

[54] **GRINDING RAW MATERIALS IN THE MANUFACTURE OF CEMENT**

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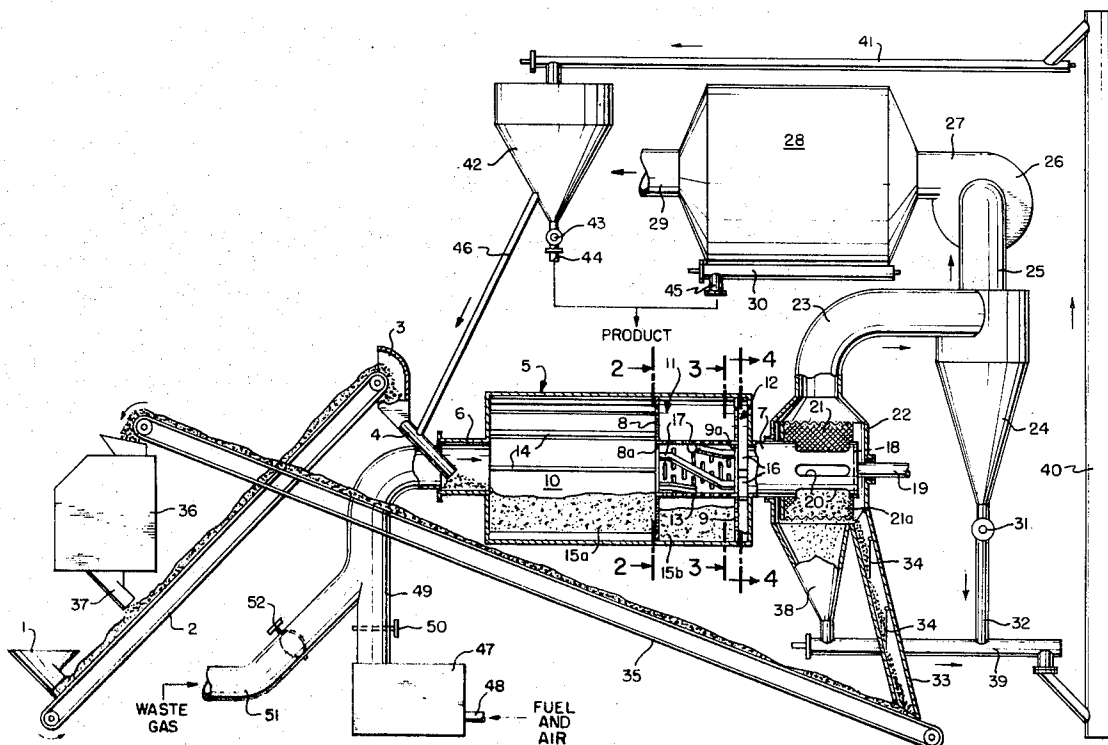
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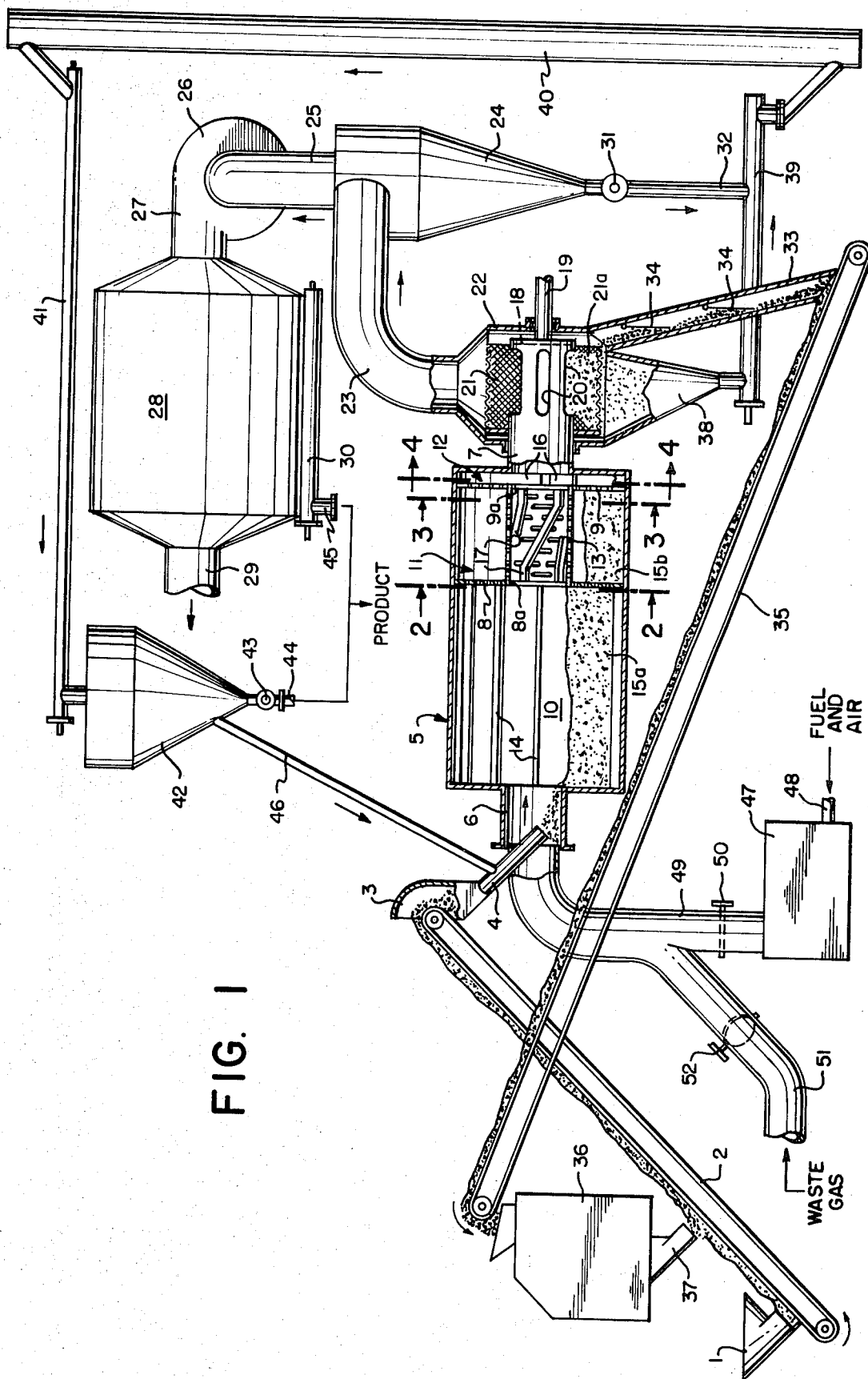
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ABSTRACT

