United States Patent [19]

Parsons

[11] **3,761,567**

[45] **Sept. 25, 1973**

[54] **VERTICAL KILN SYSTEM AND PROCESS**

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[22] Filed: **Jan. 5, 1972**

[21] Appl. No.: **215,975**

Related U.S. Application Data

[63] Continuation of Ser. No. 868,189, Oct. 21, 1969, abandoned.

[52] **U.S. Cl.** **423/175,** 432/79, 432/99

[51] **Int. Cl.** **F27b 1/00**

[58] **Field of Search** 263/29, 20, 53

[56] **References Cited**

UNITED STATES PATENTS

3,285,590	11/1966	Parsons	263/29
3,427,013	2/1969	Cavanagh	263/29 X
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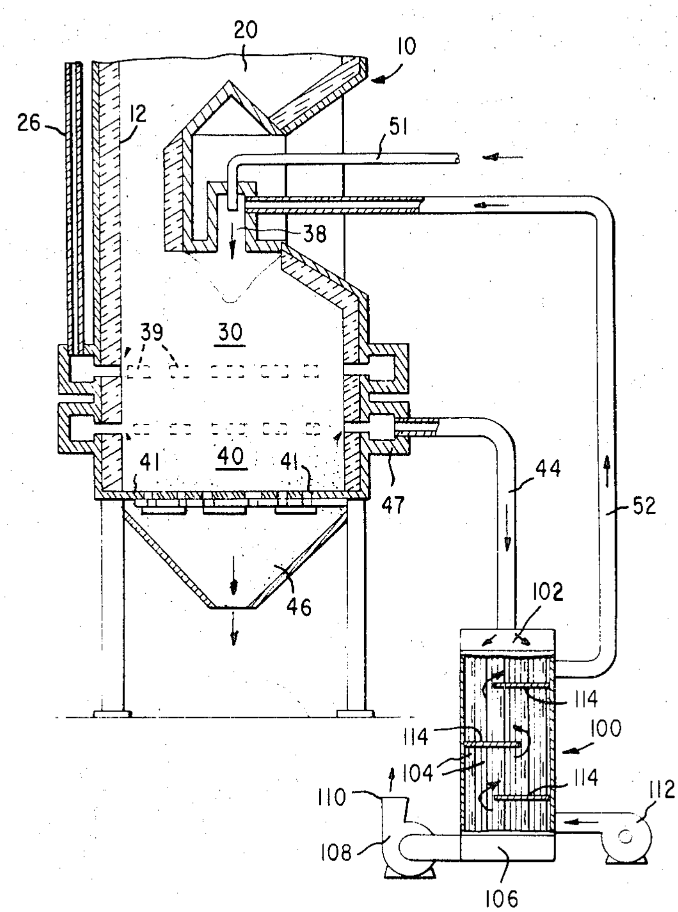
[57] **ABSTRACT**

In a continuously operating, vertical calcining kiln in which substantially complete calcining is obtained by preheating supply materials with exhaust gases, and co-current, combustion supporting fluid at an elevated temperature is supplied to a combustion zone above the calcining chamber and counter-current combustion supporting fluid is supplied beneath the calcining zone, a heat exchanger in communication with the exhaust air drawn through the calcining zone for effecting counter-current heating of atmospheric air as it is pumped through and heated in the exchanger, with minimum contaminates, whereby the available static pressure is improved at the combustion zone permitting more efficient production quantitatively as well as cooler-operation and maintenance-free air pumps operating more efficiently at lower temperatures.

