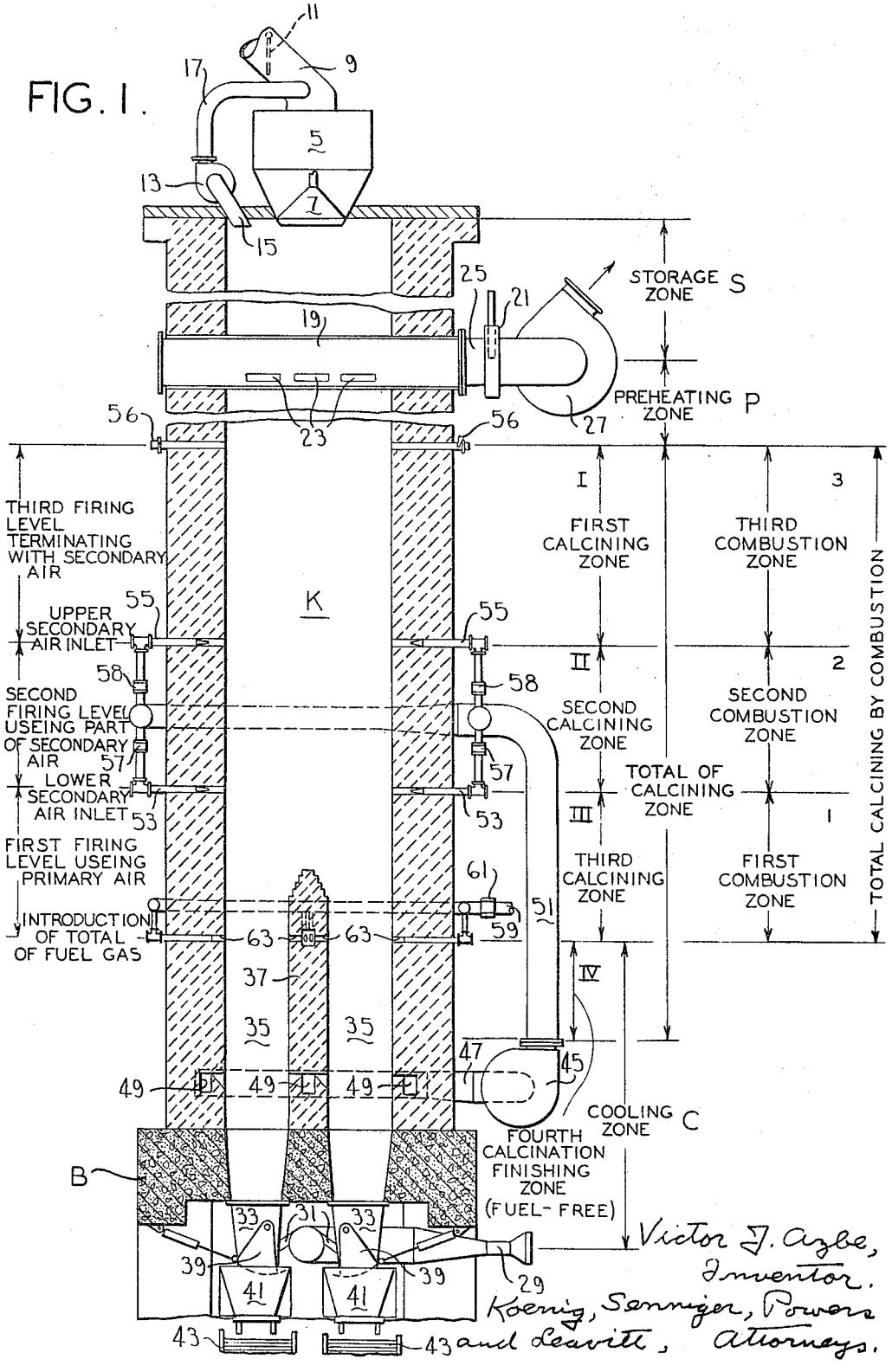
Nov. 8, 1966 V. J. AZBE 3,284,071

CALCINING METHOD AND APPARATUS

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FIG. 1.



