H. L. DOHERTY.

APPARATUS FOR BURNING CERAMIC WARE.

APPLICATION FILED SEPT. 30, 1910.

1,175,247.

Patented Mar. 14, 1916.

2 SHEETS—SHEET 1.

FIG. 3.

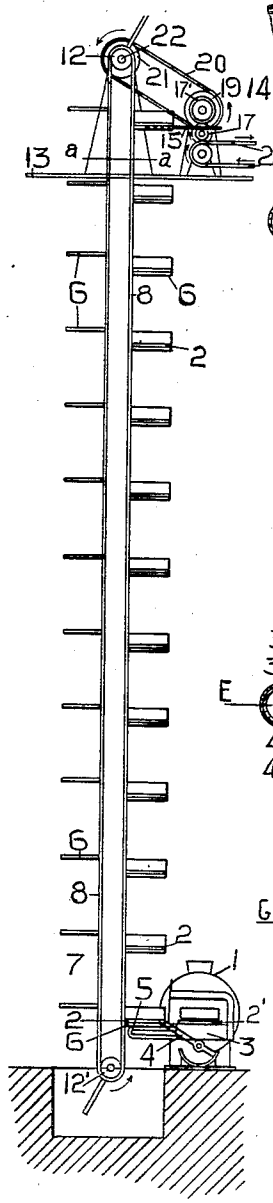


FIG. 1.

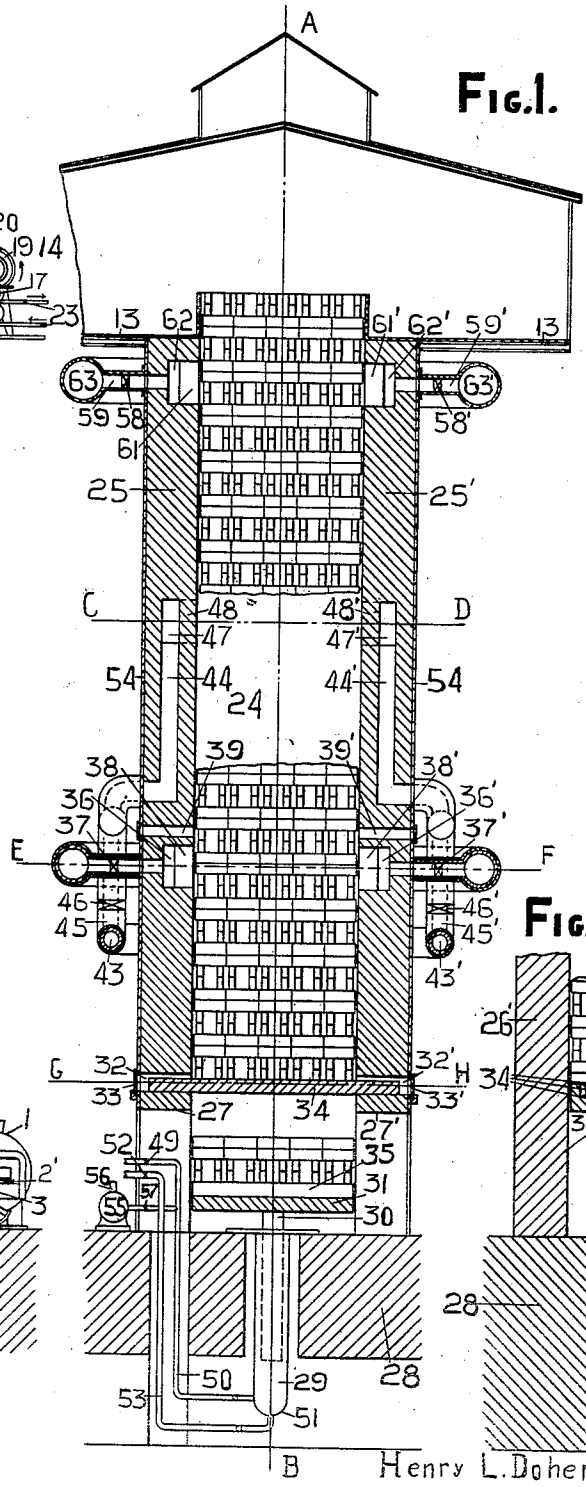


FIG. 4.

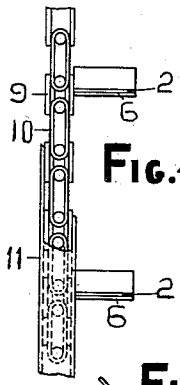


FIG. 5

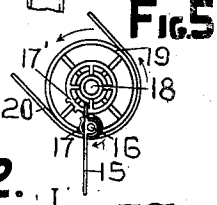
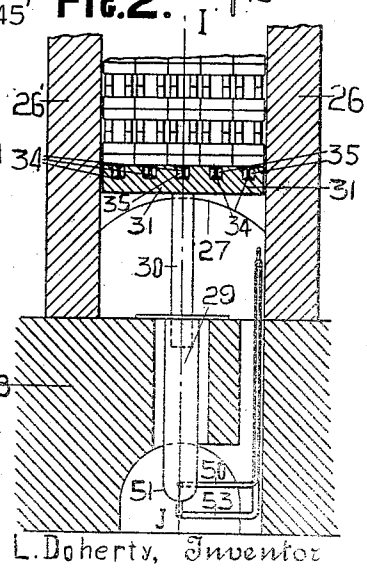


FIG. 2.



