

Sept. 9, 1930.

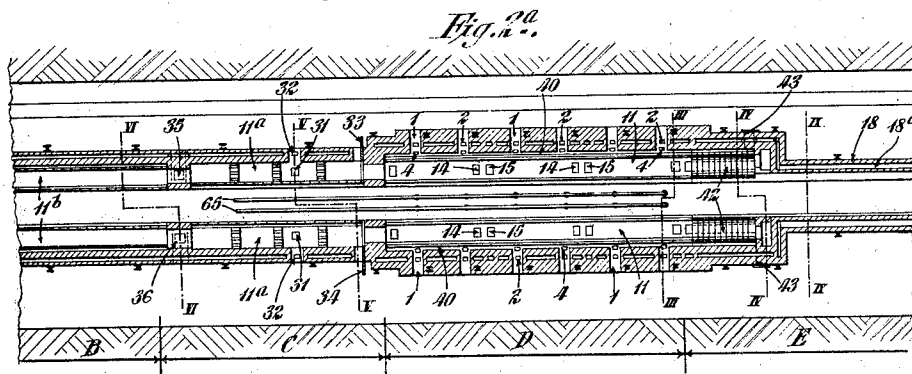
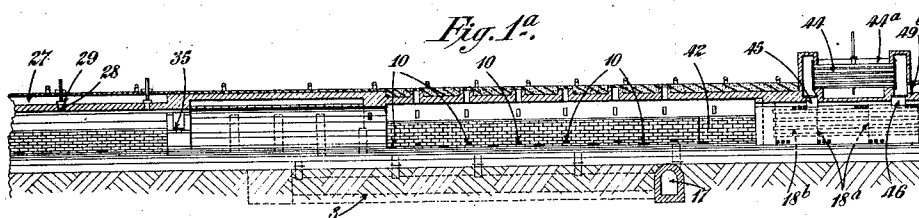
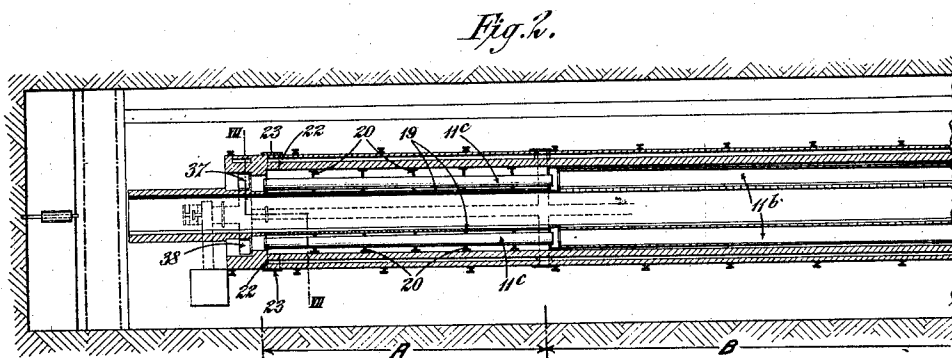
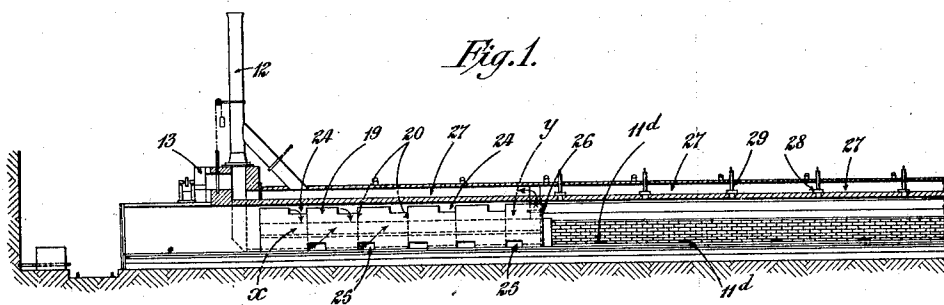
J. WILLIAMSON

1,775,302

OVEN OF THE DIRECT FLAME CONTINUOUS TUNNEL TYPE

Filed Nov. 7, 1927

6 Sheets-Sheet 1



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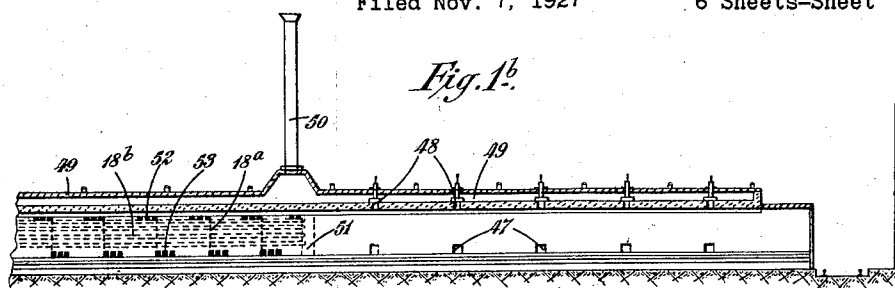


Fig. 1b.

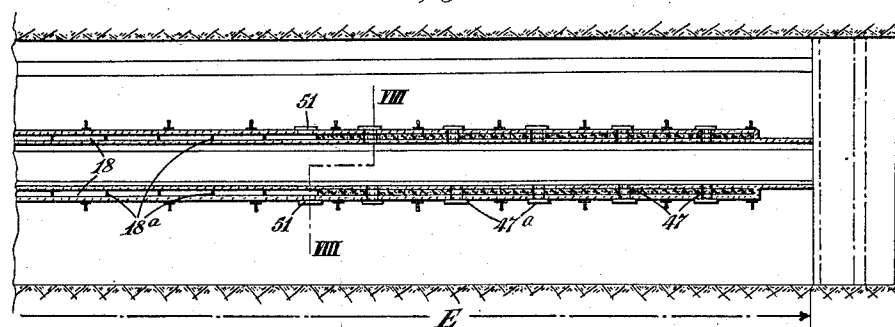


Fig. 2b.

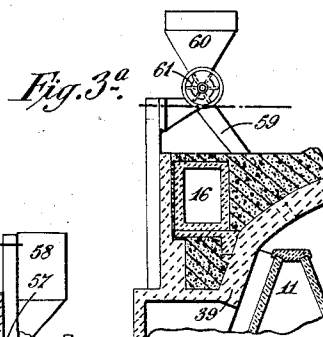


Fig. 3a.

