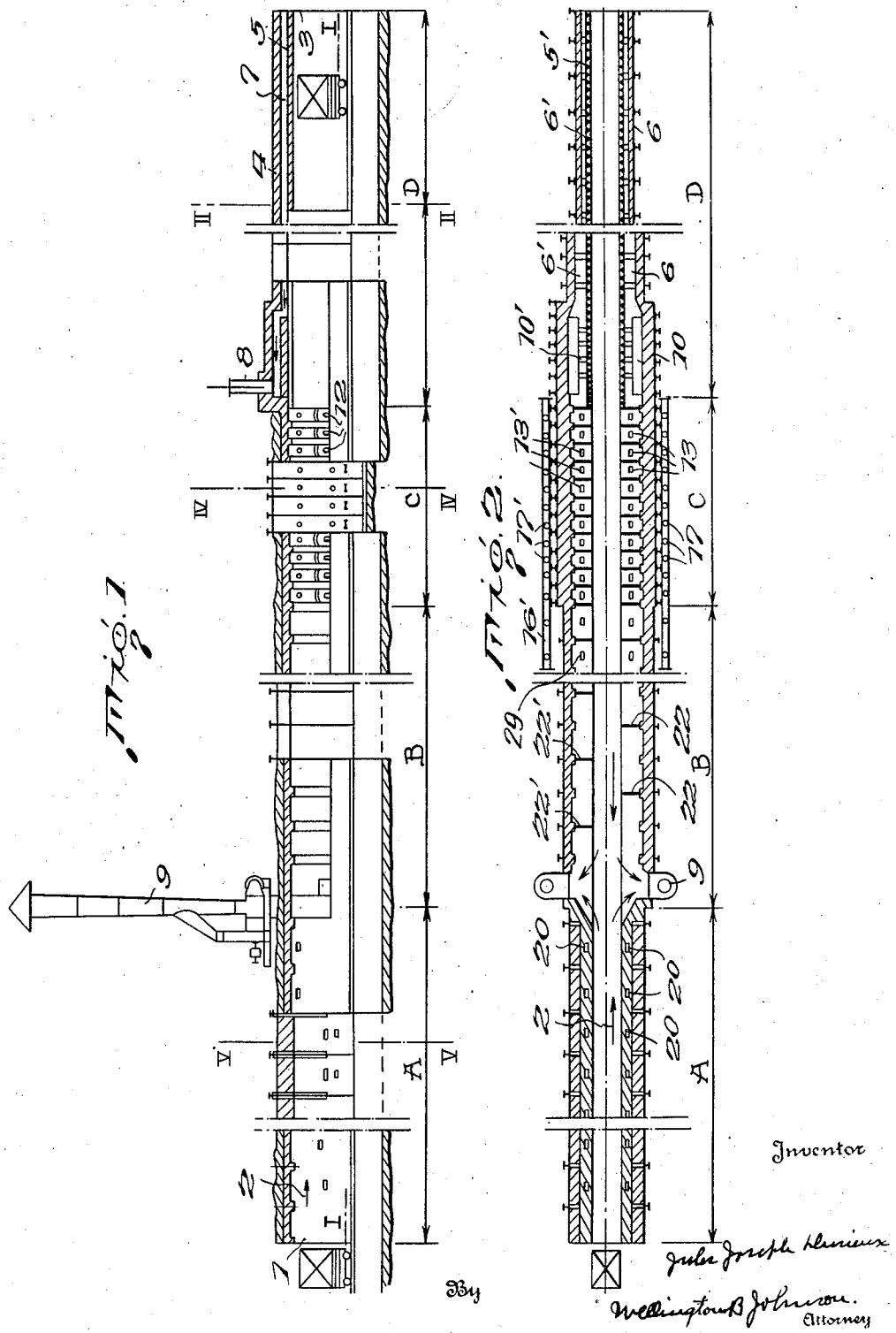
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TUNNEL KILN