Witnesses:

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2 SHEETS—SHEET 2.

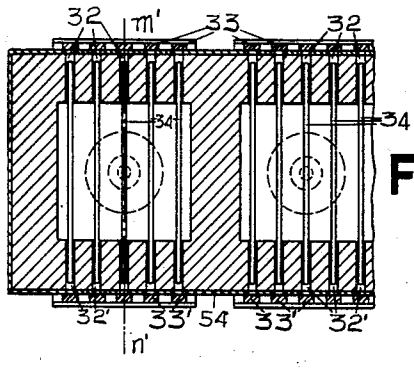


FIG. 9.

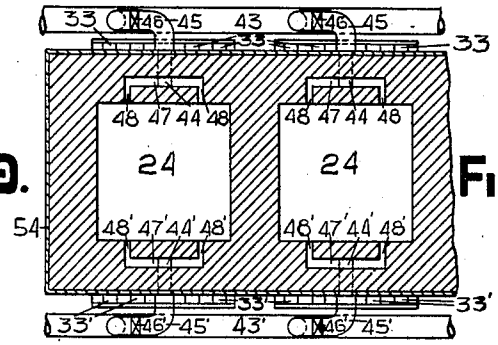


FIG. 8.

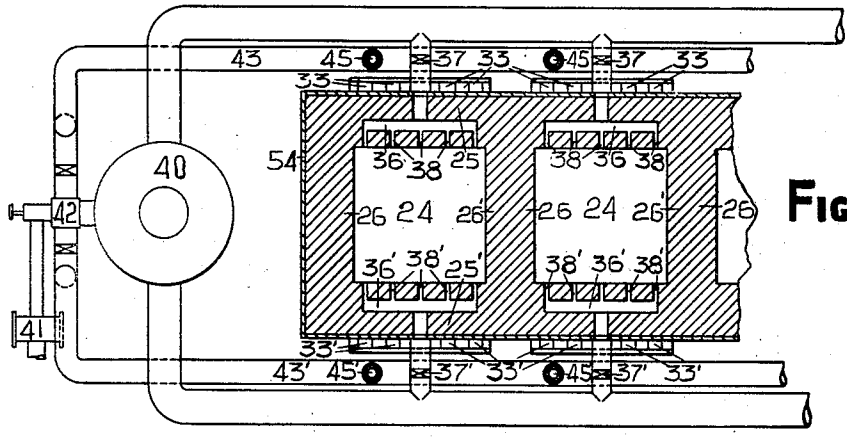


FIG. 7.

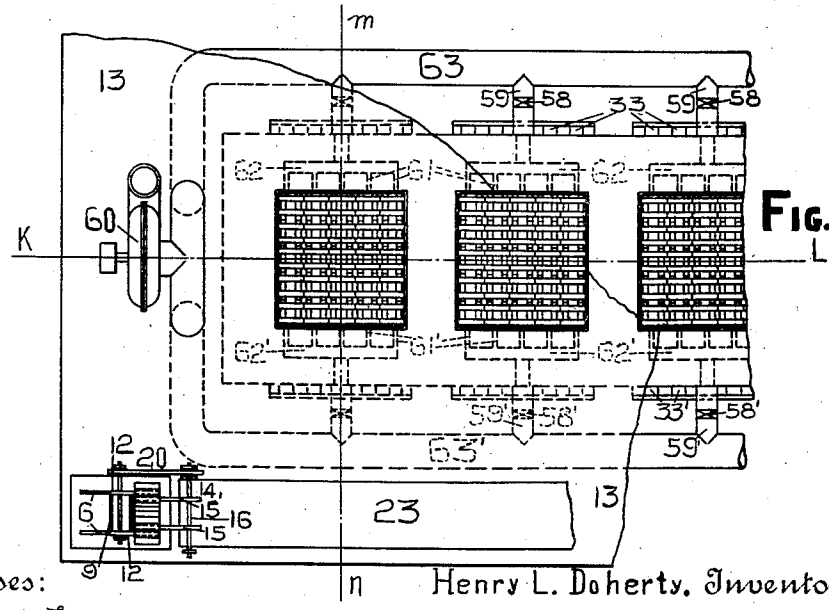


FIG. 6.

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UNITED STATES PATENT OFFICE.

HENRY L. DOHERTY, OF NEW YORK, N. Y.

APPARATUS FOR BURNING CERAMIC WARE.

1,175,247. Specification of Letters Patent. Patented Mar. 14, 1916.

Original application filed October 29, 1909, Serial No. 525,390. Renewed February 7, 1916, Serial No. 76,773. Divided and this application filed September 30, 1910. Serial No. 584,681.

To all whom it may concern:

Be it known that I, HENRY L. DOHERTY, a citizen of the United States, and a resident of New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Apparatus for Burning Ceramic Ware, of which the following is a specification.

My invention relates to apparatus for burning ceramic ware, and in particular to an apparatus for burning structural brick, tiles, etc., by the process set forth and claimed in my co-pending application Sr. No. 525390 dated Oct. 29, 1909, of which this is a division.

The object of my invention is to provide an apparatus which will insure uniformity in the burning of the product, will permit of continuous operation, and, at the same time, recuperate both the heat of the burned bricks and of the combustion gases discharging from the kiln.

