United States Patent

Lado

[15] 3,645,514

[45] Feb. 29, 1972

[54] **PRODUCTION OF REFRACTORY MATERIALS**

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[52] **U.S. Cl.** 263/29, 266/25
[51] **Int. Cl.** F27b 1/00
[58] **Field of Search** 263/29, 30, 52; 266/25, 29

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

The disclosure relates to the production of refractory material in a vertical shaft forced draft kiln wherein the air and fuel supply to the kiln are periodically and automatically interrupted for short periods of time. This effects the continuous and uniform, uncompacted downward travel of the refractory material in the kiln, thereby avoiding fusion of the refractory material in the kiln shaft.

7 Claims, 5 Drawing Figures

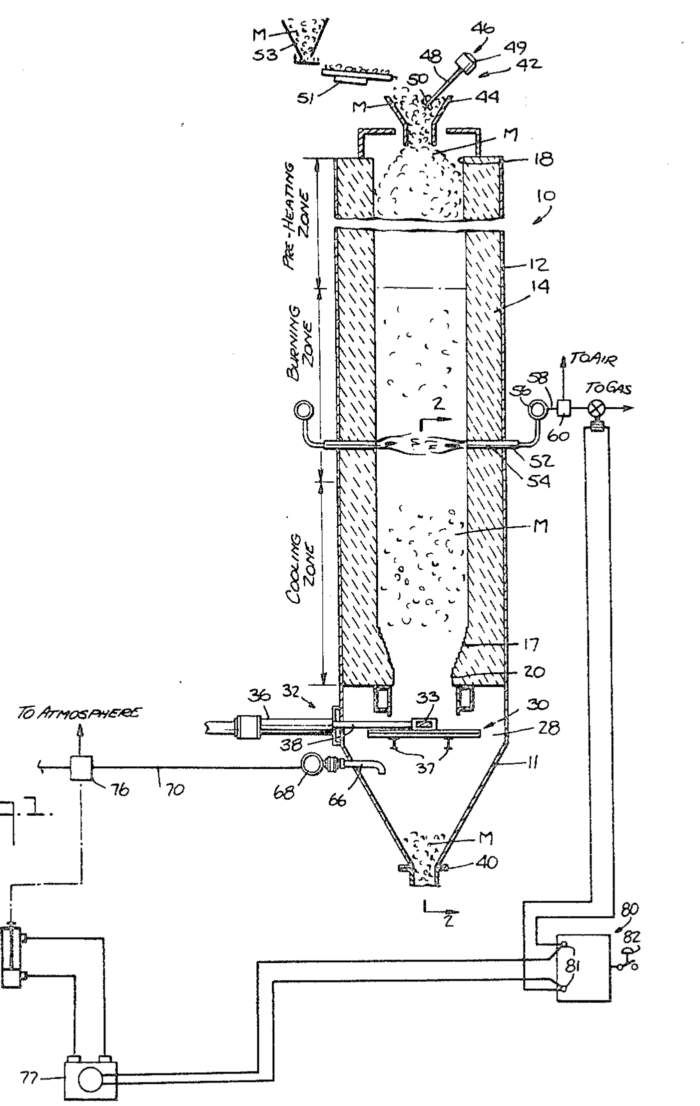

Fig.1.

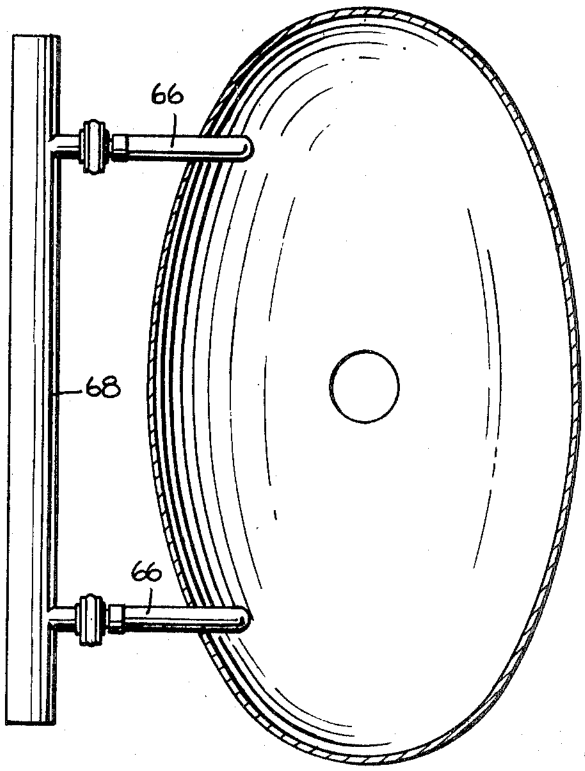

Fig. 5.