6 Claims, 2 Drawing Figures



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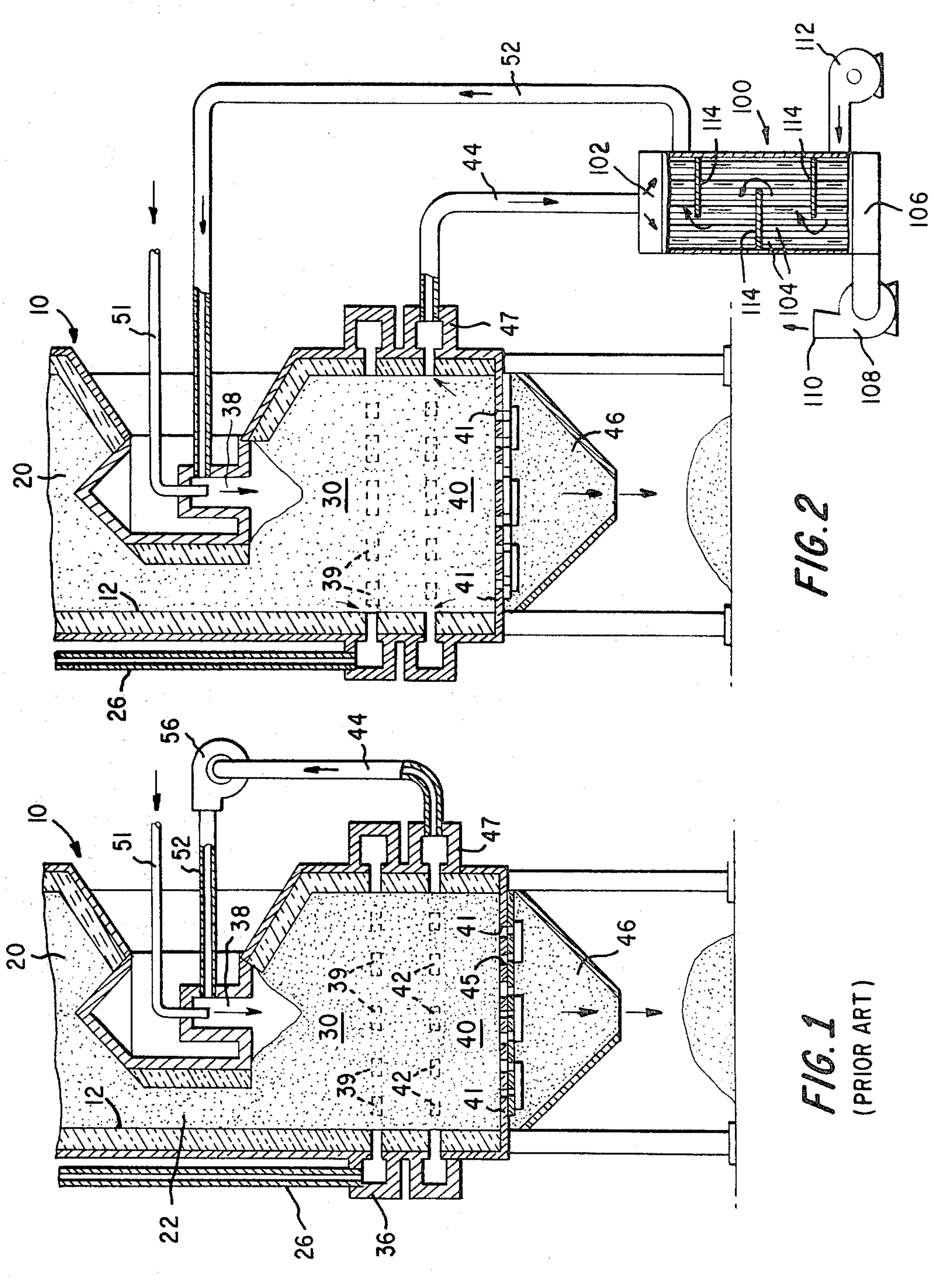

FIG.1 (PRIOR ART)

FIG.2

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VERTICAL KILN SYSTEM AND PROCESS

This is a continuation of application Ser. No. 868,189, filed Oct. 21, 1969, now abandoned.

INTRODUCTION

This invention relates to vertical calcining kilns and more particularly to improvements over applicant's U.S. Pat. No. 3,285,590 issued Nov. 15, 1966.

Applicant's issued U.S. Pat. No. 3,285,590 is incorporated by reference to supplement the disclosure of the present application, and is illustrative of the vertical calcining kiln in which the improved concept is incorporated.

Primary objects of the present invention are to provide a more efficient vertical calcining kiln and method which promotes a greater product output with respect to known kilns, and which utilizes a greater static pressure in the calcining zone permitted by reduced temperatures at the air pumps or fans whereby maintenance, repair and critical specification control of the fans or pumps is minimized; to provide a vertical calcining kiln a method in which a heat exchanger is provided in conjunction with dual fans or air pumps, and in which one pump draws combustion supporting fluid, i.e. air, for example, in counter-current flow to the material being cooled from a calcining zone, and the other pump drives air into the heat exchanger at room or atmospheric temperature and developing an optimum pressure-head, and the air, i.e. combustion supporting fluid, is raised in temperature by air being exhausted, i.e. that which was introduced counter-current into the calcining zone, and the high pressure air is forced into the combustion zone of the kiln, substantially free from dust, and combines with fuel introduced thereat, and the products of complete combustion are forced at maximum static pressure co-current from the top of the calcining zone through and with the material being calcined.

