July 9, 1929. W. L. HANLEY, JR 1,720,550

TUNNEL KILN

Original Filed Sept. 11, 1925 2 Sheets-Sheet 1

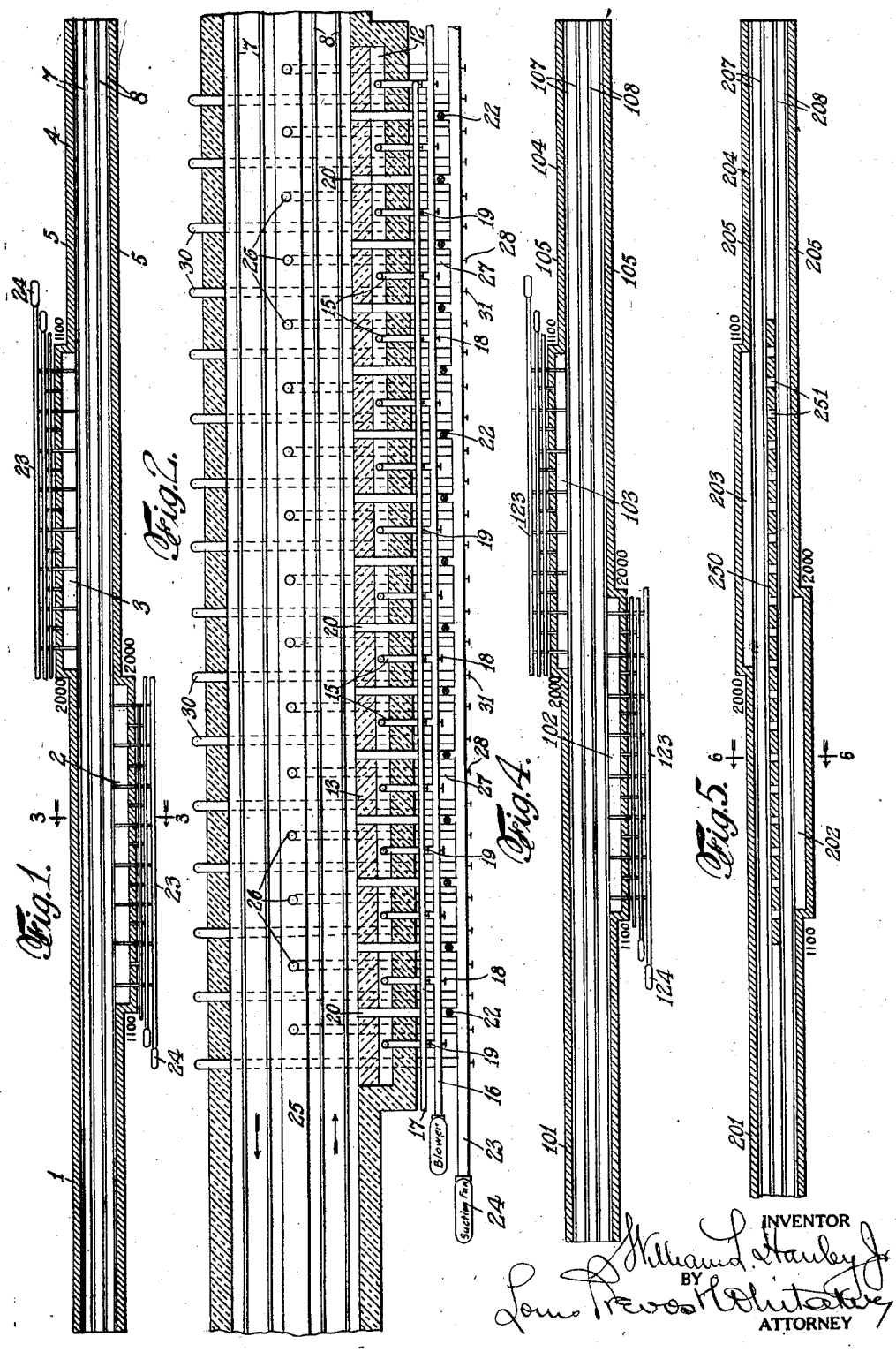

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Fig. 3.