Briefly, my invention comprises a vertical shaft divided in a general way into a drying, a burning, and a cooling zone, means for withdrawing hot combustion gases from the upper portion of said firing zone, means for converting a portion of the combustion products of said combustion gases into combustible gas and for introducing the so-formed combustible gas in admixture, or not, with ordinary producer gas, into the lower part of said firing zone, a movable platform for supporting and lowering the charge column in the shaft, and various other features described in detail below.

It is to be understood that I do not limit my invention to the exact details shown in the accompanying drawings, as it is evident that such details may be varied considerably without in any way departing from the essential features of the invention.

In the accompanying drawings the same numerals are used to denote corresponding parts in all the figures.

In the apparatus for carrying out my invention which I herein describe, Figure 1 is a vertical cross-section through one of the individual shafts or kilns on the lines I J of Fig. 2, and *m n* of Fig. 6. Fig. 2 is a vertical cross-section at right angles to the one in Fig. 1, on the line A B of Fig. 1, and K L of Fig. 6. Fig. 3 is an elevation. (diagrammatic) of the brick or tile press, and elevator for raising the molded ware to the charging platform of the kilns. Fig. 4 is a detail of the elevator. Fig. 5 is a detail of the gear actuating the discharging contrivance at the top of the kiln. Fig. 6 is a part top view of a battery of kilns. Fig. 7 is a part horizontal section through the battery of kilns on a plane through the line E F of Fig. 1 at the level of the gas ports. Fig. 8 is a similar section on the line C D of Fig. 1 at the level of the combustion gas off-takes and Fig. 9 is a similar section through the line G H of Fig. 1, at the level of the air inlets and the false bars supporting the charge in the kiln.

The construction and method of operating my apparatus is as follows:—The bricks or tiles, as the case may be, are molded in the ordinary manner by the press 1, and emerge onto a platen 2, on the cutting table 3. By operating the lever 4, the bricks are cut to the proper size and the platen on which they rest moved to one side on the arms 5, while an empty platen, 2′, is placed in position to receive a fresh lot of bricks. The charged platen is next lifted from the carriers 5 by the projecting arms 6 of elevator 7. This may be of any suitable design, the device shown consisting of a sprocket chain 8, having links 9, bearing the arms 6, connected with each other by the solid links 10. The chains 8 work in suitable guides 11, and over pairs of suitable sprocket wheels 12 and 12′, respectively, of which 12 are the driving wheels. The loaded platens supported by the arms 6 are raised to the level of the charging platform 13, at the top of the kilns. Here they are lifted from the elevator by a contrivance, 14. The contrivance here shown has 2 arms, 15, 15′, mounted on a shaft 16, which shaft carries a mutilated gear 17. This meshes into a corresponding gear wheel 17′ on the shaft 18. 18 has a pulley 19, which is connected by the belt 20 with a pulley 21 on the axle 22 of the sprocket wheels 12′. The gear wheels are of such relative diameters that the gear 17 rotates through, say, 105 degrees while the gear 17′ rotates through a lesser arc of, say, 30 degrees or more. The arms 15 and 15′ are so weighted that upon the disengagement of the gears 17—17′ they will drop to a vertical position, thereby rotating the toothed portion of the periphery of the gear

wheel 17 back into a position from which it can again engage the gear 17′ when the toothed portion of the latter again comes into the proper position on the further rotation of the sprocket wheels. These latter should be of such diameter that their circumference is equal to the interval between the arms 6 on the chains. By this device as each platen with its load of bricks, or other ware, approaches the position *a a*, the arms or rotatable skids 15 and 15′ are caused to rotate, passing upward between the arms 6 of elevator 7, lifting the platen off of the elevator. As the arms 15 and 15′ approach their upper position the platen slides down them by gravity and onto the moving belt conveyer 23, by which it is conveyed to whatever kiln is, at the time, being charged, where it is lifted off the belt by a workman and the bricks which it carries built onto the column of bricks in the kiln after the manner hereinafter described.

The kilns are arranged in batteries of any convenient number. The kilns themselves are all alike. Each consists of a shaft, 24, inclosed by end walls 25 and 25′ and side walls 26 and 26′. A steel jacket 54, may be used to incase the exterior of the kiln walls, but this is not essential if the walls themselves are made fairly air-tight. The end walls are supported on arches 27 and 27′, resting on the foundation 28. The side walls 26, 26′ rest directly on 28. If preferred, the shaft may be made circular or elliptical in section, though I do not consider it as desirable as the rectangular section illustrated.

In the foundation of the kiln is placed a hydraulic ram, 29, the plunger, 30, of which carries a platform 31. The platform is normally in the position shown in Fig. 2 and thus closes the bottom of the kiln against the indraft of an excess of air. Above the arches 27—27′ are a number of narrow openings 32, 32′, respectively. These pass entirely through the respective walls 25, 25′, and establish communication between the atmosphere and the shaft 24. Suitable dampers, 33, 33′,—simple slides as shown—serve to regulate the free area of the ports 32, 32′ and thus control the quantity of air admitted to the kiln. These ports, 32, also have another and separate function, which is to permit of the insertion of false bars, 34, bridging the shaft 24, and furnish support for the ends of the bars. The function of the bars 34 is to provide a temporary support for the column of bricks or other ware in the shaft 24, during the time occupied in lowering the platform 31 and removing the section of the charge of burned bricks which it carries. The platform, 31, has deep grooves, 35, which correspond in position with the false bars 34, and are of a depth slightly (say about $\frac{1}{2}$ inch) greater than the height of the bars. The width of the flat tops of the bars should be about that of the thickness of a brick. The number of bars should be the same as the number of bricks required to span the shaft when laid end to end, the bars being so spaced that each comes directly under the middle of the row of transverse bricks which it supports.

