

[54] **ROTARY APPARATUS FOR TREATING COLEMANITE ORE**

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[58] Field of Search **75/3-5; 23/59; 241/1; 34/129, 137; 263/32**

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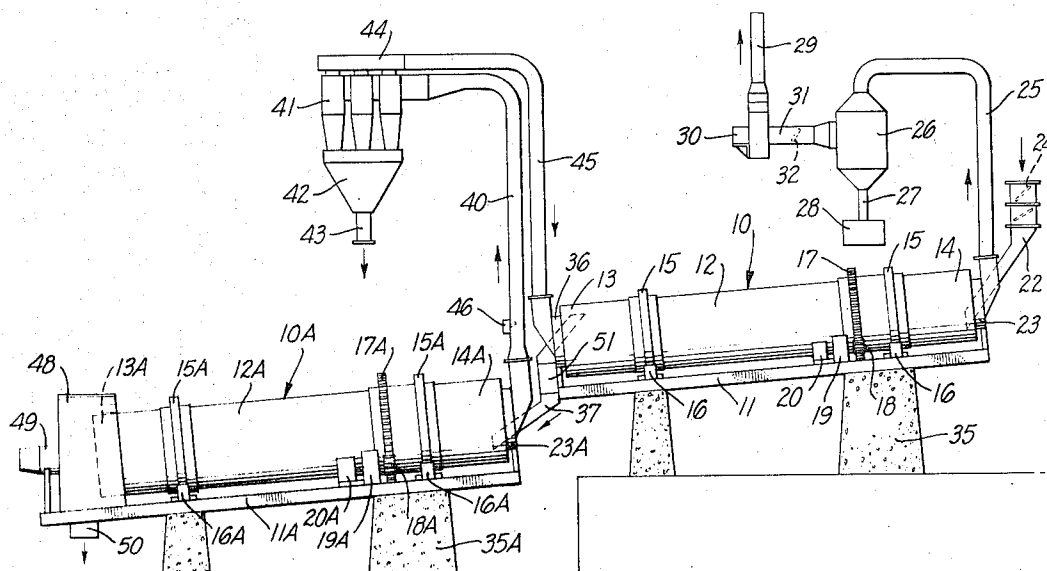
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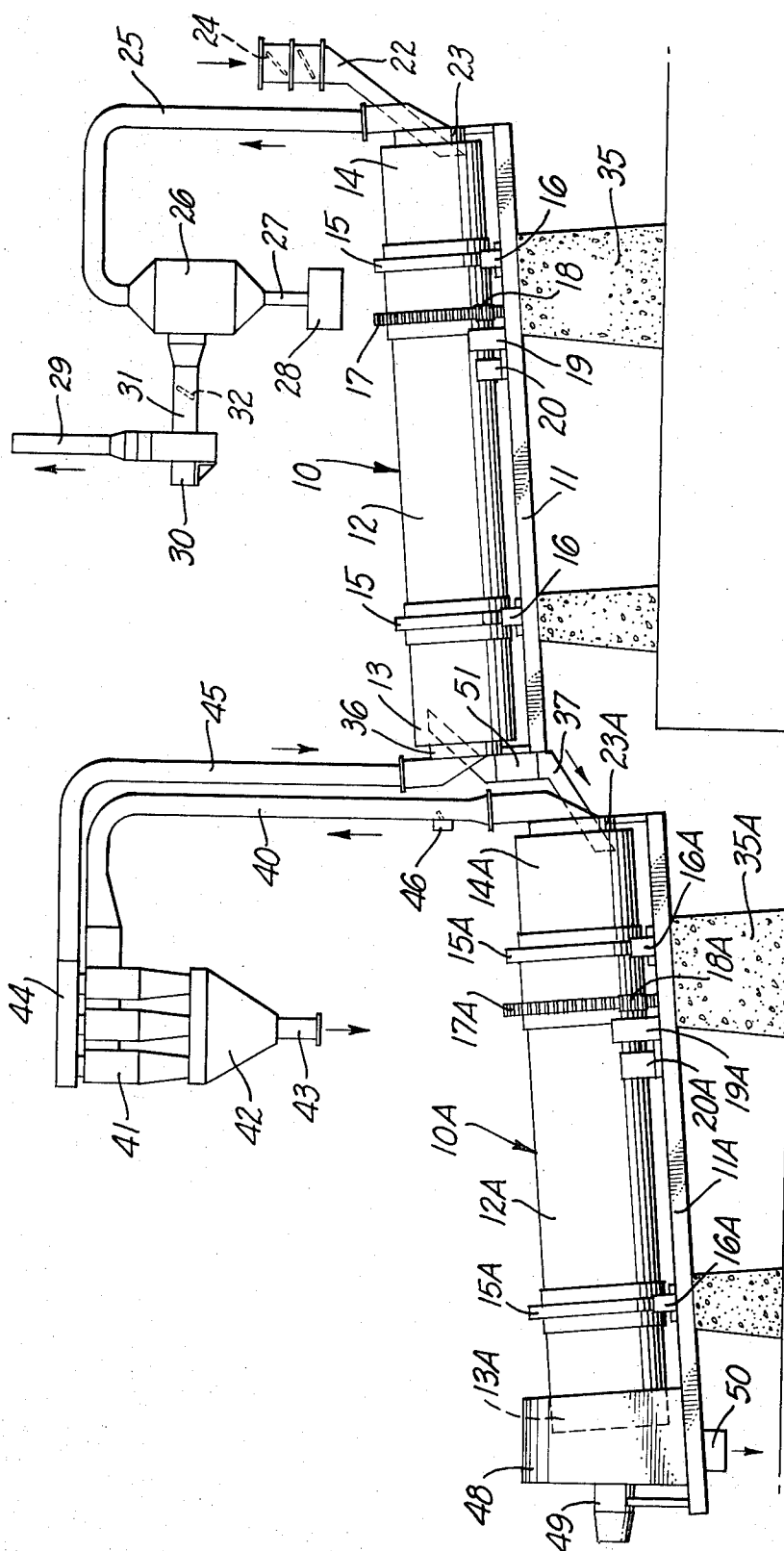
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[57] **ABSTRACT**