A method and apparatus for grinding raw materials having a maximum particle size of for example about 250 mm. to a final product with a maximum size of, say, 0.2 mm. in a closed circuit grinding system comprising only one tube mill having primary and secondary grinding chambers.

14 Claims, 5 Drawing Figures





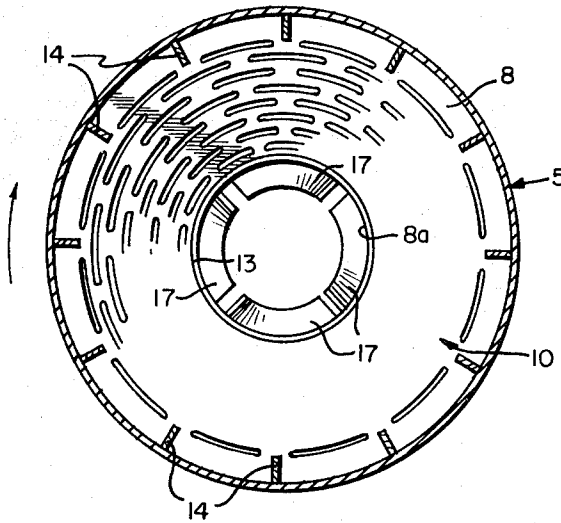


FIG. 2

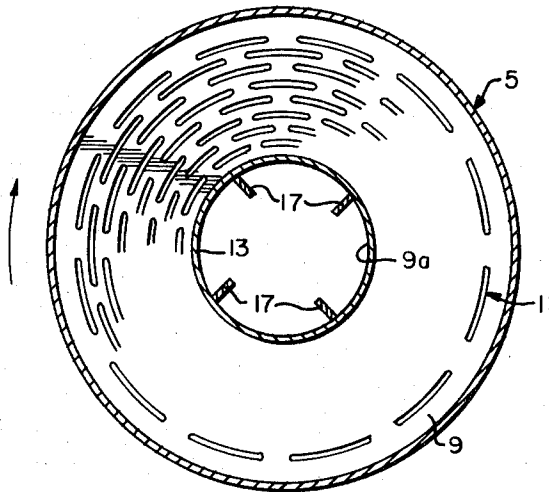


FIG. 3

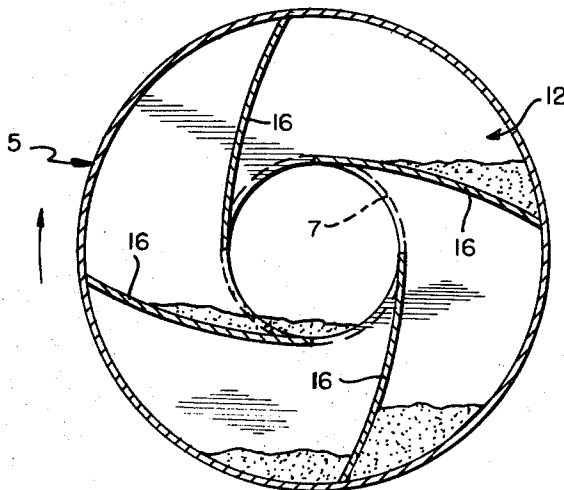


FIG. 4

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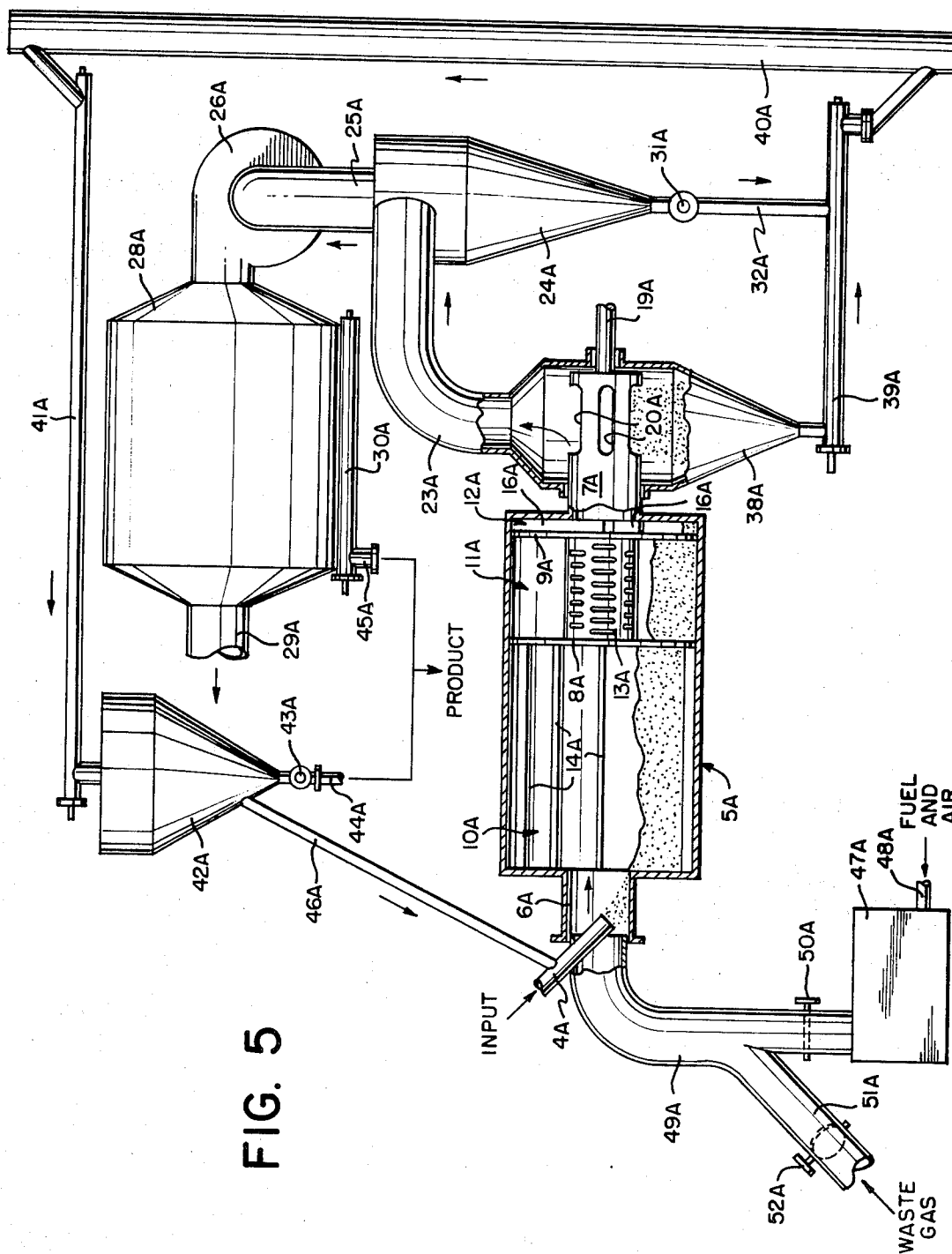


FIG. 5

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GRINDING RAW MATERIALS IN THE MANUFACTURE OF CEMENT

SUMMARY OF THE INVENTION

In the primary grinding zone the material particles may be reduced, for example, to a size no larger than between 3 and 15 mm., and in the secondary grinding zone the particle size is reduced further down to, for example, 0.2 mm. During the grinding, air is passed longitudinally through the tube mill to entrain and carry from the mill raw material ground to the desired fineness, and in some cases also to act as a drying agent for the raw material.