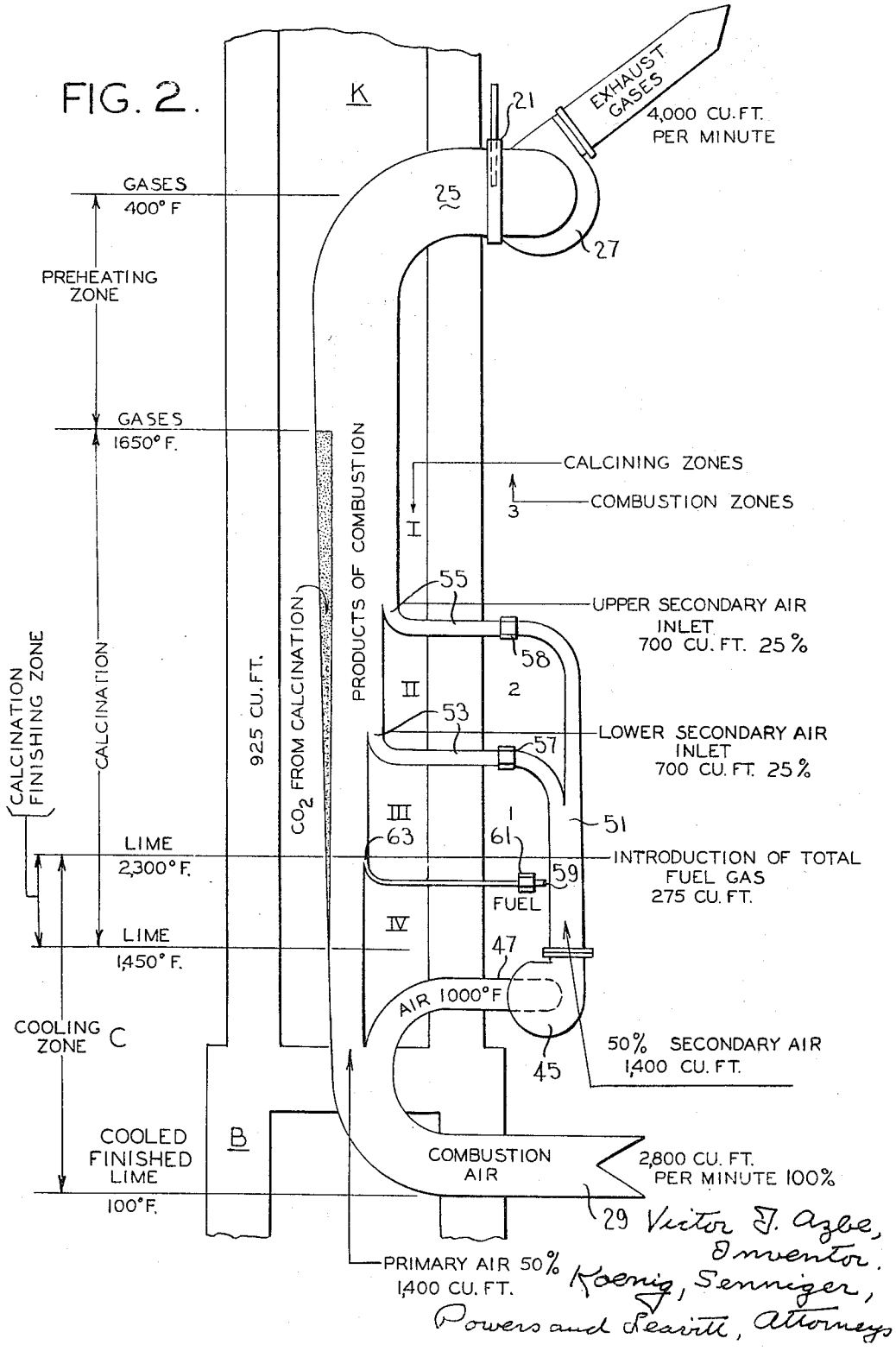
Victor J. Azbe, Inventor.
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CALCINING METHOD AND APPARATUS

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FIG. 2.



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CALCINING METHOD AND APPARATUS

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5 Claims. (Cl. 263—29)

This invention relates to a calcining method and apparatus, and with regard to certain more specific features, to a method and apparatus of this class for producing lime.