Colemanite ore is treated to prepare pure calcined colemanite which is substantially free of the ore gangue. The ore is first dried to remove all uncombined water, then calcined with a stream of hot gas at a temperature sufficient to fracture the colemanite crystals into small particles which are selectively picked up from the ore by the gas stream and carried in the gas stream in which the final calcination of the colemanite takes place. The calcined colemanite particles are then separated from the gas stream. The method can be carried out with two rotary kilns mounted in tandem and tilted for gravity feed. A burner and blower are mounted at the discharge end of the lower kiln or calciner, and a feed chute with a gas lock connects the feed end of the calciner to the discharge end of the upper kiln. An exhaust stack leads from the ore inlet end of the upper kiln. The calciner to a cyclone separator, the gas exiting from the separator into a conduit connected to the ore discharge end of the upper drier, and the balance of the ore discharges from the discharge end of the calciner. A feed chute and exhaust stack are connected to the feed end of the upper drier.

4 Claims, 1 Drawing Figure





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ROTARY APPARATUS FOR TREATING COLEMANITE ORE

BACKGROUND OF THE INVENTION

The present invention is directed to a method of calcinating colemanite ore and separating the calcined colemanite from the ore gangue, and to an apparatus that will perform the novel process.

Colemanite, $\text{Ca}_2\text{B}_6\text{O}_{11} \cdot 5\text{H}_2\text{O}$ or $2\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$, is a calcium borate material that is found in the arid regions of the United States and other areas of the world. For the last century, colemanite has been an important raw material for the production of borax. The colemanite ore contains, besides colemanite and water, clay and coarse aggregate which are difficult to separate from the colemanite. At the present, the colemanite ore is dried and calcined and then the colemanite is separated from the foreign materials by rabbling and screening. The separation method is not particularly efficient and does not recover 100 percent of the colemanite, nor does it produce a colemanite material free of foreign material, such as clay. The presence of clay is undesirable because it interferes with the efficiency of the refining operation employed in the conversion of colemanite to borax. Such conventional method is also expensive and requires elaborate equipment.