In a tube mill the primary and secondary grinding zones are usually formed by axially spaced compartments in the mill separated from one another by a screen perforated with small apertures through which the partly ground particles can pass for secondary grinding. The existence of the perforated screen, the small apertures of which become partly clogged by the material being ground, gives rise to an appreciable air pressure drop across the screen. As a result, a large power consumption is required for driving the air through the mill and the velocity of the air on entering the secondary grinding compartment is likely to be so great that material particles which are rather fine, but have nevertheless not attained the particle size which they should have attained before leaving the compartment, are suspended in the air and carried out of the mill in too coarse a state. Also, when the air is used for drying the material, the existence of the screen makes it difficult to pass a sufficiently large amount of air per unit of time through the mill to effect the necessary drying.

In accordance with the present invention these problems are overcome by a method of dry grinding raw materials in which the raw material is ground in a closed circuit grinding system comprising only one tube mill having two grinding zones, a primary grinding zone and a secondary grinding zone. The velocity of a gas current passed through the primary grinding zone is so controlled that raw material of substantially the desired end product fineness is entrained in the gas. One portion of the remaining particles is caused to pass into and through the secondary grinding zone so as to be further ground and subsequently outside the mill caused to pass into an air separator in which it is divided into a fine fraction constituting at least part of the end product and a coarse fraction which is returned to the primary grinding zone for further grinding. Another portion of the remaining particles is caused to by-pass the grinding operation in the secondary grinding zone to be later reintroduced into the primary grinding zone for further grinding. The fine particles entrained in the gas are caused to by-pass the secondary grinding zone by being forced through a tube extending centrally through the secondary grinding zone. These fine particles are subsequently outside the mill precipitated from the gas and united with the coarser particles discharged from the secondary grinding zone before they reach the air separator. Optionally the raw material may be precrushed before entering the primary grinding zone.

The invention also includes a plant for carrying out this method, the plant including a rotary tumbling mill with two or more compartments with a hollow inlet trunnion for simultaneous introduction of raw material

and a flow of gas and with a hollow outlet trunnion for carrying away ground material and the flow of gas, in which part of the ground material is suspended, wherein the first compartment of the mill is designed to serve as a primary grinding compartment, and its second compartment and any subsequent compartment serves for secondary grinding, the primary and the first secondary grinding compartment being separated from each other by a partition perforated with arcuate slots of some appreciable width. The last secondary grinding compartment and a separate outlet chamber adjacent to the outlet trunnion are likewise separated from each other by a similarly perforated partition. Each of the two partitions have a central opening through which extends centrally a tube having a length the same as the secondary grinding compartment or compartments and having a diameter the same as that of the central openings.

The provision of the central by-pass tube in the secondary grinding compartment enables a substantial part of the air to pass out of the mill through the tube instead of having to be forced through the perforations in the screen and through the secondary compartment. Advantageously the central by-pass tube also provides a discharge conduit out of the primary grinding zone through which material not sufficiently ground to exit through the arcuate perforations in the partition separating the primary and secondary grinding zones by-passes the grinding operation in the secondary grinding zone. It will be recognized that such by-passing material would otherwise tend to clog the perforations in the partition and create the undesirable pressure drop mentioned above. With the central by-pass tube according to the invention the pressure drop set up by the passage of the air through the mill, and particularly through the screen, is reduced considerably. At the same time the velocity of the air passing through the secondary compartment is appreciably reduced so that an undesirably large amount of ground particles are not taken out of the secondary grinding compartment suspended in the air, before they have been properly ground.

It is unavoidable that at least some particles of the fine part entrained in the gas flow passing through the central tube are rather too coarse for the gas flow to keep them in suspension. Such wrongly classified particles may be given access to the secondary zone through perforations provided in the wall of the central tube.

The gas which in the cyclone has been deprived of at least part of the suspended particles may be caused to pass through a dust precipitator, and into the atmosphere, with a view to catching therein the fine particles or dust still remaining in the gas. Thus dust constitutes part of the end product.

In case the raw materials are moist they may be dried simultaneously with being ground in which case the flow of gas which is passed through the mill will be a flow of hot gas.

If the raw materials involved are moist cement raw materials, they may well be simultaneously dried and ground as just explained so as to form so-called raw meal. After the drying the raw meal may subsequently be preheated, for example in a so-called raw meal preheater, to be finally brunt to cement clinker in a rotary kiln. In such burnt the hot flow of gas introduced into

the mill may at least partly consist of hot exit gas from the rotary kiln or the raw meal preheater. Alternatively, the required heat may be supplemented by heat contained in a hot gas from a separate auxiliary furnace.

The secondary grinding compartment will normally contain permanent grinding bodies, such as steel balls but the invention is useful both when permanent grinding bodies such as steel balls are provided in the primary grinding compartment and when the primary grinding compartment is intended for autogenous grinding, that is grinding by means of stones within the material.

