

July 27, 1937.

J. T. ROBSON ET AL

2,088,554

KILN

Filed June 30, 1936

8 Sheets-Sheet 1

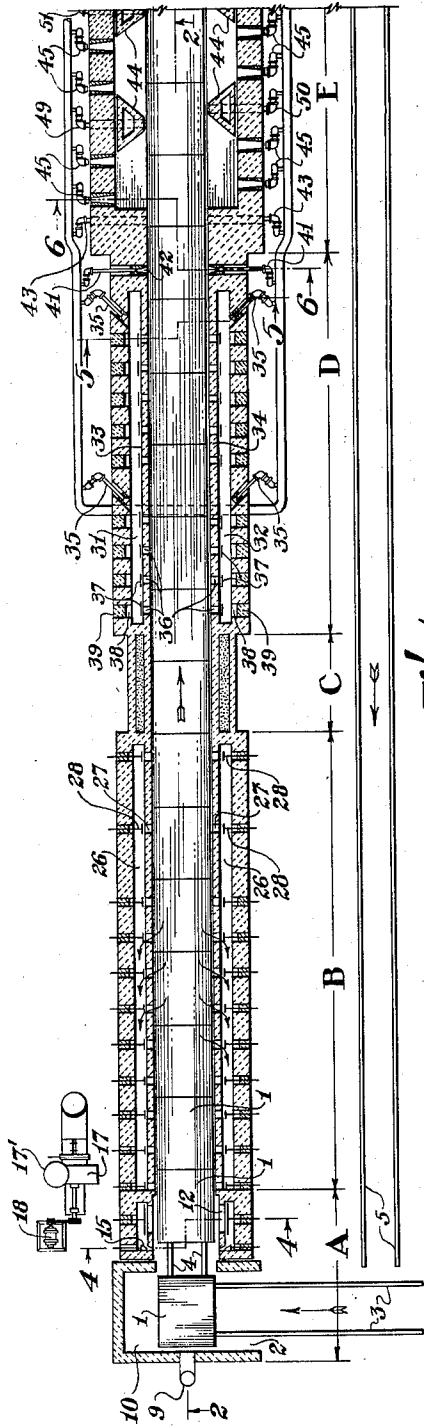


Fig. 1

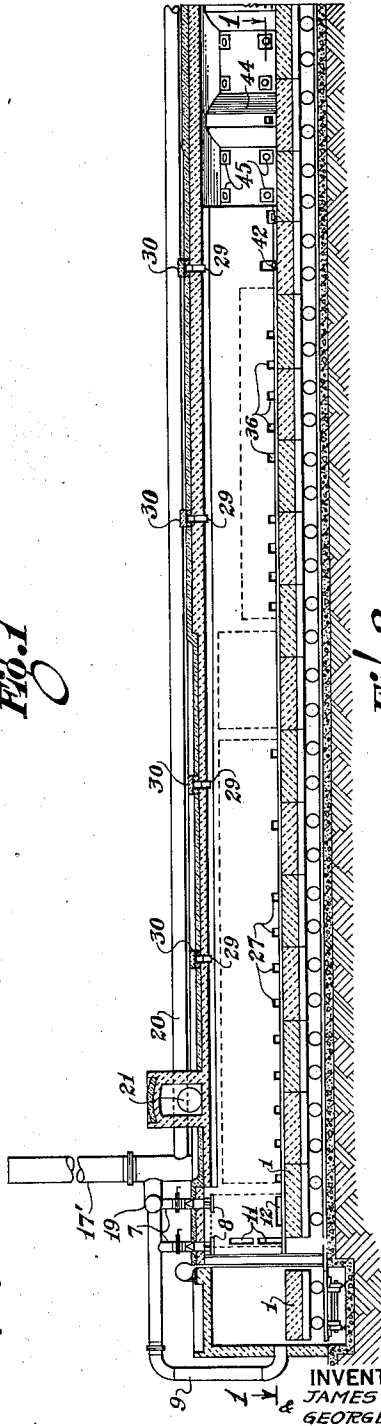


Fig. 2

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8 Sheets-Sheet 2

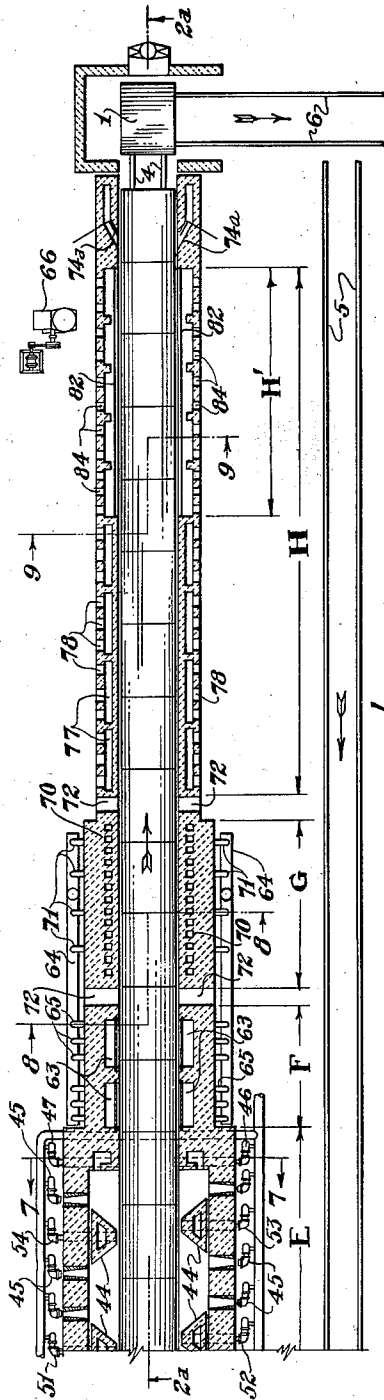


Fig. 1a

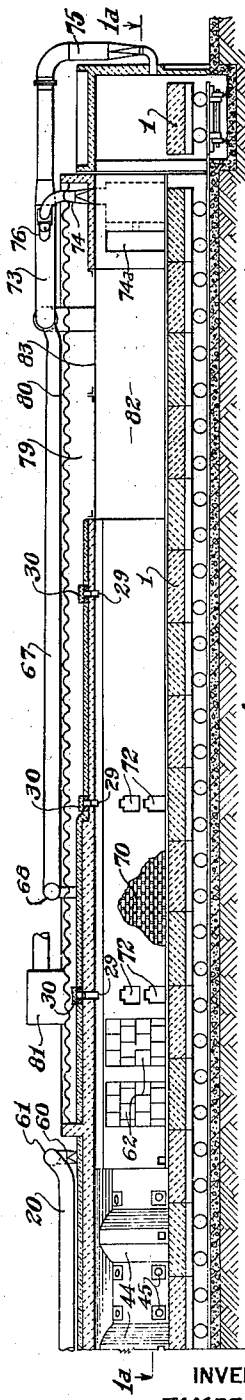


Fig. 2a

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8 Sheets-Sheet 3

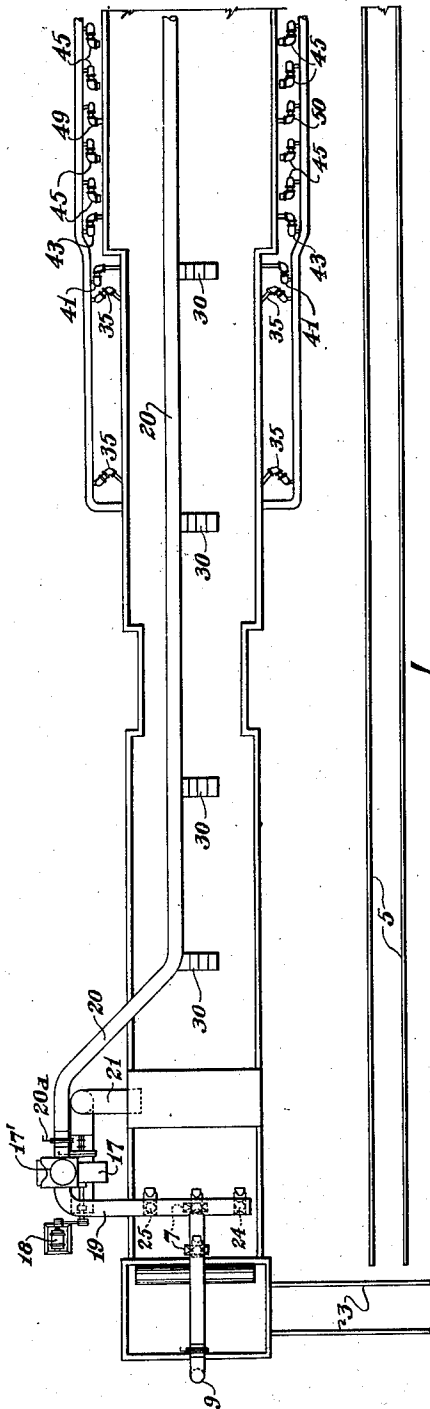


Fig. 3

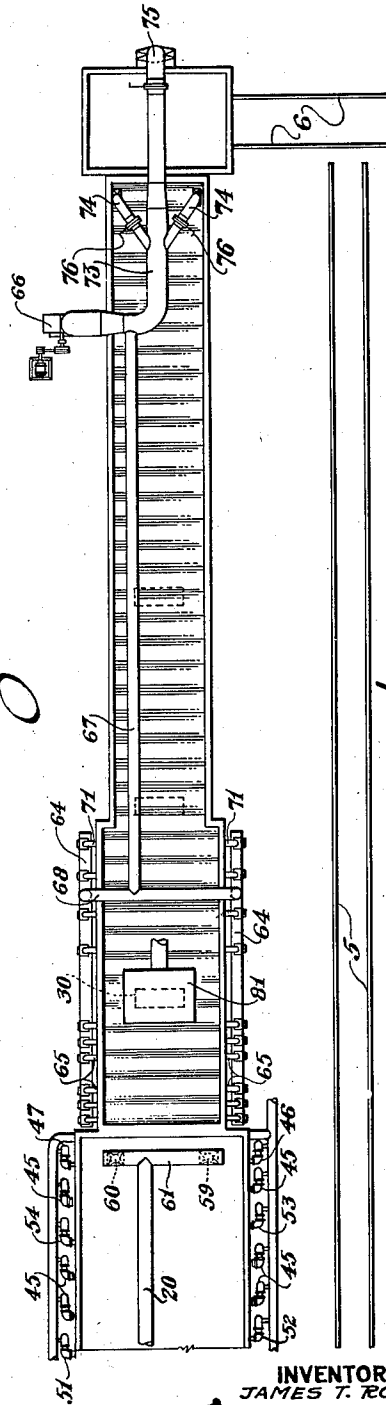


Fig. 3a

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8 Sheets-Sheet 4

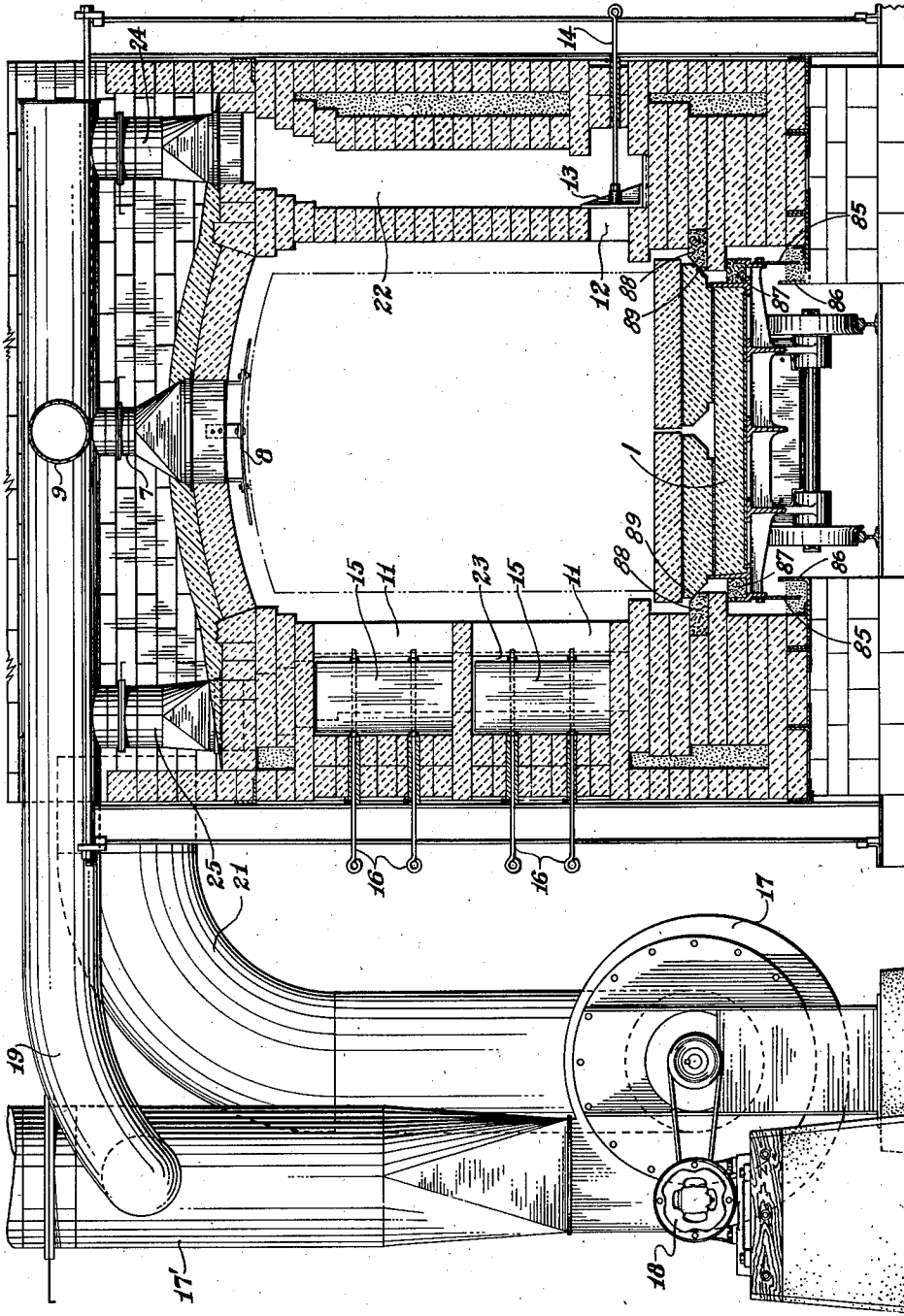


Fig. 4

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8 Sheets-Sheet 5

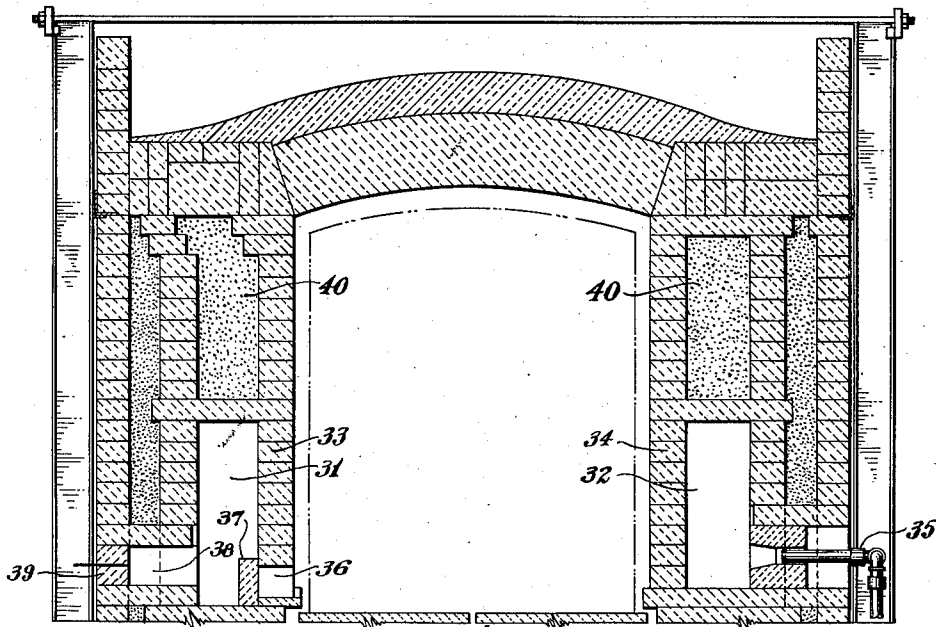


Fig. 5

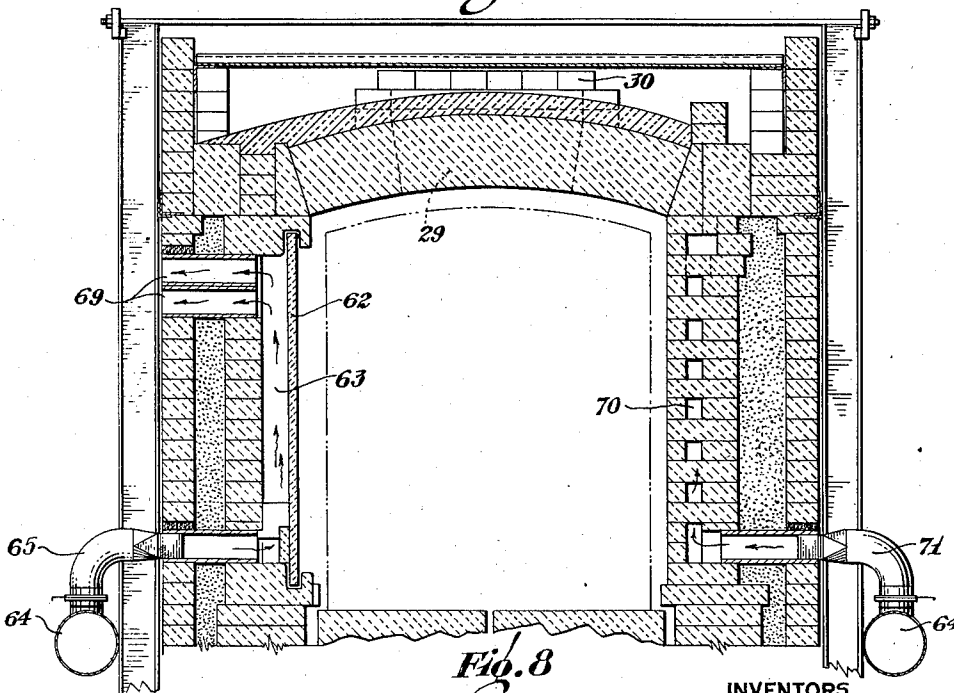


Fig. 8

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8 Sheets-Sheet 6

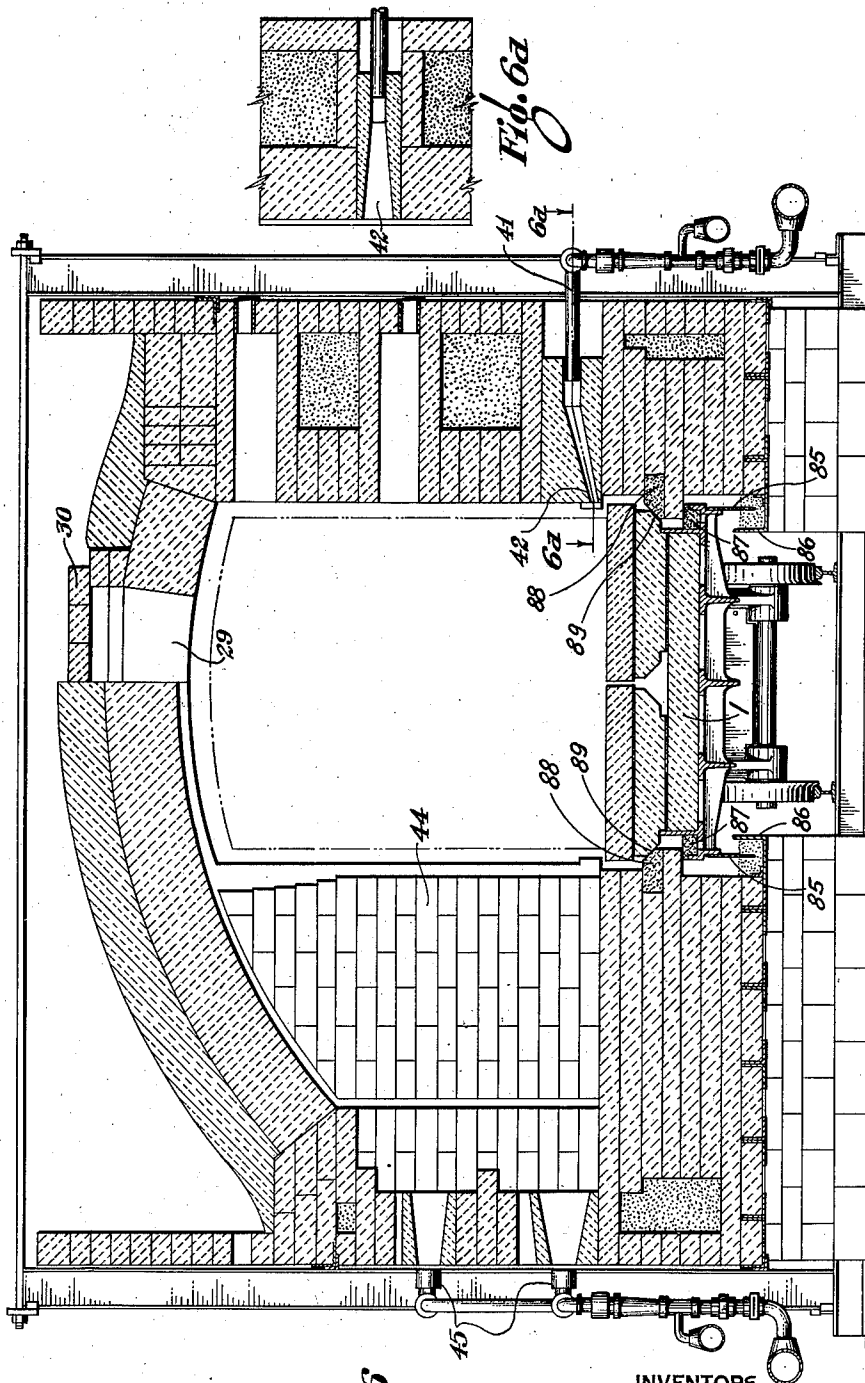


Fig. 6

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8 Sheets-Sheet 7

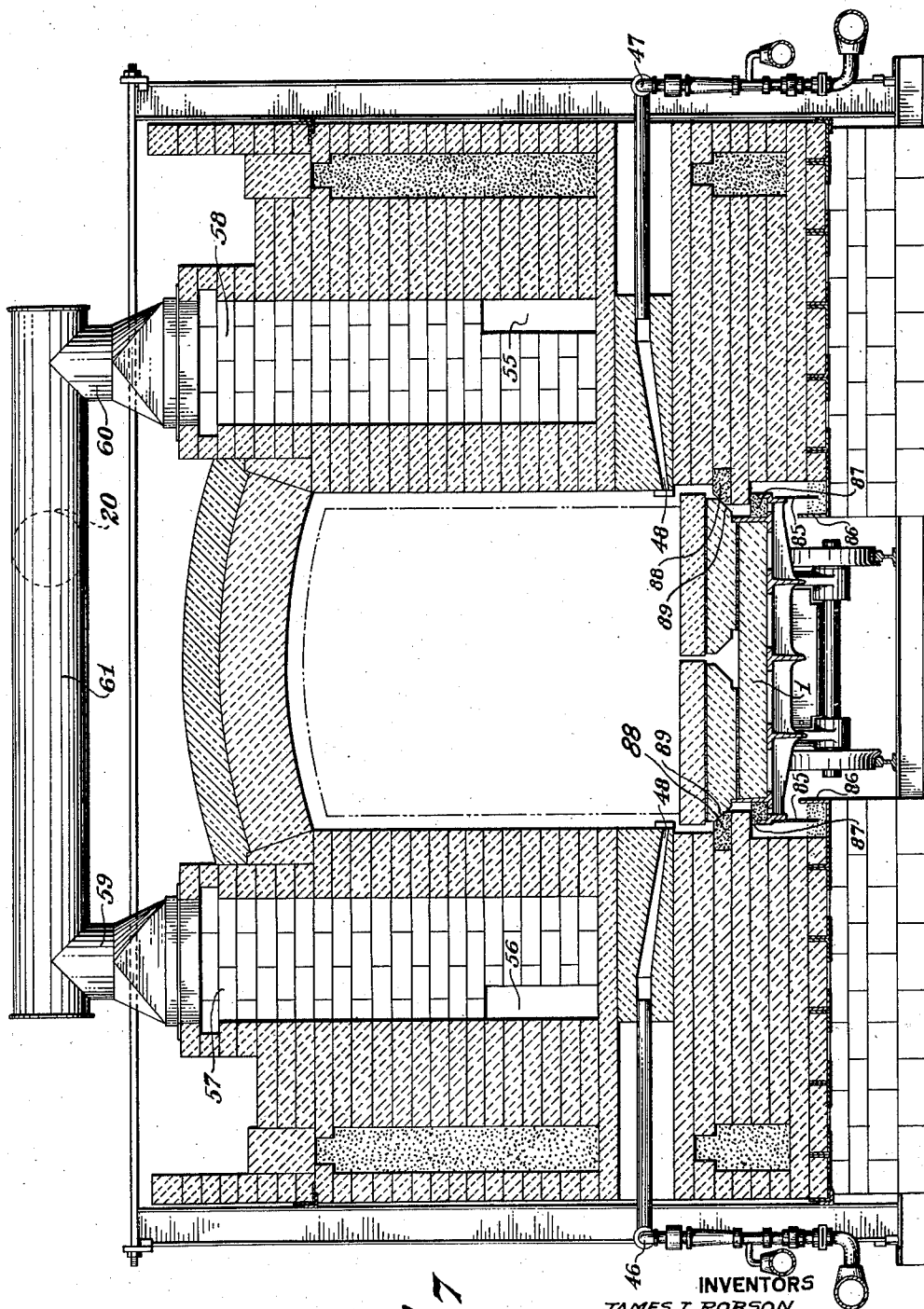


Fig. 7

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8 Sheets-Sheet 8

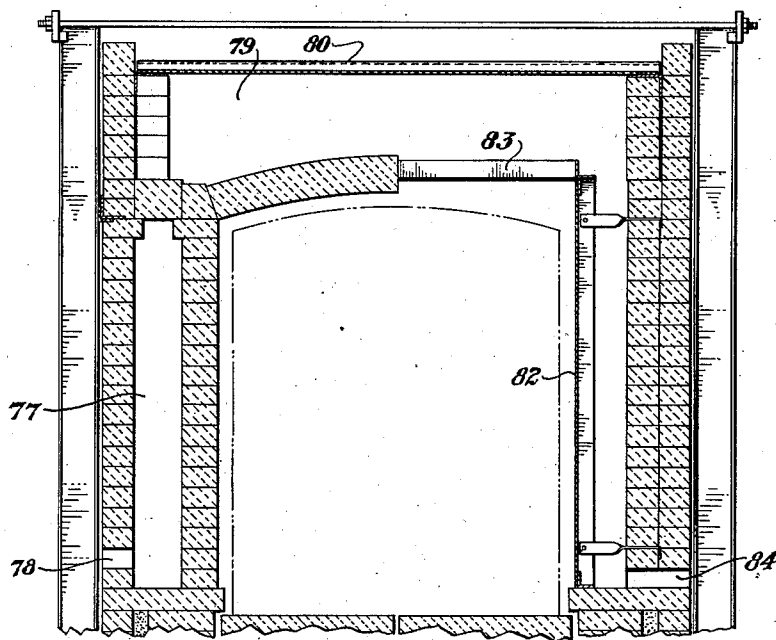


Fig. 9

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UNITED STATES PATENT OFFICE

2,088,554

KILN

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Ohio

Application June 30, 1936, Serial No. 88,180

24 Claims. (Cl. 25—142)

This invention relates to furnaces, kilns, or the like, and more particularly to improvements in tunnel kilns for continuously burning ceramic ware such as china, pottery, etc. A number of features of our kiln or furnace may also be advantageously employed in apparatus for porcelain enameling on metal or for metallurgical purposes, such as continuous annealing, etc.