Among the several objects of the invention may be noted the provision of a calcining method and apparatus for producing superior lime, even from relatively inferior limestone; the provision of a lime kiln which is economical to construct and simple to control; the provision of a lime kiln in which the work of conversion of limestone to lime is carried out at lower temperatures and heat is more evenly distributed throughout the width and length of the kiln than heretofore, whereby consistently better lime is produced under more efficient conditions of heating; and the provision of a lime kiln of the class described in which flow resistance is reduced and production increased for a given size of kiln. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, steps and sequence of steps, features of construction and manipulation, and arrangements of parts which will be exemplified in the constructions and methods hereinafter described, and the scope 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 diagrammatic axial section of a typical kiln for carrying out the invention; and

FIG. 2 is a flow diagram illustrating the new method.

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

In the production of lime from limestone it is desirable to prevent the formation of so-called hard-burned lime and to produce the desired soft-burned product. The hard-burned product is characterized in that it is dense, less reactive, and of lower available CaO content due to fluxing with silicious, aluminous and ferrous compounds which are considered to be impurities when in lime. Excessive local temperatures due to rapid stoichiometric fuel oxidizing conditions or exothermic combinations of CaO with extraneous matter have been responsible for such results. By means of the present invention these and other disadvantages are overcome.

Referring now more particularly to FIG. 1, there is shown at K a vertical hollow kiln shaft composed of suitable refractory materials. This is supported upon a base B. At the upper end of the shaft K is located a charging bunker **5** having an openable and closable outlet bell **7** for delivery, as needed, of crushed stone to the upper end of the shaft. At numeral **9** is shown a sloping chute extending from a rock supply (not shown) to the bunker **5**. In the chute **9** is a suspended trap-forming pivoted gate **11**, which opens to admit a charge down the inlet chute **9** and recloses thereafter. At numeral **13** is shown a fan having an inductive connection **15** in the upper portion of the shaft K, and a pressure connection **17** with the chute **9** below the gate **11**. By means of this fan **13**, warm spent gas may be abstracted from the upper end of the kiln and employed for pressurizing the charging system **5, 7, 9, 11**. This prevents infiltration of air into the shaft K during charging operations. Thus when the gate **11** is opened to admit material into the chute **9**, there will be an outflow of spent gas through it, rather than inward leakage of air. Consequently, when the bell **7** is opened, air

will not be drawn into the shaft K. This is a desirable feature, since any air in leakage at the top of the kiln would change the temperature and composition of spent gases and interfere with the proper operation to be described below.

At a suitable distance below the upper end of the shaft K is located a cross pipe **19** which contains ports **23** for receiving spent warm gases from the interior of the shaft. One end of the pipe has an outlet connection **25** with an exhaust fan **27**. This contains a control damper **21**. Thus a controlled flow of gas may be abstracted from the inside of the shaft through ports **23** and pipe **19**.

The location of pipe **19** determines the lower end of a storage zone S. Below this is a preheating zone P. The lower limit of the preheating zone P is determined by operating conditions in the kiln, being terminated where calcination starts, due to heating conditions in lower parts.

By means to be described, there are also established in descending order a first calcining zone I, a second calcining zone II, a third calcining zone III and a fourth calcination finishing zone IV. The fourth calcination finishing zone occurs within the upper portion of a cooling zone C. The lower end of the cooling zone C is established by the level of an induction air inlet **29** which has air-flow connections **31** with finished-lime outlets **33**. Inlet **29** is of the venturi type, as shown, to provide means for measuring the amounts of air passing through it. The outlets **33** are for withdrawing finished lime from lower divided passages **35** in shaft K. Passages **35** extend down through the base B, being established by a cross wall structure **37**. It will be understood that in ordinary sizes of kilns, the passages in the cross wall intended for fuel introduction will not be required when operating with larger sizes of stone, but are desirable when very small stone is used, or in kilns of very large diameter. But the wall itself will serve a purpose in any case by providing a constriction for the better mixing of the upflowing air with the entering fuel and also in directing the lime flow toward its respective outlet. At **39** are shown draw works, adapted to be opened from time to time to deliver finished lime through chutes **41** to take-off conveyors **43**.

Air drawn into the inlet **29** by fan **27** will be drawn upward by induction through the shaft K. At numeral **45** is shown a second fan having a connection **47** with suitable air outlets **49** in the kiln walls. By this means a proportion of the air entering the cooling zone C is abstracted, the remainder passing up through fhe shaft. The abstracted air is for use as secondary air for combustion. The abstracted air is sent through a connection **51** having branch injection passages or ports **53** and **55** under control of valves or dampers **57** and **58**, respectively. The branch air passages **53** and **55** are arranged to inject portions of the secondary air abstracted from the cooling zone at two levels, as shown. The level of air injection through branches **53** determines the upper end of the third calcining zone III and the level of air injection through branches **55** determines the upper end of the second calcining zone II. The upper end of the first calcining zone I is determined by the level at which the preheated rock reaches calcination temperature. At this level are located access devices **56** for testing instruments.

At numeral **59** is indicated a fuel gas inlet including a control valve **61** having injection connections at **63** for introducing the total amount of fuel to be introduced in the shaft K. The level of these connections **63** determines the upper end of the fourth calcination finishing zone IV. It also determines the lower end of a rising sequence of combustion zones **1**, **2** and **3** which correspond with the calcining zones III, II and I, respectively. The lower end of the first combustion zone **1** is at the level of the gas inlets **63**. The lower end of the sec-

ond combustion zone 2 is determined by the air inlet passages 53. The lower end of the third combustion zone 3 is determined by the level of the upper air inlet passages 55. The upper end of the third combustion zone 3 is determined approximately at the level at which calcination starts in the first calcining zone I.

The operation of a typical 100 ton kiln is as follows (see also FIG. 2), assuming that the shaft K is infilled with rock and lime in process, it being understood that the various volumes and temperatures set forth are given by way of example and subject to some variation within the principles of the invention. Examples of typical volumes of flow are given for one minute of operation.

Air at 2,800 cubic feet per minute, constituting all of the air to be used in about stoichiometric amounts for ultimate complete combustion, is drawn in at the inlet 29 (without any fuel) by inductive action of the fans 27 and 45. An amount slightly in excess of this is often desirable. This fuel-free air meets finished lime at a temerature of about 100° F. By heat-exchange, all of this air is preheated as the finished lime is cooled. At about 1,000° F. of preheat, approximately 50% of this air, or 1,400 cubic feet, is withdrawn from the cooling zone C below the lower level of the fourth calcination finishing zone IV. This withdrawn air is to be used for secondary combustion, to be described. This leaves a second approximately 50% or 1,400 cubic feet of fuel-free preheated inlet air to rise in the shaft K. Combustion by means of this air cannot occur before the bottom of the first combustion zone 1 is reached at the level of the fuel ports 63. Nevertheless, calcination finishing proceeds without combustion in zone IV. The heat for this is the sensible heat of the lime which enters zone IV at 2,300° F. The air rising in zone IV becomes further preheated while cooling the terminally calcining lime. Calcination ceases at about 1,450° F. Since no combustion occurs in zone IV, it receives no CO_2 from combustion. This lowers the CO_2 tension in zone IV so that CO_2 is more readily released from any unfinished material in zone IV. This accelerates transformation to lime of all (or a maximum amount of) unfinished material in IV. This minimizes the amount of uncalcined core material in the finished lime leaving zone IV.

As shown on FIG. 2, the amount of fuel gas introduced is 275 cubic feet. This, with the second 50% of what is primary air, by combustion brings the calcining temperature at the lower end of the third calcining zone III to 2,300° F. (FIG. 2). At this point the fuel is in stoichiometric excess, requiring later additional air for complete combustion. But by incomplete combustion in the third calcining zone III (first combustion zone 1) over-heating therein is avoided.

About one-half of the secondary air, or about 700 cubic feet, is introduced at the level of inlets 53, or at the lower end of the second calcining zone II (second combustion zone 2). Still the fuel available for combustion is in stoichiometric excess, whereby overheating is avoided in the second calcining zone II. The remaining approximately one-half of secondary air, or 700 cubic feet, is introduced at the level of passages 55 to establish the lower end of the first calcining zone I (third combustion zone 3). Here the introduction of the correct amount of air (or slightly in excess) is completed for complete stoichiometric combustion. About 925 cubic of CO_2 are generated in the process of calcination, as shown in FIG. 2 by the triangular stippled area, part of which arises in zones IV wherein no combustion takes place.

It is to be understood that while the ratio of primary to secondary air, and the ratio of division of the secondary air, are preferably as above stated and as shown in FIG. 2, some variations therefrom may be desired in order to adjust to the most desirable conditions throughout the length of the kiln. For example, it may be desired to have one of the calcining zones II or I made shorter and hotter and the other longer and cooler as required, in order to obtain an optimum balance of heat transfer work done throughout the kiln length. Also, some variations in the temperatures given may be desirable.