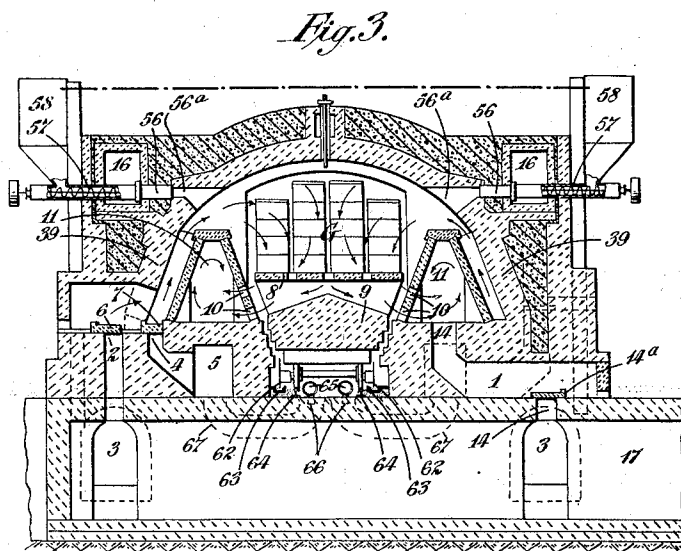


Fig. 3.

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Fig. 4.

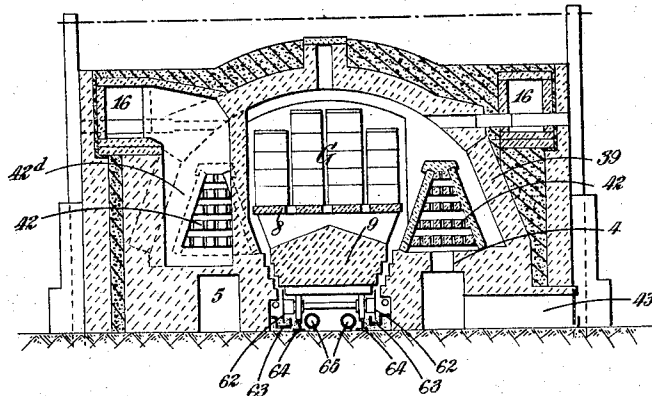


Fig. 5.

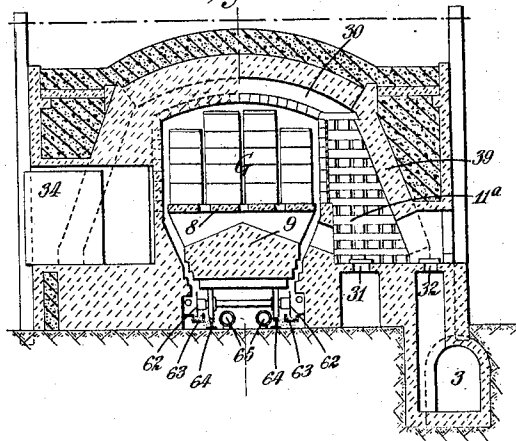
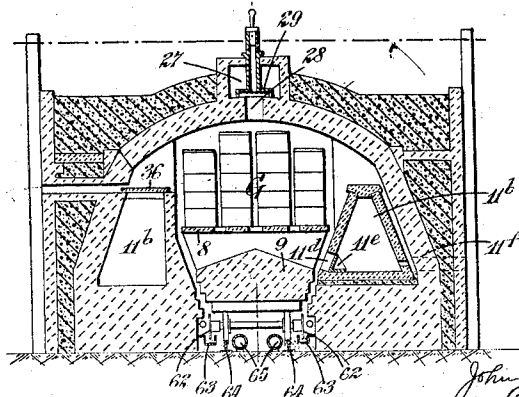


Fig. 6.



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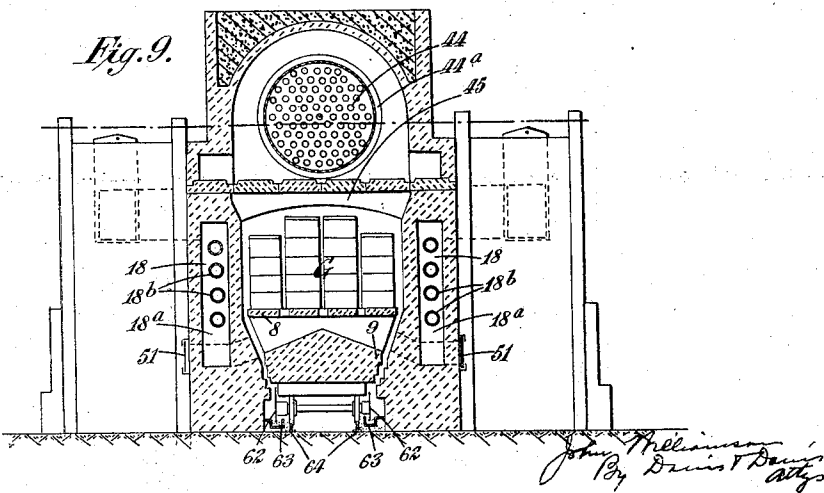
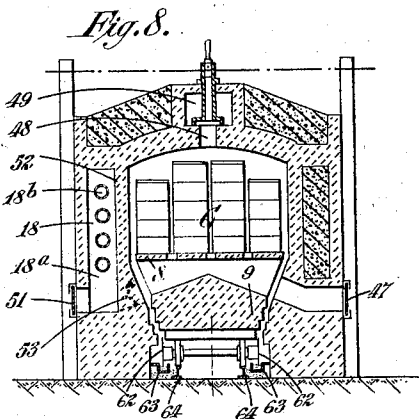
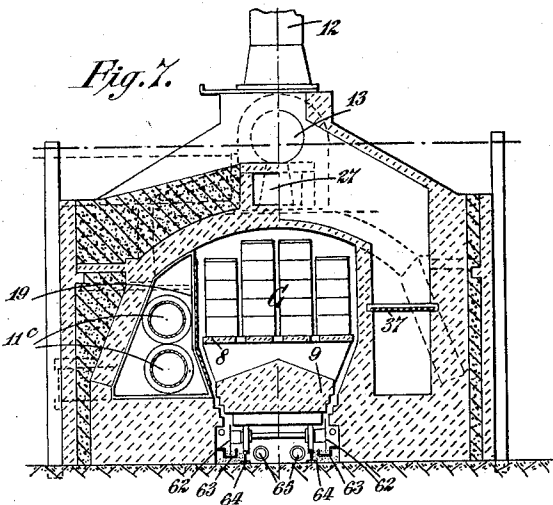
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Fig. 10.