These together with other and more specific objects and advantages will become apparent from the following description of an exemplary embodiment when taken in conjunction with the drawing forming a part thereof, in which:

IN THE DRAWING

FIG. **1** is a schematic, vertical section showing the "prior art" and more particularly a portion of one embodiment of applicant's patented kiln; and

FIG. **2** is a view similar to FIG. **1**, illustrating the improved system and method incorporated in the embodiment of FIG. **1**.

Referring to the drawing, and considering FIG. **1** in detail, with more detailed reference to applicant's issued U.S. Pat. No. 3,285,590, reference numerals used to describe the structure will correspond to those used in the patent.

Referring to the issued patent, it will be noted that FIG. **1** of the application corresponds in structure and function to FIG. 3 of the patent. Briefly, as has been explained in detail in the patent, a fragmentary portion of a vertical, down draft kiln is indicated generally at **10** and is generally cylindrical. The cylinder or kiln shaft is generally divided into three primary zones, namely: a pre-heating zone **20**, a calcining zone **30** which includes therebelow a cooling zone **40**. The kiln is lined with suitable heat resistant refractory brick **12** or the like.

As the material to be calcined is deposited into the upper end of pre-heating zone **20**, exhaust hot air is drawn from slots or ports **39** into an annular bustle passageway **36**, generally at the lower portion of the calcining zone **30** and is directed through external conduit **26** to an upper, annular passage or bustle (not shown) and moves counter-currently through material being introduced into the kiln to preheat the same. As was explained in the patent, the expenditure of fuel is minimized and economies are achieved through the preheating and salvaging of heat below the calcining zone.

Below the calcining zone **30**, i.e. below ports **39**, is a second series of circumferentially spaced outlet ports **42** which generally define the upper portion of the cooling zone **40**, and which communicate with an annular chamber **47** connected by a conduit **44** to a centrifugal pump **56** (or the equivalent) which has an outlet **52** for directing combustion supporting fluid, i.e. air, to a burner **38** which is directed onto the upper portion of the calcining zone **30**. A fuel supply line **51** communicates fuel through the upper wall **53** of the burner.

The kiln includes air inlets **41**, through which air is drawn via ports **42**, annular chamber **47**, line **44** and pump **56**, while calcined material at hopper **46** is received thereat through a conventional rotary kiln-outlet **45**.

Briefly, as is described in detail in the issued patent, the material to be calcined, limestone, for example, is fed into the kiln and proceeds therethrough by gravity flow. The withdrawal of calcined material at hopper **46** is controlled by the kiln-outlet **45**. Air is drawn through opening **41** due to the pressure differential caused by pump **56** and passes upwardly or counter-currently through the material being calcined in zone **40**. The product is not only cooled, but calcining is completed in the terminal stage, and the air is then directed to the burner **38** to move co-currently with the material in the calcining zone **30**.

The products of combustion at burner **38** impinge directly onto the product at the upper portion of the calcining zone, which is introduced therein by restricted passages **22** (only one shown), and products of combustion exit at ports **39** at about 1,800° F to 2,400° F for delivery and preheating in zone **20**. As mentioned above, gases flow through the calcining zone **30** co-current with the product flow, and the temperature of the products of combustion can leave the chamber **38** in a range from 2,800° F to 3,200° F. As was mentioned in the issued patent, preheating results in high production of CO_2 generally making it impossible to burn the material being calcined, i.e. in the lime calcining processes, for example.

The embodiment of FIG. **1** was reduced to commercial practice, however, there are certain areas that gave rise to specific consideration and improvement. Typical unobvious problem, until actual reduction to practice, was that air withdrawn at **47** to cause counter-current cooling limits the static pressure capability of the air pump or fan, and since the production capacity of the kiln is in effect directly related to the pressure applicable at the combustion chamber, i.e., at the top of the calcining zone co-currently, low static pressure is not desirable. Additionally, extreme dust or fines when at relatively high temperatures in the combustion chamber, apparently tend to cause deterioration of the refractory lining. It is desirable to recoup or salvage the BTUs or heat generated during the calcining process, thus minimizing expenses of production or at least maintaining production as efficient and economical as possible.

