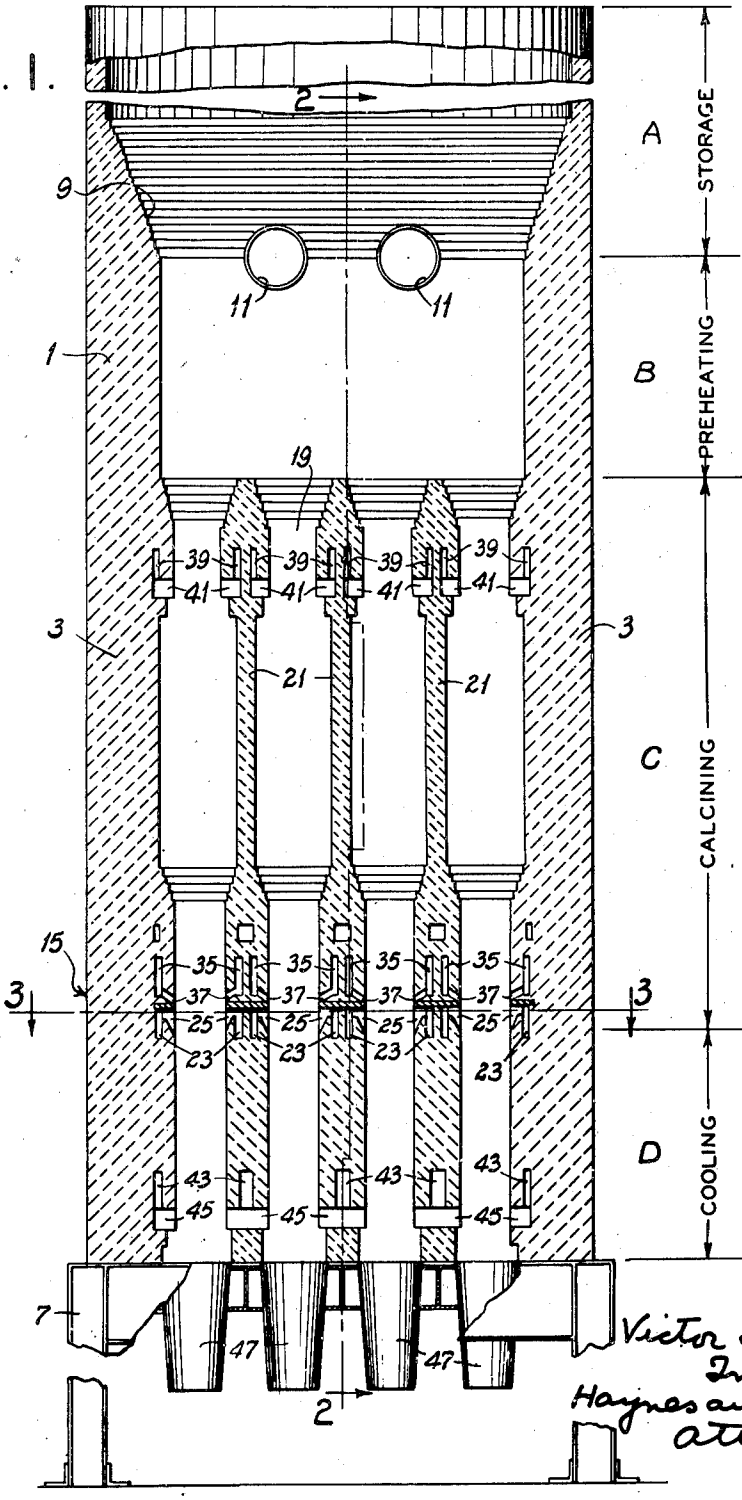
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CALCINING APPARATUS

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FIG. 1.