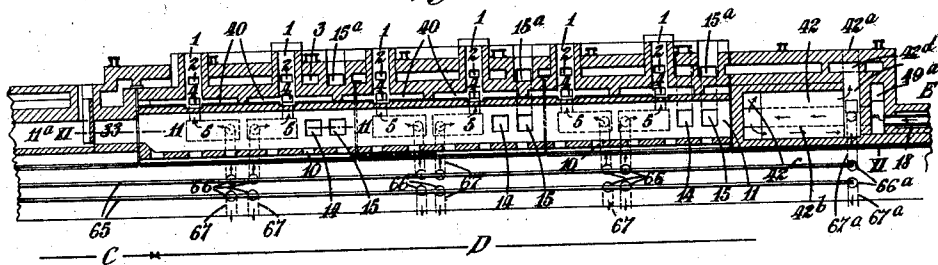


Fig. 11.

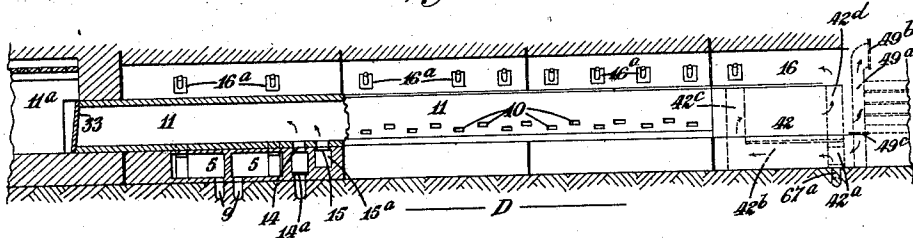
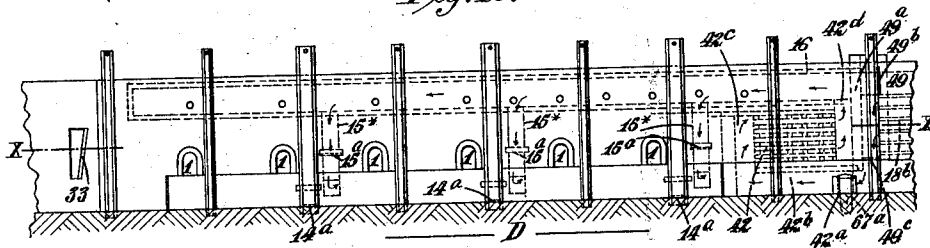


Fig. 12.



John Williamson
By David V. Davis
Atty

Sept. 9, 1930.

J. WILLIAMSON

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Fig. 13.

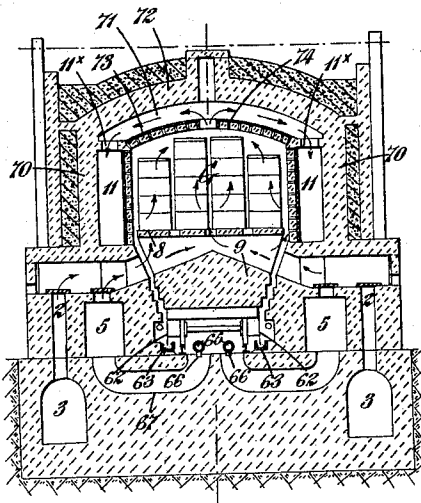
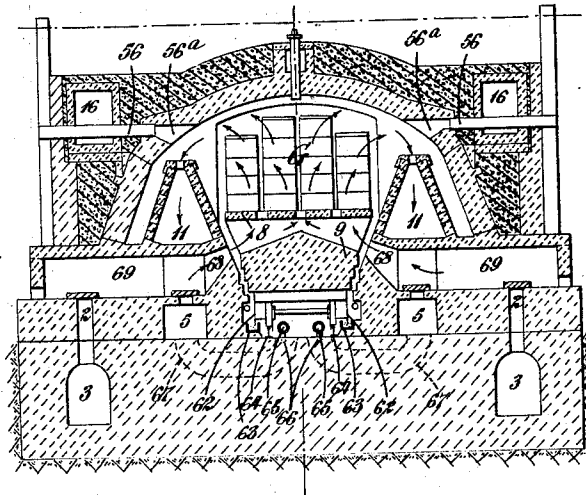
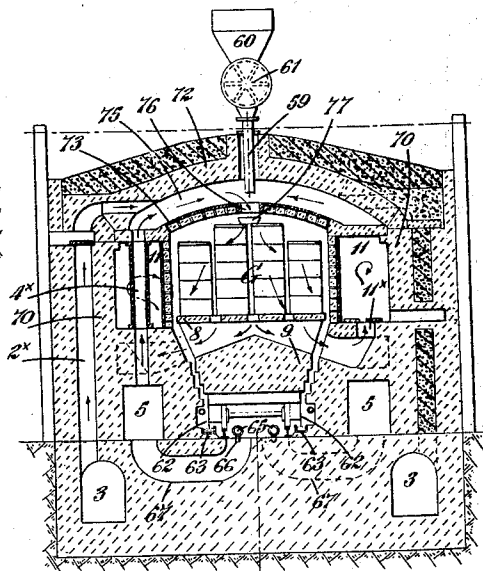


Fig. 14.

Fig. 15.



John Williamson
B. Davis & Davis
Attys

UNITED STATES PATENT OFFICE

JOHN WILLIAMSON, OF HAMWORTHY, POOLE, ENGLAND

OVEN OF THE DIRECT-FLAME CONTINUOUS-TUNNEL TYPE

Application filed November 7, 1927, Serial No. 231,744, and in Great Britain December 22, 1926.

This invention consists of improvements in or relating to ovens of the direct flame continuous tunnel type suitable for the firing of pottery, tiles, bricks, pipes and other similar ware, or the heat treatment of other materials.

One object of the invention is so to construct an oven of the type referred to that flame can be made to take various courses through the goods to suit varying requirements, that is to say, to travel upwards or downwards, or horizontally in a transverse direction, or horizontally in a longitudinal or in a diagonal direction, and also to alternate from one side of the oven to the other, giving direct contact of the flame to all parts of the truck on which goods are placed, at the same time utilizing the hot exhaust gases for indirect heating of the goods in the early stages of firing, thus tending to greater regularity of temperature than hitherto attained in ovens of the direct flame type.