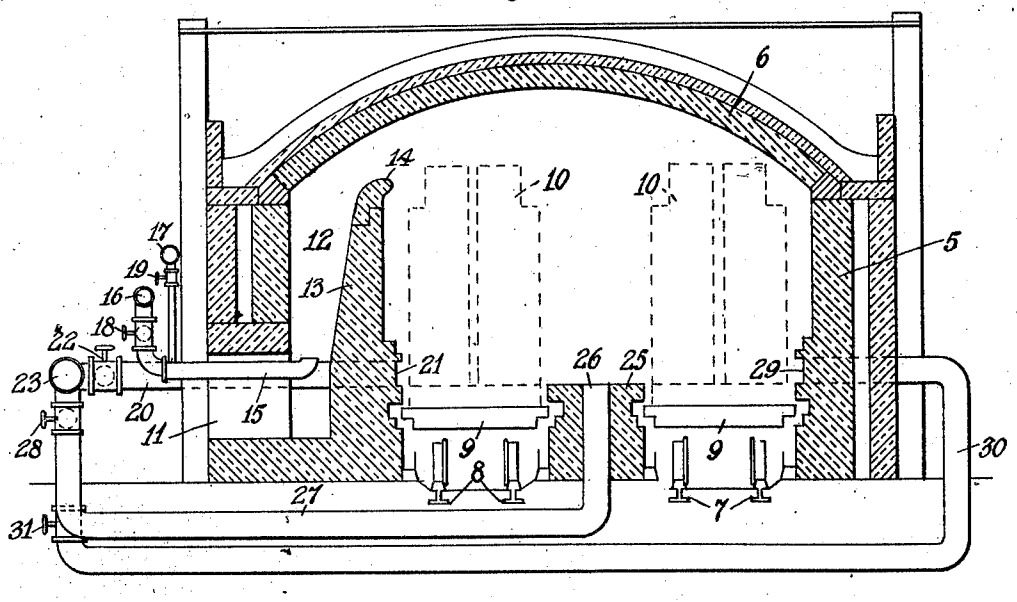
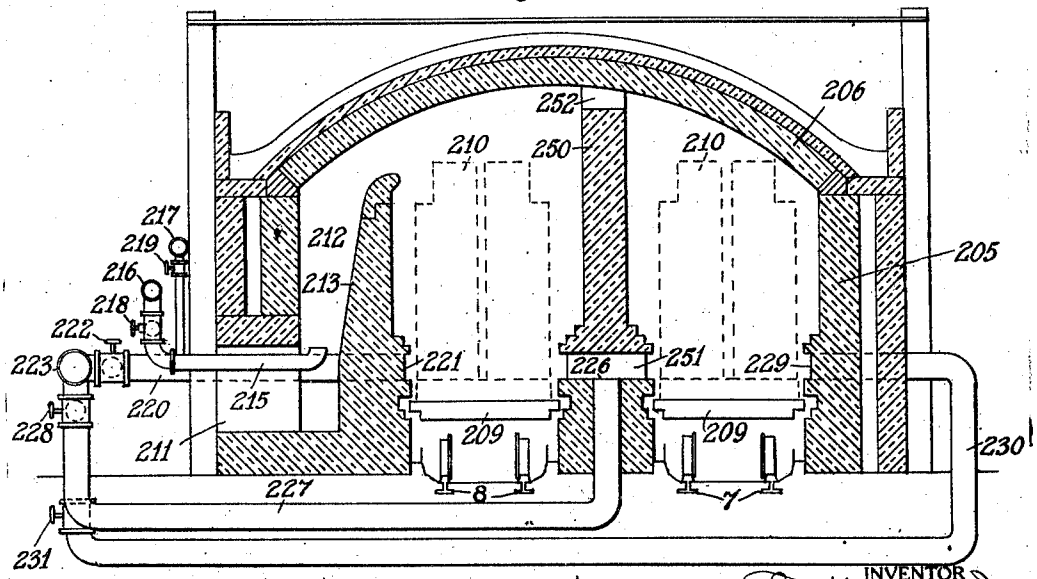


Fig. 6.



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UNITED STATES PATENT OFFICE.

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TUNNEL KILN.

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My invention consists in the novel features hereinafter described, reference being had to the accompanying drawings, which illustrate one embodiment of the same, and a slight modification thereof, selected by me for purposes of illustration, and the said invention is fully disclosed in the following description and claims.