It is customary in the manufacture of china and the like to employ a continuous or tunnel kiln for burning the ware. In such apparatus the articles to be heated are loaded on cars or other ware moving mechanism such as rotary hearth whereby the ware is moved through the kiln and given the desired heating therein. Our invention contemplates certain improvements in the application of heat to the ware in a tunnel kiln, control of the temperatures at different points in the kiln and the most effective and efficient application of heat to achieve uniform and successful burning with a minimum of defective articles. Although we have illustrated a kiln having a straight tunnel it will be understood that curved or otherwise shaped ware heating chambers or tunnels may be used.

In the operation of continuous furnaces or kilns of the type herein described it is very important to be able accurately to control the heat at different points in the furnace. It is also important to be able to control the circulation and composition of the atmosphere within the furnace. It is among the objects of our invention to provide a continuous type kiln in which the temperature and atmosphere in the pre-heating, furnace and cooling zones may be accurately and readily controlled to achieve the proper heating and burning regardless of the type of ware being handled.

The above stated general objects of our invention and others will appear from the following description of one embodiment thereof, reference being had to the accompanying drawings which illustrate our improvements applied to a direct fired tunnel kiln particularly designed for the handling of ceramic articles.

Figure 1 is a plan section of the charging half of our improved kiln taken substantially on line 1—1 of Figure 2.

Figure 1^a is a plan section taken on line 1a—1a of Figure 2^a, similar to Figure 1, but illustrating the discharge half of our kiln.