Several advantages accrue from my new method and apparatus:

(1) The finishing or residual calcination of core in the lime in zone IV is mostly at the expense of sensible heat of the external layers of the lime. Overburning is impossible while the preheating of the air is mainly by such pieces as are smaller and completely calcined.

(2) Without combustion in zone IV, finishing calcination is effective because of the absence of CO_2 due to combustion.

(3) Fuel is not injected at the level connections 63 into any large amount of excess air. Such injection heretofore tended to cause high temperatures and exothermic hot spots at the injection jets. By having a deficiency of air for combustion at the firing level, such undesirable action is minimized.

(4) Secondary air, being split for gradual introduction at spaced passages 53 and 55, extends the calcining zone high into the kiln for milder operation, whereas heretofore this calcining zone was short and overly hot.

(5) All kiln air passing through the cooling zone is preheated, the secondary air more mildly, and the primary air more highly. As to the latter, by transferring heat to the top of zone IV lime finishing is there accelerated. By abstracting heat from the finished lime at the bottom, calcination is rapidly terminated at the 1,450° F. temperature. It will be understood that limestone will not calcine materially below 1,450° F.

(6) Former complex methods of even temperature distribution and control through recirculation of spent gases are eliminated.

(7) The structure for carrying out the improved process is comparatively simple and economical to build and maintain.

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

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

What is claimed is:

1. A lime kiln comprising a substantially vertical shaft having an upper stone inlet, exhaust means in the upper portion of the shaft below said stone inlet for withdrawing substantially all spent gases from the upper portion of the kiln and determining the lower end of a storage zone and the upper end of a preheating zone, said shaft having a lower lime outlet with fuel-free air inlet means connected therewith and determining the lower end of a lime cooling zone, fuel injection means connected with the shaft at a level above said air inlet means and determining the lower end of a first combustion zone, a plurality of air injection means at spaced levels above said fuel injection means, said spaced air injection means determining a second combustion zone between their levels and the bottom of a third combustion zone above them, means for abstracting some air from the shaft at a level between said air inlet means and fuel injection means and for delivering the abstracted air to said plurality of air injection means for use as secondary combustion air for the fuel, the remaining unabstracted air being drawn upwardly through the shaft by said exhaust means to function as primary air for combustion of the fuel, whereby a fuel-free calcination finishing zone is established in the cooling zone below said fuel injection means, and whereby first, second and third calcining zones subject to air-fuel combustion are established in descending order below said preheating zone.

2. A lime kiln according to claim 1 including means for controlling said plurality of air injection means for limiting the amount of secondary combustion air to approximately 50% of all of said fuel-free air.

3. A lime kiln according to claim 2, wherein said last-named means includes individual controls for said plurality of air injection means to inject from each approximately 25% of the fuel-free air.

4. The process of calcining limestone to lime, comprising introducing the stone into an upper storage zone of an upright hollow shaft for descent by gravity through the shaft and removal as finished lime from its lower end, introducing unoxidized fuel into the shaft at a level intermediate its ends and below said storage zone, introducing fuel-free air into the shaft at said lower end in an amount sufficient for ultimate substantially complete oxidation of the fuel to produce heat for conversion of the stone to lime, abstracting from the shaft at the lower level of the storage zone substantially all products of combustion, whereby a preheating zone is established below said level of abstraction, abstracting from the shaft at a level between its lower end and the level of introduction of said fuel a first substantial portion of said fuel-free air for use as secondary air, while permitting another substantial portion to ascend through the shaft, dividing and reintroducing said secondary air into the shaft at several levels above the level of introduction of the fuel, whereby there are established a fuel-free cooling zone at the lower end of the shaft between the levels of the air and the fuel introduction, a fuel-free calcination finishing zone in the upper part of said cooling zone, and also first, second and third fuel-fired calcining zones in descending order between said preheating zone and the level of introduction of fuel.

5. The process according to claim 4, including controlling the abstraction of secondary air to be in an amount on the order of one-half of the total amount of fuel-free air introduced into the lower end of the shaft, and effecting the division of said secondary air into substantially equal parts for said reintroduction.

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