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Fig 3

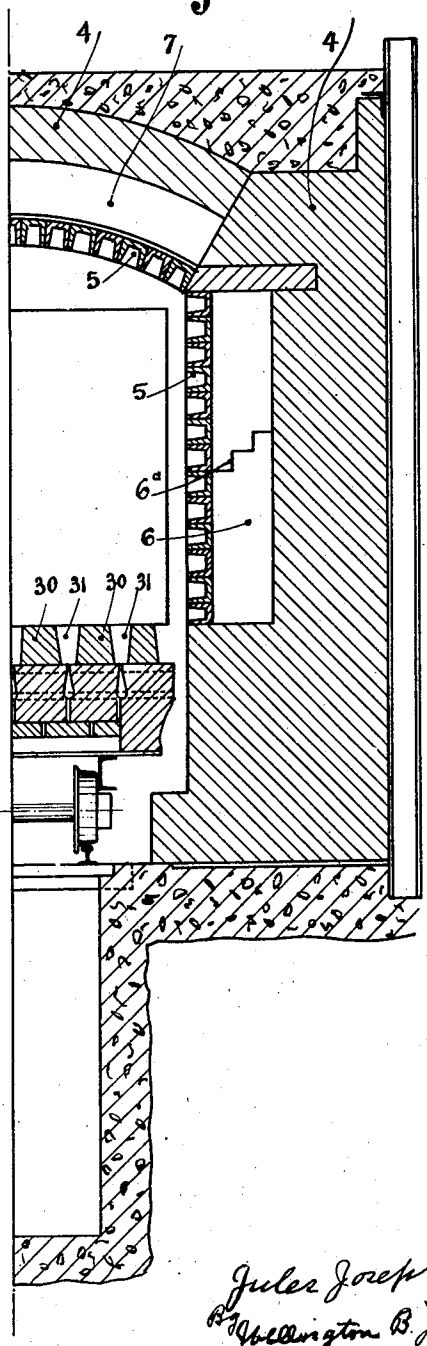
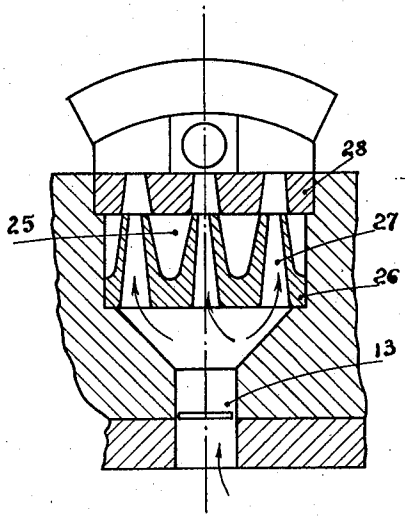


Fig 9



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Fig. 5

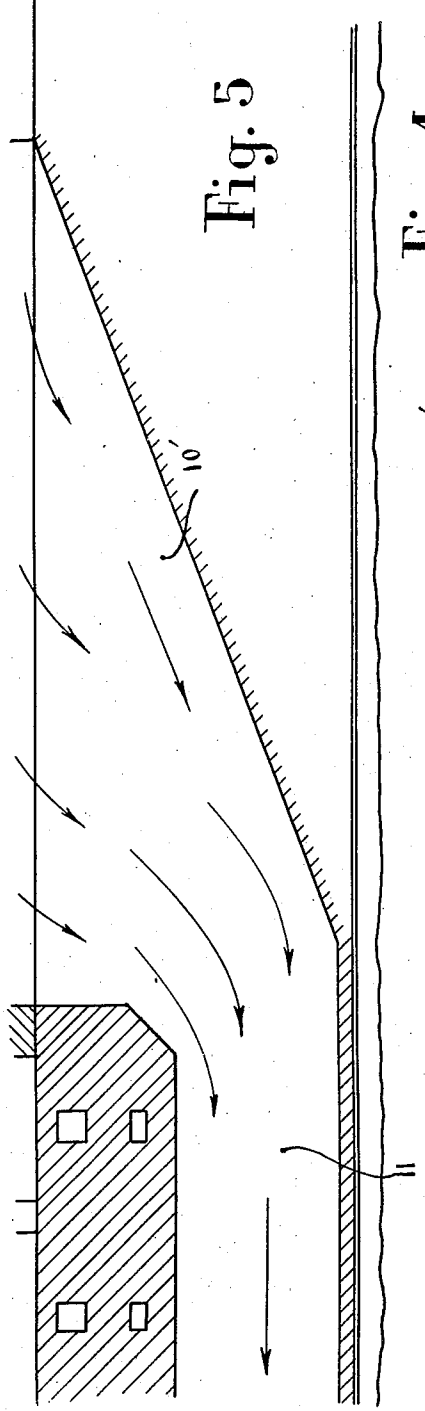
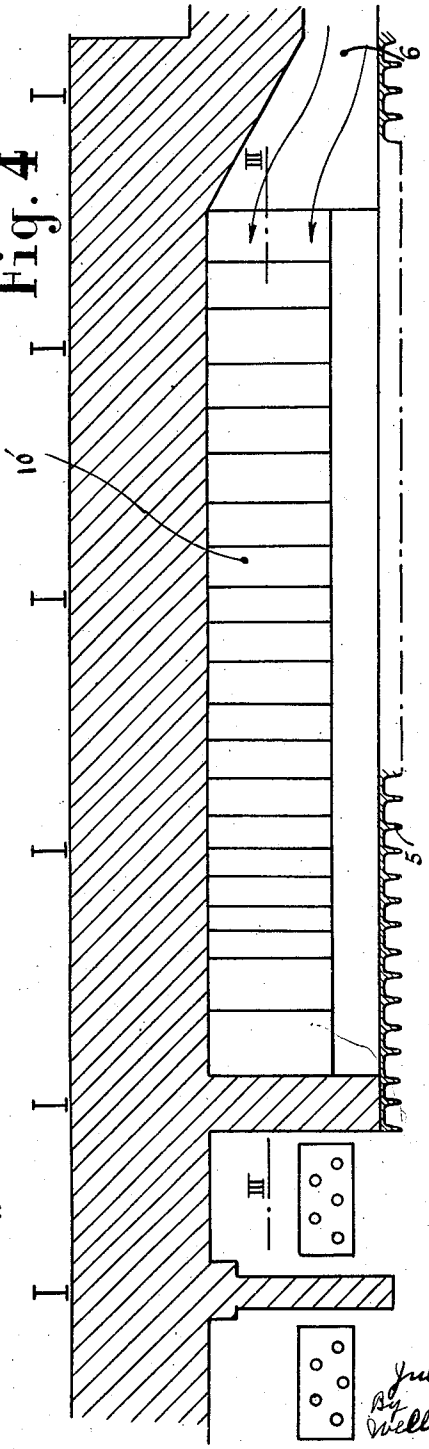