Figure 2 is a vertical section of the portion of our kiln illustrated in Figure 1 and taken on line 2—2 of Figure 1.

Figure 2^a is a view generally similar to Figure 2

but illustrating the discharge half of the kiln being taken on line 2a—2a of Figure 1^a.

Figure 3 is a plan view of the charging half of the kiln, showing the same portion of the furnace as illustrated in Figure 1 but not being in section.

Figure 3^a is a plan view of the discharge half of the kiln.

Figure 4 is an enlarged vertical cross-sectional view of the kiln taken on line 4—4 of Figure 1.

Figure 5 is an enlarged vertical cross-section taken on line 5—5 of Figure 1.

Figure 6 is an enlarged vertical cross-section taken on line 6—6 of Figure 1.

Figure 6^a is a fragmentary horizontal cross-section taken on line 6a—6a of Figure 6.

Figure 7 is an enlarged vertical cross-sectional view taken on line 7—7 of Figure 1^a.

Figure 8 is an enlarged vertical cross-section taken on line 8—8 of Figure 1^a.

Figure 9 is an enlarged vertical cross-section taken on line 9—9 of Figure 1^a.

For convenience in describing our improved kiln it may be divided into three sections, namely, the pre-heating section, the furnace section and the cooling section. It will be understood that the ware travels through the furnace from the pre-heating section through the furnace section and the cooling section. In direct fired furnaces, as is well understood, the products of combustion enter the tunnel or ware chamber as distinguished from the muffle type furnace in which the products of combustion usually are kept in a combustion chamber which is completely closed off from the ware chamber.

The pre-heating section