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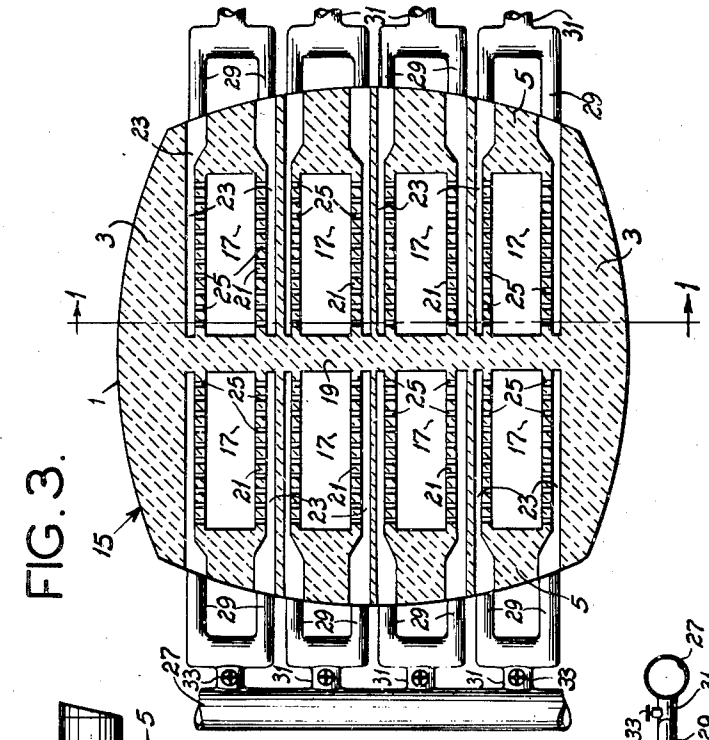


FIG. 3.

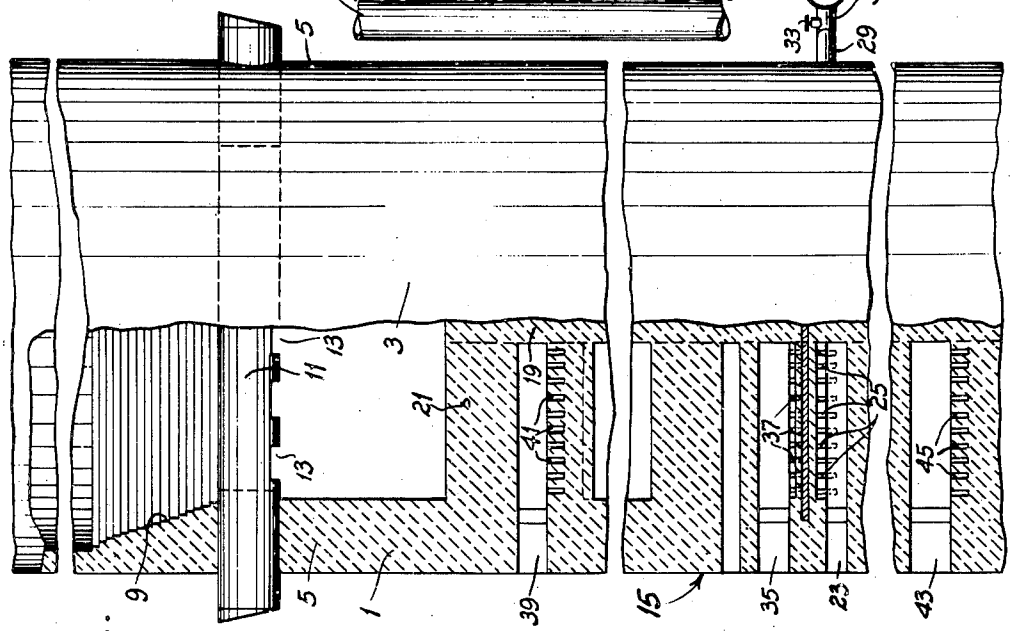


FIG. 2.

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CALCINING APPARATUS

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Application October 24, 1946, Serial No. 705,259

8 Claims. (Cl. 263—29)

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This invention relates to calcining apparatus, and more particularly to a vertical lime kiln for calcination of smaller grades of limestone. It is an improvement upon the kiln disclosed in my copending application entitled Calcining apparatus, Serial No. 588,185, filed April 13, 1945, now Patent No. 2,409,527.