Fig. 4



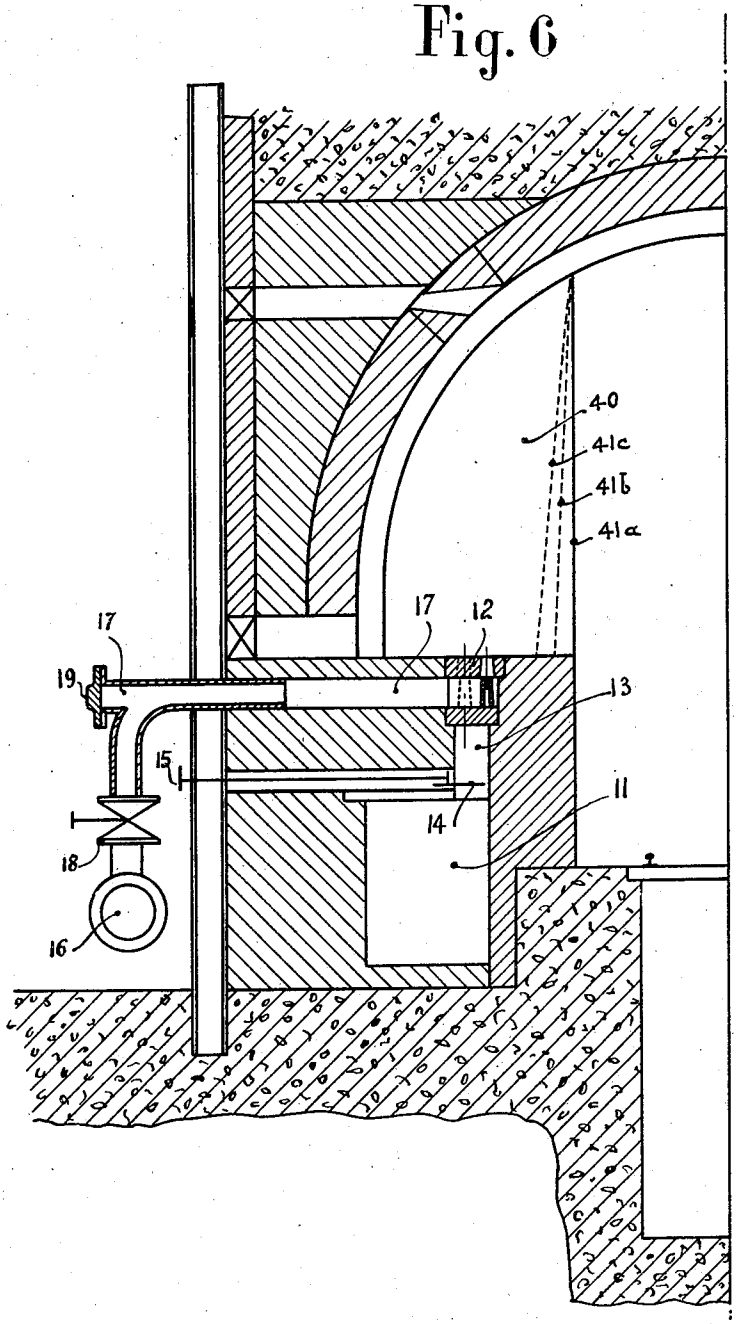
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Fig. 6