My invention is an improvement in tunnel kilns, or ovens, designed more particularly for firing coarse clay products, such as bricks, fire brick, tile, etc., although my invention is applicable to kilns for firing other classes of goods where found desirable or advantageous. My improved tunnel kiln is of the type generally designated as a twin tunnel kiln, and provides two parallel tracks extending longitudinally throughout the length of the kiln, upon which two series of cars are loaded with the brick, or other coarse clay products to be fired, and moved in opposite directions, the bricks on each series of cars being progressively heated during a portion of their travel through the kiln, until they reach a firing zone, where they are completely fired, after which they are gradually cooled during the remainder of their passage through the kiln, the hot fired bricks carried by the cars of one track communicating their heat to the bricks on the cars of the other track moving in the opposite direction, for the purpose of effecting the cooling of the heated bricks, and the preheating, water-smoking and oxidation of the unfired bricks on the cars of the other track.

In the construction of twin tunnel kilns, the initial outlay for the erection of the same, is naturally very high, as these kilns are approximately 400 feet or more in length, and it is extremely desirable to provide a construction of kiln which can be built at as low an initial cost as possible. I have also found, by experiment, that in order to obtain such a high output as will make the kiln commercially practicable, and warrant the enormous initial expense, it is essential that the following factors shall be provided. For example, it is necessary to regulate the temperature of the firing zone so that it shall have a temperature at the entering end, of, say, from 1000° to 1400° F., or less than a firing temperature, and a temperature at the outgoing end of the firing zone of approximately 1800° to 2000° F., in order that the brick shall not be too suddenly exposed to firing heat, but shall gradually be brought to the desired firing temperature, so as to avoid injury to the product, and this must be true as to the bricks on both lines of cars passing in opposite directions. Obviously, therefore, the "heat curve" for one firing zone must be the reverse of the "heat curve" of the firing zone for the bricks on the cars on the opposite track. I have also found that the most economical results are obtained by direct firing in the firing zones, that is to say, by discharging products of combustion from the furnaces whether the fuel be gaseous, liquid or solid fuel. It is, however, very injurious to the unfired brick to subject it to the direct action of the products of combustion during the preheating thereof, as it has a tendency to stain, and scum the bricks, and furthermore the products of combustion do not contain free oxygen, and therefore the proper oxidation of certain ingredients of the clays from which the brick and other coarse clay products are formed, is not effected.

In carrying out my invention, I employ a single or unitary tunnel structure, throughout the entire length of the kiln, which enables me to secure a great economy in the construction. I also eliminate all longitudinal flues which greatly add to the cost of construction and upkeep of a kiln. I provide two separate firing zones into which the products of combustion are delivered from a series of furnaces under accurate and independent control, so that the heat curve or graduation of heat can be effected in each firing zone and in the opposite direction in one firing zone from the other. The firing zones are so located that the hottest portion of each of said firing zones is adjacent to the hottest portion of the other, and the firing zones may or may not be overlapped, as may be found most desirable. I also provide for the withdrawal of the products of combustion from each firing zone adjacent to each of the independently controlled furnaces, so that after the products of combustion from each furnace have been directly brought in contact with the goods to be fired therein, they will be completely eliminated from the kiln and their heat utilized for drying green brick in suitable dryers, or for heating the air supplied to the furnaces, or otherwise, and is kept from contact with the unfired bricks within the kiln. According to my

present invention, the bricks on each track pass through the firing zone therefor, and are subjected to gradually increasing temperatures to and including the firing temperature of the kiln, and then pass through the other firing zone, where they are subjected to gradually decreasing temperature, substantially corresponding to the gradual cooling of the bricks, during which period they act as a sort of reservoir for absorbing excess heat at one point and giving it off to the bricks on the other track if their own temperature becomes higher than the temperture on the opposite side of the kiln, after which they pass through one of the cooling and preheating sections in which they give up their residual heat by direct radiation and by convection air currents in the presence of fresh atmospheric air to the bricks moving in the opposite direction on the other track, to effect preheating, water-smoking and oxidation, preliminary to the firing of said bricks, as the fired bricks are gradually cooled on their way to the discharge end of their tracks. This combined cooling and preheating action takes place in both of the end sections of the kiln at opposite ends of the firing zones, and the resulting operation is a very rapid and efficient firing of the products, insuring large output with a minimum cost of construction and up-keep. The means employed for withdrawing the products of combustion from the firing zones, which will ordinarily be fans or other suitable suction means, are also capable of adjustment, and may be so regulated as to prevent the products of combustion from the firing zones passing through the preheating and cooling sections of the kiln, and may also be caused to be withdrawn, in addition, a portion of the heated air from the preheating and cooling section, causing such quantity of air to be replaced by fresh air from the ends of the kilns adjacent to the doors by leakage, or otherwise, and insuring the proper amount of oxygen in the preheating and cooling zone.