The present improvement not only overcomes unobvious shortcomings which became apparent after having commercially reduced to practice, but provides efficient production with minimum increased fuel consumption.

In vertical, gravity-feed calcining kilns, product retention time is relatively high, and the kiln capacity can generally be said to be in direct relation to the amount of fuel that can be effectively consumed.

The amount of fuel that can be burned or consumed in the combustion chamber is dependent directly on the volume of air that can be supplied to the combustion chamber. The pressure or volume of air is directly proportional to the pressure at which the air can be supplied.

For the purpose of illustrating the statements above, the hot zone will be considered an orifice and in the basic gas flow equation

$$P = Cdu^2$$

where

P = Pressure drop at the orifice
c = a constant
d = density of the air
u = velocity of the air

It will be observed from the equation above, that P (the pressure across the hot zone of the kiln) will increase directly as the square of the volume of the combustion-supporting gages are forced co-currently through the hot or calcining zone.

In the form of the embodiment of FIG. 1, the fan 56 receives air at a relatively high temperature. As is appreciated from physical fan laws pertaining to centrifugal fans or air pumps, the static capability of any centrifugal fan is proportional to the density of the gas being handled by the fan or pump; and in view of the gas law, the density is inversely proportional to the temperature of the gas.

For example, under practical operating conditions, the maximum static pressure available from a centrifugal fan operating at 900° F, according to the kiln configuration of FIG. 1 is from 16 inches to 18 inches W.G. Since there was approximately 10 inches static pressure loss through the burner, then the available pressure in the kiln hot or calcining zone was from 6 inches to 8 inches W.G.

Before describing the improvement in detail, and using the equation above, applicant's improved system will provide combustion supporting fluid, i.e. air, at approximately 40 inches W.G. through the use of a conventional centrifugal pump or fan equipment. Assuming that there is a 10 inch static pressure loss through the burner, the net static pressure available would be 30 inches W.G. Considering the maximum available static pressure to be 8 inches in the embodiment of FIG. 1, and 30 inches in FIG. 2, the configuration of FIG. 2 will have a capacity as follows:

$\sqrt{30/8} = 1.93$ times capacity of original system per FIG. 1 with 8 inches W.G. effective static pressure available

The system of FIG. 2 results in a heat loss of from 300,000 BTU to 500,000 BTU per ton of product. This will result in a slightly higher fuel cost per unit operation; however, this is considered to be a relatively small consideration and relatively small capital expense per unit of capacity in view of increases in production output as well as less expensive equipment, and decreases in dust, and as a practical matter, the heat loss can be partially recouped for use in heating systems, batch drying, etc.

Referring to FIG. 2, the kiln 10 includes a refractory lining 12, preheating zone 20, inlet passages 22, calcining zone 30 and cooling zone 40. The burner 38 opens downwardly, and a fuel inlet line 51 communicates with the burner at the upper wall 53. Preheating gases are received in the bustle or receiver 36 and are directed through conduit 26 to preheating zone 20. Further, air is drawn upwardly through openings 41 to the chamber 47, and the product is discharged at 45 to hopper 46.

As is evident above, the structure generally described above, constitutes that described in detail relative to FIG. 3 of applicant's issued patent as well as the embodiment of FIG. 1 of this application.

As mentioned above, relative to the basic problem to be solved, the gases or air pumped by pumps 56 in FIG. 1 are very hot and only a maximum 8 inches WG effective static pressure can be supplied at the calcining or hot zone. Additionally, because of the extreme heat, the pump 56 must be produced under extreme controls and specifications to prevent wear, deterioration, etc. A heat exchanger is indicated generally at 100, has an inlet plenum 102 communicating with tubes 104 connected to an outlet plenum 106, and a first centrifugal fan or pump 108 is effective to draw gases through conduit 44′ and chamber 47. The outlet 110 of the fan or pump can be connected to auxiliary components, heating systems, boilers, etc., conventionally found around calcining plants.