In starting operations, a column of previously burned bricks is built up from the platform 31, which then occupies its highest or normal position. The bricks may be laid in checker work, according to the plan figured, or according to any plan now used in charging brick kilns provided that at uniform intervals courses are laid which provide longitudinal channels corresponding in vertical position with the ports 32, of sufficient width and depth to permit of the insertion of the bars 34. The intervals to be observed between these special courses depend principally upon the frequency with which the "draws" are to be made, and should correspond to the height of the column of brick (or other ware) that can be completely burned in the time alotted between "draws". The number of courses of the green brick or tile (or any other ware) that may be charged at one time depends upon the strength possessed by the green bricks and should correspond to the number of courses the green bricks are able to bear without deformation. This may be taken as from four to eight courses, depending upon the quality of the "metal", pressure used in molding the bricks, etc. Therefore, in my preferred method of working I charge several times during the interval between "draws", keeping, of course, the aggregate number of courses charged during an interval equal to the number of courses drawn at one time. In the plan of laying the brick shown, a uniform arrangement has been observed throughout the charge. As mentioned above, however, by putting in a special course at regular intervals any suitable arrangement may be used for the intermediate courses.

The shaft 24 having been charged with burned bricks the kiln is in a condition to start operations. Producer gas is admitted to the flues 36, 36′ by opening the valves 37, 37′. From 36, 36′ the gas passes through the gas ports 38, 38′ into the shaft 24, where it is ignited by means of suitable torches introduced through the hand-holes 39, 39′. The air for supporting combustion enters through the air ports 32, 32′. The flames from the gas ports 38, 38′ penetrate to the interior of the charge through the open channels in the alternate double courses and pass upward through the checker work, normally escaping through the open top of the kiln to the atmosphere. The gas ports 38, 38′ are, preferably, built high and narrow, the height in the case of a brick kiln being

equal—for the plan of laying the brick shown in the drawings—to two double courses of brick. There is therefore a series of open flues through the charge always facing the gas ports. These afford the necessary space for the development of the flame when starting the kiln with a cold charge. If preferred, open combustion chambers may be built into the kiln walls at the gas ports which will fulfil the same function.

The producer gas is supplied by the gas producer 40, located in the present plan at one end of the battery of kilns. I may use any type of producer in this connection, although I prefer a down-draft type. The air for the producer is supplied by, preferably, a positive-pressure blower 41. The discharge pipe of 41 is connected to the nozzle of an injector 42. Combustion-gas conduits 43, 43′, heavily insulated, connect the induction chamber of the injector with the flues 44, 44′ of each kiln through the connection 45, 45′, respectively. Valves 46, 46′, on 45, and 45′, respectively, serve to regulate or entirely cut off the connection between the kiln and the conduits 43, 43′. The flues 44, 44′ communicate with the horizontal flues 47, 47′, respectively, which in turn communicate with the sets of gas ports 48, 48′. When communication has been established between the shaft of the kiln and the conduits 43, 43′, through the passages above mentioned, by opening the valves 46, 46′ a portion of the combustion gases is withdrawn from the kiln and carried into the producer with the air discharged through the injector 42. The draft current of mixed air and products of combustion enters the producer below the grate and passes upward through the bed of fuel therein. In the method of operating the producer which I prefer I pass the draft current through the fuel bed at such a speed that only part of its carbon dioxid is dissociated. This result may be effected in three different ways. (1) I may work with a comparatively restricted gas making area; (2) I may work with a large gas making area but a limited depth of fuel; or, (3) may work at a temperature so low that the reaction between the carbon of the fuel bed and the CO_2 of the draft current takes place only sluggishly, permitting a comparatively high proportion of the CO_2 to go through unchanged. In this latter case, owing to the low temperature of the fuel bed and the consequent low rate of combustion, it is necessary to provide a relatively large gas making area for the producer.

Instead of passing all the combustion gas withdrawn from the kiln through the ports 48, 48′, through the fuel bed of my producer, I may, if I prefer, divide the current of combustion gases into two portions, adding one portion to the air current supplied to the producer in the manner described above and the other to the normal producer gas above the fuel bed. The result secured is precisely the same as by the first procedure, *i. e.*, a large volume of modified producer gas of much lower calorific value per cubic foot than the normal gas but containing a much greater number of B. T. U. of potential heat per unit of fuel consumed on the grate. I aim to introduce my combustion gases into the producer at as high a temperature as is consistent with a satisfactory operation of the kiln itself. With this in view, I withdraw my combustion gases at the upper limit of what may be considered the firing zone proper, where they are at a temperature of, say, 1700° Fah., and conduct them through heavily insulated conduits to the gas producer. By introducing the combustion gases into the producer at a high temperature I greatly reduce the net quantity of heat which is required to dissociate the CO_2 of the combustion gases, and therefore increase the proportion of combustion gases which I may supply to the producer.

As is well known to those skilled in the art, the reaction between CO_2 and carbon,

$$CO_2 + C = 2CO,$$

is a highly endothermic one. The maximum percentage of CO_2 which may be present in the combustion gases in practice is 20.8, but owing to the necessity of conducting the combustion with at least a slight excess of air the percentage present seldom reaches 19%. With this percentage of CO_2 the temperature that must be possessed by the combustion gases at their point of entrance to the fuel bed in order to make the above reaction with all the CO_2 self-supporting (*i. e.*, in order to dissociate all the CO_2 of the combustion gases without taking heat from the fuel bed) is, in practice, about 3200° Fah. Any deficiency in the sensible heat carried by the gases below that corresponding to this temperature must be supplied by the air combustion of the fuel in the producer when it is desired to carry out the reaction to the point of practical completion. By introducing my combustion gases into my producer at the highest practicable temperature I am able to deliver to my kiln the proper quantity of CO with the use in the producer of much less than the normal volume of air. It is to be noted that the gasification of the fuel by CO_2 forms double the volume of CO per unit of fuel that is given by the air gasification of the fuel. When using air gasification in the producer theoretically one-half of the total air required for combustion in the system (producer and kiln) is introduced into the producer. By my system much the larger proportion of air is used in the secondary combustion in the kiln. I thus have available a much larger volume of air for cool-

ing my bricks or other ceramic ware, without resorting to the injurious system of over-ventilating, than is possible in the ordinary method of running the producer. This is the main object in introducing the hot combustion gas into the producer. Incidentally, I am able as the result of the use of combustion gases in my producer to operate the latter at a temperature below the clinkering point of the ash of the fuel.

As stated above, my object in modifying my producer gas is to obtain a gas which, without any sacrifice of net calorific value per unit of fuel burned in the producer, will contain sufficient diluent gas to reduce the temperature developed in its combustion to that desired in burning the ware under treatment. This temperature varies from, say, 1700° to, say, 2900° according to the nature of the ware that is being fired. For ordinary hard brick I modify my gas to secure a flame temperature of about 1800° Fah. For vitrified paving brick, on the other hand, the quantity of diluent gas introduced is much less since, in this case, I require a flame temperature of about 2900° Fah.

By thus modifying my producer gas and carrying out the burning in the type of apparatus which I, herein, reveal, I am able to secure a high degree of uniformity in the burning of the bricks or other ware. With all the methods of burning known to me that are in present use, this result is impossible.

As soon as the heat in the kiln above the level of the gas ports has been brought up to about the normal temperatures I begin the actual operation of the kiln. The valves 58—58′ on the top gas off-takes 59—59′ are opened and the exhauster 60 started. The suction of the exhauster draws off the combustion gases from the upper portion of the shaft through the ports 61—61′, the horizontal cross flues 62—62′, the off-takes 59—59′ and the conduits 63—63′ to the exhauster 60. This exhauster is of sufficient capacity to, not only, draw off the entire volume of products of combustion from the kiln, but to also cause a down-draft of air through the open top of the kiln, enabling the workmen to lay fresh courses on top of the column. Green or unburned bricks (with or without having been subjected to a preliminary drying) are now built onto the column of burned bricks (or other ware) originally charged into the kiln. The number of courses laid depends, as previously mentioned, upon the strength of the green bricks, and is usually from four to eight. As the first courses of green bricks are dried by the combustion gases discharging from the kiln, additional courses are built onto the columns, until there has been laid a number of courses corresponding to the number that is to be drawn. The valve 49 on the pipe 50 of the ram 29 is now opened and the water in the cylinder 51 of the ram allowed to slowly escape into an accumulator (not shown). The plunger of the ram 29 sinks gradually against the pressure in the accumulator, the column of brick, or other ware, in the kiln shaft, of course, settling with it. When the column has settled a distance corresponding to the number of courses of green bricks added to the top of the column the valve 49 is shut and the plunger comes to rest. If the column has been built up in the manner above specified, when the motion of the plunger has been stopped, there will be open transverse flues in the brickwork corresponding in position to the sets of air ports 32—32′. The false bars, 34, are now inserted through the air ports on one side and pushed through the above mentioned flues or channels until their ends rest on the bottom of the opposite air ports. The valve 49 is again slightly opened and the plunger with its platform and burden sinks slowly until the bricks of the transverse course above the bars have come to rest on the bars. The valve 49 is now closed and the valve 52 on pipe 53 opened, allowing the water in cylinder 51 to escape to a drain. The plunger falls carrying with it that portion of the charge column below the false bars 34. When the platform 31 has come to rest these bricks are removed and placed upon a car or conveyer for conveyance to storage. The valve 52 having been closed when the plunger had reached its lowest position the valve 49 is again opened and the pressure in the accumulator lifts the plunger until the face of the platform 31 has come into contact with the bricks resting upon the beams. The bars, 34, sink into the corresponding channels, 35, in the platform 31. The valve 49 is now closed.