In each of the heating zones I prefer to employ a longitudinally disposed baffle wall interposed between the furnaces and the bricks which are to be fired, so as to deflect the products of combustion toward the roof or crown of the kiln and cause them to pass downwardly through the bricks as they are piled on the cars, and I prefer to provide several pipes or passages for the withdrawal of the products of combustion from each firing zone adjacent to each of the furnaces and having their receiving apertures located one adjacent to the lower portion of the baffle wall, and others at other portions of the kiln, as in the central longitudinal platform between the trucks on the two tracks, for example, and on the opposite wall of the kiln, said openings being substantially at or slightly above the level of the trucks, and each of said pipes or passages being preferably under the control of independent regulating valves so that the temperature of each portion of each firing zone can be regulated with very considerable accuracy by these valves in conjunction with the valves or other means which control the individual furnaces.

Referring to the accompanying drawings, which show several embodiments of my invention, selected by me for purposes of illustration,

Fig. 1 represents diagrammatically a horizontal section of the entire kiln embodying the invention showing the two firing zones disposed longitudinally with respect to each other, without overlapping.

Fig. 2 is an enlarged horizonal sectional view, also diagrammatic, illustrating one of the firing zones.

Fig. 3 is an enlarged transverse vertical section on the line 3—3 of Fig. 1, through one of the firing zones, in the direction of the arrows adjacent to said line.

Fig. 4 is a view similar to Fig. 1 showing the firing zones overlapping each other at the hottest portion of each, so that the temperature of the overlapping portions of the two firing zones will be substantially identical and will not effect the respective heat curves of the two firing zones.

Fig. 5 is a view similar to Fig. 4, in which a central perforated wall extends longitudinally through each of the unitary firing zones.

Fig. 6 shows an enlarged transverse section on the line 6—6 of Fig. 5.

Referring to the form of my invention illustrated in Figs. 1, 2 and 3, 1, and 4, represent the opposite end sections of the kiln which I term the cooling and preheating sections, while 2 and 3, represent the firing zones, which, as shown in Fig. 1, are arranged longitudinally with respect to each other between the preheating zones, so that no parts of the firing zones overlap. The entire kiln structure consists of a single unitary tunnel having side walls, 5, 5, and a single crown, 6. The outer portion of the length of the kiln may be of ordinary brick, but I prefer to build the firing zone sections of fire brick, or other suitable refractory material. Two tracks, indicated respectively at 7 and 8, extend longitudinally and preferably in a straight line through the entire kiln, parallel to each other, on which are supported the usual tunnel cars, indicated at 9, upon which the bricks or other products to be fired, indicated diagrammatically at 10 in dotted lines, are supported, and said cars are caused to be moved continuously or intermittently as preferred, in any preferred manner in opposite directions on the tracks, 7 and 8, the directions of movement

of said cars on the respective tracks being indicated by arrows in Figs. 1 and 2. The kiln is preferably of very simple and inexpensive construction entirely without longitudinal flues, which greatly add to the cost of construction, and in the preferred form of my invention the entire length of the kiln is a unitary chamber without either longitudinal or vertical intermediate walls or partitions of any kind whatsoever, with the exception of the baffle-walls in the firing zones, hereinafter referred to.