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Fig. 7

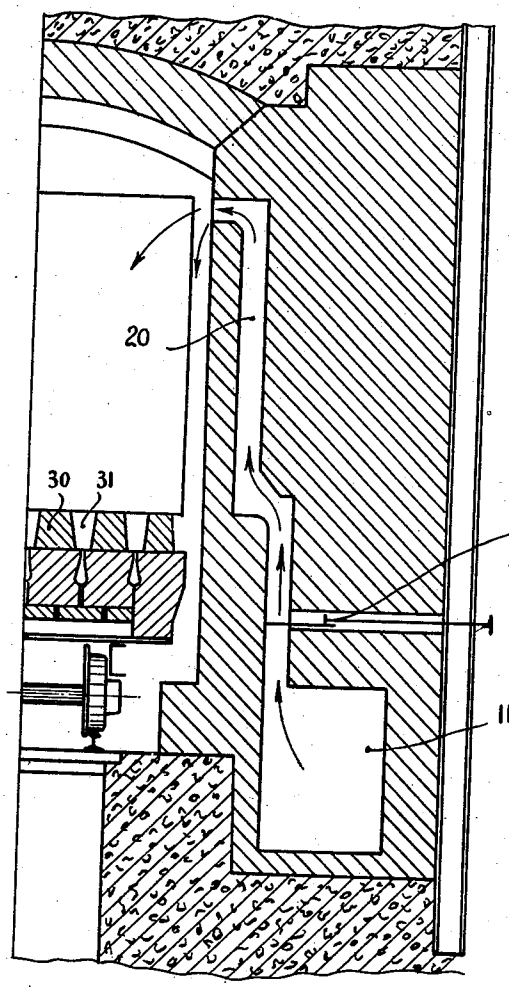


Fig. 10

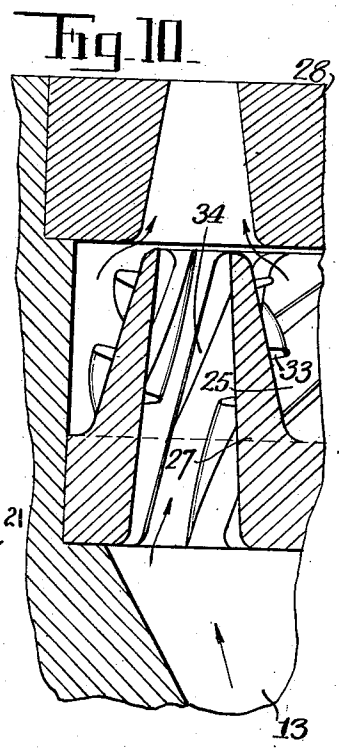


Fig. 11

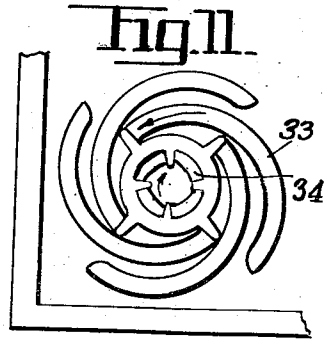
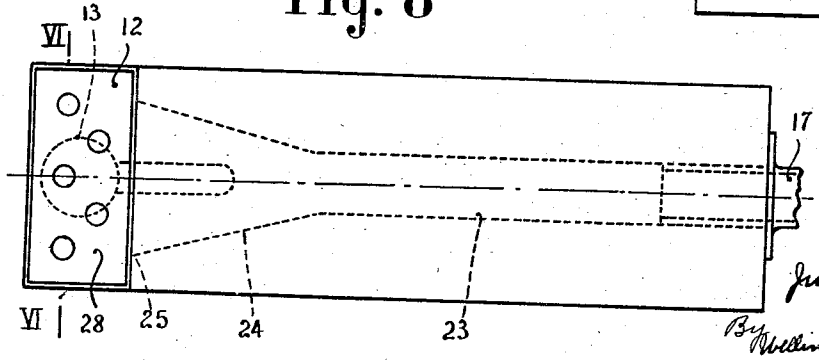