SUMMARY OF THE INVENTION

The present invention is directed to a method of preparing calcined colemanite, substantially free of any foreign material, from colemanite ore. The colemanite ore is crushed and dried and then calcined with agitation at a temperature to fracture the colemanite crystals into fine particles and calcine the colemanite. A stream of gas at a predetermined velocity is passed through the ore during the calcination step to selectively pick up and carry the calcined colemanite particles away from the ore gangue and foreign material. The colemanite particles are then separated from the gas stream and the remaining gangue is discharged as waste.

The novel apparatus used in the present process comprises two rotary kilns mounted in tandem. The discharge end of the upper kiln or drier is connected to the feed end of the lower kiln or calciner by a gravity fed feed chute with an air lock. A heater unit, for blowing a stream of hot gas heated to calcination temperature through the calciner, is mounted at the discharge end of the calciner. An exhaust duct connects the feed end of the calciner to a gas-solid particle separator unit. This unit has a gas exit duct connected to the discharge end of the drier. An ore feed hopper with an air lock and gas exhaust system are connected to the feed end of the drier. In this apparatus, the hot gas is used to calcine the colemanite ore, separate the calcined colemanite from the ore gangue and dry the colemanite ore. The gas stream runs countercurrent to the colemanite ore.

The drawing shows a side elevational view of an apparatus which embodies the invention.

DESCRIPTION OF THE INVENTION

As shown in the drawing, the apparatus includes an upper rotary kiln or drier 10 and a lower rotary kiln or calciner 10A, each of which may be of conventional form or which may be as illustrated and described in detail in U.S. Pat. No. 3,025,611. The kilns 10 and 10A may be of similar construction, so only the upper kiln 10 will be described, similar parts of the lower kiln 10A being identified by the same reference numerals with the added postfix "A."

The drier 10 has a frame 11 on which there is mounted a generally cylindrical shell 12 having a discharge end 13 and a feed end 14. The shell 12 is rotatable about its longitudinal axis and slopes downwardly from its feed end to its discharge end so that the material being heated moves from the feed end of the shell to the discharge end thereof by gravity in response to the rotation of the shell.

The shell 12 may be mounted for rotation in any suitable manner, as by providing it with circumferential rails 15 which engage rollers 16 on the frame 11. The shell carries a ring gear 17 meshed with a driving gear 18 rotatably mounted by the geared reduction box 19 on frame 11 and driven by a motor 20 to rotate the shell about its longitudinal axis. The frame 11 is mounted on pedestals 35.

The drier 10 is supplied with colemanite ore by a feed hopper 22 which is connected to and projects through a housing 23 at the feed end 14 of the drier 10. The shell 12 is connected to housing 23 in a relatively gastight relationship and is adapted for rotation thereabout. The hopper 22 has a plurality of the valve vanes 24 which comprise an air lock system for the hopper.

A gas conduit 25 is connected, at one end, to the housing 23 and to a scrubber unit 26 at the other end. A discharge duct 27 is connected at the bottom of the scrubber 26 for discharging material into a holding or settling tank 28. The discharge duct 27 has an air lock system (not shown) to prevent the escape of gas during the withdrawal of material from the scrubber. The scrubber is connected to a chimney unit 29, having an induced draft fan 30, by a gas conduit 31 which has a damper 32.

The discharge end 13 of the drier 10 is connected to a discharge housing 36 in a relatively gastight manner for rotation thereabout, and is connected to the feed end 14A of the calciner 10A, by means of a gravity feed chute 37, having an air lock 51 to prevent gas from passing directly from the feed end 14A of the calciner 10A into the discharge end 13 of the drier 10.

A gas exhaust stack 40 is connected at one end to housing 23A of the calciner 10A and at the other end to a plurality of cyclone separators 41. The bottom portions of the cyclone separators are connected to an inverted conical collector 42 which has air lock 43 mounted at the apex of the cone. The top portion of the cyclone separators 41 are connected to a gas manifold 44 which is connected to the housing 36 of the first drier 10 by a gas conduit 45. A temperature sensing device 46 is mounted on the gas exhaust stack 40 near the junction of the housing 23A and the stack 40.