The drawings illustrate a kiln through which a track extends on which ware carrying cars may be moved through the furnace or the kiln. It will, of course, be understood that any other suitable ware carrying and moving means may be used in furnaces or kilns embodying our improvements without departing from the spirit of our invention. Furthermore, the terms tunnel, tunnel structure, kiln, etc. which appear in this specification and the appended claims are used interchangeably and are each intended to refer to any suitable type or design of ware chamber in which the necessary heating and/or cooling operations may be carried out.

Referring now particularly to Figures 1, 1^a, 2 and 2^a, the ware may be carried in any suitable manner on the cars 1. These cars enter the furnace through a door or opening 2 on the tracks 3. They are then transferred from the tracks 3 to

the tracks 4 on which they move longitudinally through the tunnel. As illustrated, the cars in the kiln are shown in abutting relation and it will be understood that as a car enters the left hand end of the tunnel a car will be moved out of the right hand or cooling end of the furnace and thus the ware will be moved through the furnace in substantially continuous manner. A return track 5 is provided on which the cars, which have been through the tunnel and are withdrawn on the track 6, can be unloaded, reloaded and returned to the charging end of the kiln.

In the operation of kilns of this type the ware is frequently stacked on the cars, or other carrier, to a considerable height and it is important that the ware on the bottom of the stack be treated in the same manner as that on the top. In order to effect immediate, uniform and controlled pre-heating of the ware on the cars as they enter the kiln we provide means for distributing the exhaust gases from the kiln furnaces upon the car as soon as it enters the pre-heating end of the kiln. As is usual in kilns of this type, the cars move in a direction opposite to the flow of gas in the tunnel and with this in mind our controlled preliminary pre-heating