I will now describe one of the firing zones, as the zone 2, illustrated in cross section in Fig. 3. Each of the firing zones is provided at one end thereof with a plurality of furnaces extending side by side longitudinally of the kiln, indicated at 11, and discharging the products of combustion through a passage, 12, between the outer wall and a baffle-wall, or deflecting wall, 13, parallel with the outer wall and located adjacent to the nearest track on which are the cars carrying the bricks to be fired in this particular firing zone. This baffle wall, 13, is provided at its upper end with an inwardly and upwardly extending portion, 14, forming a deflector which directs the products of combustion towards the crown or roof of the kiln from whence they descend through the bricks to be fired imparting heat thereto, after which they are withdrawn from the firing zone. Any kind of fuel may be employed. In the present instance I have shown, diagrammatically, gas burners, indicated at 15, supplied with gas, and air pipes, 16, 17, respectively, extending longitudinally of the zone, said burners being under the control of air and gas valves, 18 and 19, respectively, so that the heating effect of each furnace may be directly controlled and regulated. If other fuel is employed, the same or equivalent regulation may be obtained by properly regulating the supply of air and fuel thereto. Adjacent to each furnace I provide a pipe or passage, 20, having an inlet aperture, 21, on the inner face of the baffle wall above the level of the cars or trucks on the adjacent tracks, said pipes or passages being provided with regulating valves, 22, and communicating with a header or eduction pipe, 23, extending longitudinally of the kiln, and connected with a suction fan or other exhausting device, indicated at 24, for the withdrawal of the products of combustion, of each furnace, after it has performed its firing effect on the goods. In some instances I prefer to provide a plurality of eduction ports, or openings, located adjacent to each furnace, and at different portions of the kiln, for enabling the removal of the products of combustion to be more efficaciously accomplished, and to better control their effect within the firing zone. For example, the usual central platform, 25, between the trucks on the two sides of tracks, is provided, and will extend through both firing zones, and preferably extends throughout the entire kiln. In some instances, as shown in Fig. 3, I may provide an eduction port in said central platform, as indicated at 26, and a pipe or passage, 27, leading therefrom to the eduction pipe, 23, and controlled by a suitable valve, 28. In some instances I may also provide the wall, 5, of the kiln, opposite the baffle-wall, 13, with an eduction port, 29, and a pipe or passage, 30, leading across, beneath the kiln, or beneath the tracks thereof, and connected to the main eduction pipe, 23, and controlled by a suitable valve, 31, so that the products of combustion may be removed at different points transversely of the kiln, adjacent to each furnace, and the control of the heat within the corresponding section of the firing zone, is very accurately controlled in conjunction with the regulation of the supply of fuel and air to said furnaces. As the construction of the two firing zones is exactly the same, I have given the same parts, of both firing zones, the same numerals in Figs. 1, 2 and 3.

In the operation of my improved kiln, it will be understood that there is a continuous line of cars at all times when the kiln is in operation, on each of the tracks 7 and 8, extending from one end of the kiln to the other, being moved in opposite directions either continuously or intermittently. Tracing the course of a particular car of goods on one of the tracks, say the track, 7, from the time it enters the kiln until it leaves the same, the operation would be substantially as follows. When the car enters the kiln, the goods thereon are unfired clay products, as they have come from the ordinary drier, and have found themselves directly opposite to a car of fired brick, on track 8, which have become materially cooled and are about ready to leave the kiln. The green bricks on the car on track 7 are moved gradually through the preheating section, 4, of the kiln (see Fig. 1) and during their progress therethrough are gradually heated by direct radiation, and also by convection air currents due to the circulation of air in said preheating and cooling section, 4, from the hot fired bricks on track, 8, so that the green bricks on track, 7, are gradually preheated in an atmosphere containing ample oxygen supply, and will be water-smoked and oxidized to the desired extent without scumming or staining, and at the time they reach the entering end of the firing zone, 3, they will have been raised to substantially, or nearly, the temperature of the said firing zone at that point, say 1000° to 1400° F., or any other desired temperature. As the bricks enter the firing zone, 3, they are subjected to the direct action of the prod-