Fig. 8



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2,180,041

TUNNEL KILN

Jules Joseph Durieux, Chatou, France

Application July 2, 1935, Serial No. 29,523
In France July 2, 1934

17 Claims. (Cl. 25—142)

The present invention relates to improvements in tunnel kilns of the type in which air for the combustion is fed to the burners of the burning zone by means of the draft of the kiln, after having served to cool the baked articles. These improvements are intended to obtain a better efficiency of the kiln and also to facilitate the operation and the regulation of said kiln.

The following arrangement has been employed in kilns of the kind above referred to: The air entering the kiln on the side from which the baked articles are removed is heated by its contact with said articles and then, moving on inside the kiln, reaches successively the burners distributed along the walls of the kiln. In this arrangement, the distribution of air to the burners takes place in a very irregular manner. The burners that are closer to the air inlet are fed with too great an amount of air while the other burners do not receive a sufficient amount of air or, more exactly, are fed with air which has lost a higher and higher amount of oxygen. These last mentioned burners may thus give a reducing flame which is detrimental to the good working of the kiln.

As the amount of air that is necessary for cooling the baked articles treated in the kiln is always greater than the amount of air necessary for the combustion of the gas at the burners, it has also been suggested to by-pass a portion of the air thus preliminarily heated and to feed this portion to the preheating zone of the kiln. This result was obtained by causing said portion of the air to flow through a passage provided at the upper part of the kiln. This arrangement has the drawback of requiring, in the portion of the kiln subjected to the greatest variations of temperature, the construction of superposed vaults for providing the passage in question, although this portion of the structure is liable to injury from many causes.

The chief object of the present invention is to provide a tunnel kiln which obviates these drawbacks.

An essential feature of the present invention consists in disposing the burners in parallel, on either side of the kiln, these burners being connected with a main air conduit disposed laterally at the lower part of the kiln, along the burning zone of said kiln, in such manner that the heated air from the cooling zone flows through said conduit and each burner receives from said conduit, through an adjustable feed intake, the necessary amount of air, the fuel gas being also supplied from a main conduit through an adjustable feed intake.

Another feature of the present invention consists in heating the air that is admitted to the cooling zone of the kiln not by direct contact with the baked articles but by radiation from and conduction through the wall of a muffle extending along said cooling zone and separated from the wall of the kiln by one or several channels through which the air admitted to the kiln moves along a zig-zag path.

Still another feature of the present invention consists in evacuating the excess of cooling air through a passage provided in the top of the kiln and extending along the cooling zone thereof.

Still another feature of the present invention consists, in the case in which the fuel is a gaseous fuel, in constructing each burner with several nozzles, disposed in staggered arrangement, and parallel to the axis of the kiln, with a view to obtaining complete combustion at the very outlet of the burner, so that the heat of the flames may radiate over the greatest possible length of the ware to be treated.

Still another feature of the present invention lies in a special construction of burners provided with a plurality of nozzles as above mentioned, this construction being applicable to burners for a tunnel kiln of any kind whatever.

Still another feature of the present invention consists in prolonging under the preheating zone as far as the drying zone of the kiln the main air conduits which, on either side of the kiln, convey to the burners the air that has been heated in the muffle, with a view to feeding into this drying zone hot air that contributes to the drying and the heating of the articles to be baked.

Still another feature of the invention consists in providing in the refractory platforms of the cars that carry the ware, longitudinal channels which are chiefly intended to distribute expansion without producing outward thrusts and which also serve to facilitate the circulation of hot gases under the ware.

Other features of the present invention will be seen to result from the following detailed description of a specific embodiment thereof.

A preferred embodiment of the present invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example, and in which:

Fig. 1 is a diagrammatic vertical section of the tunnel kiln;

Fig. 2 is a horizontal sectional view on the line I—I of Fig. 1;

Fig. 3 shows on an enlarged scale a part of a cross section of the cooling zone of the kiln, on the line II—II of Fig. 1;

Fig. 4 shows in vertical section on an enlarged scale the part 10' of Fig. 2;

Fig. 5 is a vertical sectional view on the line III—III of Fig. 4;

Fig. 6 is a vertical sectional view of a part of the kiln in the burning zone thereof, taken on the line IV—IV of Fig. 1;

Fig. 7 is a transverse vertical sectional view on the line V—V of Fig. 1;

Fig. 8 is a horizontal diagrammatic view of a burner according to the present invention:

Fig. 9 is a vertical section on the line VI—VI of Fig. 8;

Figs. 10 and 11 are an axial sectional view and a plan view, respectively, of a modification of the nozzle of a burner.

The kiln illustrated by the drawings is a tunnel kiln, employing a gas as fuel and in which the flames are of the naked type.

This kiln may include, in the known manner, a drying zone A, a preheating zone B, a burning zone C, in which are disposed the burners, and a cooling zone D. The ware carried by cars circulates through this tunnel kiln, entering for instance at I and moving inside the tunnel in the direction of arrow 2, the baked articles being discharged at the opposite end of the kiln, that is to say at 3.

The air serving for the combustion of the fuel is admitted into the kiln at this end 3, and it circulates in a direction opposed to that of the motion of the ware, as it will be hereinafter explained.

The tunnel kiln, in the cooling zone thereof, designated by D (Figs. 1, 2 and 3), is constituted by an outer masonry work 4 and by an inner muffle 5 extending over the whole of said zone. This muffle is made of honeycomb bricks and is separated from the outer masonry work by spaces 6, 6' in the lateral walls of the tunnel, and a passage 7 at the top of the tunnel. These spaces and this passage open into the atmosphere at the end 3 and their orifices may be more or less stopped by closing devices not shown in the drawings.

The external air that is admitted into these spaces and which moves toward the burning zone of the kiln heats up by contact with the walls of the muffle and takes off from said walls the heat imparted thereto by the baked articles.

The walls of the muffle are connected to the outer masonry work by cross members 6a (Fig. 3), which act as baffles and compel air to move along a zigzag path.

The cross sectional area of passages 6, 6', and 7 for air increases gradually from the end 3 of the tunnel toward the other end of the cooling zone, in order to correspond to the gradual increase of volume of the air that is being heated in these passages.

Cold air penetrates into the passage 7 provided in the top part of the tunnel and circulates therein under the effect of the suction of vertical conduit 8, mounted substantially in the vertical plane of the other end of the cooling zone, said conduit being connected either to a chimney opening into the atmosphere or to a system of pipes for the heating of drying chambers or other rooms.

Cold air penetrates into spaces 6, 6' and circulates therein either under the action of the main aspirator, located at 9, at a suitable point of the preheating zone, or under the action of an air blast forcing air through the inlet orifices.

The air passages 6, 6' are provided at their ends with downwardly directed connection passages 10, 10', of gradually decreasing cross section, playing the part of Venturi tubes and shown on an enlarged scale in horizontal section and in longitudinal cross section in Figs. 4 and 5 respectively. These connection passages open respectively into air flues 11, 11', disposed laterally on either side of the kiln, along the burning zone thereof, in the lower part of the masonry works, under the sets of burners 12, 12'.

The burners 12 of a set of burners (Fig. 6) are fed with hot air from air flue 11 through vertical conduits 13. The adjustment of the rate of flow through these conduits is obtained by means of horizontal metallic registers 14, operated from the outside by means of levers 15. The fuel gas is fed from conduit 16 through metallic tubes 17, each of which is provided with a regulating valve 18 and eventually with a sight hole 19. The feed of the other set of burners 12' on the other side of the kiln is effected in an identical manner from hot air flue 11' and gas conduit 16'. The burners are thus fed individually, each from a conduit of hot air and a conduit of gas, both of which are adjustable, which makes it possible to obtain a predetermined mixture of air and gas at the very outlet of the burners.

Flues 11 and 11' extend under the burning zone and beyond the end thereof under the preheating zone B. They lead either to the smoke exhaust 9 or, beyond this point, to the drying zone A when the articles to be baked are to be dried before entering the preheating zone. In the latter case, the hot air circulating through the flues is distributed in the drying zone of the kiln through a series of vertical ascending passages 20, 20' (Figs. 2 to 7) the cross sections of which are adjustable by means of horizontal gates 21, said passages opening into the kiln at different levels. Hot air, after having absorbed the moisture present in the articles to be baked, is finally drawn, in the direction of arrow 2, toward the suction device 9 through which it is evacuated together with the smoke.