Among the several objects of the invention may be noted the provision of a vertical lime kiln for uniform calcination at a high rate of small stone; the provision of a kiln of this class wherein uniform downward flow of stone and uniform upward flow of hot calcining gases throughout the cross section of the kiln is assured; the provision of a kiln of this class which will consistently produce homogenous lime of high quality; and the provision of such a kiln which is relatively economical to construct, operate and maintain. Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

Fig. 1 is a vertical section through the kiln of this invention, being taken on line 1—1 of Fig. 3;

Fig. 2 is a vertical section taken on line 2—2 of Fig. 1, parts being in elevation; and,

Fig. 3 is a horizontal section taken on line 3—3 of Fig. 1.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

A primary problem in the manufacture of lime is the provision of a kiln in which every piece of limestone will be subjected to the same amount and the same intensity of heat for production of homogeneous, high quality lime. It is most difficult to solve in cases wherein small stone is to be processed. This problem is common both to rotary and vertical kiln construction.

The difficulty in the case of the rotary kiln is due to the fact that the main stream of hot gases passes along the roof of the kiln while the stone travels along the bottom of the kiln, so that there is little effective flow of hot gases through the mass of stone. Most heat transfer is by downward radiation which, to be effective, must be at an undesirably high temperature. Also, since a rotary kiln acts as a mechanical

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classifier, the largest of the limestone will repeatedly pass over the heat-absorbing slope, thus becoming flash burned, while the smallest will be shielded, coming out of the kiln possibly only partly burned. This tends to produce a non-homogeneous product.

The difficulties in the case of prior vertical kilns are that the mass of stone may not flow uniformly downward and that the hot calcining gases may not flow uniformly upward throughout the cross section of the calcining zone of the kiln. Non-uniform downward flow of stone in the calcining zone of prior kilns is due to the difficulty involved in uniformly withdrawing calcined stone from the bottom of the kiln throughout its cross section. It will be clear that if stone is withdrawn fairly rapidly from one side of the calcining zone of the kiln and slowly or not at all from the other side, the downward flow of stone in the calcining zone will be non-uniform. The result is unevenly calcined stone and non-homogeneous lime.

Non-uniform upward flow of hot calcining gases in the calcining zone of prior kilns is due to the difficulty in maintaining the temperature of the gas uniform throughout the cross section of the kiln. The result is that the main ascending stream of gas is divided into individual streams some of which are hotter than others. The hotter streams ascend more rapidly than others and tend to draw into them surrounding cooler gas. The resulting stratification and unequal flow of the hot and cool gases results in unevenly calcined stone.

Non-uniform upward flow of hot gases in prior kilns also results from non-uniform downward flow of stone therein. Where downward flow of stone is most rapid, upward flow of gases is less effective. Excessive withdrawal of calcined stone from any zone of the kiln cools that zone. Any gas flowing in that zone is also cooled and hence upward flow thereof is inhibited. In extreme cases, the gas may even locally flow downward instead of upward. The result is that the least amount of heat is available where the most heat is required.

I have found that the above difficulties may practically be eliminated in a vertical kiln by properly dividing the calcining zone of the kiln into a plurality of vertical passages defining a plurality of channels of properly shaped cross sections to avoid non-uniform downward flow of stone in any channel and to avoid non-uniform upward flow of gases in any channel. The arrangement is such that calcined stone may be

withdrawn from the lower end of any one of these channels without affecting the flow of stone and gases in any other channel.

Referring now to the drawings, there is shown at 1 the vertical hollow shaft of the kiln of this invention. This shaft has side walls 3 and end walls 5 defining a passage of generally rectangular cross sections from its lower to its upper end. It is constructed of suitable refractory material, as will be understood, and rests upon a foundation 7. The passage through the shaft, as illustrated in Fig. 1, is divided vertically into four zones: a storage zone A, a preheating zone B, a calcining zone C and a cooling zone D.

The storage zone A is constituted by the uppermost portion of the shaft. This zone holds a supply of crushed limestone, the supply being replenished through an inlet in the top of the shaft. The storage zone is constricted at its lower end, as indicated at 9, and merges into the preheating zone B directly below. The juncture of the storage zone and the preheating zone is best defined by a pair of horizontal offtake pipes 11 spanning the shaft and extending outward beyond the walls. These pipes have apertures 13 serving as inlets for admitting relatively cool gas from the upper end of the preheating zone, thus providing an offtake for cool gas corresponding to the cool gas offtake pipe (15) of the kiln disclosed in my aforesaid copending application.