The firing is now continued until the hot gases passing up through the kiln have completed the burning of a fresh section of brick and have dried the green bricks to an extent that will enable them to bear the burden of another series of charges each of 4 or 8 courses, as may be, of fresh brick. When this condition has been attained the pump 55, whose suction pipe 56 is connected with the accumulator mentioned, is started and valve 57 on the discharge pipe of the pump, which pipe is connected into the pipe 50, is opened. The water forced into the cylinder 51 raises the plunger 30 with its platform and burden until the weight of the latter has been lifted off the bars 34. These latter are now withdrawn, the valve 57 closed and the valve 49 opened, allowing the water in the cylinder 51 to escape to the accumulator as before. The column is dropped for the proper number of courses as before, the bars 34 again inserted, the portion of the column below the

bars removed from the kiln as before, and the platform 31 again raised to its normal position. The fan 60 is again started, and another series of charges of 4 courses (or whatever number has been decided upon as suitable) of green bricks is built upon the top of the charge, and the operation continued as before.

When all the original charge of burned brick has been withdrawn, the kiln has assumed its normal operating condition. In this condition the kiln is filled with bricks (or other ware) in all stages of burning. The latest charged courses are subjected to the action of the comparatively cool combustion gases discharging from the kiln. These, while at a comparatively low temperature, owing to their relatively great volume, rapidly absorb the moisture in the new courses of green bricks on top of the charge. As the bricks are withdrawn at the bottom of the kiln and the charge sinks, the partially dried bricks are carried further down into the shaft, where they are subjected to a current of gas of somewhat higher temperature, and completely dried, while another set of courses of green bricks are built up upon them. After each draw, the particular lot of bricks whose course we are tracing through the kiln, is exposed to gases of increasing temperature until it has been brought up to the previously determined temperature of burning. It now enters and passes through the firing zone, proper, where it is exposed to the flame of modified producer gas of the selected temperature. As shown in the drawings, the gas ports are high and narrow, the height being equal to two double courses of bricks. There is, therefore, always a course of bricks laid end on toward the ports presenting clear transverse channels facing the ports, and affording a free passage for the flame to the interior of the column of bricks filling the shaft. This results in a very uniform distribution of the flame throughout the column, with the result that all the bricks in the lot are exposed to practically identical conditions. As the bricks pass below the firing zone, they meet the ascending current of heated air which has passed through the previously burned bricks in the lower part or "cooler" of the kiln. This air, while cooler than the bricks just leaving the firing zone, is still of such a temperature that there is no sudden chilling effect exerted upon the bricks with the resulting brittleness, such as occurs when cold air is admitted to the kiln after drawing the fires in the ordinary method of burning. As the bricks sink through the cooler, they are exposed to air of gradually decreasing temperature, until upon reaching the bottom of the cooler, they have had their temperature reduced to nearly that of the atmosphere. The heat carried out of the firing zone by the bricks is thus returned to the same by air supplied for the combustion. On the other hand, when the hot combustion gases leave the firing zone and pass through the cooler bricks above they give up their heat to the latter which, in effect, restore it to the firing zone. I am thus able to secure, in my method of burning, a practically perfect recuperation of both the heat of the combustion gases and that of the burned bricks. Moreover, all parts of the charge are exposed successively to absolutely identical conditions. Further, the arrangement of my kiln is such that the most favorable possible conditions of treatment are secured. The bricks are first dried by contact with gases of comparatively low temperature, they are then slowly annealed up to the burning temperature, exposed to this temperature for a sufficient length of time to secure thorough burning, and then gradually annealed down to atmospheric temperature.

As mentioned above, I may build in a special course of already burned bricks at each charging designed to engage the false bars. These special bricks or tiles may be made stronger and larger than the ordinary bricks which constitute the bulk of the charge, and therefor give greater security against breakage due to the failure of the "bridge" bricks resting on the false bars.

The kilns are all operated in the same manner, the producer, blower, and exhauster being common to the battery of kilns, although it is of course possible to provide each kiln with a separate producer, blower and exhauster if such an arrangement be preferred. The various operations of charging and drawing are arranged to take place on the different kilns successively so that it is possible to operate a large battery of kilns with one set of workmen. This also permits of a very uniform quality of combustion gas being supplied to the producer. During the time of drawing a kiln, there is necessarily, a considerable inrush of air at the bottom which results in the presence of a considerable percentage of free oxygen in the combustion gases. During this period the kiln that is being drawn may be cut off from the fan, and the combustion gas supplied to the producer drawn only from the kilns which are in normal condition.

It is understood that the term "modified producer gas" means a gas made in a gas producer under such conditions that the resultant gas designedly contains a more or less abnormal proportion of diluent gas, the proportion of said diluent being adjusted to that which will give on the subsequent combustion of the gas a flame temperature slightly above the temperature at which it is designed to burn the ceramic material. Owing to the poor conducting power of

ceramic materials a slight differential must exist between the temperature of the flame and the temperature at which it is designed to burn the ceramic ware. For example, if I intend to burn the material at 1800° Fah. I would aim to make a producer gas which on combustion with the hot air in the kiln would give an initial flame temperature of 1900° to 2000° Fah. It is to be understood, also, that by the term "ceramic ware" which I use in the claims I mean to include all varieties of structural bricks and tiles which are subjected to burning as a step in their manufacture as well as paving bricks, fire bricks, terra-cotta ware, pipes, etc.