ucts of combustion therein, and as they pass through the firing zone they are raised to firing temperature and fired, leaving the firing zone at the highest temperature thereof, say approximately 2000° F., more or less. Within the firing zone, 3, on the track, 8, there will be a line of cars of fired brick which have left the firing zone, 2, and are being gradually moved in a direction toward the cooling and preheating zone, 4. These bricks are of course subjected, to a certain extent, to the products of combustion in the firing zone, 3, and as they are moving in the opposite direction to the bricks on track, 7, they will be permitted to gradually cool and at each longitudinal point in the firing zone, 3, the temperature of these fired bricks on track, 8, will be caused to conform substantially to the temperature of that portion of the firing zone. The fired bricks, therefore, after leaving the firing zone in which they were fired, and passing through the other firing zone, act as a sort of reservoir of heat, and if their temperature is in excess of that of the products of combustion in the particular portion of the second firing zone, through which they are passing, they will yield a portion of their heat, and vice versa, being gradually lowered in temperature as they move toward the cooling and preheating zone, 4. In like manner, the bricks on track, 7, having been fired by passing through the firing zone, 3, act in the same way, while they pass through the firing zone, 2, on track, 7, longside of the bricks on the cars on track, 8, which are being fired in the firing zone, 2, there being an equalization of heat at different points in each firing zone between the products which are being fired therein, and the products which have been fired in the other firing zone. After leaving the firing zone, 2, the bricks on track, 7, are gradually cooled as they pass toward the end of the preheating and cooling section, 1, giving up their heat to the green bricks, on tracks, 8, moving in the opposite direction, until they are sufficiently cooled to be removed from the kiln.

In Fig. 4 I have illustrated a slight modification in which the firing zones, here indicated at 102 and 103, are slightly overlapped at their portions of highest temperature, and in order to facilitate the understanding of my invention, I have indicated the temperatures at the entering and discharging ends of each firing zone in Figs. 1, 4 and 5, as 1100 and 2000 respectively, to indicate the rising heat curve in each. I wish it to be understood, however, that the temperatures which I have mentioned herein, are only mentioned as examples, and that I do not limit myself to either the maximum or minimum temperatures herein referred to as the actual temperatures, minimum as well as maximum, may be varied to a considerable extent in practice. It will be seen from Fig. 4, that there will be substantially no different effect produced by overlapping the hottest portions of the firing zones, 102 and 103, as the temperature within the overlapping portions of the two firing zones will be substantially the same as would be the case if they were not overlapped, and this overlapping of the firing zones, which may be convenient in some installations, does not interfere with the proper and accurate regulation of temperature in the several firing zones in accordance with the desired heat curve. The other features of the kiln illustrated in Fig. 4 are identical with those previously described and illustrated in Figs. 1, 2 and 3, and will not be further referred to or described. They are given the same reference numerals with the addition of 100.

In Figs. 5 and 6 I have illustrated another slight modification of my invention, in which I have provided a central vertical partition, indicated at 250, extending through the firing zones of the kiln and provided with apertures, 251 and 252, at approximately the level of the trucks and adjacent to the crown or roof of the kiln, respectively. The other features of the kiln are identical with those previously described, and will not be further referred to or described. They have been given the same reference numerals with the addition of 200. The operation of the kiln illustrated in Figs. 5 and 6 will be substantially identical with those previously described, excepting that the radiation from the previously fired bricks on the track remote from the baffle-wall will be through the partition wall, 250. The heat, transmitted by convection by currents of the products of combustion being substantially the same, as said products of combustion, will pass through the communicating apertures in the partition wall.

My improved kiln produces an extremely cheap and efficient construction to build and operate, and will produce a very high output of fired clay products with an economy of fuel. The kiln also can be kept in a high state of efficiency with a minimum amount of expense for repairs, to which the entire absence of longitudinal flues greatly contributes. It will also be seen that by means of the control of the furnaces and the eduction passages, a very accurate control of temperatures in each firing zone according to the predetermined heat curve desired, can be readily effected, and the products of combustion from each furnace are withdrawn from the firing zone adjacent thereto and entirely removed from the kiln, so that the products of combustion do not pass into the preheating and cooling sections of the kiln at the end portions thereof, thus preventing

staining and scumming the bricks during the preheating thereof, and also insuring the preheating and water-smoking of the bricks in the presence of an adequate supply of oxygen. The pipes or passages for the withdrawal of the products of combustion are preferably of more than adequate size for the withdrawal of all of the products of combustion of the furnaces, and by properly adjusting their controlling valves, it is possible to withdraw not only the products of combustion from the firing zone, but also considerable quantities of air from the adjacent portions of the preheating and cooling sections of the kiln, which will be replaced by fresh air entering around the doors at the opposite ends of the kiln, and thus insuring, where necessary, a sufficient supply of oxygen in the preheating and cooling sections of the kiln.