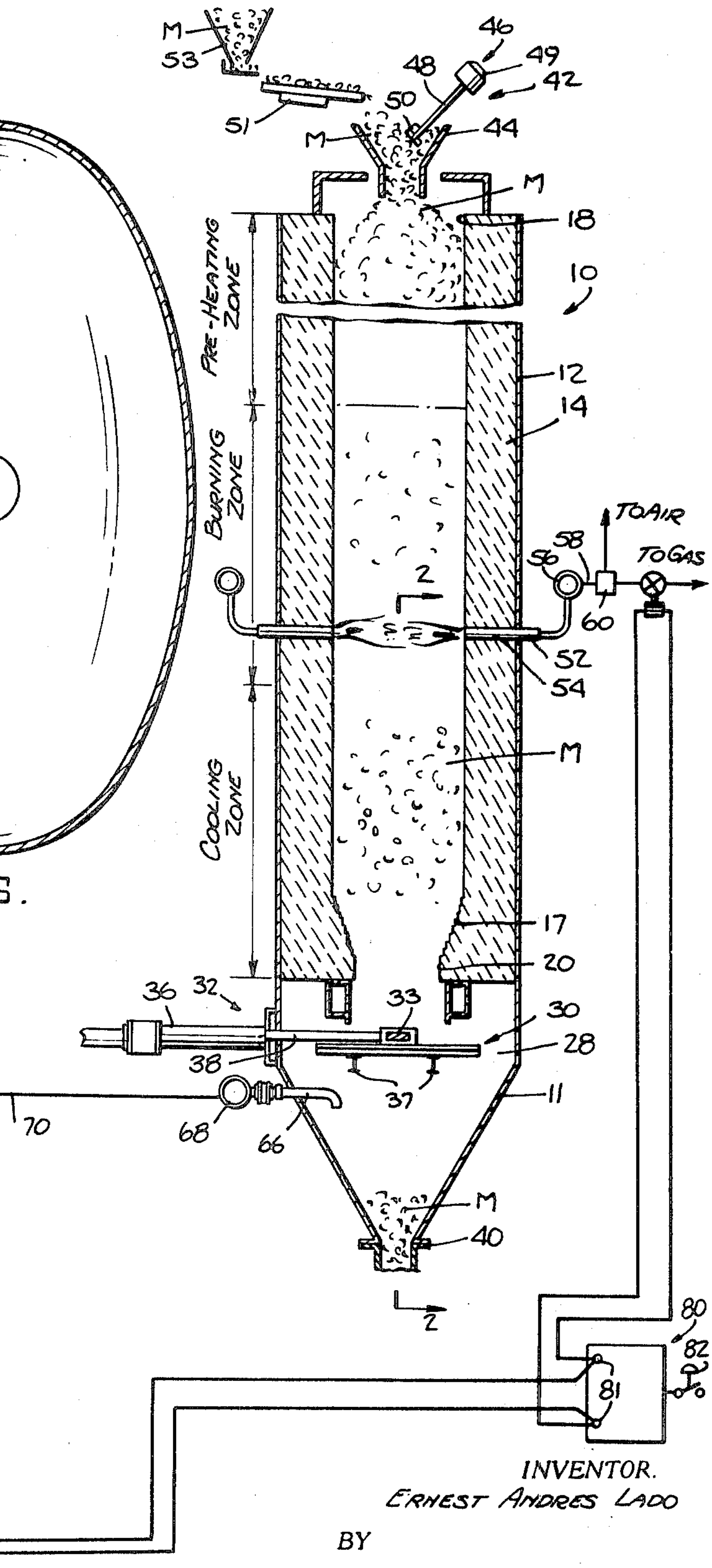

Fig. 1.