may be readily understood by reference to Figures 1, 2, 3 and 4. In the preliminary heating section of the kiln, indicated at A in Figure 1, the exhaust gases are directed against the car from above through the pipes 7 which are provided at their lower ends with the baffles 8 which diffuse and distribute the gas entering the kiln. A pipe 9 directs the exhaust gases against the lower portion of the ware on the car while the car is in the entering chamber 10. Vertically spaced side flues or ports 11 direct the gas against the side of the ware on the cars while the horizontal bottom ports 12 direct the exhaust gas at the bottom of the ware while it is in the preliminary heating zone (see Fig. 2). As seen in Figure 4 the ports 12 are provided with sliding closure plates 13 operated by rods 14 extending outside of the kiln. By this means the flow of gas through the ports may be controlled. The vertical ports 11 are controlled by the tapered wedge type valve members 15 which are also externally movable by means of the rods 16. This controlled method of introducing heat insures uniform heat over the entire setting. The blower fan 17, driven by any suitable means such as the motor 18, is provided for forcing the exhaust gases through the pipe 19 (see Fig. 3) and the pipes 7 and 9 into the preliminary heating zone A. In addition to the downwardly extending discharge pipe 7 the header pipe 19 also supplies the exhaust gases to the chambers 22 and 23 from which they are discharged against the ware through the ports 11 and 12. Vertical pipes 24 and 25 connect the header 19 and the chambers 22 and 23. A stack 17' is adapted to discharge exhaust gas which is not to be returned to the kiln. The intake of the blower fan 17 is connected to the pipe 21 which in turn is connected to the chambers 26 which extend along the sides of the pre-heating section of the kiln.