Stone gravitates downward from the storage zone A through the preheating zone B wherein it is heated to some extent by the gases flowing upward from the calcining zone C immediately below the preheating zone. Stone gravitates downward from the preheating zone through the calcining zone C wherein it is calcined by hot gases issuing from the combustion region 15 of the kiln. This region defines the lower end of the calcining zone where calcination is completed and also the top of the cooling zone D wherein the calcined stone is cooled by the flow of primary air for combustion, in a manner to be described.

The calcining and cooling zones are divided into a plurality of vertical passages 17. This is accomplished by means comprising a dividing wall or bridge 19 extending centrally across the shaft from one side wall 3 to the other and a plurality of firing walls or bridges 21 extending between end walls 5 and the dividing wall. Each passage 17 constitutes a channel for downward flow of material to be calcined. Each passage 17 extends from the upper end of the calcining zone through the cooling zone to the lower end of the shaft, inasmuch as walls 19 and 21 extend from the lower end of the shaft upward to the upward end of the calcining zone. The passages thus defined are relatively long rectangles in cross section. Three-dimensionally considered, they are long, flat parallelepipeds.

Each firing wall has fuel ducts 23 extending longitudinally in opposite sides from the outside of end walls 5 to the dividing wall 19 for introducing fuel, such as natural gas or the like. These ducts are located in the combustion region 15 of the kiln. Longitudinally spaced outlets 25 in opposite sides of the firing walls lead from the ducts 23 to interior regions 17 of the shaft. Corresponding fuel ducts 23 and outlets 25 are provided in the side walls 3 of the shaft.

The gaseous fuel is supplied to ducts 23 from headers 27 through inlet pipes 29. The inlet pipes for the pair of ducts 23 at opposite sides of a passage 17 are merged, as indicated at 31, and

the flow of fuel to each pair of ducts is under control of a suitable regulator 33. It will be clear that the fuel is supplied to the passages 17 through ducts 23 and outlets 25 in substantially uniformly distributed manner at opposite sides.

Just above the fuel ducts 23 are ducts 35 extending longitudinally in opposite sides of firing walls 21 and in side walls 3 from the outside of ends walls to the dividing wall 19 for introducing diluent gas to the passages 17. These ducts 35 correspond to the diluent gas ducts (41) of my aforesaid copending application. Longitudinally spaced lateral outlets 37 in opposite sides of the firing walls and in the side walls 3 of the shaft lead from ducts 35 to the interior of the shaft for supply diluent gas in a substantially uniformly distributed manner to passages 17 at opposite sides thereof. Diluent gas is thus introduced into passages 17 with the fuel and functions as an inert mixing gas for more evenly distributing the combustion throughout the cross section of passages 17 and for preventing overburning.

The diluent gas is preferably supplied to ducts 35 from the interior of the kiln from the pipes 11 and from ducts 39 in the firing walls 21 and side walls 3. Ducts 39 extend longitudinally in opposite sides of firing walls 21 and side walls 3 from the outside of end walls 5 to the dividing wall 19 adjacent the upper end of the calcining zone. These ducts correspond to the hot zone recirculating pipe (21) of my aforesaid copending application. Inlets 41 lead from passages 17 to the ducts 39 for intake of gas. It will be understood that means such as disclosed in my aforesaid application is provided for drawing cool gas from pipes 11 through ducts 39 and tempering the hotter gas therein, and for delivering the resultant tempered diluent gas to the ducts 35.

The side walls 3 and firing walls 21 have ducts 43 therein adjacent their lower ends for introducing primary air to passages 17. These ducts extend longitudinally in the firing walls and in the inside regions of the side walls from the outside of end walls 5 to the dividing wall 19. Longitudinally spaced outlets 45 lead from the ducts to the interior of the shaft. It will be understood that primary air is forced through the ducts 43 and outlets 45 into the kiln to flow upward through passages 17 as by means of a fan (not shown) as in my aforesaid copending application. The upward flow of primary air cools the calcined stone gravitating downward from the calcining zone.

It will be understood openings 25, 37 and 45 are inlets and openings 41 are outlets when considered with respect to passages 17. When the openings are considered with respect to their ducts, the inverse relation applies.