I might also provide, in the portion of the air flues extending under the preheating zone, vertical conduits branching off from flues 11, 11' and opening into the kiln so as to allow a portion of the hot air circulating through the air flues to escape into said zone of the kiln in which it mixes with the gases.

In the preheating zone, the path of travel of the gases is preferably rendered sinuous immediately after the outlet from the burning zone by means of baffles, consisting of refractory partitions 22, 22', disposed in staggered relationship (Fig. 2). This arrangement causes the gases to travel along a zigzag-shaped path in the horizontal plane and to flow more satisfactorily along the articles that are being preheated.

An essential condition of good working of a tunnel kiln is the complete combustion of the gas serving for the heating of the kiln as this gas escapes from the burners. In order to comply with this condition, and also in order to distribute the flames in the form of an elongated curtain, as uniformly as possible, in the direction of the length of the kiln, the burners are given the form of the device shown in Fig. 6 and, on an enlarged scale, on Figs. 8 and 9, which device has the further advantage of having a good resistance to the action of fire.

The gas, issuing from tube 17, before entering burner 12, passes into a masonry conduit 23, widening at its end at 24 (Fig. 8). Then said gas enters a chamber 25 and when issuing therefrom it draws hot air from conduit 13 along with it, the whole then passing into the nozzle or nozzles of the burner. Instead of burners having each a single nozzle, I employ, preferably, burners including each several nozzles disposed in staggered relationship parallel to the axis of the kiln. At the top of vertical conduit 13, there is provided a plate 26, made for instance of a ceramic material (Fig. 9) and provided with a plurality of tapered nozzles 27. These nozzles, which serve for the inflow of air, project from the upper face of the plate. Above this plate 26 there is provided another plate 28, also made of a refractory material and which forms one of the walls of the chamber 25 into which the fuel gas is fed. This second plate is provided with tapered holes which fit upon nozzles 27, respectively, so as to form an arrangement similar to an ejector. The fuel gas entering chamber 25 on the outside of nozzles 27 enters the furnace through the orifices of plate 28, drawing along, together with it, air from said nozzles.

The mixture of the two fluids that is formed at the outlet of nozzles 27 can be rendered more intimate in the following manner: The outer wall of the nozzles or the inner wall, or both (as shown in Figs. 10 and 11) are provided with helical ribs, shown respectively at 33 on the outer wall and at 34 on the inner wall.

The fuel gas, which flows along ribs 33, is given a rotary motion which is combined with its ascending motion. The same is true of the air flowing inside the nozzle. This whirling motion ensures a more intimate mixture of air and fuel gas and consequently improves combustion. There may be, of course, any number of ribs on each of the walls and said ribs may wind in the same direction on both walls, or, on the contrary, in opposite directions on said respective walls.

Plates 26 and 28 might also be made of a metal adapted to resist heat.

The respective burners may be separated from one another by partitions 40 (Fig. 6) extending inwardly close to the lateral sides of the stack of ware supported by the kiln cars.

Preferably, according to the present invention, the inner edges of these partitions are more and more remote from the sides of the stack of ware, as shown at 41*a*, 41*b*, 41*c*, etc., in the direction of flow of the gases, so as to afford a passage of increasing section for said gases between said respective edges and the lateral sides of the stack of ware.

When it is desired to bake the articles in a reducing atmosphere, these articles must be subjected, as soon as they enter the preheating zone, to the action of smoke containing an excess of unburnt gas. This kind of atmosphere can be obtained in a simple manner with the kiln according to the present invention by suitably adjusting, in the burning zone, the registers and gates through which the respective rates of feed of air and gas are adjusted.

When, on the contrary, the reducing atmosphere is required only in the preheating zone and the baking proper must take place in an oxidizing atmosphere use is made of means for feeding gas into the preheating zone of the kiln.

These gas feeding means supply gas, without burning it, as shown at 29, this reducing gas mixing with the smoke and travelling together with it toward the outlet.

The ware is generally transported inside the kiln on cars the platform of which is made of a refractory material. Advantageously, this platform is provided with longitudinal channels, as explained. It will be for instance constituted as shown by Fig. 7 of juxtaposed refractory elements 30, leaving between them channels 31, the cross section of which is so chosen as to permit of easily passing a poke bar therethrough.