That portion of the pre-heating end of the kiln which is indicated at B in Figure 1 includes longitudinally extending chambers 26 from which a plurality of ports 27 extend into the tunnel through which the ware is moved. Each of these ports 27 is controlled by a sliding valve 28 which may be generally similar to the valve and operating rod 13 and 14 described above and illustrated in detail in Figure 4. As is seen in Figure

2 these ports 27 are disposed adjacent the lower portion of the tunnel and the gas in the tunnel will pass downwardly through these ports as is generally indicated by the arrows in Figures 1 and 2. By providing individual valves 28 for each of these ports 27 the control of the flow of gas through the pre-heating zone and also the entire kiln may be greatly facilitated.

In order further to assist in the control of the pre-heating zone of the kiln we also provide a plurality of crown relieving slots 29 which extend through the kiln top and are provided with adjustable covers 30. The general arrangement of these relieving slots is illustrated in Figure 8. By fully or partially opening one or more of these slots air can be caused to enter the tunnel or gas to be discharged therefrom and by spacing the slots along the roof of the tunnel an effective way is provided for assisting in controlling the tunnel atmosphere both as to composition and temperature.

Next in the pre-heating section of the kiln, as we move in the direction of ware travel, is the insulated wall section C which separates the exhaust section B and the pre-heating furnace section D. The section D includes combustion chambers 31 and 32 disposed on opposite sides of the tunnel and separated therefrom by the tunnel side walls 33 and 34. Suitable burners 35 (either oil or gas depending upon the fuel used) extend through the outer walls of the combustion chambers and are directed angularly therein, in a direction opposite to the ware movement, so that the flame and hot gases do not impinge directly against the walls of the tunnel but sweep along it thus distributing the heat and flame and permitting the products of combustion to pass into the tunnel through ports 36. As is seen in Figures 1 and 5 these ports 36 are provided with refractory cover plates 37 which may be moved away from the ports 36 or moved therealong to vary the effective opening of the ports. Hand holes 38 are provided opposite each port 36 to facilitate such adjustment. These are normally closed by plugs 39 (see Fig. 5).

Also, as is illustrated in Figure 5, the longitudinally extending combustion chambers or pre-heating furnaces 31 and 32 are disposed at the bottom of the tunnel chamber, the upper half of the tunnel wall being insulated as seen at 40. Just beyond (in the direction of ware travel) the bottom heating furnaces 31 and 32 and their tangential or angularly arranged burners are disposed preliminary heating burners 41, the heat from which plays directly at the bottom of the ware to heat the lower portion of the ware on the car uniformly with the upper portion of the ware before the cars enter the furnace or firing zone. As is seen in Figures 6 and 6^a these burners are preferably provided with flared outlet openings 42 which spread the heat in a fan shape at the bottom of the ware. Another set of these bottom heating burners may be provided at 43 just ahead of the furnace chamber.

The furnace section

The furnace section proper, in which the actual firing occurs, (indicated at E in Figures 1 and 1^a) is divided into a plurality of sections by means of baffles 44. In each of the sections formed by these baffles are provided a plurality of burners which are arranged in spaced vertical relation so as to heat both the top and bottom of the ware. The arrangement of these burners, all of which will be referred to by the numeral 45, is seen in

Figures 6 and 2. By separating the furnace or firing chamber into a plurality of compartments the temperature and atmosphere in each compartment can be controlled. In the usual operation of kilns of this type it is desired to bring the temperature of the ware up to a predetermined point when it first enters the furnace section and then to maintain it at this temperature for the desired time. This soaking operation can be readily accomplished by our arrangement.

Figure 7 illustrates a pair of oppositely disposed bottom heating burners 46 and 47 which have flared slotted outlet openings 48 similar to those of burners 41. Similar bottom heating burners, preferably having flared outlet openings, may also be provided at each of the baffle walls, as is indicated in Figures 1 and 1^a at 49, 50, 51, 52, 53 and 54. Figure 7 also illustrates the exhaust gas flues 55 and 56 which connect the furnace chamber with exhaust gas passages 57 and 58. Pipes 59 and 60 carry exhaust gas to the passages 57 and 58 from the pipe 61 which is connected to the pipe 20, thus making possible the establishment of a reducing atmosphere or a controlled composition of atmosphere throughout the furnace zone. This makes possible the firing of ware under definite oxidizing or actual reducing atmospheric conditions and is especially valuable in the firing of flashed ware, wherein the flame and atmosphere are both controlled. In such instances it may be desired to direct exhaust gases or products of combustion back into the furnace section to overcome an excess quantity of air or oxygen in the furnace or to keep the furnace atmosphere in reducing condition. The provision of the above described exhaust gas connections to the exit end of the furnace or burning chamber provides means for so introducing exhaust gases when desired. As seen in Figure 3, a valve 20a is provided in the pipe 20 closely adjacent the blower 17 by which the pipe 20 may be shut off when it is not desired to re-direct exhaust gas into the burning chamber.

The cooling section

After leaving the burning section E of the kiln the ware enters the cooling portion of the kiln in which the temperature of the ware is reduced to the desired value and in the desired manner. The first portion of the cooling section of the kiln is indicated at F in Figure 1^a and may be termed the indirect rapid cooling section. As is most clearly seen by reference to Figure 8 this consists of panels 62, preferably of carborundum or other suitable material, which form the sides of the tunnel. These panels 62 form the inner wall of the cold air chambers 63 which are located on opposite sides of the tunnel. Relatively cold air enters the bottom of the chambers 63 through the header pipes 64 and suitable branch pipes 65. A blower fan 66 (see Fig. 3^a) is adapted to force this cold air, which may conveniently be at room temperature, through the pipes 67 and 68 to the headers 64. Openings or ports 69 at the top of the chambers 63 provide outlets for the cooling air and by varying the rate of flow of air through the cooling chambers 63 the degree of indirect rapid cooling which is effected in the section F of the kiln may be regulated. Similar panels and chambers may be provided extending across the top wall of the kiln to give a similar cooling drop in the ware temperature.

The indirect rapid cooling section prevents cold air from striking the hot ware and cracking it. As will be understood, the air which passes

through the chambers 63 will be heated and may be used to heat the plant or for any other desired purpose. In this indirect rapid cooling section clay ware may be quickly cooled from the burning temperature, which may be as high as 2500° F., down to dull red heat (1300° F. to 1400° F.) without cracking. Our indirect rapid cooling section uniformly cools the ware without subjecting it to blasts of cold air and effects the first rapid cooling in a very short tunnel travel.