Another object of the invention is so to construct a continuous tunnel oven of the direct flame type that the goods can be heated indirectly by the products of combustion, up to or beyond the stage where the water of chemical combination is given off, in a purely oxidizing atmosphere, and that the vapour thus produced can be taken away as it is formed, thus preventing cracking, scumming, and other defects on the goods which are common in other ovens where the preheating is done by direct contact of the exhaust gases with the goods.

Another object of the invention is so to construct a tunnel oven of the direct flame type, that air from each end thereof can be circulated through it in a helical or screw like direction towards the furnace zone, so as to enable the heating and cooling, by radiation, conduction and convection, to be effected in a more complete manner than is now done in the usual type of direct flame oven.

Another object of the invention is so to construct a tunnel oven that the rate of cooling can be accelerated or retarded at any particular point in the cooling process, and that the heat given up can be utilized to provide supplementary hot air for combustion of fuel

and to provide the necessary power required to work the system or plant so as to provide an almost complete thermal system.

Another object of the invention is so to construct a tunnel oven that a current of air can be made to flow between the base of the trucks carrying the goods and the rails on which the trucks run, so as to keep the bearings, rails, and lower brickwork of the oven cool in the furnace zone.

A further object of the invention is so to construct a tunnel oven of the direct flame type that salt glazing or other similar processes can be carried out in a continuous or in an intermittent manner, that is to say, in a glazing atmosphere in the furnace zone all the time, or alternating from an oxidizing to a glazing atmosphere as the goods travel through this zone, and so that the salt used can be distributed in an effective manner and the amount thereof regulated to suit requirement.

For attaining the above mentioned objects a direct flame continuous oven embodying the invention, is constructed as shown in the accompanying drawings, a longitudinal sectional elevation whereof is represented by the three parts Figs. 1, 1^a and 1^b, Figs. 2, 2^a and 2^b, being corresponding sectional plan views. Figs. 3 to 9 inclusive are transverse sections taken on the lines III—III to IX—IX respectively, appearing in Figs. 2, 2^a and 2^b. Fig. 3^a is a detail view showing a modification. Fig. 10 is a horizontal section of one half of the firing zone of the oven and an adjacent recuperator, to a larger scale than the corresponding portion of the oven shown in Fig. 2^a, the section corresponding to the line X—X of Fig. 12. Fig. 11 is a vertical section taken on the line XI—XI of Fig. 10. Fig. 12 is an external elevation of the same portion of the oven with recuperator. Figs. 13, 14 and 15 are cross sections through the furnace zone of modified constructions of the oven.

As shown in Figs. 1 to 12 inclusive, the oven comprises five successive zones, namely preheating, heating, equalizing, furnace and cooling zones lettered respectively A, B, C, D and E through which the goods to be fired,

placed either in containers, or uncovered, upon trucks, are caused to travel slowly, entering at the preheating end A and leaving at the cooling end E as is usual.

5 The portion of the oven constituting the furnace zone D is provided at a number of points along each side thereof with burners, the burners being separately controlled by dampers so that a very long soaking heat is obtainable in this zone. The said furnace zone which may advantageously be arranged more or less centrally of the length of the oven can be heated either by the combustion of gas, or oil, issuing from ports or nozzles, or by the combustion of solid fuel on open fire-grates. In the example illustrated, the heating is effected by the combustion of gas each burner, located at 1, (Figs. 2^a, 3, 11 and 12) being constituted by ports 2 leading from two long gas ducts 3 and ports 4 leading from a number of short air ducts 5 the gas and air ports being controlled by dampers 6 and 7 respectively. Along each side of the furnace zone and at points that are below the perforated platform 8 of each truck 9 are also provided a number of outlets 10 through which, after the flame has done its work on the goods G under treatment, the resulting products of combustion can escape into side flues 11 arranged at opposite sides of the oven. These side flues are in communication with other side flues 11^a, 11^b, 11^c extending from the furnace zone D through the portions C, B, A of the oven constituting the equalizing heating and preheating zones of the oven and finally communicate with the external atmosphere, either by way of a chimney 12 (Fig. 1), or through a fan 13. The flues 11 at opposite sides of the firing zone D are adapted to be heated by radiation and conduction from the incoming flame playing on the outside of the flues and also it may be by heat from supplementary burners arranged inside them so that the products of combustion can be again raised in temperature before entering the flues 11^a traversing the heat equalizing zone C. The supplementary burners for each flue 11 are constituted as shown in Fig. 2^a, on the right hand half of Fig. 3, and in Figs. 10, 11 and 12, by gas ports 14, each communicating with the corresponding gas flue 3 below, and air ports 15 each communicating by a vertical air flue 15^a with a longitudinal overhead hot air flue 16. The supplementary gas and air supply passages may advantageously have associated therewith separate valves or dampers 14^a and 15^a to control the supply of gas and air therethrough so as to enable the goods under treatment to be fired in various ways.

Conveniently, the combustible gas supplied to the main and supplementary gas ports 2 and 14, may be obtained from an independent gas producer, the gas being fed into a

duct 17 (Figs. 1^a and 3) and thence to the main ducts 3 which may be arranged in the foundation of the oven, as shown, or in any other convenient position. The air supplied in the main and supplementary air ports 4 and 15 is heated in the manner hereinafter described.

Air is drawn into the oven from each end thereof, and travels towards the furnace zone D. The air entering the inlet end portion of the oven is heated by the hot exhaust gases flowing through the exhaust flues 11^b and 11^c and used for preheating goods admitted to the oven and in part is further heated in the heating zone B by the exhaust gases flowing through the flues 11^b, and used for expelling water of combination in clay goods and for combining with and removing any carbon from such goods. These portions of heated air are, after use, drawn off by a fan or a chimney and may be utilized for heating parts of the factory, if required, or for generating steam. Other air admitted to the heated portion of the oven after becoming heated thereby, is used for supporting combustion of gas at the main and supplementary burners. The air admitted to the cooling zone of the oven is used for cooling the heated goods. Part of it is caused to circulate in a helical manner through side flues 18 and the interior of the cooling zone so as to come in contact with the goods intermittently, the air thereby heated being re-cooled by other air that flows through tubes traversing the flues and is afterwards used as supplementary air for the burners, as hereinafter described.

The side flues may be of any desired section but may advantageously be of approximately triangular shape as shown. Their walls may be plain in section, or of cavity, or honeycombed type, but in order to produce a large heat absorbing and radiating surface they are preferably made with honeycombed surfaces inside and out. The side flues 11, 11^a and 11^b in the furnace, equalizing and heating zones D, C, B respectively are made of good refractory material having a high ratio of conductivity, whilst the walls of the flues 11^c of the preheating zone A, may be made of material of a lower refractory character but of greater conductivity, such as cast iron or other suitable material being shown in Figs 2 and 7 as constituted by a pair of iron pipe runs at each side of the oven.