While I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. A horizontal tunnel kiln which comprises, in combination a burning zone, a plurality of burners arranged in a horizontal longitudinal row in said zone, collective air feed means for said burners in said zone, individual air feed means leading from said collective means to each burner, and a cooling zone having at least one horizontal passage provided in its wall, said passage opening directly into the atmosphere at one end of the kiln and into said collective air feed means at the other end.

2. A tunnel kiln which comprises, in combination, a burning zone, at least one row of burners distributed along said zone, one conduit at the lower part of said zone extending in the longitudinal direction thereof, for feeding air to said burners, means for connecting each of said burners individually with said conduit, and a cooling zone having an air passage in its side walls, throughout the length of said zone, and of the height of the stack of ware moving the tunnel, said passage opening into the atmosphere at one end of the kiln and into said air feed conduit at the other end.

3. A tunnel kiln which comprises, in combination, a burning zone, two rows of burners distributed along said zone, one on either side thereof, an air feed conduit below each row of burners extending in the longitudinal direction thereof, means for connecting each of the burners of a row individually with the air feed conduit located below said row, a cooling zone having double vertical walls arranged in such manner that the space between the two wall elements of each vertical wall forms a lateral passage opening at one end of the kiln into the atmosphere the other end of the passage entering into one of said conduits, respectively, and a preheating zone communicating with said burning zone whereby the burnt gases can pass from said burning zone into said preheating zone.

4. A tunnel kiln according to claim 3 further including partitions provided in each of these passages and extending over a portion of the height thereof, said partitions being located alternately at the upper part and at the lower part of said passage so as to cause air flowing through said passage to move along a sinuous path.

5. A tunnel kiln according to claim 3 in which the cross section of each of these passages increases from the end thereof at which it opens into the atmosphere toward the end thereof at which it opens into the corresponding air feed conduit of the burning zone.

6. A tunnel kiln according to claim 3 including between each of said passages and the corresponding air feed conduit a flaring passage the cross section of which gradually decreases in the direction of flow of air, that is to say from the first mentioned passage toward the air feed conduit.

7. A tunnel kiln according to claim 3 in which each burner includes a plurality of jets disposed in staggered rows parallel to the axis of the kiln.

8. A tunnel kiln according to claim 3 in which the inner cross section of the preheating zone is larger than that of the burning zone, further including transverse partition elements in said preheating zone extending from the lateral walls thereof to a distance from said walls, these partition elements being disposed in staggered relationship so as to compel the gases to move along a sinuous path in a horizontal plane.

9. A tunnel kiln according to claim 3 in which the top of the cooling zone of the kiln is double walled so as to form therein a passage for cooling air, said last mentioned passage opening into the atmosphere at one end of the kiln and being of the full length and width of said cooling zone.

10. A tunnel kiln according to claim 3 further including a fuel feed conduit under each row of burners, and means for individually connecting each of the burners of one row to the corresponding fuel feed conduit.

11. A tunnel kiln according to claim 3 further including means for individually adjusting the connecting means between each of the burners of a row and the air feed conduit located below said row.

12. A tunnel kiln according to claim 3 further including a fuel feed conduit under each row of burners, means for individually connecting each of the burners of one row with the corresponding fuel feed conduit, and means for separately adjusting said connecting means, respectively.

13. A tunnel kiln according to claim 3 in which said air feed conduits extend below the preheating zone, and vertical passages connecting the inside of said preheating zone of the kiln with said prolonged portions of the air feed conduits.

14. A tunnel kiln according to claim 3 further including a drying zone located adjacent said preheating zone, in which said air feed conduits extend below said drying zone, and vertical passages connecting the inside of said drying zone with said prolonged portions of the air feed conduits.

15. A tunnel kiln according to claim 3 further including means for adjustably feeding combustible gas into said preheating zone.

16. A tunnel kiln according to claim 3 further including transverse vertical partition elements between two consecutive burners of a row, said partition elements extending inwardly toward the axis of the kiln to a distance which decreases when moving inside the kiln toward the preheating zone thereof.

17. In a tunnel kiln, a muffle-like chamber arranged to permit passage of a stack of ware, and divided into a pre-heating zone, a heating zone, and a cooling zone, gas burners arranged along each side of the heating zone, an air chamber arranged at each side and immediately above said cooling zone, said air chambers being open to the atmosphere at the outer end of the cooling zone, the air chamber above the cooling zone ending in a passage open to the atmosphere, the air chamber at the sides of said zone ending in a passage which lies below the burners.

JULES JOSEPH DURIEUX.