devices which are directly exposed to the heat of the kiln being considerably less than the width of the largest horizontal cross section of the respective pieces which they support.

8. In the combination as defined by claim 7, said tunnel being provided with radiating surfaces closely flanking the said wares.

9. The combination of a tunnel kiln, means for heating the kiln, supporting devices upon which the wares are mounted, said supporting devices being adapted to be moved through the kiln, and including metallic bottom portions remote from the combustion chamber and top portions directly exposed to the heat of the kiln of reduced dimensions compared with the dimensions of the wares to effect a reduction in the amount of heat passing from the wares to the said supporting devices.

10. In combination, a tunnel kiln, a refractory wares carrying means, said kiln being provided with a slot through which the

wares carrying means is adapted to travel, wares mounted upon said carrying means and openly exposed in the tunnel, portions of the walls of the tunnel adjacent the said slot being shaped to roughly conform in contour to the exposed surfaces of the wares to effectively heat the latter.

11. A tunnel kiln having the firing zone thereof formed with top wall, bottom wall, and side walls, the bottom wall being provided with a slot for receiving the travelling supports for the wares to be treated, the portions of the bottom wall adjacent the slot diverging upwardly.

12. In the combination as defined in claim 11, longitudinally extending troughs being provided at the junction of the side walls and the bottom wall.

13. A travelling support for ceramic wares during their passage through a tunnel kiln, comprising metallic supporting members, a refractory body portion supported on said members, reduced portions extending upwardly from the body portion and adapted for exposure to the heat of the furnace, and means for supporting the ware upon said projecting portions.

14. In the structure as defined by claim 13, said reduced portions being provided with pins of refractory material for entering sockets in the ware.

15. A support of refractory material upon which ceramic wares are mounted during their passage through a tunnel kiln having the upper portion thereof which is directly exposed to the heat of the kiln of reduced width, the lower portions of the support serving to diffuse the heat.

16. A tunnel kiln having a heating zone comprising top, bottom and side walls, said bottom wall being provided with a slot therein, conveying means for transporting wares through said tunnel, said conveying means including refractory portions extending into said slot and adapted to support wares within said tunnel so that the wares are exposed to direct radiation from all of the walls of said tunnel facilitating rapid and uniform heating, the said refractory portions being of substantially less width than the greatest width of the wares carried thereby.

17. In the combination as defined in claim 16, said refractory portions and the walls of said slot co-operating to substantially seal said slot to prevent the escape of heat.

18. A tunnel kiln having a heating zone and a cooling zone, a baffle between said zones, a carrier for transporting wares through said kiln in single file, said baffle being provided with a passage therethrough conforming closely in shape to the shape of the wares and carrier in cross-section to prevent the escape of heat from the heating zone to the cooling zone.

19. The combination of a tunnel kiln pro-

vided with a longitudinal slot, a carrier for
wares formed of refractory material and oc-
cupying said slot and having reduced por-
tions exposed within said tunnel for sup-
5 porting wares therein.

20. In the combination as defined in claim
19, the walls of said slot and the correspond-
ing surfaces of the carrier interfitting to pre-
vent the projection of radiant heat out-
10 wardly of the tunnel.

21. The combination of a tunnel kiln pro-

vided with a longitudinal slot, a carrier for
wares including metallic running gear re-
mote from the interior of the tunnel and re-
fractory portions supported on said gear and 15
exposed within said tunnel, the walls of said
slot and the corresponding surfaces of the
carrier interfitting to prevent the projection
of radiant heat upon said running gear.

In testimony whereof I affix my signature.

TAINÉ G. McDOUGAL.