Opposite the flue tubes 11^c at each side of the preheating zone A is arranged a screen wall 19 (Fig. 7) of heat insulating material, so as to shut off radiant heat from the flues to the goods, and transverse walls 20 (Figs. 1 and 2) are placed between this screen and the adjacent side wall of the oven at intervals apart equal to one or more truck lengths, so as to form a series of separate compartments around the flues 11^c at each side of the oven.

The arrangement is such that air admitted to the bottom of the first compartment *x* at each side of the oven through an opening at 22 under the control, it may be, of a damper 23, can pass from one compartment to the other by convection, the air entering the bottom of the first compartment *x* then flowing round the hot walls of the pipes 11^c and discharging into the oven through an opening 24 in the top of the screen wall 19, then descending through the goods and entering the bottom of the next compartment through an opening 25 and so on, as indicated by the arrows, until it reaches the last compartment *y* where it is drawn away through a damper controlled passage at 26 (Fig. 1) and a flue 27 (Figs. 1, 6 and 7) by the fan 13 or chimney 12. The first chamber *x* at each side of the oven may take air from the interior of the oven through an opening in the screen 19 instead of from the surrounding atmosphere through the opening 22, as described, the air travelling in each case through the compartments *x*, *y* and oven in a helical course, and in the same direction as the trucks travel.

In the heating zone B, the goods are heated by radiation from the walls of the flues 11^b and by convected air currents and as the vapour from the water of combination in the goods is given off, it is drawn into the overhead flues 27 through openings 28 formed in the vault of the oven and controlled by dampers 29, the overhead flue being in communication with the chimney 12, or fan 13. Or, if desired, the vapour laden air may be drawn from the bottom of the truck through port holes 11^d (Figs. 1 and 6) in the inner walls of the side flues 11^b and thence be discharged into the external atmosphere, as through the flues 11^b, 11^c. The port holes 11^d are controlled by dampers 11^e, one of which is shown in Fig. 6, capable of being operated through openings 11^f in the outer walls of the oven and aligned holes in the outer wall of the flues 11^b.

In the heat equalizing zone C, the side flues 11^a are, as shown in Fig. 5, of larger cross section than the other flues, so as to present a greater heat radiating surface and at the same time allow the hot products of combustion therein to expand freely. Where great regularity of temperature is required, such flues 11^a may be connected to an overhead flue 30 (Fig. 5) forming a double vaulted common chamber extending over the truck or trucks in the form of a muffle so that the goods will be heated by direct radiation from the hot walls behind which the hot exhaust gases travel, and as the water of combination has been driven out of the goods in the previous zone B, the goods are here gradually raised in temperature until they reach the furnace or direct flame zone D. The flues 11^a may, as shown in Fig. 5, be provided with chequer-work division walls.

31 and 32 are damper-controlled air and gas inlet ports constituting burners by which the flues 11^a can be independently heated. 33 and 34, Figs. 2^a, 10, 11 and 12, are dampers whereby the flues 11 can be isolated from the flues 11^a; 35 and 36, Figs. 2^a and 6, are dampers whereby flues 11^a can be placed in communication with zone C, and 37 and 38, Figs. 2 and 7, are dampers whereby communication between the flues 11^c and the chimney 12 or fan 13 can be interrupted.

In the furnace zone D, when firing with a descending flame, the combustible gas and air are caused to enter the oven on each side through the openings 2 and 4 and combustion takes place in the space formed between the main walls 39 (Fig. 3) of the oven and the side flues 11, each burner at 1 being separated from its neighbour by a dividing wall 40 (Figs. 2^a and 10) so as to form a separate combustion space for the gas to burn in. The dividing walls 40 are so arranged as to form between both pairs thereof, a gradually increasing space proceeding upwardly, and thus to cause the flame to assume a fan-like shape before it reaches the goods. As the spacing of the dividing walls 40 may be made equal to the length of a truck, a sheet of flame of this length enters the oven from each burner at each side thereof and rises to the vault where the flames from opposite sides meet and immediately equalize in temperature. The combined flame then descends through the goods G and passes through and under the perforated truck platform 8 and enters the side flues 11 through the port holes 10 in the inner side walls thereof and traverses the remaining flues 11^a, 11^b, 11^c to atmosphere.

By means of the series of dampers referred to, flame issuing from the various burners can be caused to travel through the goods G in any of the directions hereinbefore mentioned. Thus, within the flues 11 in the furnace zone D, flame may also be produced by the burners constituted by the air and gas supply ports 14, 15, and by closing one of the dampers 33 and 34 between the flues 11 and 11^a on one side of the oven, say the damper 34, opening the other damper, say 33, and opening the gas and air dampers 6 and 7 controlling the supply of gas and air to the ports 2 and 3 of the main burners and those controlling the supply of air and gas through the ports 14 and 15 to the flue 11 on the side of the oven at which the closed valve 34 is located, flame can be produced outside and within the said flue and be caused to pass respectively over the flue and through the port holes 10 in the flue and travel across the oven and the truck therein and the goods in a transverse direction and enter the opposite side flue 11 through the port holes 10 therein. The products of combustion can then travel through the latter flue 11 and the flues 11^a, 11^b, 11^c at the same side of the oven to the

end of the oven and into the external atmosphere if the corresponding exhaust valve 37 be open and the other exhaust valve 38 be closed. If both exhaust valves are open half of the products of combustion can pass from the one side flue 11^a through the overhead connecting flue 30 (Fig. 5) to the opposite flue 11^a so that the products of combustion will then flow simultaneously through the flues 11^a, 11^b and 11^c at each side of the oven to the external atmosphere.

By closing the dampers 33 and 34 between both side flues 11^a and 11^a and opening the two dampers 35, 36 arranged between the side flues 11^a, 11^b, between the heating zone B and equalizing zone C, the flame from all the burners at each side of the furnace zone can be caused to travel in a horizontal longitudinal direction through the goods in the equalizing zone C until it reaches the ports controlled by the said dampers 35, 36 where the products of combustion will be caused to pass into the side flues 11^b of the heating zone B and thence through the flues 11^c into the atmosphere as before, if both exhaust valves 37 and 38 be open.