Autogenous grinding in the primary grinding zone is useful when the raw material, incorporating the necessary stoney impurities, has a high moisture content, of 20 percent or more, and a sticky composition such that it cannot be precrushed by say a hammermill to a size smaller than say 250 mm. Such material can be ground to a particle size of say between 1 and 3 mm., by autogenous grinding provided that there is sufficient drying air current through the mill, and this requirement is met by the invention. Autogenous grinding also has the advantage that there is no steady consumption of large size steel grinding balls or heavy wear on the lining plates of the mills, which would otherwise occur during the primary grinding. Furthermore the central tube provided through the secondary compartment in accordance with the invention enables very coarse particles which remain unground in the primary compartment to pass the secondary compartment and be returned for precrushing and reentry into the primary compartment for further autogenous grinding.

BRIEF DESCRIPTION OF THE DRAWINGS

Two examples of grinding plant constructed in accordance with the invention are illustrated in the accompanying drawings, in which:

FIG. 1 is a side view of one plant, shown partly in section;

FIG. 2 is a cross-section through a mill of the plant, taken perpendicularly to the axis of the mill taken on the line 2—2 in FIG. 1;

FIG. 3 is a cross-section through the mill taken on the line 3—3 in FIG. 1;

FIG. 4 is a cross-section through the mill taken on the line 4—4 in FIG. 1; and

FIG. 5 is a schematic side view of the second plant.

DETAILED DESCRIPTION

The first illustrated plant has a hopper 1 by means of which moist raw material, coarsely crushed to sizes of not more than about 250 mm., is placed on the lower end of an upwardly inclined conveyor belt 2, the upper end of which discharges into a hood-like casing 3 which at its lower end is connected to a tube 4 which leads the material into a mill 5 (the part of the plant or apparatus with which the invention is particularly concerned).

The mill 5 is provided with a hollow inlet trunnion 6 and a hollow outlet trunnion 7 and is continuously rotated about the axis determined by the trunnions, the trunnions resting in bearings (not shown), and the mill being provided with a power drive (also not shown).

Inside the mill there is a perforated partition 8 with a central opening 8a, and near the outlet end of the mill is a similar perforated partition 9 likewise with a central opening 9a. These perforations are arcuate slots of ap-

preciable width as indicated in FIGS. 2 and 3. The mill is thus divided into three chambers, a primary grinding compartment 10, intended either for grinding by foreign grinding bodies or for autogenous grinding, a secondary grinding compartment 11 and a separate short outlet chamber 12. A circular central perforated tube 13 extends between the central openings 8a and 9a of partitions 8 and 9.

The compartment 10 has lifters 14 and a charge 15a of material to be ground which, in the construction shown in the drawings, contains large pieces of foreign material which act as grinding bodies to grind the other material autogenously.

The compartment 11 has a charge 15b consisting of material to be ground and steel grinding bodies.

The outlet chamber 12 is provided with scoops 16 (FIG. 4) which during the rotation of the mill will lift the ground material up into the hollow outlet trunnion 7, and the perforated tube 13 is fitted with conveying scoops 17. To the end of the hollow outlet trunnion 7 of the mill is bolted a circular plate 18 to the central part of which is attached a shaft 19 by means of which the rotative force may be transmitted to the mill from the power drive (not shown) which may consist of an electromotor coupled to a suitable reduction gear.

The wall of the outlet trunnion 7 has longitudinal slots 20 through which the material ground in the mill may leave the hollow trunnion, this trunnion being surrounded by a screen 21 rotating with the mill. This screen has a free open end 21a, facing away from the mill. The outlet trunnion 7 and the screen 21 are surrounded by a casing 22 provided with two sealed openings through which the trunnion 7 and the shaft 19 pass, and at its upper end the casing joins a pipe 23 which leads tangentially into a cyclone 24. The upper central gas discharge pipe of the cyclone is denoted by 25 and leads to the suction side of a fan 26, the delivery side of which communicates through a pipe 27 with an electrostatic dust precipitator 28 which catches the dust contained in the gas which flows along path 6, 5, 7, 20, 22, 23, 24, 25, 26 and 27, the flow being established by the fan 26. The gas relieved of the dust leaves the dust precipitator 28 through a pipe 29, which communicates with the atmosphere through a chimney (not shown). The dust caught by the dust precipitator 28 is collected at its bottom and is collected away by a worm conveyor 30. This dust constitutes part of the end product and leaves the worm conveyor through a pipe 45.

Cyclone 24 serves to catch fine material which together with gas is fed to the cyclone through the pipe 23. The material intercepted is collected at the bottom of the cyclone and is then passed continuously through a rotary gate valve 31 which prevents the intake of atmospheric air into the cyclone 24 by suction. The material then proceeds by gravity through a vertical pipe 32.