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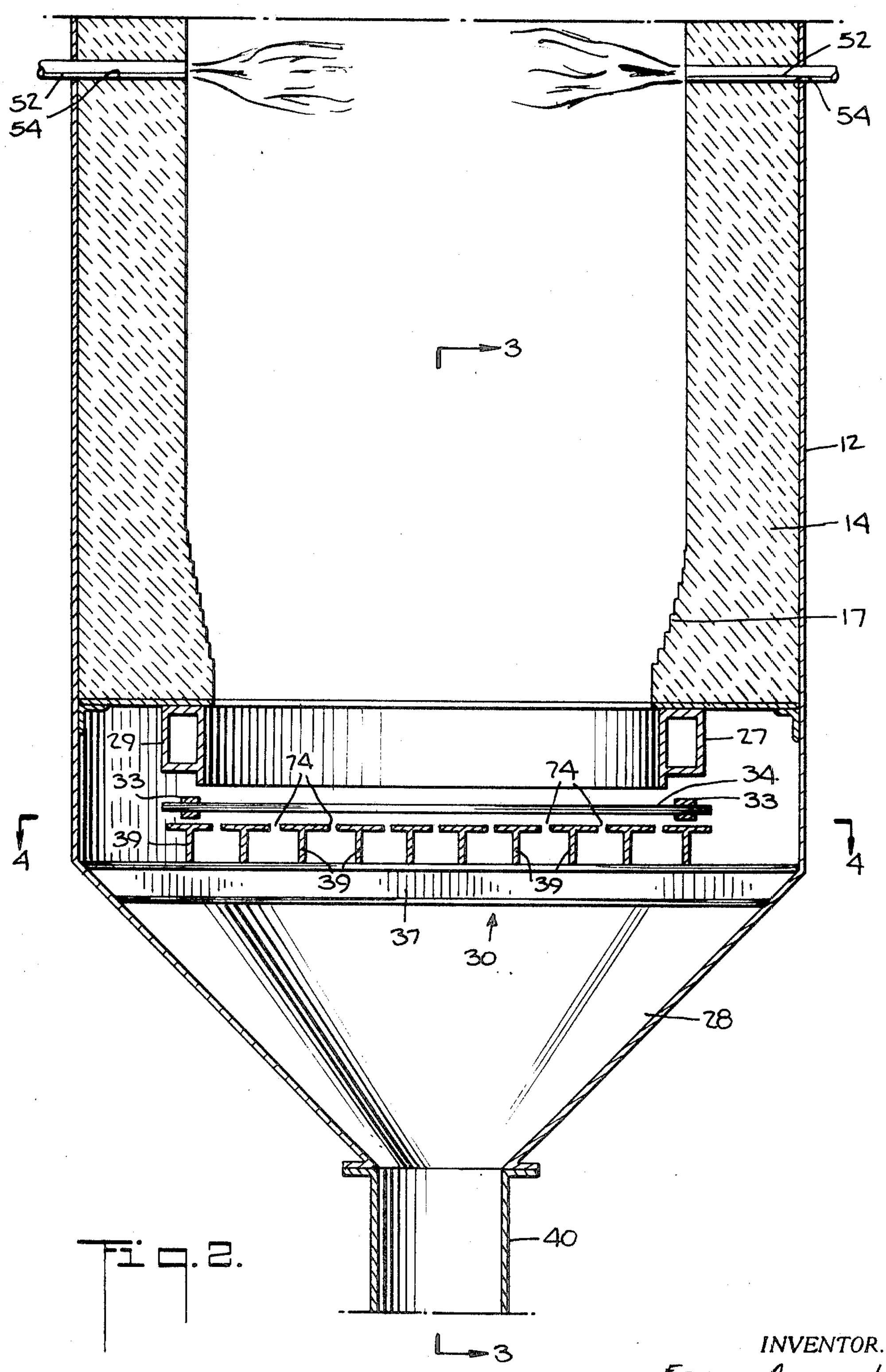

Fig. 2.

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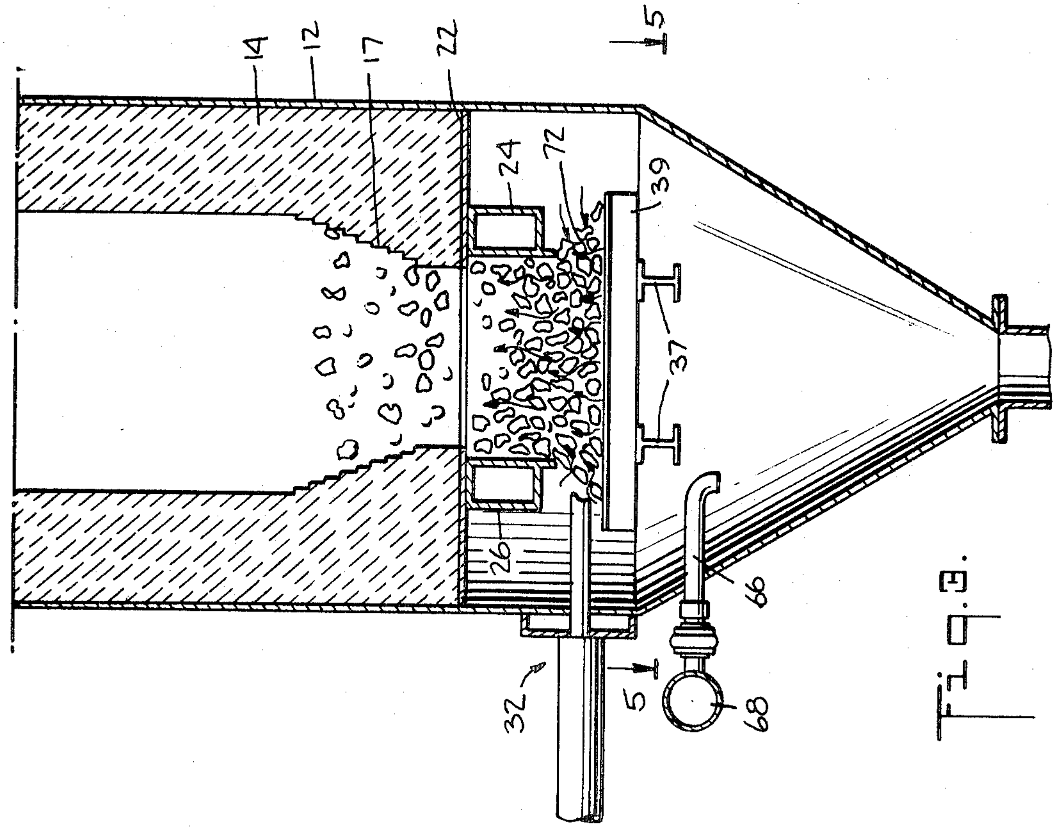

Fig. 3.