It will be obvious that by alternately opening and closing the exhaust dampers 37, 38 arranged at the fan or chimney end of the oven, and leaving the other dampers 35 and 36 as they last were, flame can be caused to travel through the furnace and equalizing zones alternating from one side of the oven to the other. Likewise, by closing the dampers 35, 36 and again opening dampers 33, 34 and alternately closing and opening the exhaust dampers 37, 38 as before, the flame will reverse from one side of the oven to the other, travelling in a horizontal transverse direction across the furnace zone D.

In the cooling zone E, immediately adjacent the furnace zone D and in the same line as the exhaust flues, and on each side of the oven, is a recuperator 42 comprising chequer brickwork (Figs. 1^a, 2^a, 4, 10, 11 and 12) through which air can be caused to flow, the chequer work being heated by the goods during cooling thereof and whilst they are passing between the recuperators. The heat of each recuperator is given up to air which enters through a valve controlled transversely arranged inlet passage 42^a, then flows through a longitudinal passage 42^b below the recuperator 42 to a chamber 42^c, then through the recuperator to a rear chamber 42^d up which it flows and thence enters the rear end of the overhead hot air flue 16 hereinbefore referred to. From this flue the hot air can be supplied to the main and supplementary burners hereinbefore described and through ports 16^a to the oven chamber over the flues 11. Air is or may also be supplied to each recuperator 42 from other sources as herein-after described.

Extending from this air heating and goods

cooling zone to the exit of the oven, the oven is made of a narrower cross section (Figs. 2^b and 11). In this portion of the oven the last stage of cooling is effected, partly by air in direct contact with the goods, and partly by air in indirect contact therewith. By a system of flues and dampers, the goods in any particular section of this zone can be cooled quickly or slowly. When cooling the goods by air in direct contact therewith, the cooling may, as shown in Figs. 1^a and 9, be effected on the thermo-syphon system, by passing the hot air from the cooling goods through the tubes 44 of a vessel 44^a around which cold air or water is caused to circulate, the hot air from the oven after being thus cooled, returning to the oven to be again heated, and so on, 45 and 46 representing air inlet and outlet passages connecting the interior of the tubes to the interior of the oven. Or cold air may be drawn direct into the oven, as through a number of openings 47, controlled by dampers 47^a (Figs. 1^b and 2^b) passed through and over the goods and discharged into the external atmosphere through valve controlled openings 48 in the roof of the oven, which openings lead to a flue 49 and chimney 50. When cooling by indirect methods, the cooling is effected by radiation and conduction, the section of the zone being of muffle construction, the inner walls of which may be constructed of thin material of high conductivity behind which air is caused to flow. Thus, referring to Figs. 1^b, 2^b and 9, each of the flues 18, which extend along part only of the length of the cooling zone E, is divided into a number of compartments by vertical transverse division plates 18^a and traversing the said compartments, are air tubes 18^b through which cold air is caused to flow from the external atmosphere. The interior of the oven communicates with the said compartments through top and bottom openings 52 and 53, so that air heated by contact with the goods enters the compartments by the top ports 52, is cooled by the tubes 18^b and re-enters the oven by the bottom ports 53, the air thus being caused to circulate through the heated goods and cooling compartments in a helical direction along the cooling zone and in an opposite direction to the travel of the goods. The cooling air enters the tubes 18^b through a damper controlled opening 51 (Figs. 1^a, 1^b and 8). The other ends of the said tubes can be placed in communication with the overhead flue 49 through a by-pass duct 49^a controlled by a damper 49^b (Figs. 10, 11 and 12), so that the air heated in the tubes 18^b can be delivered into the external atmosphere. Or by closing the damper 49^b, and opening a damper 49^c, previously closed, the heated air leaving the tubes 18^b can be directed into the flue 42^b, below the corresponding recuperator 42, and the chamber 42^c, then through the recuperator, wherein it

will be further heated, and thence be delivered through chamber 42^a into the corresponding overhead hot air flue 16.

When goods being fired require salt glazing, they are first brought to the desired temperature in any of the ways hereinbefore mentioned and vapourized salt brought into contact with them. By way of example, it will be assumed that the goods are heated by a down draught flame. The process of glazing is then carried out by introducing salt through openings formed for this purpose in the walls of the oven, in close proximity to the burners, the salt being fed forward by means of screw conveyors or other suitable distributing mechanism so that the quantity thereof and period of glazing can be regulated at will. The salt is immediately volatilized by and mixes freely with the flame which then reaches the goods, the salt combining with the silica in the clay thereof and forming therewith a glaze on the goods. The exhaust gases, pass under the truck platform and entering the side flues 11, pass away to the external atmosphere as before, so that the on-coming goods do not come in contact with any salt fumes until they have reached a temperature high enough to bring about the chemical change.

For distributing the salt, there may be arranged in the walls of the oven, in close proximity to the main burners, or some of them earthenware pipes 56, inside each of which is a screw conveyor 57 driven at any speed to suit requirement. Immediately over the conveyors is a hopper 58 containing the salt, and as the conveyors revolve slowly the salt is conveyed through the pipes and discharged through passages 56^a on to the top of the side flues 11 inside the oven in such a position that the flames pass through it, carrying it forward to the goods as hereinbefore described. Or, as shown in Fig. 3^a, the salt may be distributed to the burners by chutes 59 connected to hoppers 60 inside each of which is arranged a drum 61 having a series of blades or paddles arranged round its circumference. The arrangement is such that as each pair of blades comes under the hopper, a quantity of salt enters the drum, and as the drum revolves slowly, the salt is discharged into the chutes 59 leading to the burners, the salt being finally discharged, as before on to the top of the side flues 11 or in such other position that the flame will carry it forward to the goods.

Instead of distributing the salt as hereinbefore described it may be vapourized in a separately heated vessel and the vapour passed into the furnace through the oven flames.