Just as the casing 22 has an upwardly extending pipe 23 for carrying away fine material suspended in gas, there are also two downwardly extending discharge paths. One is constituted by a pipe 33 through which material that cannot pass the screen 21 and cannot be lifted by the gas leaves the casing 22. Inside the pipe 33 are flaps 34 having the same function as the rotary gate valve 31, that is, to prevent the intake of the at-

mospheric air by suction. The material passing through the pipe 33 is discharged by same onto an upwardly inclined conveyor belt 35 which passes the material to a hammer mill 36. The crushed material falls through a conduit 37 onto the conveyor belt 2 so as to join the fresh material supplied through the hopper 1. Both kinds of material are thus fed through the tube 4 into the mill 5.

The second of the two outlet paths extending downwardly from the casing 22 is formed by chute 38 which serves to lead material fine enough to pass through the openings of the screen 21 into a worm conveyor 39 into which the vertical pipe 32 also opens. The total amount of material conveyed by the worm 39 is lifted by an elevator 40 to another worm conveyor 41, which carries it from the top of elevator 40 to the top of a separator 42 which is adjusted so as to divide the mixture into two fractions of which one is so fine that it constitutes the major part of the end product of the process, whereas the other is coarser and requires further grinding. The latter leaves the separator 42 through a pipe 46 discharging into the tube 4 and is returned to the mill 5 for renewed grinding.

The fine fraction leaves the bottom of separator 42 through a valve 43 which prevents air intake, thereafter entering a pipe 44. The combined material discharged from pipes 44 and 45 constitutes the total amount of the end product.

As previously mentioned it is presumed that the raw material is moist and thus requires a drying in addition to grinding for which reason hot drying gas is introduced through the hollow mill inlet trunnion 6. In this gas the fine fraction from the mill is suspended and carried away through the pipe 23. The hot, dry gas may wholly or partly be combustion gas from a furnace 47 which receives fuel and air through a pipe 48 for the production of combustion gas. From furnace 47 a pipe 49 carries the gas into the hollow inlet trunnion 6 of the mill. By means of a valve 50 and by altering the supply of fuel to the furnace it is possible to regulate the amount and temperature of the drying gas.

In many cases, however, hot gas from the rotary kiln in which the ready-ground material is burnt to cement clinker is available. This kiln is not shown in the drawings, but a pipe 51 carrying waste gas from such kiln joins the pipe 49 referred to above. In the pipe 51 is a regulating valve 52.

It is thus possible to procure heat for the drying of the raw materials at will, either from the furnace 47 through the pipe 49 or from the rotary kiln through the pipe 51, or from both heat sources, depending upon how the valves 50 and 52 are adjusted.

The grinding plant described above operates in the following way.

Through the hollow inlet trunnion 6 the material is passed into the mill 5. This material consists of fresh, moist material introduced through the hopper 1 and of partly dried, crushed and/or ground material introduced through the conduit 37 or the pipe 46.

In the primary grinding compartment 10 of the mill 5 the primary autogenous grinding takes place in the charge 15a. During the grinding the material to be ground is elevated by the lifters 14 and falls down again, and according to the principle of autogenous grinding the grinding effect is established that the large

pieces of material crush and grind the smaller pieces, as well as themselves, by impact.

From the pipe 49 a hot gas stream or current is passed through the mill. As the grinding proceeds in the compartment 10, particles sufficiently fine to be suspended in and carried out by the gas stream through the mill are produced. This gas stream containing the suspended particles preferably flows along the path through the pipe 13 and out through the hollow outlet trunnion 7, slots 20 and pipe 23. The material thus discharged from the mill constitutes the fine part, and a substantial part thereof is fine enough to be described as end product and forms part of the end product leaving precipitator 28 through pipe 45.

During the grinding in the compartment 10 the material moves forward through the compartment from the left to the right forced by the pressure exerted by the following material. Material which is sufficiently fine to pass through the arcuate slot perforations in the partition 8 (FIG. 2), moves through these into the subsequent, secondary grinding compartment 11 in which an additional grinding takes place by means of the steel grinding bodies in the charge 15b in this compartment. At the outlet end of compartment 11 the material passes through the arcuate slot perforations in the partition 9 (FIG. 3).

The material thus leaving grinding compartment 11 reaches the special short chamber 12 and is lifted out of this and into the hollow outlet trunnion 7 by means of the scoops 16 (FIG. 4). It will pass along the bottom of the trunnion, where part of the material may be caught by the gas stream through the trunnion.

The material in the primary grinding compartment 10 which is not fine enough to penetrate through the arcuate slot perforations in partition 8 and not fine enough to be caught up by the gas current constitutes the coarse part. This is forced into the central tube 13 by the pressure exerted by the following material and its movement through this tube is facilitated by the conveying scoops 17 which at the same time to some extent lift the material whereafter it repeatedly falls down to the bottom of the tube. If this material contains particles which are too fine to be included in the coarse part, said fine particles may penetrate through the perforations in the tube wall 13 into the secondary grinding compartment 11 for further grinding. Furthermore, if there are particles which are so fine that they can be caught by the gas current through tube 13 this will happen and they will be carried into the hollow outlet trunnion 7 together with the particles constituting the fine part suspended in the gas.