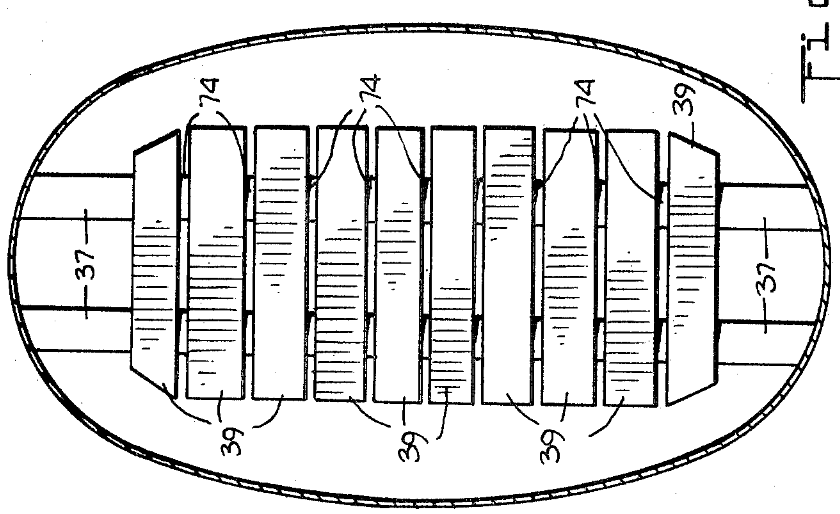

Fig. 4.

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PRODUCTION OF REFRACTORY MATERIALS

The present invention relates to the production of refractory materials, and more particularly to the production of dead-burned refractory materials such as periclase.

Periclase or dead-burned magnesia (M_gO) is normally produced by first calcining magnesium hydroxide, carbonate or other magnesium compounds to produce so-called caustic magnesia. At this stage in the process, the material is in the form of a fine powder or a mixture of fines with some small lumps. Next, the caustic magnesia is briquetted; that is, the powdered magnesia is subjected to a large compressive force (about 10,000–15,000 p.s.i.) to form it into briquettes of approximate rounded or almond-like shape. The briquettes so produced are generally 1–1½ inches long, three-fourths–1 inch wide and one-half–three-fourths inch thick and are known conventionally as "green" briquettes.

The next step in the production of periclase is to subject the so-called "green" briquettes to a dead-burning temperature of approximately 3,500°–4,000° F. This converts the "green" briquettes to briquettes of dead-burned magnesia or periclase. It is in this final stable form that the product is useful as a refractory material.

The present invention is directed to this final step in the production of dead-burned magnesia. The conversion of the "green" briquettes to periclase is preferably accomplished in a shaft kiln which consists basically of a refractory lined vertical shaft of varying cross section and height. The kiln is generally operated full at all times under a so-called flood or demand feed.

In the modern vertical shaft kiln operation, the kiln charge consists of the "green" briquettes as well as accompanying caustic magnesia broken pieces and fines. The charge is fed to the top of the kiln and flows downwardly under the effect of gravity to and through a burning zone. However, the kiln gases used to both heat and cool the kiln charge flow upwardly through said charge under the effect of a pressure differential created (1) by the introduction of air and/or other gases into the kiln bottom, or (2) by the application of suction to the top of the kiln. Normally, air and/or other gases are fed to the kiln bottom.

Generally, in the modern forced draft vertical kiln, there is provided three distinct zones through which the kiln charge passes. There is a preheating zone adjacent the top of the kiln where the cold charge is preheated to reaction temperature by upward passage of heated kiln gases therethrough. There is also a burning zone adjacent the middle section of the kiln wherein fuel is normally introduced into the kiln and burned wherein the charge is raised to its desired dead-burning temperature of about 3,500°–4,000° F. Fuels can be either liquid or gaseous, but for the sake of simplicity, they will be hereafter referred to as gaseous. After passing through the burning zone, the dead-burned charge continues through a cooling zone where it is subjected to a cooling upward flow of air prior to its discharge from the kiln proper. It will be understood that the cooling air, flowing upwardly in the kiln, is thus preheated before reaching the burning zone where it is partially used for combustion also.