Each passage 17 leads to a discharge hopper 47 constituting an outlet through which the cooled calcined stone is drawn from the kiln. The arrangement is such that stone may be drawn from any one of passages 17 to cause downward flow of stone in that passage without affecting the downward flow of stone in any other passage. The walls 19 and 21 divide the total flow of stone from the preheating zone to the lower end of the kiln into a plurality of separate independent flows. The rate of flow in one passage is independent of the rate of flow in any other passage. Due to this independence of flow in any one passage and to the relatively small cross section of each passage, the flow in each

passage is substantially uniform throughout the cross section of the passage from the upper end of the calcining zone to its outlet at the lower end of the kiln. The flat, long, rectangular shape of each passage assures that the gas projected from the inlets at each side will properly distribute throughout its entire cross section.

The arrangement is also such that the upward flow of gases in each passage 17 is substantially uniform throughout its cross section. This is because the walls 19 and 21 divide the calcining zone of the kiln into passages of such shape and limited cross section that a substantially uniform temperature is maintained throughout the cross section of each passage and statification and unequal flow of gases in each passage is thereby avoided.

Another important feature of the kiln of this invention is that the division of the calcining and cooling zones into separate passages 17 enables the flow of fuel, diluent gas and primary air into each passage properly to be controlled in accordance with the downward flow of stone in that passage. The gases introduced into a passage 17 are confined to that passage until they leave the calcining zone. Thus, it is assured that the controlled quantity of gas introduced into a passage all flows in that passage and does not escape to some other part of the kiln, thereby avoiding uneven calcination. The gases leave the calcining zone and enter the preheating zone properly distributed. Although the preheating zone is not divided into passages as is the calcining zone, this is not essential since the temperatures in the preheating zone are sufficiently low that gas stratification is unlikely to develop.

Thus, the construction of the kiln of this invention is such that uniform downward flow of stone and uniform upward flow of hot calcining gases in each of passages 17 is assured, and the flow of stone and gases in each passage may be controlled so that the kiln produces homogeneous, high quality lime. While the walls 19 and 21 for dividing the calcining zone into passages 17 obstruct downward flow of stone from the preheating zone to some extent, such obstruction is not objectionable in view of the relatively small size of stone calcined in the kiln (of the order of 1½ inches).

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A kiln comprising a vertical hollow shaft wherein material to be calcined gravitates downward from a storage zone constituted by the uppermost portion of the shaft successively through a preheating zone, a calcining zone and a cooling zone, means including a plurality of firing walls extending from the lower end of said shaft through said cooling and calcining zones substantially to the upper end of the calcining zone dividing these zones into a plurality of vertical passages, each passage constituting a channel for downward flow of said material and having an outlet at the lower end of the shaft, whereby material flowing downward from the preheating zone is divided to flow independently in the respective channels, each firing wall and the walls of said shaft having ducts therein for introduction of fuel independently into each of said channels at the lower end of said calcining zone, gas offtakes within said kiln for withdrawing diluent gas therefrom, said offtakes being located, respectively, at the upper end of the preheating zone and in the firing walls and walls of said shaft adjacent the upper end of the calcining zone, each firing wall and the walls of said kiln having ducts therein for introducing said diluent gas into said channels adjacent the lower end of said calcining zone.

2. A kiln comprising a vertical hollow shaft wherein material to be calcined gravitates downward from a storage zone constituted by the uppermost portion of the shaft successively through a preheating zone, a calcining zone and a cooling zone, means including a plurality of firing walls extending from the lower end of said shaft through said cooling and calcining zones substantially to the upper end of the calcining zone dividing these zones into a plurality of vertical passages, each passage constituting a channel for downward flow of said material and having an outlet at the lower end of the shaft, whereby material flowing downward from the preheating zone is divided to flow independently in the respective channels, each firing wall and the walls of said shaft having ducts therein for introduction of fuel independently into each of said channels at the lower end of said calcining zone, gas offtakes within said kiln for withdrawing diluent gas therefrom, said offtakes being located, respectively, at the upper end of the preheating zone and in the firing walls and walls of said shaft adjacent the upper end of the calcining zone, each firing wall and the walls of said kiln having ducts therein for introducing said diluent gas into said channels adjacent the lower end of said calcining zone, said firing walls and the walls of said shaft also having ducts therein for introduction of air into said channels at the lower end of said cooling zone.