The remaining part of the coarse particles will bypass the grinding operation in the secondary grinding compartment or zone via central by-pass tube 12 and pass thence into the hollow outlet trunnion 7 together with material conveyed out from the special outlet chamber by the lifting scoops 16 provided in the said chamber.

In other words, all three parts will pass through the hollow outlet trunnion 7, the fine part, however, suspended in the gas current. This fine part passes through the pipe 23 into the cyclone 24 in which it is separated from the gas flowing along the path 25, 26, 27, 28, 29 into the atmosphere, whereas the fine material relieved of the gas in the cyclone flows along

the path 31, 32, 39, 40, 41 to separator 42. Separator 42 is adjusted in such a way that the fine fraction discharged from its bottom along the path 43, 44 constitutes part of the end product, whereas what remains is passed into the mill 5 anew through the pipe 46 as insufficiently ground material. The remaining part of the end product is discharged in the form of dust through pipe 45.

The two other parts of material leaving mill 5 through the hollow outlet trunnion 7 fall by gravity through the longitudinal slots 20 onto the rotating screen 21 and are hereby divided into two fractions, of which one comprises material pieces which are so big that they cannot pass through the screen openings,

ing balls was present in the secondary grinding compartment.

The operation of the closed circuit grinding system of which the mill forms part can be derived from the table following. The reference numerals given in column 3 of the table refer to reference numerals taken from FIG. 1 of the drawings.

It appears from the table that a 3000 HP motor and 50 t of steel grinding balls applied in a closed circuit grinding system including only one tube mill and only one air separator are capable of reducing 175 t/h of a material having a maximum particle size of 250 mm. to a meal in which only 1 percent is coarser than 0.2 mm. and only 12 percent is coarser than 0.09 mm.

TABLE

Product	Reference numeral	T./h.	Percent coarser than, given in mm.										
			200	100	50	20	10	5	2	1	0.5	0.2	0.09
New feed.....	1	175	5	32	58	81	90	94	97	98			
Feed to hammer mill....	35	30	1	5	72	93	97	98					
Out of hammer mill....	37	30				8	29	50	72	83	90	95	97
Feed to air separator....	41	430					1	2	4	5	13	30	48
Coarse from separator....	46	260					1	4	7	9	21	50	73
Feed to dust filter.....	27	3											1
Total end product.....	44 plus 45	175										1	12

whereas the other fraction comprises medium-sized particles, which will pass through the screen openings. The coarse pieces will be reduced in the hammer mill 36 and carried into the mill again along the path 37, 2, 3, 4. The particles constituting the part of medium-size particles are together with the fine material from the pipe 32 carried along the same path as the latter, farther on to the separator 42.

The above description of a preferred plant clearly discloses the principle that the large constituents of the material are first utilized as grinding bodies for grinding the finer constituents and themselves by impact during the autogenous grinding in the primary grinding compartment 10. The remaining coarse particles are thereafter by-passed the fine grinding in the secondary grinding compartment 11 and are carried to the hammer mill 36 in which they are crushed. Then they are returned to the mill for grinding. The total amount of material, i.e., coarse and fine, final ends as finished material at 44 and 45, having been subjected to drying by means of the hot gases simultaneously with the grinding.

EXAMPLE

A tube mill as shown in the drawings had the following particulars:

Inner diameter 5 m., inner overall length 8 m., length of primary grinding compartment 5 m., of second grinding compartment 2.7 m. and of outlet chamber 0.3 m.

The slots in the partitions and in the central tube had a width of 4 mm. and the mill was driven by a 3000 HP motor coupled to a reduction gear giving the mill a speed of 14.5 rpm.

The mill was so operated that a charge of about 70 tons was maintained in the primary grinding compartment, consisting of material fed to the mill and including large material pieces acting as grinding bodies, whereas a charge of 50 tons of 15-30 mm. steel grind-

The second plant is shown in FIG. 5. The parts of this plant which are substantially identical with the corresponding parts in the first example (FIG. 1) are given corresponding reference numerals with the suffix A. The plant has a mill 5A which is supplied with hot gas through a pipe 49A and with moist raw material through a tube 4A, after precrushing to a particle size of about 25 mm. However in this case the primary grinding compartment 10A contains permanent steel grinding bodies similar to but larger than those in a secondary grinding compartment 11A.

In operation, the moist raw material is ground in the primary compartment 10A to a size of say 3 mm. The current of hot air through the mill dries the material while it is being ground and some of the finely ground particles in the primary compartment 10A will be entrained in the gas and pass out of the mill through central tube 13A. The heavier of these particles will fall through a casing 38A onto a screw conveyor 39A while the lighter particles will be carried by the air through a riser pipe 23A into a cyclone 24A. The particles will be separated from the air, except for a little dust, and will fall through a pipe 32A back to the conveyor 39A. The dust will be carried by the gas through a fan 26A into an electrostatic dust precipitator 28A from which the air will be discharged to a chimney through a pipe 29A and the precipitated dust will fall through a pipe 45A to join the final product.

After grinding in the primary compartment 10A most of the partly ground material will pass through the first partition 8A perforated with arcuate slots into the secondary grinding compartment 11A and will be ground to the final desired size by permanent steel grinding bodies in this compartment. After the secondary grinding the material will pass out of the mill, some of it being entrained in the gas flow and carried into the cyclone 24A and the rest also falling onto the screw conveyor 39A from whence it is carried up an elevator 40A and along a screw conveyor 41A into an

air separator 42A. The separator 42A divides the material into a fine fraction which leaves through a pipe 44A as part of the final product, whereas the coarser fraction leaves the separator 42A through a pipe 46A and is returned through the pipe 4A to the primary compartment 10A of the mill.

I claim:

1. In a method for dry grinding raw material which includes the steps of feeding the raw material to a grinding mill having a primary and secondary grinding zone, separating the ground material in the primary zone into a first fraction which constitutes fine ground finished product and a second fraction which requires further grinding, said separation being accomplished by subjecting the ground material to a gas flow through the mill whereby said first fraction is carried out of the mill entrained in the gas stream, the improvement in combination therewith comprising the steps of:

a. separating the second fraction in the primary grinding zone into a first part constituting intermediate ground material having sufficiently reduced particle size for immediate entry into the secondary grinding zone and a second part constituting coarse ground material not sufficiently reduced in size for immediate entry into the secondary grinding zone; and

b. conveying said second part out of the mill for reentry into the primary grinding zone along a path of travel which by-passes the grinding operation in the secondary grinding zone.

2. The improvement according to claim 1 including the further steps of:

a. separating the said first part after grinding in the secondary zone into a first portion constituting finished product and a second portion which requires further grinding; and

b. conveying said second portion out of the mill for reentry into the primary grinding zone for additional grinding.

3. The improvement according to claim 2 wherein the step of separating the first part into said first and second portions is accomplished by reuniting said first part with the material forming said second part and subjecting the mixture so formed to a sifting operation.

4. The improvement according to claim 3 wherein simultaneously with said sifting operation the mixture is subjected to the flow of gas through the mill such that said first portion is entrained in said gas flow and carried out of the mill for collection.

5. The improvement according to claim 4 wherein at least a segment of said by-pass path coincides with the path of gas flow through the mill.

6. The improvement according to claim 5 wherein the path of gas flow and the by-pass path segment extend centrally through the secondary grinding zone.

7. The improvement according to claim 6 wherein

said second portion of the first part is subjected to an ancillary crushing operation before reintroduction into the primary grinding zone.

8. The improvement according to claim 7 in which raw material is pre-crushed before entering the primary grinding zone and the grinding operation in both the primary and secondary grinding zones is carried out substantially by use of foreign grinding bodies.

9. The improvement according to claim 8 in which the raw material is moist raw material and wherein said gas flow is heated in order to dry the raw material simultaneously with the grinding thereof in the mill.

10. The improvement according to claim 6 wherein any ground material forming the second part which should have been initially separated for immediate entry into the secondary grinding zone is permitted to enter the secondary grinding zone during the by-pass operation.

11. In a rotary mill for grinding raw material which includes an inlet for the simultaneous introduction of raw material and a current of gas into the mill, a primary and at least one secondary grinding zone, and an outlet chamber for carrying finished fine ground material entrained in the current of gas out of the mill, said grinding zones being separated by perforated annular partitions adapted to allow substantially free passage of intermediate ground material between grinding zones, the improvement in combination therewith which comprises:

a. a tubular conduit extending centrally through the secondary grinding zone in axially open communicating relationship between the outlet chamber and the primary grinding zone, said conduit defining the primary path of gas flow through the mill and said conduit being adapted to convey coarse ground material internally thereof in the direction of gas flow through the mill along a path by-passing the grinding operation in the secondary grinding zone.

12. The improvement according to claim 11 wherein said conduit is equipped with auxiliary conveying means comprising:

a. scoop members adapted to advance said coarse ground material in the direction of gas flow through the conduit.

13. The improvement according to claim 12 wherein said conduit is provided with a series of perforations which define a path of entry for said intermediate ground material into said secondary grinding zone from the interior of said conduit.

14. The improvement according to claim 13 wherein the outlet chamber is provided with a screen member disposed in surrounding relation thereto for separating the ground material exiting from said chamber into fractions according to particle size by a sifting action.

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