However, a serious fusion problem has been encountered in the use of forced draft vertical shafts for dead-burning of magnesia or similar refractory materials. As noted hereinabove, the charge moves through the kiln under the influence of gravity only. However, resisting the downward movement of the charge is the movement of the kiln gases which are generally fed into the lower part of the kiln and travel upwardly through the charge. Theoretically, the upward pressure of the gases is less than the gravitational force acting on the kiln charge. But the desired optimum density of the end product is a function of both the temperature at which the product is dead-burned as well as the upward velocity of the kiln gases. Thus, to achieve optimum density, it is desirable to use as high a dead-burning temperature as possible in the burning zone. This, however, requires a correspondingly high velocity of kiln gases to effect the necessary cooling and preheating of the charge.

The kiln charge consists, however, of various sized particles including normal "green" briquettes, broken briquettes and powdered fines. The high-kiln gas velocity required to achieve optimum density in the end product causes an entrainment of the smaller charge particles in the gases and instead of such particles moving downward through the kiln with the charge, these smaller particles, generally in the range of one-eighth to one-quarter inch, are driven upward becoming entrapped within the voids of the charge located above the burning zone.

The buildup of fines in this area is cumulative. As more fine particles are entrapped within the charge voids, the free or voids area in the charge through which the kiln gases can pass is decreased. Since the volume of air and gases supplied to the kiln generally remains constant, this reduction in free area results in an increase in gas velocity. The higher velocity, in turn, causes progressively larger and larger particles to move upwardly through the kiln rather than downwardly until the entire charge directly above the burning zone becomes plugged with trapped fines, forming a stationary arch or dome supported by the combined effect of fines wedged in between larger particles and by the upward force of the kiln gases. This is known generally as a "hand-up." In this condition, the portion of the charge above the arch ceases to move through the kiln, while the portion of the charge below the arch continues to move normally.

The portion of the charge which has become arched continues to heat up under the intense heat of the trapped kiln gases until the particles of charge in the area of the arch become fused together into clustered masses and likewise fused to the refractory lining of the kiln. Once this occurs, it is necessary to suspend all kiln operations, partially or totally, cool the kiln, remove the charge above the fused area and then "rod out" or "shoot out" the fused mass.

"Rodding out" entails the use of long steel rods to chip the fused mass apart and away from the refractory lining of the kiln, while "shooting out" literally means actually firing many rounds of lead or zinc slugs into the fused mass to accomplish such results. In either event, damage to the refractory lining results from the rapid heating and cooling thereof as well as from the rodding and shooting of the fused mass away from the kiln walls. Thus, when a "hand-up" occurs, not only is production time lost and effort required to remove the "hand-up," but often, it is also necessary to patch or reline a portion of the kiln with refractory lining material. "Hang-ups," therefore, are very expensive and are to be strictly avoided in refractory kiln operations.

Another factor contributing to "hand-ups" is that the "-green" briquettes exhibit a marked tendency toward formation of interfacial growth and eventual fusion into massive clusters within the charge when the briquettes are subjected to the high temperatures employed in the dead-burning of periclase and other refractory materials, if care is not taken to effect continuous movement between adjacent particles within the charge.

Heretofore, since the temperatures and gas velocities necessary to achieve optimum product density also closely approach the conditions which maximize "hang-ups," refractory kilns have been operated at less than desirable conditions to avoid "hang-ups." The product so produced did not have the optimum density, but the operating conditions are safer as regards the arching or "hang-up" problem.

The present invention, however, virtually eliminates "hang-ups" while permitting the kiln to operate at the temperatures and pressures required to produce an end product of optimum density. In the kiln of the present invention, air under pressure is supplied to the kiln at the lowermost or discharge end of the shaft thereof. Also, there is provided at the burning zone, an air-gas fuel mixture for effecting combustion within the kiln charge, the fuel being supplied preferably peripherally of the shaft at approximately the midpoint thereof.

In the present invention, the kiln charge is continuously and uniformly permitted to flow downwardly in an uncompacted state through the kiln shaft. In order to ensure substantially continuous movement of the kiln charge through the shaft, the air supply to the kiln is periodically and automatically interrupted for short periods of time. This is done continuously during the kiln operation at frequent regular intervals, i.e., every 1 to 5 minutes for 1 to 5 seconds. This frequent, periodic short interruption of the air supply prevents formation of an arch or dome in the charge since the upward force of the air pressure which forms and supports the arch or dome is momentarily withdrawn, allowing the gravitional downward force on the kiln charge to dislodge any incipient arches or domes. Thus, in the present invention, the kiln charge moves downwardly through the kiln shaft in a continuous, uniform manner with the charge in a free-flowing loose condition. At no time is the charge allowed to remain stationary in the shaft since, as noted hereinabove, a stationary charge results in a so-called undesirable "hang-up." Further, interfacial growth and formation of massive clusters within the charge are also virtually eliminated since continuous movement between adjacent charge particles is effected in the present invention.

Other objects and advantages of the invention will be set forth in part hereinafter and in part will be apparent herefrom or may be learned by practice with the invention, the same being realized and obtained by means of the instrumentalities and combinations pointed out in applicant's claims.