Further indirect forced cooling, but at a slower rate, may be carried out in the checker work section G (Fig. 1^a). This portion of the kiln is shown in cross section in Figure 8 and it will be seen that cold air enters the bottom of the checker work 70 through pipes 71 which lead off from the same header 64 as supplies air to the indirect rapid cooling chamber 63. The checker structure 70 is preferably formed of refractory brick in well known manner. At each end of the checker section G are relief outlets 72 for the cooling air which is directed into the kiln at its exit end as will be later described. These outlets 72 extend through the walls of the tunnel providing direct connection to the atmosphere.

The blower fan 66 is adapted to force cool air through the pipes 73, 74 and 75 into the exit end of the tunnel. The pipes 74 are supplied with valves 76 and, as seen in Figure 1^a, they connect with ports 74a which direct the cool air into the kiln in streams which move opposite to the movement of the ware through the tunnel. A large part of the air blown into the furnace in this manner by the blower 66 passes out of the tunnel through the cold air relief passages 72.

Further means are provided for cooling the section of the tunnel indicated at H in Figure 1^a. This consists of indirect waste heat induced draft cooling. As is seen in Figure 1^a the sides of the tunnel at H are formed with double walls forming chambers 77 which have openings 78 at the bottom connecting them to the atmosphere. They are connected at the tops with the longitudinally extending waste heat flue 79 (Fig. 9) which extends over the entire cooling section of the furnace as is seen in Figure 2^a. As illustrated the flue 79 is formed by extending the side walls of the tunnel upwardly and providing a corrugated composition roof 80 which extends across between the side walls and may be supported in any suitable manner. This waste heat flue 79 is connected through a hood 81 to a suitable suction fan which together with the natural draft induced by the heated walls and roof of the cooling section of the kiln causes cool air from the room to be drawn in through the bottom ports 78. This air, of course, cools the inner walls of the tunnel and by varying the number of openings 78 which are provided the degree of cooling thus obtained may be regulated. A portion of this induced draft cooling section, as shown at H' in Figure 1^a and also seen in Figure 9, is provided with sheet iron walls 82 and top 83. This portion of the tunnel is the coolest part and by providing air cooled sheet metal walls and top, which are well able to withstand the temperatures encountered in this portion of the kiln, greater heat transferring efficiency and thus more effective cooling is obtained. The outer walls of this portion of the kiln are also provided with cool air inlet ports 84 and the air which is drawn therein by natural draft, and the above noted suction fan, passes upwardly over the sheet metal walls and is carried away through the collecting hood 81.

Another valuable feature of our kiln construction is shown in Figure 7 and consists of means for creating and maintaining an effective seal between the floors of the cars or other type of moving support which carries the ware and the sides of the kiln tunnel. It is, of course, important to prevent the escape of heat from or the inflow of air to the tunnel at all points except where desired. As the cars must move through the tunnel some sliding joint arrangement should be provided. In our arrangement the floor of the car 1 is provided with downwardly extending vertical plates 85 which extend into troughs 86 which are filled with sand, gravel, or the like, thus forming a seal. In addition to this sealing arrangement we provide a row of relatively soft bricks 87 which have horizontal top surfaces and are supported along each side of the car 1. These bricks are so disposed that they will rub against the underside of an overhanging flange 88 which is of a harder brick and which extends the entire length of the tunnel. The upper sides of the overhang 88 are bevelled, as is clearly seen in Figure 7, and are of soft material. These engage similarly bevelled surfaces 89 which are of hard material and which form a part of the ware supporting floor of the car 1. By providing a pair of vertically spaced surfaces on each side of each car, which surfaces engage and grind themselves into a proper sliding fit with complementary surfaces on the inwardly extending ribs or overhangs 88 of the tunnel walls, a very effective seal is provided which, in combination with the sand seals 85, prevents undesired inflow or outflow of the gas to or from the tunnel kiln. The wearing surfaces of soft brick on the cars may, of course, be readily renewed and thus the maintenance of a good seal is facilitated.

Although we have described in considerable detail the particular kiln which is illustrated in the drawings it will, of course, be understood by those skilled in the art that the features of our invention may be modified and changed to suit the requirements of different types and sizes of kilns or furnaces. We do not, therefore, wish to be limited to the particular arrangement shown and described herein but claim as our invention all embodiments thereof coming within the scope of the appended claims.

We claim:

1. In apparatus of the type described, a tunnel structure including a pre-heating section, a furnace section and a cooling section, means for withdrawing gas from said pre-heating section at a point removed from the entering end thereof and directing it back into the tunnel at the entering end of the pre-heating section, and means for conveying ware through said tunnel.

2. In apparatus of the class described, a tunnel structure having a pre-heating section, a track extending through said tunnel and adapted to support and guide ware carrying cars, the entering end of said pre-heating section having double side walls forming chambers, the inner walls of said double side walls having apertures extending into said chambers at approximately the floor level of the ware carrying cars, means for withdrawing gas from the tunnel through said apertures and chambers and discharging at least a portion of the gas so withdrawn against ware on the cars entering the tunnel structure whereby preliminary pre-heating is obtained.

3. In apparatus of the class described, a tunnel structure having a pre-heating section and a furnace section, means for withdrawing hot gas

from said pre-heating section and means for directing the so withdrawn hot gas back into the entering end of said pre-heating section at the bottom of the ware and against the sides and top thereof.

4. In apparatus of the class described, a tunnel structure having a pre-heating section, said pre-heating section including combustion chambers disposed on opposite sides of the tunnel at the lower portion of the side walls thereof, burners adapted to direct fuel into said combustion chambers in a direction opposite the movement of ware through the tunnel and adjustable means for conducting the products of combustion from said combustion chambers into said tunnel.

5. In apparatus of the class described, a tunnel structure having a pre-heating section, said pre-heating section including combustion chambers disposed on opposite sides of the tunnel at the lower portion of the side walls thereof, burners adapted to direct fuel into said combustion chambers, and adjustable means for conducting the products of combustion from said combustion chambers into said tunnel.

6. In apparatus of the class described, a tunnel structure having a pre-heating section, said pre-heating section including combustion chambers disposed on opposite sides of the tunnel at the lower portion of the side walls thereof, burners adapted to direct fuel into said combustion chambers in a direction opposite the movement of ware through the tunnel and adjustable means for conducting the products of combustion from said combustion chambers into said tunnel, said adjustable means including a plurality of ports from said combustion chambers to the tunnel and valves for varying the degree of opening of said ports.

7. In apparatus of the class described, a tunnel structure having a pre-heating section, said pre-heating section including combustion chambers disposed on opposite sides of the tunnel at the lower portion of the side walls thereof, burners adapted to direct fuel into said combustion chambers, and adjustable means for conducting the products of combustion from said combustion chambers into said tunnel, said adjustable means including a plurality of ports from said combustion chambers to the tunnel and valves for varying the degree of opening of said ports.

8. In apparatus of the type described, a tunnel structure including a furnace section disposed between a pre-heating and a cooling section and a burner in said pre-heating section having an outlet flared parallel to the direction of ware travel only whereby a fan shaped flame is formed, said outlet being disposed closely adjacent the path of the ware through the tunnel, said burner being disposed at the bottom of the ware and being adapted to direct its heat directly upon the ware.

9. In apparatus of the type described, a tunnel structure including a furnace section disposed between a cooling section and a pre-heating section, said tunnel structure having top and side walls, said top wall being provided with a plurality of slots spaced along the entire length of the tunnel, extending transversely of the tunnel and opening directly to the atmosphere.

10. In apparatus of the type described, a tunnel structure including a furnace section disposed between a cooling section and a pre-heating section, said tunnel structure having top and side walls, the top wall being provided with a plurality of slots spaced along the entire length of the

tunnel, extending transversely of the tunnel and opening directly to the atmosphere, and means for varying the degree of opening of said slots.

11. In apparatus of the type described, a tunnel structure including a furnace section disposed between a pre-heating section and a cooling section, said furnace section being wider than said pre-heating and cooling sections and having baffle walls dividing it into a plurality of compartments, vertically spaced burners in each of said compartments and means for controlling said burners whereby the temperature in adjacent compartments of said furnace section may be varied as desired.

12. In apparatus of the type described, a tunnel structure including a furnace section disposed between a pre-heating and a cooling section, said furnace section being wider than said pre-heating and cooling sections and having baffle walls dividing it into a plurality of compartments, burners in each of said compartments and means for controlling said burners whereby the temperature in adjacent compartments of said furnace section may be varied as desired.

13. In apparatus of the type described, a kiln or furnace structure including a pre-heating section and a furnace section, means for causing hot gases from said furnace section to flow through said pre-heating section, and means for withdrawing gas from said pre-heating section and directing the so withdrawn gas back into said furnace section.

14. In apparatus of the type described, a kiln or furnace structure including a pre-heating section and a furnace section, means for causing hot gases from said furnace section to flow through said pre-heating section, means for withdrawing gas from said pre-heating section and directing the so withdrawn gas back into said furnace section, and means for conveying ware through said tunnel structure in a direction opposite to the movement of gas in said tunnel.

15. In apparatus of the type described, a tunnel structure having a furnace section, means for applying heat to ware in said furnace section, and a cooling section arranged for passage of the ware therethrough after leaving said furnace section, said cooling section including an indirect rapid cooling chamber in a wall of the tunnel, said chamber having a refractory wall on its inner side, a second indirect cooling portion comprising a checker brick structure adjacent the tunnel walls, and means for blowing cooling fluid through said cooling chamber and said checker structure.

16. In a tunnel kiln or the like, a tunnel structure, track extending through the tunnel structure, a car adapted to move on and be supported by said track, said car having a solid floor and a pair of downwardly and inwardly sloping surfaces of brick material extending along the sides of the car adjacent the floor and parallel to said track, said tunnel structure having a complementary pair of brick surfaces extending parallel to said track and adapted to engage said surfaces on said car with sliding contact whereby the portion of the tunnel above said car floor will be sealed from the portion below during movement of the car through the tunnel.

17. In a tunnel kiln or the like, a tunnel structure, track extending through the tunnel structure, a car adapted to move on and be supported by said track, said car having a solid floor and a pair of surfaces of brick material extending along the sides of the car adjacent the floor and

parallel to said track, said tunnel structure having a complementary pair of brick surfaces extending parallel to said track and adapted to engage said surfaces on said car whereby the portion of the tunnel above said car floor will be sealed from the portion below during movement of the car through the tunnel, one of said brick surfaces on the car being softer than its complementary surface on the tunnel and the other brick surfaces on the car being harder than its complementary surface on the tunnel.

18. In a kiln of the type described, walls defining a heating chamber arranged for passage of the ware therethrough, means for supporting the ware during its passage through said chamber and sealing means between the chamber walls and the ware support including engaging complementary brick scaling surfaces on a wall and the support, one of said complementary surfaces being of harder brick than the other and said surfaces sloping downwardly and inwardly toward the center of the ware chamber.

19. In a kiln of the type described, walls defining a heating chamber arranged for the passage of ware therethrough, conveying means for supporting and conveying ware through said chamber, and sealing means between said conveying means and the chamber walls including complementary solid material sealing surfaces on a wall and the conveying means, the sealing surface on the conveying means being of a softer material than the sealing surface of the wall whereby the major wear due to engagement of said sealing surfaces will occur on the conveying means surface.

20. In apparatus of the type described, a tunnel structure including a furnace section, means for applying heat to ware in said furnace section, and a cooling section arranged for passage of the ware therethrough after leaving said furnace section, said cooling section including an indirect rapid cooling chamber in a wall of the tunnel, said indirect rapid cooling chamber having a refractory wall on its inner side, a second indirect cooling portion comprising a checker brick structure adjacent the tunnel walls, means for forcing cooling fluid through said indirect rapid cooling chamber and said checker structure, and a third indirect cooling portion comprising a double side wall portion forming side wall chambers, said side wall chambers having outlets in their upper portions and connections in their lower portions to the atmosphere whereby the natural draft created by the heat of the ware will cause relatively cool air from the atmosphere to move through said double side wall portions.

21. In apparatus of the type described, a tunnel structure including a furnace section, means for applying heat to ware in said furnace section, and a cooling section arranged for passage of the ware therethrough after leaving said furnace section, said cooling section including an indirect rapid cooling chamber in a wall of the tunnel, said indirect rapid cooling chamber having a refractory wall on its inner side, a second indirect cooling portion comprising a checker brick structure adjacent the tunnel walls, means for forcing cooling fluid through said indirect rapid cooling chamber and said checker structure, and a third indirect cooling portion comprising a double side wall portion forming side wall chambers, said side wall chambers having outlets in their upper portions and connections in their lower portions to the atmosphere whereby the natural draft created by the heat of the ware will cause relatively

cool air from the atmosphere to move through said double side wall portions, and mechanical means for assisting said natural draft to cause cooling air to flow through said double side wall portions.

22. In apparatus of the type described, a tunnel structure having a furnace section and a cooling section, said cooling section including an indirect cooling chamber in the wall of the tunnel and means for directing cooling air into direct contact with the ware.

23. In apparatus of the type described, a tunnel structure having a furnace section and a cooling section, said cooling section including an indirect cooling chamber in the wall of the tunnel and

means for directing cooling air into direct contact with the ware in a direction opposite to the direction of ware movement.

24. In apparatus of the type described, a tunnel structure including a furnace section of greater width than the adjacent portions of the tunnel, said furnace section including means for dividing it into a plurality of combustion compartments, a burner in each of said compartments and means for controlling said burners whereby the temperature of adjacent compartments and of adjacent portions of said furnace section may be controlled.

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