The air or exhaust gases drawn through inlets 41 and counter-currently through cooling zone 40 afford completion of cooling and the air exiting at 110 is reduced in temperature due to conduction in the heat exchanger 100.

The heat exchanger includes a second pump or fan 112 generally operating at atmospheric or room temperature; generally assumed to be about 60° F, and a static pressure head of at least 40 inches WG can be readily developed. The heat exchanger includes alternately staggered baffle plates 114 defining a torturous path to an outlet connected with a conduit 52′ communicating with the burner 38 as does conduit 52 in FIG. 1.

It will be noted that although some heat is lost, the air forced by pump 112 gains heat as it moves through the heat exchanger; however, the air does not have entrance therein to extreme fines or dust entrained and which tends to break down and deteriorate refractories. Additionally, although the air is not as hot when introduced into burner 38, oxygen is not preconsumed by passage counter-currently through the cooling zone 40 as in FIG. 1, but is fresh and thus sustains maximum combustion.

Those skilled in the art will appreciate that the heat exchanger ie exemplary in character as are the pumps or fans.

Briefly summarizing, the improved method and system of this invention retains all of the advantages and attributes of the vertical kiln of the issued patent and is adapted for use with vertical kilns of a similar functional character, and yet affords greater efficiencies and advantages both in production, maintenance and repair; these were unexpected and unobvious until the commercial kiln was effected and operated.

What is claimed as new is as follows:

1. In a process for calcining materials comprising the steps of:

a. introducing material to be calcined into a substantial vertically disposed kiln and permitting the material to have substantially free-gravity flow therethrough;

b. establishing a fuel-combustion zone intermediately of said substantially free-flowing material and a calcining zone beneath said fuel-combustion zone;

c. establishing a restricted zone for said free-flowing material above said fuel-combustion zone to a degree sufficient to impede the upward travel of a substantial portion of combustion gases emanating from said fuel-combustion and calcining zones;

d. removing combustion gases adjacent the lower portion of calcining zone and introducing at least a portion of such gases to the material above said restricted zone to preheat the material before it encounters said restricted zone;

e. introducing a first source of combustion-supporting fluid into said calcined material zone adjacent a lower portion of said calcining zone; the improvement comprising:

f. exhausting gases generally below said calcining zone; and

g. transferring heat from the gases exhausted below the calcining zone to a second source of combustion-supporting fluid and gases this second source of combustion-supporting fluid to said fuel-combustion zone in a fuel direction with the material substantially through the entire calcining zone.

2. The process as claimed in claim **1** including the steps of introducing said exhausted gases and said second source of combustion-supporting fluid through a heat exchanger.

3. The process as claimed in claim **1** removing the exhaust gases at substantially terminal calcining temperature and introducing said second source of combustion-supporting fluid at substantially approximately atmospheric temperature and recovering at least 50% of the BTUs from said exhausted gas.

4. The process as claimed in claim **1** including using dual, independent fluid pumps for respectively exhausting said exhaust gases and introducing said second source of combustion supporting fluid and burning the fuel in the fuel combustion zone in relation to air being supplied by said second source of combustion supporting fluid.

5. The system for continuously calcining materials comprising, in combination:

vertically-disposed kiln means;

supply means communicating with said kiln means for charging said kiln means with material to be calcined;

said kiln means comprising, in series, preheat chamber means, restricted passage means, calcining chamber means, and cooling chamber means,

said kiln means including downwardly directed burner means adjacent the upper end of said calcining chamber means and forming a combustion chamber at the upper portion of said calcining chamber means,

said calcining chamber means including one outlet port means for directing heated gases to said preheat chamber means,

a second outlet port means communicating generally below said calcining chamber means for drawing a combustion-supporting fluid countercurrent into said calcining chamber;

heat exchanger means in communication with said second outlet port means of said calcining chamber and said combustion chamber for withdrawing exhaust gases from the calcining chamber and preheating from atmospheric temperature a combustion-supporting fluid directed to said combustion chamber, and

pump means operatively connected to said heat exchanger means for effecting the exhausting of gases and introduction of combustion-supporting air.

6. The system as claimed in claim **5** in which said pump means comprises separate pumps, one pump drawing exhaust gases through said heat exchanger, and said other pump communicating with the atmosphere and driving air under pressure through said heat exchanger to be heated by conduction by the exhaust gases.

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