The invention consists in novel parts, construction, arrangements, combinations and improvements herein shown and described.

The accompanying drawings referred to and constituting a part hereof illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

FIG. 1 is a schematic front sectional elevation of a shaft kiln embodying the concept of the present invention;

FIG. 2 is an enlarged view taken along line 2—2, FIG. 1;

FIG. 3 is a view taken along line 3—3, FIG. 2;

FIG. 4 is a view taken along line 4—4, FIG. 2; and

FIG. 5 is a view taken along line 5-5, FIG. 3.

Referring to the drawings, there is illustrated a vertical shaft kiln designated generally at **10** which comprises an outer metallic shell **12**, preferably of steel, and an inner lining **14** of refractory material. The outer configuration of kiln **10** is preferably oval with the lowermost portion thereof **11** tapered inwardly, as shown in FIGS. 4 and 5. Lining **14** defines an internal vertical kiln shaft **16**, also of generally oval cross section and having a top opening **18** and a bottom opening **20**.

Lining **14** is supported on a bottom plate **22**, in turn carried by water-cooled support beams **24**, **25**, **26** and **27** and, as will be noted, shaft **16** likewise is tapered inwardly at its lowermost section **17**. However, shaft **16** is tapered such that bottom opening **20** is generally rectangular (see FIG. 4). In effect, there is a transition from oval to rectangular at the bottom of the kiln.

Opening **20** leads from the shaft **16** proper into a kiln discharge section designated generally **28** which houses a discharge table **30** and a discharge device **32** adapted to remove dead-burned refractory material deposited on table **30**. Device **32** comprises a drag bar **34** mounted by means of spaced yokes **33** to a pair of push rods **38** which are actuated by suitable hydraulic cylinders **36** for reciprocating movement back and forth across table **30** to remove refractory material M from the discharge table **30** to a collection chamber **40**. Table **30** is supported on a series of I-beams **37** and preferably is comprised of a plurality of closely-spaced T-sections **39** or other suitable spaced structural members.

To feed material M to the kiln **10**, there is provided at the top thereof a flood or demand feed device **42** which comprises a supply hopper **14** for holding material M to be fed to the kiln shaft **16**. A level controller **46** disposed within hopper **44** is adapted to rotate within hopper **44** when feed material in the hopper drops below the desired level. The drive shaft **48** of level indicator **46** is provided at its free end positioned within the kiln feed hopper **44** with a paddle member **50**. When the level of the material in the shaft **16** falls below paddle **50**, paddle **50** and drive shaft **48** are free to rotate and are rotated from the source of power **48**. This in turn causes operation of a vibrating screen **51** and feeder **53** to effect a feed of material M into hopper **44**. (See FIG. 1). Material M is thus fed into hopper **44** until the level thereof rises so as to interfere with and stop rotation of paddle **50** and shaft **48**, disengaging shaft **48** from driven relationship with its associated source of power **49**. This in turn deactivates the vibrating screen **51** and feeder **53** and thus interrupts the feed of material M until the level of the material M drops sufficiently in feed hopper **44** so as to permit paddle **50** to again rotate so as to effect material feed.

COMBUSTION FUEL SUPPLY

For combustion of the fuel within the voids of the material M in the shaft **16**, there is provided adjacent the middle section of kiln **10** a plurality of burners **52** disposed in ports **54** in shell **12** and lining **14** at spaced intervals around the periphery of the kiln. A gas and air mixture is introduced through the burners **52** into the kiln shaft **16** to effect the dead-burning of the refractory material in shaft **16**. Burners **52** are interconnected to a manifold **56** which is, in turn, supplied with the combustible material or fuel from a supply line **58**. Line **58** is connected through a suitable gas-air mixer **60** to gas line **62** and air line **64**, each of which is, in turn, connected to a suitable source of supply such as a natural gas line and an air compressor, respectively, (not shown).

FORCED AIR SUPPLY

Air for the forced draft is supplied to the kiln at the kiln discharge section **28**. Adjacent the bottom **20** of shaft **16** there is provided one or more air ducts **66** discharging into section **28**. (See FIGS. 3 and 5). Ducts **66** are fed from a common air manifold **68** and an air line **70** connected to a suitable source of supply; such as a compressor (not shown).

The pressure buildup in the section **28** from air discharging thereinto from ducts **66** forces the air to flow between the voids in the kiln charge and upwardly through the kiln shaft **16**. Thus air enters the kiln charge and the forced air supply is in fluid communication with the kiln shaft **16** through the void spaces at the sloping sides **72** of material M on table **30**. Air also enters the charge vertically upwardly through the spaces **74** (FIG. 3) provided between adjacent T-sections **39**. (See arrows, FIG. 3).