Having described my invention, what I claim is:—

1. A shaft-kiln comprising a shaft, said shaft comprising a preheating zone, a firing zone and a cooling zone, a plurality of ports in opposite walls of said kiln near the bottom of said firing zone for the admission of combustible gas to said shaft, openings for the admission of air to said shaft near the bottom of said cooling zone, a plurality of ports near the top of said firing zone for the withdrawal of combustion gases, a conduit connecting the said ports near the top of said firing zone with the said ports near the bottom of said firing zone, and a chamber adapted to contain a comparatively deep bed of ignited fuel interposed in said conduit, whereby combustion gases withdrawn from said shaft may be returned to said shaft after traversing said deep bed of ignited fuel.

2. In a kiln for the continuous burning of ceramic ware, the combination of a substantially vertical shaft comprising a preheating section, a firing section and a cooling section, all in substantially vertical alinement, one or more ports in opposite walls of said shaft at the bottom of said firing section, one or more ports in opposite walls of said shaft near the top of said firing section, a conduit connecting the port or ports at the top of said firing section with the port or ports at the bottom of said firing section, and a chamber adapted to contain a comparatively deep bed of fuel and a draft-inducing means interposed in said conduit.

3. In a kiln for the continuous burning of ceramic ware the combination of a vertical shaft, inclosing walls for said shaft, a plurality of removable bars near the bottom of said shaft for the purpose of temporarily supporting the charge of ceramic ware in said shaft during the interval of discharging material, a vertically-movable platform adapted to form the normal closure for the bottom of said shaft and in its highest position to lift the weight of the charge in said shaft from said plurality of removable bars, a plurality of dampered ports in said inclosing walls for permitting the withdrawal of said bars from said shaft when said platform is in its highest position and for regulating the admission of air to said shaft, a plurality of ports in the walls of said shaft for the admission of combustible gas thereto, flues in said inclosing walls connecting said plurality of gas ports, passages connecting said flues with supply conduits for combustible gas, valves on said connections, a plurality of ports in said inclosing walls above said gas ports for the withdrawal of a portion of the combustion gases from said shaft, cross flues in the walls of said shaft connecting said plurality of ports, flues connecting each of said cross flues with corresponding combustion gas conduits conducting the combustion gases withdrawn through said ports to a gas producer, valves on said connecting flues, and an opening at the top of said shaft for the escape of the waste combustion gases therefrom and for charging unburned ceramic ware thereto.

4. In a kiln for the continuous burning of ceramic ware, the combination of a vertical shaft, inclosing walls for said shaft, openings at the bottom of said shaft for the withdrawal of burned ceramic ware therefrom, a plurality of removable bars near the bottom of said shaft for the purpose of temporarily supporting the charge of ceramic ware in said shaft during the period of discharging material, a vertically-movable platform adapted to form the normal closure for the bottom of said shaft above said opening for the withdrawal of burned ceramic ware and in its highest position to lift the weight of the charge in said shaft from said plurality of removable bars, a plurality of dampered ports in said inclosing walls for permitting the withdrawal of said bars from said shaft when said platform is in its highest position and for regulating the admission of air to said shaft, a plurality of ports in the walls of said shaft for the admission of combustible gas thereto, flues in said inclosing walls connecting said plurality of gas ports, passages connecting each of said flues with supply conduits for combustible gas, valves on said connections, a plurality of ports in said walls above said gas ports for the withdrawal of a portion of the combustion gases from said shaft, cross flues in the walls of said shaft connecting said plurality of ports, flues connecting each of said cross flues with corresponding gas conduits conducting the combustion gases withdrawn through said ports to a gas producer, valves on said connecting flues, an opening at the top of said shaft for the escape of waste combustion gases therefrom and the charging of unburned ceramic ware thereto, a plurality of ports in the walls of said shaft located below said opening for permitting the with-

drawal of combustion gases there-through, cross-flues connecting said ports, flues connecting said cross-flues with combustion gas conduits, valves on said connections, and a draft-inducing means for inducing a draft current through said gas conduits.

5. In a kiln for the continuous burning of ceramic ware, the combination of a vertical shaft, inclosing walls for said shaft, openings at the bottom of said shaft for the withdrawal of burned ceramic ware therefrom, means for detaching from the lower portion of the charge of ceramic ware in said shaft a section of said charge containing the burned and cooled ceramic ware, said means comprising a plurality of removable bars in said shaft for supporting the charge during the period occupied by the withdrawal of material, a plurality of dampered ports in the walls of said shaft for the insertion and withdrawal of said plurality of bars, the bottoms of said ports furnishing supports for said bars, a vertically-movable hydraulically-actuated platform having channels corresponding in position with said removable bars, said channels being of a section slightly greater than said bars and adapted to receive said bars when the said platform is in its highest position, the said platform being adapted to form the normal closure for the bottom of said shaft and to engage and lift the weight of said charge from said bars when in its highest position, and, after the withdrawal of said removable bars to cause the charge in said shaft to sink with it on its downward movement, and after the re-insertion of the said removable bars to detach and carry down with it that section of the charge in said shaft below said removable bars, a plurality of ports in the walls of said shaft for the admission of combustible gas thereto, flues in said inclosing walls, connecting said plurality of gas ports, passages connecting each of said flues with producer gas conduits connected with a gas producer, valves on said connections to said conduits, a plurality of ports in said walls above said gas ports for the withdrawal of a portion of the combustion gases from said shaft, cross-flues in the walls of said shaft connecting said plurality of ports, flues connecting each of said cross-flues with corresponding gas conduits conducting the combustion gases withdrawn through said ports to a gas producer, valves on said connecting flues, an opening at the top of said shaft for the escape of waste combustion gases therefrom and for charging unburned ceramic ware thereto, a plurality of ports in the walls of said shaft located below said opening for permitting the withdrawal of combustion gases there-through, cross-flues connecting said ports, flues connecting said cross-flues with combustion-gas conduits, valves on said connections, and a draft inducing means for inducing a draft current through said gas conduits.