A heating unit 48, supplied with air by a blower 49, communicates with the discharge end 13A of the shell 12A. The stream of hot gas, produced by the heating

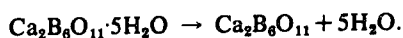
unit and the blower, is blown through the shell 12A, countercurrent to the flow of solid material therethrough, and is discharged at the feed end 14A of the shell through the gas exhaust stack 40. The device 46 is connected to a control device (not shown) which controls the heat output of the heating unit 48 in response to the gas temperature sensed by the device 46. A discharge duct 50 is mounted at the lower end of the frame 11A and communicates with the discharge end 13A of the calciner 10A. The duct 50 preferably is also supplied with an air lock (not shown).

OPERATION OF THE APPARATUS

Colemanite ore is supplied to the feed end 14 of the drier 10 by the feed hopper 22. The colemanite ore, as mined, is in large crystal forms usually containing about 5 moles of combined water or water of crystallization. The ore is a mixture of fine clay, coarse gangue or aggregate and colemanite crystals: about 50 percent of the ore is colemanite. The ore has a free moisture content of about 16 percent. Prior to feeding the ore to the apparatus, the ore is crushed so that at least 90 percent of the ore particles are about $\frac{3}{4}$ inch size. Preferably the ore is crushed so that about 90 percent of the ore's particle sizes are between $\frac{3}{8}$ inch and $\frac{1}{2}$ inch Tyler mesh.

As the shell 12 is rotated, the ore cascades downwardly from the feed end 14 to the discharge end 13 of the drier 10, with constant agitation and cascading. A draft of hot air is blowing countercurrent thereto from the discharge end 13 to the feed end 14 of the drier. The hot air preferably enters the discharge end 13 at a temperature of around 850° F. and leaves the feed end 14 at a temperature of about 300° F. through the gas conduit 25 to dry the ore. During the drying operation in the drier 10, free moisture is removed from the ore, and the ore is heated to a temperature above 212° F., preferably to a temperature of about 265° F.

At the discharge end 13 of the drier 10 the ore enters feed chute 37 through which it flows by gravity into the feed end 14A of the calciner 10A. The air lock 51 in the feed chute 37 prevents hot gases from flowing through the chute countercurrent to the flow of solid material therethrough. As the calciner shell 12A rotates the dry colemanite ore therein is lifted up and allowed to cascade downwardly within the shell in streams. As the dried ore progresses downwardly from the feed end 14A to the discharge end 13A of the calciner 10A, with constant agitation and cascading, a stream of hot air is blown countercurrent thereto from the discharge end to the feed end of the calciner. The stream of hot air from the heater unit 48 and the blower 49 is adjusted to heat the ore to an average temperature of about 850° F. before it reaches the discharge end of the calciner. At a temperature of about 850° F., the colemanite crystals in the ore are dehydrated and lose their combined water or water of crystallization according to the following reaction:



During dehydration the colemanite crystals are fractured into tiny particles having an average size of about 100 Tyler mesh. The velocity of the stream of hot air is adjusted so that these tiny crystals of dehydrated colemanite are picked up and made airborne in the gas

stream and are selectively carried out of the calciner in the gas stream. I have found that a gas stream velocity of about 400 to 600 lineal feet per minute is quite satisfactory for this step. The velocity can be varied over this range somewhat to obtain optimum results. Preferably the gas stream velocity is about 500 lineal feet per minute.

The stream of hot gases, carrying the dehydrated colemanite particles, exits out of the calciner 10A through the gas duct 40 into the cyclone separators 41. In the separators the dehydrated colemanite particles are centrifuged out of the gas stream and collect in the conical collector 42. Periodically or continuously collected particles are withdrawn from the collector 42 through the airlock 43, for packaging, bulk loading, or storage.

The stream of hot gas, substantially free of all solid particles, discharges from the separators 41 into the gas manifold 44 and flows therefrom through gas conduit 45 into the discharge end 13 of the drier 10, supplying the drier with a stream of hot drying gas. After passing through the drier 10 the stream of hot gas exits through gas conduit 25 into scrubber 26.