FORCED AIR SUPPLY AND FUEL CONTROLS

As noted hereinabove, kiln "hang-ups" are generally caused initially in forced draft vertical kilns such as kiln **10** by the upward travel of the kiln gases from burners **52** and by forced air flowing upward through the kiln charge from section **28**. It is these gases which entrain the smaller particles of refractory material M therewithin, driving them upward into the voids within the kiln charge, ultimately resulting in a so-called kiln "hang-up."

To avoid such "hang-ups" and to ensure substantially continuous downward movement of the material M in the kiln shaft **16**, means is provided for periodically and automatically interrupting the flow of kiln gases. Air line **70**, which feeds ducts **66**, is provided with a control valve **76** which, alternatively, interconnects line **70** in operative condition with manifold **68** or in nonoperative condition directly to the atmosphere. To operate valve **76**, there is provided a solenoid-actuated air cylinder **78**. The solenoid **77** for air cylinder **78** is electrically connected to a suitable timing mechanism **80**. Preferably, timing mechanism **80** is comprised of a pair of interconnected timing devices **81** such as are commercially available from Automatic Timing & Controls, Inc., King of Prussia, Pennsylvania, Model ATC-305B, which are presettable at the desired duration and frequency of interruption of air to kiln **10**. Timer **80**, in turn, is electrically connected through a suitable manual control switch **82** to a suitable source of electrical potential.

For safety reasons, gas line 62 is likewise provided with a solenoid-actuated control valve 84 which is electrically interconnected in common with cylinder 78 to timer 80 so as to stop the feed of fuel to burners 52 when the forced draft to kiln 10 is interrupted.

OPERATION

In operation, the refractory material M to be sintered or "-dead-burned" is fed upon demand by vibrating screen 51 and vibrating feeder 53 from supply hopper 44 through top opening 18 into kiln shaft 16, as described hereinabove, until the level of material M prevents rotation of paddle 50. Normally, shaft 16 is entirely filled with refractory material M which moves by gravity successively through the preheating, dead-burning and cooling zones of the kiln 10 (see FIG. 1).

To effect the requisite dead-burning of the refractory material M, an air-gas mixture is introduced from burners 52 into the shaft at the burning zone. It has been found that sufficient fuel must be introduced so as to raise the temperature of the refractory material in the burning zone to preferably about 3,500°–4,000° F. to achieve the desired sintering or dead-burning thereof.

At the same time, air under pressure is introduced into shaft 16 through air ducts 66 into section 28. It will be understood that the air so introduced travels upwardly through shaft 16, cooling the refractory material M which has passed through the burning zone prior to its exit from the kiln shaft 16. The forced draft air likewise is partially used for combustion of the fuel in the burning zone and contributes to the preheating of the refractory material M located in the kiln preheating zone.

After exiting from shaft 16, the dead-burned refractory material is deposited on table 30 and systematically and continuously removed therefrom by reciprocating drag bar 38 into section 28 and thence to collection chamber 40.

Normally, at the start of kiln operations, valves 84 and 76 are operative to permit passage of fuel and air from their respective sources of supply (not shown) through their associated supply lines 62 and 70 to burners 52 and ducts 66. With the timing devices 81 of timer 80 preset to the desired frequency and duration of fuel and gas interruption, switch 82 is closed, actuating timer 80. At the preselected frequency, timer 80 actuates the solenoids associated with valve 84 and air cylinder 78. Air cylinder 78 causes valve 76 to vent line 70 to atmosphere interrupting the flow of air to ducts 66, while safety control valve 84 is closed, interrupting the flow of gas to burners 52. At the end of the period for interruption of air, about 1–5 seconds, timer 80 again actuates the solenoids associated with valve 84 and air cylinder 78 to effect return of valves 84 and 76 to normal operative position and permitting resumption of gas flow to burners 52 and the airflow to ducts 66. The momentary or short but frequent interruption of air removes the upward force which resists the downward travel of material M in the kiln 10, permitting the kiln charge to travel in a generally loose, uncompacted state substantially continuously downward through shaft 16 and virtually eliminates kiln "hang-ups."

It will be understood that, while the foregoing description of the present invention was directed preferably to the dead-burning of magnesia, the principles of the present invention are applicable to the operation of vertical shaft kilns generally where the material to be treated exhibits tendencies to arch or dome, interrupting movement of the material through the kiln. However, it is in the dead-burning of refractory materials, such as periclase and dolomite, that the present invention finds its preferable application.

Likewise, as noted hereinabove, the principles of the present invention are applicable to a suction-type kiln as well as the pressurized air type of kiln described Hereinabove. In such case, however, the feed of material to be dead-burned must be introduced into the kiln through a suitable seal mechanism since the kiln shaft is under a negative pressure, i.e., suction. Also, suitable suction means at the top of the kiln shaft and air entry means at the bottom of the kiln shaft are provided for effecting the requisite upward airflow through the kiln charge.

The presently preferred embodiments of the invention have been described for purposes of explanation. It should be understood that modifications may be made therein as will appear evident to those skilled in the art to which the invention pertains. It is, therefore, intended to encompass all such changes as fall within the true spirit of the invention.