6. In a kiln for the continuous burning of ceramic ware, the combination of a substantially vertical kiln chamber, walls inclosing said kiln chamber, said kiln chamber comprising a cooling zone, a firing zone and a preliminary heating zone, all in substantially vertical alinement, said preliminary heating zone being located in the upper part of said kiln chamber, said cooling zone located in the lower part of said kiln chamber and said firing zone being located between said preliminary heating zone and said cooling zone of said kiln chamber, means for charging said kiln chamber at the top of said preliminary heating zone, means for introducing combustible matter into said kiln chamber at the bottom of said firing zone, means for introducing air into said kiln chamber at the bottom of the said cooling zone, means near the top of the said preliminary heating zone for withdrawing products of combustion from said kiln chamber, ports near the top of the firing zone for withdrawing a part of the products of combustion from the kiln chamber, a conduit connecting said ports with said means for introducing combustible matter, a fuel container interposed in said conduit, means at the bottom of said cooling zone for supporting the charge in said kiln chamber and means at the bottom of said cooling zone for withdrawing the burned ware from said kiln chamber.

7. In a kiln for continuous burning of ceramic ware, the combination of a shaft comprising a preheating zone, a firing zone and a cooling zone, all in substantially vertical alinement, means for charging unburned ware into said shaft at the top thereof, means for withdrawing the burned ware from the bottom of said shaft, means for introducing air into said shaft near the bottom of said shaft through the sides thereof, means for introducing a combustible gas into said shaft at a plurality of points on opposite walls of said shaft and at the lower part of the firing zone of said kiln, ports for withdrawing from said shaft the products of combustion of said gas and said air from the upper part of the firing zone and from the upper part of the preheating zone, a conduit connecting the said ports for withdrawing products of combustion from the upper part of the firing zone with the said means for introducing combustible gas, a fuel container interposed in said conduit, and means for supporting the charge in said shaft.

8. In a kiln for the continuous burning of ceramic ware the combination of a comparatively long substantially vertical kiln chamber, said chamber comprising a preheating

zone, a firing zone and a cooling zone, a movable support for supporting the charge of ceramic ware in said chamber, a stationary support for supporting the charge of ceramic ware in said chamber when said movable support is withdrawn from the charge in said chamber, means for introducing gas and air into said chamber, means for withdrawing products of combustion of said gas and air from said chamber from the upper part of the preheating zone of the same and means for withdrawing the remainder of the products of combustion from the upper part of the firing zone of said chamber, means for reducing a substantial proportion of the carbon dioxid in the portion of said products of combustion withdrawn from the said firing zone to carbon monoxid and means for returning the carbon monoxid formed and its accompanying gaseous diluents to the lower part of said firing zone.

9. In a kiln for the continuous burning of ceramic ware, the combination of a comparatively long substantially vertical kiln chamber having a preheating zone, a firing zone and a cooling zone, walls inclosing said kiln chamber, a hydraulic elevator for supporting the charge in said kiln chamber and for advancing said charge through said kiln, a plurality of bars for supporting said charge when the upper part of said hydraulic elevator has been withdrawn from said charge in said kiln chamber, a conduit for withdrawing hot combustion gases from the upper part of said firing zone, a gas-generator adapted to contain a deep bed of fuel in communication with said conduit, a conduit for conducting effluent gas from said generator to the lower part of said firing zone, and means for maintaining a circulation of hot combustion gases from the upper part of said firing zone to and through said bed of ignited fuel and back to the lower part of said firing zone.

10. In a kiln for the continuous burning of ceramic ware the combination of a comparatively long substantially vertical kiln chamber having a preheating zone, a firing zone and a cooling zone, walls inclosing said kiln chamber, a platform connected to the plunger of a hydraulic elevator, said platform being adapted to normally support the charge in said kiln and for forming the normal closure to the bottom of said kiln chamber and containing a plurality of grooves, a plurality of bars coöperating with said plurality of grooves when said hydraulic elevator is at its highest position, said bars being adapted to support the charge in the kiln when the hydraulic elevator has been withdrawn from the charge in said kiln, ports in the walls of said kiln chamber at the upper part of said firing zone for the withdrawal of hot combustion gases from said zone, a gas-generator adapted to contain a deep bed of ignited fuel, a conduit for conducting said hot combustion gases to said gas-generator and a conduit for conducting effluent gases from said gas-generator to the lower part of said firing zone, whereby combustible gas for maintaining combustion in said firing zone is generated with a minimum proportion of air and the maximum proportion of the total air-supply to said kiln chamber is rendered available for use in said cooling zone.

Signed at New York city in the county of New York and State of New York this 29th day of September A. D., 1910.

HENRY L. DOHERTY.

Witnesses:

WM. N. MACLEAN,

LOUIS ANTONSANTI.