In the drier 10, the stream of hot gas picks up and carries away fine particles of clay and aggregate. This foreign material in the gas is scrubbed with water within the scrubber 26 to form a slurry which settles to the bottom of the scrubber. From time to time or continuously the slurry is removed from the scrubber 26 through the discharge duct 27 into the settling tank 28 or other point of disposal. The hot moist gases in the scrubber are pulled from the scrubber by the action of the induced fan 30 and drawn through gas conduit 31 and out through the chimney unit 29. The damper 32 is adjusted to provide the optimum gas stream velocity in the calciner 10A.

The temperature sensor 46 is connected to the gas conduit 40, and is electrically connected to a control system which adjusts the heat output of the heater unit 48. If the temperature of the gas stream exiting from the calciner 10A falls below 850° F., the control system increases the heat output of the heater unit 48 to insure that a minimum temperature of 850° F. is maintained at the feed end of the calciner, thus insuring calcination or dehydration of the colemanite crystals. The gas stream temperature is important because I believe the complete calcination or dehydration of the colemanite occurs in the gas stream after the colemanite crystals have fractured into fine particles which become airborne.

The hot ore gangue, free of the colemanite material, is discharged from the discharge end 13A of the calciner 10A and falls through the discharge duct 50 to a waste bin, hopper, conveyor system or other means of transporting and disposing of the waste gangue.

By employing the above apparatus to practice the above described method, I have obtained almost 100 percent complete recovery of the colemanite (as dehydrated colemanite) from colemanite ore. The calcined colemanite recovered is substantially free of all foreign materials such as fine clay and coarse aggregate.

In the embodiment of the invention described above, the method and the apparatus were described employing a calciner and a drier. This is not the only embodi-

ment of the invention intended. For example, dried colemanite ore can be used, thus eliminating the need for the drier. Alternatively, other types of driers can be employed in the present invention, such as refractory lined driers, fluidized bed driers and the like. Moreover, the drying and calcination steps can be carried out in a single rotary drier unit with the separation step to be carried out in the exhaust gases from the "drier" end of the unit. However, it should be noted that by employing a rotary drier, as disclosed in the present invention, the colemanite ore, in the drying stage, is blown free of all fine particles that would contaminate the dehydrated colemanite collected after calcining. Thus, when the dried colemanite ore enters the calciner 10A, there are virtually no particles or fines in that ore which are picked up and carried along by the air stream with the dehydrated colemanite particles. It should also be noted that this invention is not limited to the use of cyclone separators. There are many separators, well known in the art, for separating solid particles in gas streams. Any of these can be used if they can be employed within the operating parameters of the invention.

To further illustrate the present invention, the following working example is provided.

A colemanite ore was washed free of fine clays by washing and contained approximately 50 percent colemanite crystals, 16 percent free water and a remainder of clay and coarse aggregate. The analysis of 2,000 pounds of feed was:

Free H ₂ O	320 lbs.	
Pure Colemanite	840 lbs.	(including 184 lbs. combined H ₂ O)
Gangue	840 lbs.	

2,000 lbs.

The discharge from the system was:

Solids Phase		Gaseous phase	
Colemanite	656 lbs.	Water Vapor	506 lbs.
Gangue	840 lbs.		

The 656 lbs. of dehydrated colemanite was the desired product.

HEAT BALANCE

The net heat required to process 2,000 pounds of feed, based on 60° F. initial feed temperature, 800° F. product discharge temperature and 300° F. final exhaust temperature, was calculated as follows:

Heat Solids	$1,496 \text{ lbs.} \times .25 \times (800-60) =$	277,000 BTU	
Heat free H ₂ O	$320 \text{ lbs.} \times (212-60) =$	48,600 BTU	
Evap. free H ₂ O	$320 \text{ lbs.} \times 970 \text{ BTU} =$	311,000 BTU	
Heat vapor free H ₂ O	$320 \text{ lbs.} \times .477 (300-212) =$	13,430 BTU	
For Chemical reaction	$184 \text{ lbs.} \times 1548 \text{ BTU/lbs.} =$	285,000 BTU	
Heat vapor comb. H ₂ O	$184 \text{ lbs.} \times 105 \text{ BTU/lbs.} =$	19,300 BTU	
	Net	954,330 BTU	
Calculated radiation losses 16.8%		160,000 BTU	
Total heat given up by gases in system		1,114,330 BTU	
Calculated heat available for drying per lb. of fuel=		15,476 BTU	
Calculated fuel consumption			
$1,114,330/15,476 = 72 \text{ lbs./Ton of Feed,}$			