3. A kiln comprising a vertical hollow shaft comprising side and end walls, a portion of said shaft constituting a calcining zone, a dividing wall extending across the shaft from one side wall to the other, a plurality of firing walls extending between the end walls and said dividing wall, said dividing wall and firing walls extending from the lower end of the shaft substantially to the upper end of the calcining zone and dividing said zone into a plurality of vertical passages each of which has an independent outlet, each firing wall having ducts in opposite sides thereof and each side wall having ducts therein for introduction of fuel independently into each of said channels at the lower end of said calcining zone, said ducts extending from the outside of the end walls of the shaft to the dividing wall.

4. A kiln comprising a vertical hollow shaft wherein material to be calcined gravitates downward from a storage zone constituted by the uppermost portion of the shaft successively through a preheating zone, a calcining zone and a cooling zone, said shaft comprising side and end walls, a dividing wall extending across the shaft from one side wall to the other, a plurality of firing walls extending between the end walls and said dividing wall, said dividing wall and firing walls extending from the lower end of the shaft through said cooling and calcining zones substantially to the upper end of the calcining zone and dividing these zones into a plurality of vertical passages each of which has an independent out-

let, each firing wall having ducts in opposite sides thereof and each side wall having ducts therein for introduction of fuel independently into each of said passages at the lower end of said calcining zone, each of said ducts extending from the outside of the end walls of the shaft to the dividing wall.

5. A kiln comprising a vertical hollow shaft wherein material to be calcinated gravitates downward from a storage zone constituted by the uppermost portion of the shaft successively through a preheating zone, a calcining zone and a cooling zone, said shaft comprising side and end walls, a dividing wall extending across the shaft from one side wall to the other, a plurality of firing walls extending between the end walls and said dividing wall, said dividing wall and firing walls extending from the lower end of the shaft through said cooling and calcining zones substantially to the upper end of the calcining zone and dividing these zones into a plurality of vertical passages, each of which has an independent outlet, each firing wall and side wall having therein offtake diluent gas ducts adjacent the upper end of said calcining zone, ducts for introduction of diluent gas independently into each of said passages adjacent the lower end of said calcining zone, ducts for introduction of fuel independently into each of said pasages at the lower end of said calcining zone, and ducts for introduction of air into each of said pasages at the lower end of said cooling zone, each of said ducts extending from the outside of the end walls of the shaft to said dividing wall.

6. A kiln comprising a vertical hollow shaft of four-sided inner cross section, one portion of said shaft constituting a calcining zone and a lower portion constituting a cooling zone, a dividing wall extending across said inner section and dividing the hollow shaft into two rectangular portions, said wall traversing the calcining and cooling zones, a plurality of firing walls also traversing said zones and constructed to form a plurality of passages on each side of the wall of cross sections which are rectangular and which on their short sides abutt said shaft and dividing wall, and outlet elements for the respective passages at the lower end of the cooling zone.

7. A kiln comprising a vertical hollow shaft of four-sided inner cross section, one portion of said shaft constituting a calcining zone and a lower portion constituting a cooling zone, a dividing wall extending across said inner section and dividing the hollow shaft into two rectangular sectional portions, said wall traversing the calcining and cooling zones, a plurality of firing walls traversing said zones of a number adapted to form a plurality of passages on each side of the wall of cross sections which are rectangular and abutting said wall endwise, and outlet elements for the respective passages at the lower end of the cooling zone, each of said passages having respectively in the long sides thereof multiple air inlets and multiple firing inlets.

8. A kiln comprising a vertical hollow shaft of four-sided inner cross section, one portion of said shaft constituting a calcining zone and a lower portion constituting a cooling zone, a dividing wall extending across said inner section and dividing the hollow shaft into two rectangular sectional portions, said wall traversing the calcining and cooling zones, a plurality of firing walls traversing said zones of a number adapted to form of said sectional portions a plurality of passages on each side of the wall of cross sections which are rectangular and abutting said wall endwise, outlet elements for the respective passages at the lower end of the cooling zone, each of said passages having respectively in the long sides thereof multiple air inlets and multiple firing inlets, and multiple outlets and inlets for recirculating gas above said firing inlets.

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