What I claim and desire to secure by Letters Patent is:—

1. A tunnel kiln having a unitary tunnel structure throughout its length, the central portion of the kiln forming two consecutively arranged, unitary firing zones, and the opposite end portions of the kiln forming unitary cooling and preheating zones, said kiln being provided with parallel goods conveying means, movable in opposite directions, each of which passes through each of said cooling and preheating zones and each of said firing zones, heating means for each of said firing zones including direct fired furnaces discharging their products of combustion into said firing zones, the furnaces for each firing zone being located on the opposite side of the kiln from the furnaces for the other firing zone, means for independently regulating each of said furnaces for each of said firing zones to maintain a gradually increasing temperature in each firing zone from the entrance end thereof toward the other firing zone, each of said firing zones being provided with eduction ports located at different points transversely thereof, and means connected with said eduction ports for withdrawing the products of combustion.

2. A tunnel kiln having a unitary tunnel structure throughout its length, the central portion of the kiln forming two consecutively arranged, unitary firing zones, and the opposite end portions of the kiln forming unitary cooling and preheating zones, said kiln being provided with parallel goods conveying means, movable in opposite directions, each of which passes through each of said cooling and preheating zones and each of said firing zones, heating means for each of said firing zones including direct fired furnaces discharging their products of combustion into said firing zones, the furnaces for each firing zone being located on the opposite side of the kiln from the furnaces for the other firing zone, means for independently regulating each of said furnaces for each of said firing zones to maintain a gradually increasing temperature in each firing zone from the entrance end thereof toward the other firing zone, each of said firing zones being provided adjacent to each of said furnaces with a plurality of eduction ports located at separated points transversely of the kiln, and means connected with said eduction ports for withdrawing products of combustion from the adjacent firing zone.

3. A tunnel kiln having a unitary tunnel structure throughout its length, the central portion of the kiln forming two consecutively arranged, unitary firing zones, and the opposite end portions of the kiln forming unitary cooling and preheating zones, said kiln being provided with parallel goods conveying means, movable in opposite directions, each of which passes through each of said cooling and preheating zones and each of said firing zones, heating means for each of said firing zones including direct fired furnaces discharging their products of combustion into said firing zones, the furnaces for each firing zone being located on the opposite side of the kiln from the furnaces for the other firing zone, means for independently regulating each of said furnaces for each of said firing zones to maintain a gradually increasing temperature in each firing zone from the entrance end thereof toward the other firing zone, each of said firing zones being provided with eduction ports located at separated points transversely of the kiln, separate eduction passages connected with said ports for withdrawing the products of combustion from each firing zone, and independent controlling means for each of said eduction passages.

4. A tunnel kiln having a unitary tunnel structure throughout its length, the central portion of the kiln forming two consecutively arranged, unitary firing zones, and the opposite end portions of the kiln forming unitary cooling and preheating zones, said kiln being provided with parallel goods conveying means, movable in opposite directions, each of which passes through each of said cooling and preheating zones and each of said firing zones, heating means for each of said firing zones including direct fired furnaces discharging their products of combustion into said firing zones, the furnaces for each firing zone being located on the opposite side of the kiln from the furnaces for the other firing zone, means for independently regulating each of said furnaces for each of said firing zones to maintain a gradually increasing temperature in each firing zone from the entrance end thereof toward the other firing zone, each of said firing zones being provided adjacent to each of its furnaces with a plurality of eduction ports lo-

cated at different points transversely of the kiln, means for withdrawing the products of combustion from each of said firing zones connected by independent passages with said eduction ports, and independent controlling means for each of said eduction passages.

5. A direct fired tunnel kiln having a unitary tunnel structure throughout its length, the central portion of the kiln forming two consecutively arranged, unitary firing zones, and the opposite end portions of the kiln forming unitary cooling and preheating zones, said kiln being provided with parallel goods conveying means, movable in opposite directions, each of which passes through each of said cooling and preheating zones and each of said firing zones, said consecutive firing zones being provided with longitudinally disposed vertical partitions located between the parallel goods conveying means passing therethrough and provided with apertures therein for the passage of the products of combustion.

In testimony whereof I affix my signature.

WILLIAM LEE HANLEY, JR.