Net heating value of fuel (No. 2 oil)
Net heat to material

No. 2 fuel oil
= 18,389 BTU/lbs.
= 12,876 BTU/lbs.
(70% efficient)
= 2,600 BTU/lbs.
= 2,913 BTU/lbs.
gases/min./ton of feed/Hr.
362 ACFM at 300°F.
874
289
1,525 ACFM at 300°F.

Radiation losses
Stack and conduit losses
Calculated volume of exhaust
Combustion gases
Tempering air
Water vapor
Total:
 $66.51/1525 = .0437 \text{ lbs./cu. ft.}$
density leaving system.

2 thousand pounds of ore was fed to the drier 10 and 1,680 pounds of dried ore was discharged therefrom into the calciner 10A. The calciner was supplied with 3,487 pounds of hot gas heated to a temperature of about 1,475° F. and blown through the calciner at a velocity of about 500 lineal feet per minute. 840 pounds of gangue at about 800° F. was discharged from the calciner, and 656 pounds of dehydrated colemanite was collected in the conical collector 42. The hot gas containing the combined water removed from the colemanite was passed into the drier at a temperature of about 850° F. and about 3,991 pounds of exhaust gas was discharged from the drier via conduit 25. The exhaust gas contained about 504 pounds of water, which was removed from the ore and colemanite during the drying and calcinating steps.

As will be understood, the relationship between the rate of air flow and its temperature, as it exits from the calciner 10A, and the length of the hot air passage between the calciner 10A and the drier 10 is such that the temperature of the air stream is reduced by the time it enters the drier to a temperature suitable for the first drying of the ore therein, but insufficient to produce any substantial calcination of the colemanite as the ore passes through the drier. This is an important feature of the invention as it insures maximum efficiency in the recovery of colemanite from the ore. Also, it employs the same air stream for both calcining and preliminary drying, which provides further economy and is another advantage of the invention.

I claim as my invention:

1. An apparatus for treating colemanite ore including colemanite crystals and aggregate material, including:
 - a drying zone;
 - a calcining zone;
 - means for conveying said ore through said drying zone and then through said calcining zone;
 - means for blowing a current of hot air through said calcining zone and then through said drying zone countercurrent to the movement of ore through said zones, said air current calcining said colemanite crystals in said calcining zone, reducing them to colemanite dust, and conveying such dust from said calcining zone, said air current in passing through said drying zone evaporating free water from the ore therein;
 - means for separating said colemanite dust from said air current after said air current leaves said calcining zone and before it enters said drying zone; and
 - means for discharging said aggregate material from said calcining zone separate from said air current.
2. An apparatus for treating colemanite ore, including colemanite crystals and aggregate material, including:
 - a drying zone having inlet and outlet ends;
 - means for supplying ore to the inlet end of said drying zone through an air lock device adapted to per-

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mit the introduction of the ore but preventing any substantial discharge of air from the drying zone through said air lock device;
a calcining zone having inlet and outlet ends;
means for transferring ore from the outlet end of said drying zone into the inlet end of said calcining zone through a second air lock device adapted to permit the introduction of the ore into the calcining zone but preventing any substantial discharge of air from the calcining zone through said second air lock device;
means at the outlet end of said calcining zone for blowing air through said calcining zone at a temperature and velocity sufficient for calcination of colemanite crystals in said zone and the removal of calcined colemanite therefrom;
conveyor means between the inlet end of said calcin-

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ing zone and the outlet end of said drying zone for passing said air current therebetween and cooling said air current to a temperature suitable for drying ore in said drying zone, said conveyor means including separating means for separating calcined colemanite from the air current after said air current leaves said calcining zone and before it enters said drying zone; and
means for discharging said air current from the inlet end of said drying zone.

3. An apparatus as defined in claim 2 wherein said drying and calcining zones comprise rotary kilns.

4. An apparatus according to claim 3 wherein said separating means includes at least one cyclone separator.

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