The following arrangement may be adopted for cooling the trucks. Fixed to opposite sides of each truck base 9 are metal plates 62, hereinafter called apron plates, and resting on the floor of the oven are

longitudinally arranged channel plates 63, which are filled with sand and extend from one end of the oven to the other, so that as the trucks travel along the oven, the apron plates 62 dip into the sand and form an efficient seal, isolating the upper portion of the oven from the lower portion, as is usual in other types of tunnel ovens. Between the rails 64 in the base of the oven on which the trucks travel, are arranged pipes 65 (Figs. 2^a and 3) through which air or steam, or both, under pressure, is or are caused to flow, these pipes extending to a point beyond the furnace zone D. At intervals in the furnace zone, these pipes are provided with a series of outlet branches 66 each discharging into an open ended bent pipe 67 of much larger diameter. One end of each of these bent pipes is connected to the corresponding air flue 5, the other end of the pipe communicating with the space underneath the truck. The arrangement is such that the pressure of the air discharged from the outlet branches 66 into the bent pipes 57, induces a flow of air to take place underneath the trucks, on the same principle as a steam and water injector, this air then entering the flues 5 in the brickwork and in cooling the latter becomes heated and is used for supporting combustion, as hereinbefore described. The air inlet pipes 65 may, as shown in Fig. 10, be extended beyond the furnace zone D and air be caused to issue from each of them through an outlet 66^a into one end of a bent pipe 67^a the other end of which opens into the aforesaid flue 42^b of the corresponding recuperator 42, so that the air escaping from such outlet 66^a will induce hot air to flow from below the goods G into the corresponding recuperator and thence into the overhead hot air flue 16, this supplementary air being afterwards used for supporting combustion at the main and supplementary burners. Thus, it will be seen that the recuperators 42 may receive air from three different sources. Hot air may also be delivered from the overhead hot air flues 16 through outlet 16^a and thence over the flues 11 to the interior of the oven.

Fig. 13 shows how the furnace zone portion of the oven can be modified to adapt it for working with upwardly moving flames. For this purpose the oven is provided on each side, at each burner position, and below the side flues 11, with ports 68 through each of which gas and air supplied through the damper controlled ports 2 and 4 can be supplied and burnt below the perforated platform 8 of the truck 9, the resulting flames passing upward through the goods G and entering the top of the side flues 11 as indicated by arrows. Salt for glazing purposes may be admitted to each flame through a chamber 69.

Fig. 14 shows a modification of the construction shown in Fig. 10, suitable for use

where the lateral space for the oven is limited. In this case the side flues 11 are each made of rectangular cross section, its outer side wall being formed by the corresponding side wall 70 of the oven and the top of each flue is in communication through openings 11* with a flue 71 formed between the roof 72 of the oven and a lower crown or roof 73. The latter is provided with a longitudinal row of outlet openings 74 through which upwardly flowing flames and products of combustion can pass from the furnace zone into the flue 70 and thence to the side flues 11.

Fig. 15 shows a modification of an oven for producing downwardly moving flames, suitable for use where the lateral space for the oven is limited, the section being taken through the oven in different transverse planes. In this case each side flue 11 is also of rectangular shape and has the outer wall constituted by the adjacent side wall 70 of the oven, as in Fig. 11, but it has inlets 11* at its lower end for flame and products of combustion. Also, the gas from each side main 3 is supplied at each burner position through a damper controlled passage 2* in the corresponding side wall 70 of the oven to a combustion chamber 75 formed between the top wall 72 of the oven and a lower crown or roof 73 and into which air is also supplied from each side main 5 through a conduit 4* extending upward through the corresponding side flue 11. The flame resulting from the combustion of the gas and air in the chamber 75 passes downward through holes 76 in the crown or roof 73 and through the goods G in the furnace zone the products of combustion entering the side flues 11 through the lower inlets 11* therein. In this case, glazing salt may, when required, be dropped from salt distributing means 60, 61 and 59 through the holes 76 in the crown 73 and into a receptacle 77 carried by the goods and be vapourized by the flame present.

The arrows in Figs. 13, 14 and 15 indicate the direction of flow of the gas, air, flame and products of combustion.

At the inlet end of the oven, in each case, the hot exhaust gases may be passed through a water tube boiler before reaching the atmosphere. By means of a separate pump the hot water from the hot water heater 44-44^a (Figs. 1^b and 9) is pumped into the boiler where it is converted into steam, this steam being afterwards used for driving a turbine or other engine for propelling the trucks through the oven for driving the fan to withdraw exhaust gases, and for supplying steam if required, for the gas producer. In this way, practically the whole of the heat in the system can be utilized, except that lost by radiation, which is reduced to a minimum by an efficient system of insulation, thus effecting a very large economy in fuel.

What I claim is:—

1. In a direct flame tunnel oven, a furnace zone for goods, having at each side thereof a number of burners and a flue, the burners being arranged to deliver flame into the furnace zone between the side flues and the side walls of the furnace zone and the side flues being in communication with the furnace zone, and means whereby flame is enabled to take various courses longitudinally and transversely through the goods.

2. In a direct flame tunnel oven, a furnace zone for goods, having at each side thereof, a number of separately controlled burners adapted to deliver flame into the furnace zone, and a flue in communication with the furnace zone, and one or more supplementary burners arranged in each flue.

3. In a direct flame tunnel oven, a furnace zone for goods, having at each side thereof, a number of separately controlled burners adapted to deliver flame into the furnace zone, and a flue in communication with the furnace zone, and one or more supplementary burners arranged in each flue, each of the latter burners comprising gas and air ports in the floor of the flue, and separate gas and air ducts for delivering gas and air to said gas and air ports.

4. In a direct flame tunnel oven comprising preheating, heating, equalizing and furnace zones through which the goods to be treated successively pass, flues arranged at each side of each of the said zones, the flues being normally in communication with each other, and the flue at each side of the furnace zone being in communication with that zone, and means for separately controlling the flow of hot gases through each set of side flues.

5. A direct flame tunnel oven according to claim 4, wherein the side flues at opposite sides of the equalizing zone are in communication with each other through an overhead flue.

6. A direct flame tunnel oven according to claim 4, wherein the side flues at opposite sides of the equalizing zone are in communication with each other through an overhead flue and each of said flues is provided with controlled gas and air ports to form burners whereby the said flues can be heated.

7. A direct flame tunnel oven according to claim 4, wherein the roof of the heating zone is provided with valve controlled outlet apertures for moist air and with an exhaust duct with which said apertures can be placed in communication and which is adapted to be placed in communication with the external atmosphere.

8. A direct flame tunnel oven according to claim 4, wherein the roof of the heating zone is provided with valve controlled outlet apertures for moist air, and with an exhaust air duct with which said apertures can be placed in communication and which is adapted to be placed in communication with the external at-

mosphere, and the flues at opposite sides of the said heating zone are provided at their inner sides with moist air inlet ports controlled by dampers.