What is claimed is:

1. A method of dead-burning refractory material in a vertical shaft kiln comprising the steps of: feeding material to be dead-burned into the upper end of the kiln shaft, removing dead-burned material from the lower end of said kiln shaft, supplying combustion fuel to said kiln shaft adjacent the middle thereof to effect dead-burning of material in said kiln shaft, causing an air flow upwardly into the lower end of said kiln shaft, passing said material in said kiln shaft from the upper to the lower end thereof through successive preheating, burning and cooling zones, and at preselected periodic intervals interrupting the flow of air to said kiln shaft for a predetermined short interval whereby said material is caused to travel through said kiln shaft substantially continuously and in an uncompacted state.

2. The method of claim 1 including maintaining the material in said kiln at a predetermined level.

3. A method of dead-burning refractory material in a vertical shaft kiln comprising the steps of: feeding material to be dead-burned into the upper end of said kiln shaft, maintaining said material in said kiln shaft at a predetermined level, continuously removing dead-burned material from the lower end of said kiln shaft to a collection chamber, injecting combustion fuel into said kiln shaft adjacent the middle section thereof to effect dead-burning of material therein; causing air to enter the lower end of said kiln shaft and flow upwardly therethrough, travelling said material substantially continuously in said kiln shaft from the upper to the lower end of said kiln shaft through successive preheating, burning and cooling zones, and momentarily stopping the flow of air to said kiln shaft at regular preselected intervals for predetermined short periods whereby the travel of said material in said kiln is uninterrupted.

4. Apparatus for dead-burning refractory material in a vertical shaft kiln having preheating, burning and cooling zones therein comprising: means for feeding material to be dead-burned into the upper end of the kiln shaft to a predetermined level therein, an upper opening in said kiln for communicating said feeding means with said kiln shaft to admit material to be dead-burned thereinto for downward passage therethrough through successive preheating, burning and cooling zones, a collection chamber at the lower end of said kiln shaft for the accumulation of dead-burned material, a lower opening in said kiln shaft for communication between said kiln shaft and said collection chamber, a discharge table positioned adjacent the lower opening in said kiln shaft for receiving dead-burned material exiting from the lower end of said kiln shaft after passage therethrough, means for removing dead-burned material from said discharge table into said collection chamber, a plurality of burners extending into said kiln shaft at the burning zone for supplying combustion fuel to said kiln shaft to effect dead-burning of material in said kiln shaft, means mounting said burners in spaced relationship about the periphery of said kiln shaft, means for supplying combustion fuel to said burners, means for introducing air into the lower end of said kiln shaft at the cooling zone, means for supplying air to the lower end of said kiln shaft for upward travel therethrough, and control means for said combustion fuel supply means and said air supply means, said control means including valve means for selectively communicating said air supply means to atmosphere or to said kiln shaft, means for periodically actuating said valve means to interconnect said air supply means to atmosphere and for deactuating said valve means after a predetermined short interval to reestablish com-

munication of said air supply means and said kiln shaft, whereby the upward travel of air in said kiln shaft is regularly and momentarily interrupted to effect substantially continuous movement of material through the preheating, burning and cooling zones of said kiln.

5. The apparatus of claim 4 including valve means for said combustion fuel supply means, actuating means for said combustion fuel supply valve, and means interconnecting said combustion fuel supply valve actuating means with said air valve actuating means whereby said combustion fuel supply valve is actuated to nonoperative position, interrupting the supply of combustion fuel to said burners when said air valve is venting said air supply means to atmosphere.

6. The apparatus of claim 4, wherein said air supply valve actuating and deactivating means includes an electrically responsive device for controlling actuation and deactuation of said valve means, a timing device for interrupting an electric circuit at preselected intervals and reestablishing said circuit after a predetermined period, a source of electric potential, means for establishing an electric circuit which includes said source of electric potential, said timing device and said electrically responsive device whereby said timing device is operative to effect activation of said air supply valve at preselected intervals for a predetermined period and then to effect deactivation of said air supply valve whereby said air supply means is alternately in communication with the atmosphere and then with said shaft kiln.

7. The apparatus of claim 6 including valve means for said combustion fuel supply means, an electrically responsive device for controlling actuation and deactuation of said combustion fuel supply valve, means mounting said electrically responsive control device for said combustion fuel supply valve in said circuit whereby said timing device is operative to effect actuation and deactuation of said combustion fuel supply valve simultaneously with the actuation and deactuation of said air supply valve whereby said combustion fuel supply to said burners is interrupted when said air supply means is vented to atmosphere and is reestablished when said air supply means is in communication with said shaft kiln.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,645,514 Dated February 29, 1972

Inventor(s) ERNEST A. LADO

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, lines 22, 42 and 48 change "hand-up" to --hang-up--

Column 3, line 66, insert --MATERIAL FEED-- (as a heading)

Signed and sealed this 28th day of November 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents