May 24, 1932. W. L. HANLEY, JR 1,859,507

TWIN TUNNEL KILN

Filed May 3, 1928 3 Sheets-Sheet 1

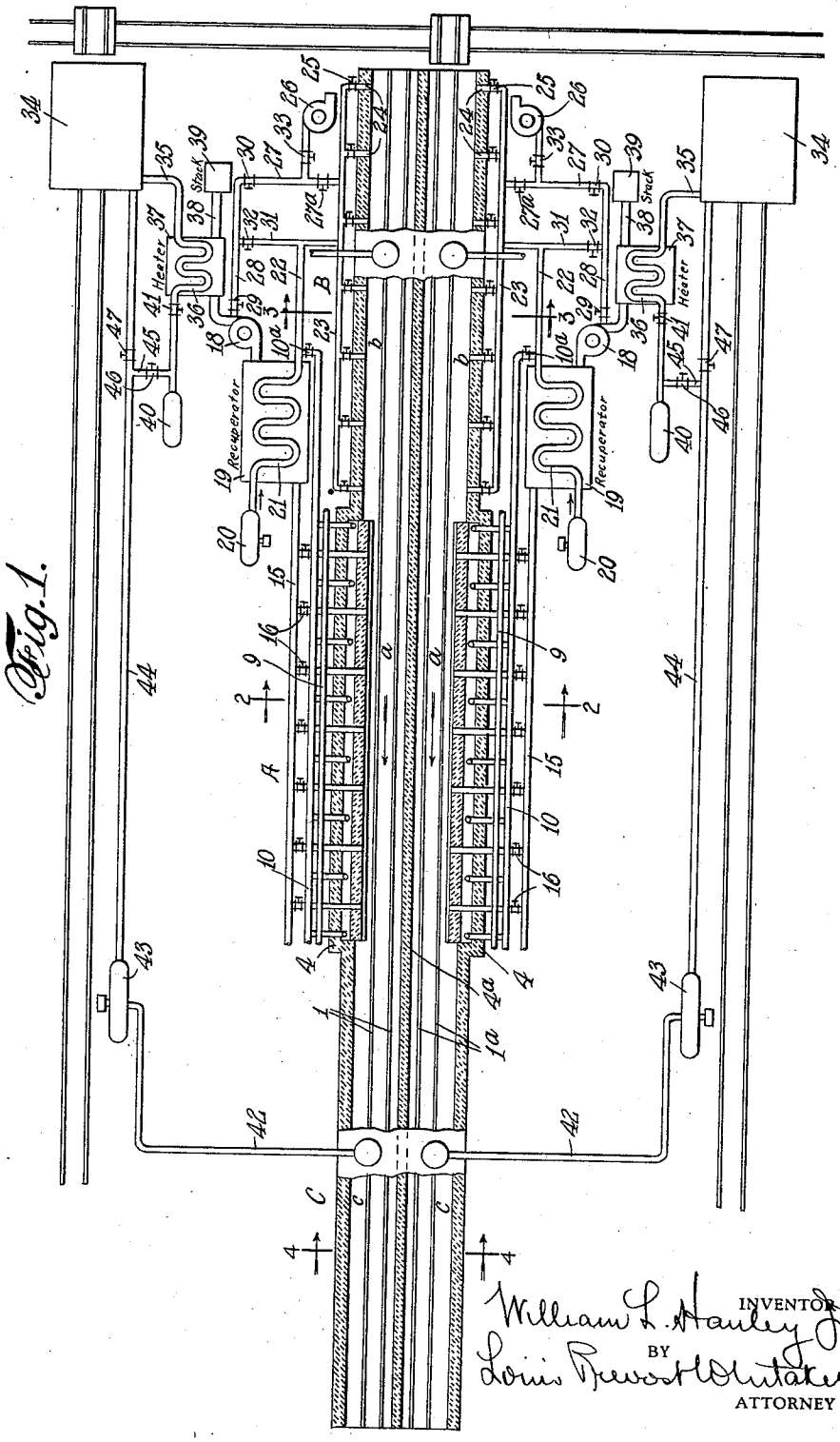


Fig. 1.

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May 24, 1932. W. L. HANLEY, JR 1,859,507

TWIN TUNNEL KILN

Filed May 3, 1928 3 Sheets-Sheet 2

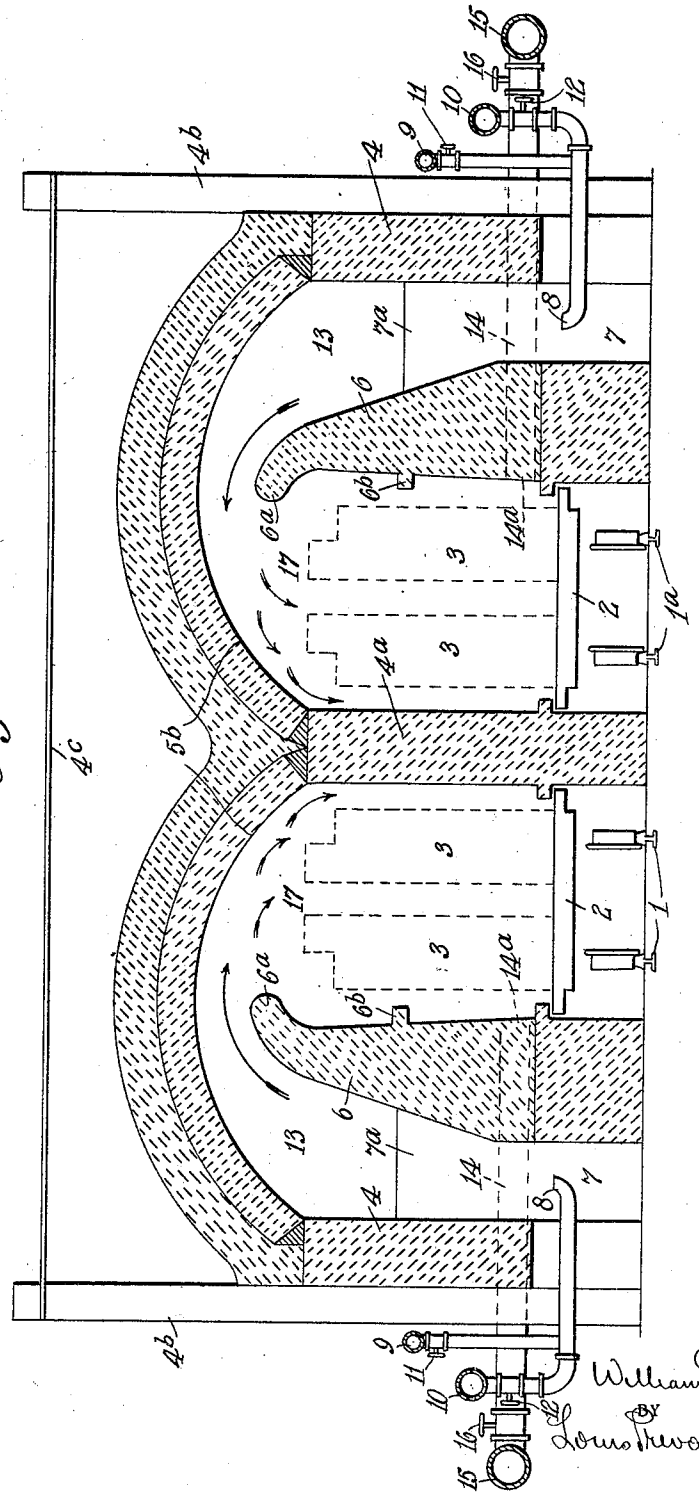


Fig. 2.

May 24, 1932. W. L. HANLEY, JR 1,859,507

TWIN TUNNEL KILN

Filed May 3, 1928 3 Sheets-Sheet 3

Fig. 3.

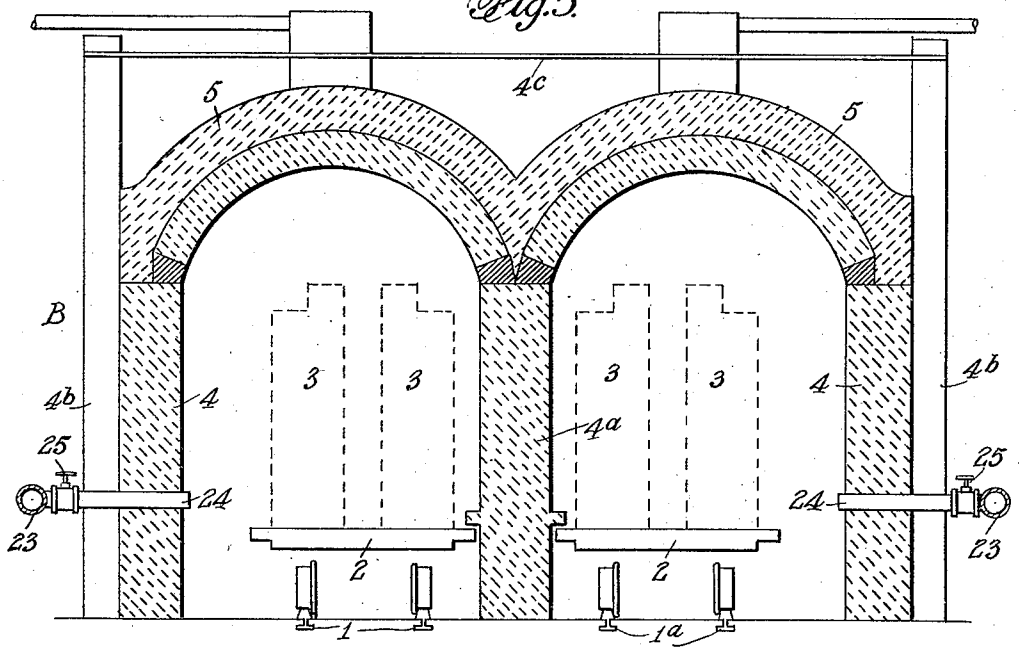
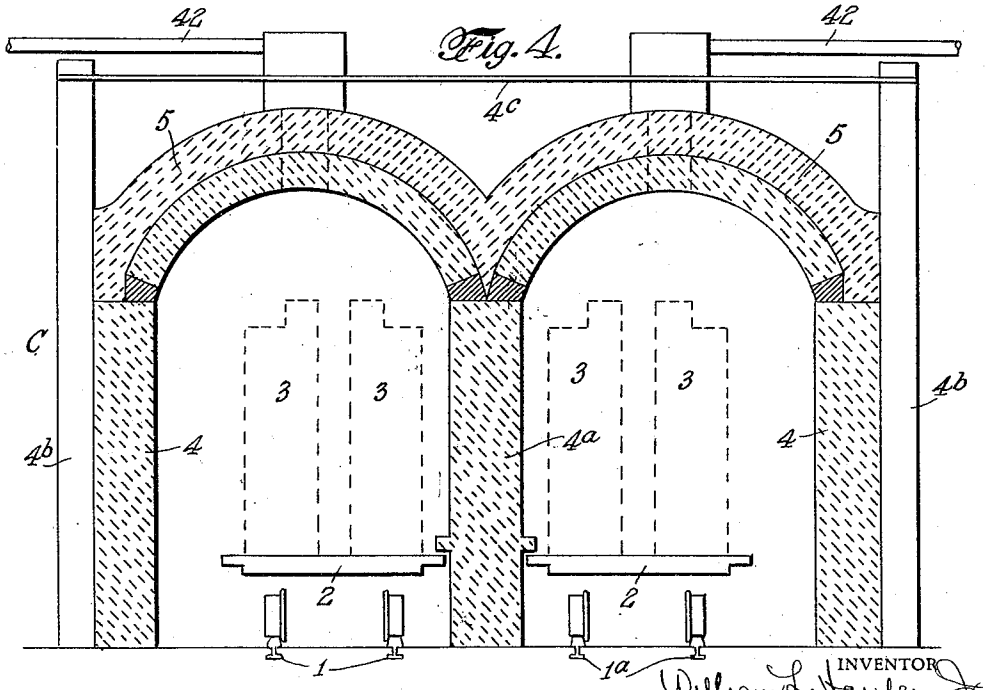


Fig. 4.



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Patented May 24, 1932 1,859,507

UNITED STATES PATENT OFFICE

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TWIN TUNNEL KILN

Application filed May 3, 1928. Serial No. 274,730.

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

The object of my invention is to produce a twin tunnel kiln for firing bricks and other coarse clay products, and for other purposes of extremely simple and economical construction, and which may also be maintained with minimum of expense for upkeep and repair. In carrying out my present invention, I employ a simple form of double tunnel structure throughout which is entirely free from longitudinal flues or passages, so that it can be very cheaply constructed. The kiln comprises essentially the exterior vertical walls, a central partition and crown extending from each end of the exterior walls to the central partition, the exterior walls being reinforced by vertical supports of iron or steel, connected by cross rods or tie-rods, extending from one side of the kiln to the other, thus affecting a very material economy in the metallic elements of the kiln. The central portion of the kiln, with respect to its length, constitutes the firing zone, and is provided on opposite sides with rows of furnaces, the furnaces of each row discharging their products of combustion inwardly over the top of a longitudinal deflecting wall and downwardly into the goods space between the deflecting wall and the central partition. At one end of the firing zones, the twin tunnel provides a pair of preheating zones each communicating with one of the firing zones, and at the opposite end of the firing zones, the twin tunnel construction provides a pair of cooling zones, each communicating directly with one of the firing zones. Separate tracks extend longitudinally through the preheating zone, firing zone and cooling zone at each side of the central partition wall of the tunnel, to receive cars or trucks on which the goods are placed, the loaded trucks extending on each track from one end of the kiln to the other and being moved through the kiln on both tracks in the same direction, the goods being preheated, watersmoked and oxidized in the preheating zones, fired in the firing zones and cooled in the cooling zones, so that they issue from the cooling zones in a condition to be transported or stored, as finished products. As each heating zone communicates directly with the preheating zone and cooling zone in alignment therewith, I provide means for withdrawing the products of combustion completely from each firing zone, to the exterior of the kiln, in order to prevent the products of combustion from passing into the preheating zone, where their presence would interfere with the proper oxidation of the clay products, and also have the effect of scumming or staining them during the watersmoking and preheating thereof, and the withdrawal of the products of combustion also prevents them from passing into the cooling zone where they would necessarily interfere with the proper cooling of the fired products. In order to utilize the heat of the products of combustion withdrawn from the firing zones, they are preferably passed through a recuperator, or recuperators, wherein the heat of the products of combustion is imparted to clean fresh air, which is delivered into each of the preheating zones at intervals along the same, and under the control of regulating valves, so that the temperature of each preheating zone may be gradually increased from the entering end of the kiln to the firing zone, in alignment with the preheating zone, so that the temperature of the products is gradually raised and the products are preheated and watersmoked on their way to the firing zones, the introduction of clean, heated air into the preheating zone also providing the necessary oxygen for oxidizing the oxidizable materials in the products, being treated, while avoiding the danger of staining or scumming and the products are passed from each preheating zone into the aligned firing zone at the entering end thereof, at substantially the temperature of the entering end of the firing zone. The row of furnaces of each firing zone is under the control of suitable regulating valves, or dampers, controlling the fuel supply and air supply to the furnaces, and eduction passages are also provided, preferably adjacent to each fur-

nace, for the withdrawal of the products of combustion, which passages are also provided with suitable independent dampers, or controlling valves, so that the temperature in various parts of the firing zone may be regulated and gradually increased from the entering end to the discharge end of each firing zone, according to a predetermined heat curve.

The products of combustion when they leave each firing zone, will be at extremely high temperature, and will therefore raise the temperature of the fresh clean air in the heat exchanger, or recuperator, in which they are not permitted to mingle with the air, to a very high degree, making it readily possible to properly preheat the goods in the preheating zone, by means of this heated clean fresh air, up to substantially the temperature of the entering end of the firing zone. As the products of combustion leaving the heat exchanger, or recuperator, still contain a very considerable amount of heat, I prefer to employ this heat for the purpose of heating additional quantities of clean fresh air, which is supplied to the drier, or driers, in which the clay products are dried to remove occluded water before entering the kiln. I also prefer to withdraw the air from the cooling zones of the kiln, which has been heated to a very high temperature by the fired goods passing therethrough from the firing zone and to conduct this highly heated air through a recuperator, or recuperators, or directly to the drier, so that the heat of the fired products may also be conserved and utilized for the drying of the clay products, preliminary to firing, or otherwise.

My invention also contemplates the provision of means for employing a certain quantity of the products of combustion from the firing zones after they have imparted some of their heat to the air in the recuperator, or recuperators, to the preheating of the goods, if desired, and also the provision of means for mixing these gases of combustion with cool, clean air, also with clean preheated air from the recuperator, or recuperators, as may be desired, and under the control of the operator, by means of suitable valves or dampers. I also provide means for preheating the air employed in the furnaces for the combustion of the fuel by passing it through the recuperator on its way to the burners, or furnaces.

Referring to the accompanying drawings, Fig. 1 is a horizontal sectional view of a twin tunnel kiln and connected parts embodying my invention.

Fig. 2 is a vertical transverse sectional view through the firing zones, on the line 2—2 of Fig. 1, drawn to an enlarged scale.

Fig. 3 is a similar sectional view on the line 3—3 of Fig. 1, through the preheating zones.

Fig. 4 is a similar view, on the line 4—4 of Fig. 1, through the cooling zones.

Referring to the embodiment of the invention illustrated in Figs. 1 to 4, inclusive, the kiln comprises a double tunnel, of which the central portion, indicated at A, is the firing chamber, containing the two firing zones, *a*—*a*, the section B, at one end of the kiln containing the preheating zones, *b*—*b*, and the section, C, at the opposite end of the firing zones containing the cooling zones, *c*—*c*, the separate tunnels throughout all three of the zones mentioned, being separated from each other by a central partition wall. Two lines of tracks, indicated at 1 and 1^a, extend longitudinally through the entire kiln, each track extending through one preheating zone, firing zone and cooling zone, as shown, and in operation each track is occupied by a continuous line of tunnel cars, 2, each supporting a carload of bricks, or other coarse clay or ceramic products, to be fired, indicated at 3 in dotted lines in Figs. 2, 3 and 4, the cars being moved in the same direction on both tracks, as indicated by the arrows in Fig. 1.

It will be understood that the kiln provides two longitudinally extending goods spaces, each extending from one end of the kiln to the other, without either transverse or longitudinal partitions, and without any longitudinal flues, said goods spaces being separated throughout the length of the kiln from each other by the central partition wall. The end portions, B and C of the kiln, are of very simple construction, as indicated in Figs. 3 and 4, and comprise the side walls, 4, 4, the central partition wall, 4^a, and the roof portion, which is preferably in the form of two crowns, indicated at 5—5, extending from the outer walls to the central partition, the outer side walls being provided with vertical columns or girders, indicated at 4^b, 4^b, connected by transverse tie-rods, indicated at 4^c, extending from one side of the kiln to the other, and connecting said columns or girders. The end portions of the kiln may be formed of ordinary brick or other suitable material, and a considerable economy of construction is obtained over the construction of two separate kilns, in that one vertical wall is dispensed with altogether, with two sets of vertical columns or girders, which would otherwise be required if the kiln units were formed separately. There is also a very considerable economy of operation obtained, as there is no loss of heat by radiation at one side of each longitudinal goods space, as any heat passing through the partition wall, 4^a, will be conveyed into the adjacent zone, and thus prevented from escaping, so that the only loss of heat by radiation will be through the exterior walls, 4, 4, and the roof portions, which may be protected by insulation, if desired.

The central portion, A, of the tunnel, which comprises the firing chamber containing the two firing zones, *a*, *a*, is also a double tunnel

structure, comprising the side walls, 4, 4, the central partition, 4^a, and crowns, 5^a, reinforced by the vertical columns or girders, 4^b, and tie-rods, 4^c, the side walls being spaced further apart in order to accommodate an interior longitudinal baffle wall, 6, in each firing zone on the outer side of the goods space (see Fig. 2), and the furnaces, indicated at 7—7. The furnaces are of any desired construction and designed for the consumption of any type of fuel, solid liquid or gaseous, as may be preferred. As indicated in Fig. 1, I prefer to employ a row of furnaces, 7, on each side of the firing chamber, A, that is to say, along the outer side of each firing zone, and in this instance I have shown the furnaces provided with burners indicated at 8, for a mixture of gas and air supplied respectively by the gas-pipes, 9—9, and air pipes, 10—10, under the control of regulating valves, 11 and 12, respectively, for each burner, so that each individual furnace may be independently regulated, and a predetermined heat curve maintained, gradually increasing from the entering end of each heating zone to the discharging end thereof. For example, a temperature of from 900° to 1400° F., more or less, may be maintained at the entering end of each firing zone, the temperature of the different portions of the firing zones increasing more or less gradually in the same direction longitudinally of the kiln, to a temperature of, say, from 1800° to 2100° F., more or less, at the discharge ends, adjacent to the cooling zones, *c*—*c*, respectively. The products of combustion discharged from the furnaces are conducted upward through passages, indicated at 13, in Fig. 2, between the side walls of the kiln and the adjacent baffle walls, 6, and the upper ends of the baffle walls are preferably provided with inwardly extending portions, indicated at 6^a, 6^a, and may also be provided at one or more points below the upper edge on the inner faces, adjacent to the goods space, with horizontal longitudinal ribs, indicated at 6^b, for the purpose of causing the hot products of combustion from the furnaces to descend upon and through the goods on the cars instead of between the goods and the baffle walls, as far as possible. This construction also tends to direct the hot products of combustion from the furnaces downwardly against the central partition wall, 4^a, through the length of the firing zones, as indicated by the arrows in Fig. 2. This is especially true where the kiln is provided with the double crown construction therein illustrated, the curved, downwardly extending portions, 5^b, of the crown adjacent to the partition wall, deflecting the products of combustion downwardly and along the partition wall on both sides of the same, and as before stated, the heat which passes into the central partition wall cannot escape by radiation, and as the hot products are directed against the central partition wall and away from the exterior walls, 4, 4, less heat will be lost from each firing zone by radiation in this duplex construction than would be the case if the two tunnel sections were made as separate kilns. Each firing zone is provided with means for withdrawing the products of combustion therefrom to prevent them from passing into the preheating zone, or into the cooling zone. I preferably provide each firing zone with a plurality of horizontal eduction pipes or passages, indicated at 14, extending from the inner face of each of the baffle walls to the exterior of the kiln, where they are connected with a header or eduction flue, 15. The inner ends of the eduction passages constitute eduction ports, indicated at 14^a, and are located at the lower portion of the goods space in each firing zone. I prefer to locate the passages, 14, between the adjacent furnaces of each row, and they conveniently pass through the vertical transverse partition walls, 7^a, which separate the furnaces from each other, said partition walls, 7^a, however, not extending to the top of the furnace so that the products of combustion from adjacent furnaces unite above the partition walls, 7^a, and pass in a continuous sheet extending from one end of each firing zone to the other, over the top of the baffle wall therein. The eduction pipes, 14, are also each provided with an independent damper, indicated at 16, in order that they may be independently controlled to assist in controlling the temperature within the adjacent firing zone, and to maintain a predetermined heat curve therein, while insuring the withdrawal of all of the products of combustion from the interior of the firing zone, which is indicated by the numeral, 17. In order to secure the proper and continuous withdrawal of the products of combustion from each firing zone, any suitable type of eduction device may be employed, as for example, the suction fans or blowers, indicated at 18—18.

The products of combustion leaving the firing zones are at a very high degree of heat, ranging in the neighborhood of 1800° F., and being the products of combustion from all of the furnaces for each zone. By preventing the products of combustion from entering the preheating zone, straining and scumming of the bricks during the preheating thereoef, is prevented, and in order to secure the proper oxidation of the bricks, during the preheating, and to provide the necessary heat for preheating and water-smoking them, I propose to recover a large portion of the heat from the products of combustion withdrawn from the furnaces and to employ it for heating fresh air drawn from the atmosphere, which can thereby be heated to a

temperature of approximately 1400° F., and which is then introduced into the preheating zone, *b*, of the kiln, preferably at separated points longitudinally of each of the preheating zones. For this purpose I preferably employ a recuperator, or heat interchanger, of any desired character, through which the products of combustion are conducted, separated from the air to be heated. In the present instance I have shown on each side of the furnace, a recuperator, indicated at 19, connected with the adjacent eduction flue, 15, and receiving the products of combustion from the adjacent firing zone. The fresh air is introduced into the recuperators by fans, 20, through passages separated from the products of combustion, as a heating coil, 21, or pipe system, or passages, and is discharged in a highly heated condition from each recuperator through pipes, 22. Obviously a recuperator of sufficient capacity receiving the products of combustion from both firing zones could be employed if desired. The highly heated fresh air leaving each recuperator is delivered to a header, 23, extending along the preheating section of the kiln, and connected by pipes or passages, 24, having valves or dampers, 25, with the adjacent preheating zone at different points longitudinally thereof, so that the desired range of temperatures in different portions longitudinally of the preheating zones may be maintained, and this arrangement not only provides the necessary heat for preheating and water-smoking, but also the necessary oxygen for oxidizing the oxidizable portions, of the dry ceramic products treated. Some of the hot fresh air delivered by each recuperator may be conveyed to the air pipes, 10, which supply the air for combustion to the furnaces, as indicated in Fig. 1, in which each of the air pipes, 10, is connected with the pipe, 22, and is shown provided with a suitable valve, 10^a.

In some instances it may be desirable to supply cool, fresh air to the preheating zones in addition to the highly heated fresh air from the pipe, 22, and in this instance I have shown additional fans, 26—26, connected with the cool air supply pipes, 27, connected with the headers, 23, 23, respectively, under the control of valves, 27^a.

It is to be understood that the construction just described for supplying heat and fresh air to the preheating zones of the kiln is quite different from the constructions in which heated air is withdrawn from a cooling zone or compartment, in which the fired bricks are cooled and introduced into the preheating section of the kiln. Such air is not heated to a sufficiently high temperature to effect the preheating, water-smoking and oxidation of the bricks preparatory to burning in a satisfactory manner. In my construction, however, by taking the products of combustion directly out of the firing zones, at the extremely high temperature therein existing, and employing them in the heating of fresh air, such air may be readily heated to a very high degree, as 1400° F., for example, or higher, and such highly heated air can be efficiently used to effect preheating and water-smoking, and will in addition, by reason of the oxygen present therein, efficiently oxidize the oxidizable matter in the product.

In some cases, and in firing certain products, it may be found desirable to introduce into the preheating zone, or a portion thereof, some of the products of combustion after they leave the recuperator. I have therefore shown, in this instance, each of the fans or suction devices, 18, provided on the pressure side, with a pipe, 28, connected with the fresh air pipe, 27, leading to the adjacent header, 23, the pipe, 28, being controlled by valves, 29, 30, so that portions of the hot products of combustion may be deflected to the preheating zone, if desired, and delivered thereinto, together with fresh atmospheric air containing free oxygen, to avoid staining or scumming the products, and to insure their proper oxidation. I also provide each of the pipes, 28, with a branch pipe, 31 under the control of a valve, 32, by means of which a certain amount of fresh, highly heated air from the recuperator may be mixed with the products of combustion, leaving the recuperator before the latter are delivered into the preheating chambers. If it is desired to temper the products of combustion passing through the pipes, 28, to the preheating zones, to reduce their temperatures, cool fresh air may be admitted to them by the pipe, 27, under the control of the valve, 33. By the adjustment of the several valves, 29, 30, 32 and 33, the preheating zones may be supplied with heated air, products of combustion, or cool fresh air, in any desired combination required to effect the proper preheating water-smoking and oxidizing of the products, as they are passed therethrough on the way to the firing zone.

The products of combustion leaving the recuperators will be at high temperature, and this heat may be advantageously employed in heating additional quantities of air, which can be employed, for example, in drying coarse clay products before they enter the kiln. For example, I have shown at each side of the kiln, a drier, indicated at 34, connected by a pipe, 35, with a heating coil, 36, of a heater, 37, to which the discharge end of the adjacent suction fan, 18, is connected, the products of combustion passing from the heater to a stack, indicated at 39, through a pipe, 38. The coil, 36, of the heater may be supplied with air by means of a blower, 40, under the control of a valve, 41.

The cooling zones, *c*, *c*, of the kiln are each provided with an eduction pipe, 42,

which may be connected to the top of the kiln structure and provided with a suction fan, 43, the discharge end of which is connected by a pipe, 44, in this instance with the drier, 34, under the control of a valve, 47, so that the air from the cooling zones, which will be very highly heated by the burned products passing therethrough after leaving the firing zones, may be withdrawn and discharged into the driers. I have also indicated a by-pass, 45, connecting the pipe, 44, with the pipe leading from the blower, 40, and provided with a valve, 46, so that by opening the valve, 46, and the valve, 47, the cool fresh air may be mingled with the hot air from the adjacent cooling zone before reaching the drier, if desired, or by closing the valve, 47, the heated air from the cooling zones may be passed through the heater, 37, if desired, and mingled with the heated fresh air from the fan, 40, before reaching the drier.

It will be understood that in the operation of my improved tunnel kiln, a row of tunnel cars loaded with the products to be treated will extend entirely through the length of the kiln on each side of track rails, which extend through the separate tunnels on opposite sides of the central partition. It will also be understood that both trains of cars move in the same direction through their respective tunnels, either continuously or intermittently, by any usual or preferred means, and that as cars of fired products are taken out of the discharge end of the kiln from each tunnel at the exit end of the cooling section thereof, a car of dried, unfired products is inserted at the entering end of the preheating section of the same tunnel. The heaters, 37, may obviously be located either on the outside of or within the interior of the driers.

My invention presents a very simple and inexpensive type of twin tunnel kiln, and it will be seen that the cost of construction will be very much less than the cost of two single tunnel kilns of the kind described in my prior Patent No. 1,658,333 dated February 7, 1928. This economy is effected by eliminating one longitudinal wall running the entire length of the kiln, and also by eliminating two sides of vertical beams or grinders, which effects a material saving in the steel or iron work required. It will also be seen that by moving the cars in the same direction, through both tunnels, and by the construction of the firing zones previously described, in which the heat curve will rise from the entering end of each firing zone to the exit end thereof, in the same manner as in the adjacent firing zone, that there is a very material saving of fuel, as there is no loss by radiation on the inner side of each tunnel, adjacent to the partition wall. In the firing zones, the products of combustion are carried over the top of the baffle walls, and deflected downwardly by the arched roof sections, upon the cars, and necessarily sweep downward on opposite sides of the partition wall. This central partition wall, therefore, becomes highly heated, and acts as a stabilizer or reservoir of heat tending to assist in securing uniform firing temperature in the various portions of the firing zones throughout their length. There is practically no loss of heat from the partition wall, which will be made of highly refractory material, and any heat passing through this partition wall and being radiated therefrom will be retained within the kiln, and must be availed of in one firing zone or the other, and as a matter of fact this central partition wall will, as above stated, act as a reservoir to maintain the same temperatures on opposite sides thereof in the adjacent firing zones, throughout their entire length, and will have the same effect in a more limited degree within the preheating zones and cooling zones.

In the firing zones, as the walls, 4, 4, are remote from the goods space in which the highest temperatures are maintained, and the products of combustion are swept over the partition wall, 6, toward the central partition, there is less opportunity for radiation of heat from the exterior walls, 4, and a greater fuel economy is thus obtained in this type of twin tunnel kiln. That this is accomplished is due to the fact, also, that the goods pass through both tunnels in the same direction, as otherwise the transmission of heat from the central partition wall from a zone of one tunnel to a zone of the other, would interfere, instead of assist, in the operation of the kiln. In my improved twin tunnel kiln, however, the temperatures on opposite sides of the partition are uniform throughout the entire length of the kiln and in each of the zones of each tunnel, and therefore the partition wall acting as a heat stabilizer, assists in maintaining the same identical temperatures in each zone on opposite sides of the partition wall through all the variations of temperature from one end of the kiln to the other.

While I have shown in Fig. 1, an arrangement in which each of the firing zones is provided with separate recuperating means, and separate means for utilizing the residual heat of the products of combustion therefrom, and independent means for supplying fresh air to each preheating zone, it will be understood that the products of combustion from both sets of furnaces might be passed through a single recuperating means, if desired, and that a single air heating means, for utilizing the residual heat of the products of combustion, may be employed in connection therewith, the heated air from the recuperating means being in such case supplied to both of the preheating zones with or without the admixture of the products of combustion, and cool fresh

air, as desired under the control of the independently operably regulating valves, with which each preheating zone is provided. It will also be understood that while I have shown two driers, a single drier of the required capacity to supply the cars passing through both tunnels could be employed and heated by the residual heat imparted to the air by the products of combustion, or by heated air withdrawn from the cooling zones, or admixtures of the two, as may be desirable, without departing from the spirit of my invention.

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

1. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces at different points longitudinally thereof, discharging their products of combustion into the firing zone, in a direction toward the said partition wall, independent means for controlling said furnaces for maintaining a gradually increasing temperature in the same direction longitudinally of each firing zone, means for withdrawing the products of combustion from each of the firing zones, each tunnel being provided with a preheating zone, communicating with one of said firing zones, and a cooling zone communicating with the opposite end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, and means for utilizing the products of combustion for heating air and discharging it into the preheating zones, whereby said central longitudinal partition wall between said tunnels will act as a heat reservoir and stabilizer, and assist in maintaining the same temperatures on opposite sides thereof in the separate tunnels at all points throughout the range of temperatures from one end of the tunnel to the other.

2. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces at different points longitudinally thereof, discharging their products of combustion into the firing zone, in a direction toward the said partition wall, independent means for controlling said furnaces for maintaining a gradually increasing temperature in the same direction longitudinally of each firing zone, means for withdrawing the products of combustion from each of the firing zones, each tunnel being provided with a preheating zone, communicating with one of said firing zones, and a cooling zone communicating with the opposite end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from the firing zones and heating fresh air, and means for conducting said heated fresh air from the recuperating means to the said preheating zones, said central longitudinal partition wall acting as a heat reservoir and assisting in maintaining the same temperatures on opposite sides thereof in the adjacent zones of said tunnels throughout the entire range of temperatures from one end of the kiln to the other.

3. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces at different points longitudinally thereof, discharging their products of combustion into the firing zone, in a direction toward the said partition wall, independent means for controlling said furnaces for maintaining a gradually increasing temperature in the same direction longitudinally of each firing zone, means for withdrawing the products of combustion from each of the firing zones, each tunnel being provided with a preheating zone, communicting with one of said firing zones, and a cooling zone communicating with the opposite end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones and heating fresh air, means for conducting said heated air from the recuperating means and delivering it to each of said separate preheating zones at different points longitudinally thereof, and independent regulating means for controlling the admission of said fresh heated air to each of said preheating zones at said separated points, the central longitudinal partition wall acting as a heat reservoir and stabilizer to maintain the same temperature in each tunnel on opposite sides of said wall at all points longitudinally of the tunnels throughout the range of temperature therein.

4. A twin tunnel kiln provided with two exterior walls, an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces at different points longitudinally thereof, discharging their products of combustion into the firing zone, in a direction toward the said partition wall, independent means for controlling said furnaces for maintaining a gradually increasing temperature in the same direction longitudinally of each firing zone, means for withdrawing the products of combustion from each of the firing zones, each tunnel being provided with a preheating zone, each communicating with one of said firing zones, and a cooling zone

communicating with the opposite end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones and heating fresh air, means for conducting said heated air from the recuperating means and delivering it to each of said separate preheating zones at different points longitudinally thereof, independent regulating means for controlling the admission of said fresh heated air to each of said preheating zones at separated points, means for supplying portions of the heated products of combustion from the furnaces to said preheating zones with said highly heated fresh air, and independent controlling mechanism for said products of combustion.

5. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces, discharging their products of combustion into the firing zone, in a direction toward the said partition wall, independent means for controlling said furnaces for maintaining a gradually increasing temperature in the same direction longitudinally of each firing zone, means for withdrawing the products of combustion from each of the firing zones, said tunnels being provided with parallel preheating zones, each communicating with one of said firing zones, and parallel cooling zones each communicating with the opposite end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones and heating fresh air, means for conducting said heated air from the recuperating means and delivering it to each of said separate preheating zones at different points, independent regulating means for controlling the admission of said fresh heated air to each of said preheating zones at separated points, and means for withdrawing air heated by the fired products in said cooling zones and conducting it to a point of use outside of the kiln.

6. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces at different points longitudinally thereof, discharging their products of combustion into the firing zone, in a direction toward the said partition wall, independent means for controlling said furnaces for maintaining a gradually increasing temperature in the same direction longitudinally of each firing zone, means for withdrawing the products of combustion from each of the firing zones, said tunnels being provided with parallel preheating zones, each communicating with one of said firing zones, and parallel cooling zones each communicating with the opposite end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones and heating fresh air, means for conducting said heated air from the recuperating means and delivering it to each of said separate preheating zones at different points, independent regulating means for controlling the admission of said fresh heated air to each of said preheating zones at separated points, means for withdrawing the air heated by the fired products in said cooling zones and conducting it to a point of use outside the kiln, means for utilizing the residual heat of the products of combustion after leaving the recuperating means for heating additional quantities of air, and means for conducting such additional quantities of air to a point of use outside of the kiln.

7. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces at different points longitudinally thereof, discharging their products of combustion into the firing zone, each of said firing zones being provided with a longitudinal baffle wall between the furnaces and the goods space thereof extending to a point near the top of the firing zone and forming a passage for the products of combustion from each furnace, discharging them downwardly upon the goods in the goods space between the baffle wall and the central partition wall and away from the exterior wall of the firing zones, each of said firing zones being provided adjacent to the lower portion of its goods space on the side thereof adjacent to the baffle wall with eduction means for withdrawing the products of combustion from said zone, each tunnel being provided with a preheating zone communicating with the entrance end of one of said firing zones, and a cooling zone communicating with the exit end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones, and heating fresh air, means for conducting said heated air from the preheating means and delivering it to each of said preheating zones, and independent regulating means for controlling the admission of said highly heated air to the preheating zones at separated points longitudinally thereof, the said central partition wall between said tunnels acting as a heat reservoir and stabilizer to maintain

the same temperatures on opposite sides thereof in adjacent tunnels throughout the range of temperatures longitudinally of the kiln.

8. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces, discharging their products of combustion into the firing zone at different longitudinal points, each of said firing zones being provided with a longitudinal baffle wall between the furnaces and the goods space thereof extending to a point near the top of the firing zone and forming a passage for discharging the products of combustion from each furnace downwardly upon the goods in the goods space of one of the tunnels and away from the exterior wall of the firing zones, eduction means for withdrawing the products of combustion from said zones, each tunnel being provided with a preheating zone communicating with the entrance end of one of said firing zones, and a cooling zone communicating with the exit end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones and heating fresh air, means for conducting said heated air from the preheating means and delivering it to each of said preheating zones, independent regulating means for controlling the admission of said heated air to the preheating zones at separated points longitudinally thereof, means for admitting portions of the products of combustion from the furnaces to said preheating zones, controlling valves thereof, and means for supplying fresh cool air, with the products of combustion so admitted, to said preheating zones for tempering the products of combustion and supplying additional quantities of oxygen thereto, and independent regulating means for controlling the admission of said cool air.

9. A twin tunnel kiln provided with two exterior walls, and an impervious central partition wall extending throughout the length of the kiln, each tunnel comprising a centrally located firing zone provided with a series of furnaces discharging their products of combustion into the firing zone at different longitudinal points, each of said firing zones being provided with a longitudinal baffle wall between the furnaces and the goods space thereof extending to a point near the top of the firing zone and forming a passage for discharging the products of combustion downwardly upon the goods in the tunnels and away from the exterior wall of the firing zone, each of said firing zones being provided adjacent to the lower portion of its goods space on the side thereof adjacent to the baffle wall with eduction means for withdrawing the products of combustion from said zone, each tunnel being provided with a preheating zone communicating with the entrance end of one of said firing zones, and a cooling zone, communicating with the exit end of one of said firing zones, goods conveying means movable in the same direction through each tunnel, recuperating means for receiving the products of combustion from said firing zones, and heating fresh air, means for conducting said heated air from the reciprocating means and delivering it to each of said preheating zones, independent regulating means for controlling the admission of said highly heated air to the preheating zones at separated points longitudinally thereof, means for admitting portions of the products of combustion from the furnaces to said preheating zones, controlling valves therefor, and means for supplying cool fresh air, with the products of combustion, to said preheating zones, independent regulating means for controlling the admission of said cool air, means for utilizing the residual heat of the products of combustion from the recuperating means for heating additional quantities of air, means for conducting said additional quantities of heated air to a point of use outside of the kiln, and means for withdrawing heated air from the cooling zones and conducting it to a point of use outside of the kiln.

In testimony whereof I affix my signature.

WILLIAM LEE HANLEY, JR.