5 9. A direct flame tunnel oven comprising preheating, heating, equalizing, furnace and cooling zones through which goods to be treated successively pass, flues at opposite sides of the preheating, heating, equalizing and furnace zones, the set of flues at each side of the oven being normally in communication with one another, the flues at each side of the furnace zone being in communication with that zone through openings in their inner walls, 10 exhausting means connected to the exit ends of the flues at opposite sides of the preheating zone, dampers adapted to close the communication between the flues at each side of the furnace and equalizing zones, damper controlled inlets whereby the flues at opposite sides of the heating zone can be placed in communication with that zone, means for separately controlling the communication between the exit ends of each set of flues and the ex- 15 hausting means, burners for delivering flame into the furnace zone from opposite sides thereof and supplementary burners within the flues at opposite sides of the furnace zone.

10. A direct flame tunnel oven according to claim 9, wherein the flues at opposite sides of the equalizing zone are in communication with each other through an overhead flue.

11. A direct flame tunnel oven according to claim 4, wherein the side flues at opposite 20 sides of the preheating zone, consist of two sets of tubes of good heat conducting material, longitudinal screens arranged at opposite sides of the said zone and each adapted to form with the corresponding side wall of the oven, a chamber through which the corresponding set of tubes extend longitudinally and transverse walls arranged between each screen and the corresponding side wall of the oven and adapted to subdivide the corre- 25 sponding chamber into a series of vertical compartments the first of which, at the inlet end of the oven, is adapted to be placed in communication with a source of air supply, and an exhaust flue in communication with the last compartment, said screens being 30 formed with upper and lower openings arranged to enable air to circulate through the said compartments and the preheating zone in a helical manner, substantially as described for the purpose set forth.

12. In a direct flame tunnel oven, a furnace zone having at each side thereof a number of gas burners and a flue in communication with the said furnace zone, each gas 35 burner comprising valve controlled gas and air ports and a combustion chamber in communication with the furnace zone, gas ducts each common to all the gas supply ports at one side of the furnace zone, a number of air 40 ducts at each side of the said zone, each com-

municating with one of the air supply ports at the corresponding side of the oven, a number of compressed air supply pipes extending along the floor of the oven below trucks carrying goods and each provided with outlet 45 branches and pipes of larger diameter than said branches and into which the said branches can deliver compressed air, said pipes being each in communication at one end with the space at the bottom of the oven below the trucks therein and at the other end with one of the hot air ducts connected to the gas supply port of a burner. 50

13. In a direct flame tunnel oven, a furnace zone for goods, having at each side thereof, a number of separately controlled main gas burners with combustion chamber adapted to deliver flame into said furnace zone and a flue in communication with said zone, a number of supplementary gas burners adapted to produce flame in each flue, each main and supplementary burner comprising valve controlled gas and air supply ports, gas supply ducts in the base of the oven communicating with the gas supply ports of the main and supplementary burners; hot air supply ducts arranged in the base of the oven and connected to the air supply ports of the main burners and overhead hot air supply ducts adapted to be connected to the air supply 55 ports of the supplementary burners.

14. In a direct flame tunnel oven, heat recuperators arranged at each side of the cooling zone of the oven and immediately adjacent to the furnace zone, each recuperator comprising a chamber charged with chequer brickwork and having a valve controlled air inlet passage leading to one end thereof and a hot air outlet passage at the other end thereof and an overhead hot air flue extending from the hot air outlet passage longitudinally of the corresponding side of the oven, adjacent to the furnace zone of the oven. 60

15. In a direct flame tunnel oven, heat recuperators arranged at each side of the cooling zone of the oven and immediately adjacent to the furnace zone, each recuperator comprising a chamber charged with chequer brickwork and having a valve controlled inlet passage leading to one end thereof and a hot air outlet passage at the other end thereof, an overhead hot air flue extending from the hot air outlet passage longitudinally of the corresponding side of the oven, adjacent to the furnace zone of the oven, and compressed air supply pipes extending along the floor of the oven to the furnace zone and there connected to the air inlet ends of the two recuperators. 65

16. In a direct flame tunnel oven, air cooling means arranged above the cooling zone of the oven and near to the furnace zone of the oven, the said cooling means comprising a vessel traversed by a number of tubes around 70

which a cooling medium can be caused to flow, and air chambers located at the opposite ends of the tubes and communicating with the interior of the cooling zone at different points in the length of the latter.

17. In a direct flame tunnel oven, a cooling zone having at each side thereof, for part of its length, a goods cooling arrangement comprising a number of vertical compartments formed by and between the adjacent side walls of the cooling zone, the adjacent side walls of the oven and a series of transverse vertical divisions, and air tubes extending longitudinally through the compartments and transverse divisions and adapted to be placed in communication with the external atmosphere for admittance of cool air, the inner walls of said compartments being formed with upper and lower air inlet and outlet openings arranged to admit of air heated by goods in the cooling zone, passing into the upper portions of the said compartments, and after descending over and becoming cooled by contact with the air tubes passing through said compartments, re-entering the lower portion of the cooling zone and again coming in contact with the heated goods.

18. In a direct flame tunnel oven, a goods cooling arrangement at each side of the cooling zone of the oven and for part of its length, each cooling arrangement comprising a series of vertical compartments the inner walls of which, forming part of the side wall of the cooling zone, has upper hot air inlets and lower cool air outlets communicating with the cooling zone, and cold air supply tubes extending horizontally through the said compartments, a valve controlled air inlet connected to said tubes, an overhead hot air exhaust flue at each side of the cooling zone, a heat recuperator arranged at each side of the cooling zone, adjacent to the furnace zone of the oven, and having a valve controlled inlet passage for admission of cool air to one of its ends, and a hot air outlet passage at its other end, an overhead hot air flue connected to said hot air outlet passage and extending along the side of the oven adjacent to the furnace zone portion thereof, and means whereby the hot air leaving the said tubes can, at will, be directed into the corresponding overhead exhaust flue or into the corresponding recuperator.

19. In a direct flame tunnel oven, a furnace zone having at each side thereof, a number of gas burners and combustion chambers, and a flue having in its inner wall a number of openings in direct communication with the furnace zone, the combustion chambers extending upward between each flue and the adjacent side of the oven and communicating with the interior of the furnace zone over the top of the flue, means for delivering salt for glazing goods in the furnace zone on to the top of the flue, and cars adapted to pass

through the tunnel, each car being provided with a perforated platform for supporting the goods, this platform having a space beneath it which as the car moves along comes adjacent the aforesaid openings, whereby the products of combustion carrying the glaze will pass down through the goods and the holes in said platform and thence into said flue.

Signed at Hamworthy, Poole, Dorset, this 21th day of October, 1927.

JOHN WILLIAMSON.