United States Patent [19]

Fagerholt

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[45] **Feb. 27, 1973**

[54] **METHOD AND APPARATUS FOR GRINDING MINERAL MATERIALS**

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Related U.S. Application Data

[62] Division of Ser. No. 790,020, Jan. 9, 1969, Pat. No. 3,633,832.

[52] **U.S. Cl.** **241/30,** 241/54, 241/70

[51] **Int. Cl.**.....**B02c 17/06**

[58] **Field of Search**.....241/18, 30, 54, 70, 71, 72

[56] **References Cited**

UNITED STATES PATENTS

1,427,234	8/1922	Sherban	241/54 X
634,254	10/1899	Yates	241/72 X
1,360,725	11/1920	Coplan et al.	241/70
1,454,491	5/1923	Soper	241/70 X
2,291,618	8/1942	Frisch	241/54 X
2,517,451	8/1950	Sorteberg	241/54 X

Primary Examiner—Granville Y. Custer, Jr.

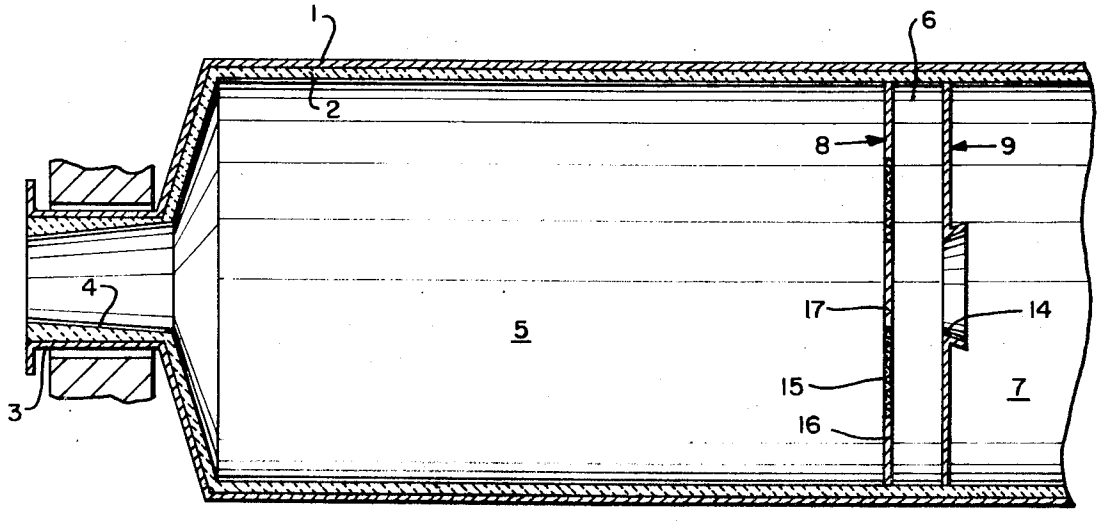
Attorney—Pennie, Edmons, Morton, Taylor and Adams

[57] **ABSTRACT**

Method of grinding granular mineral materials in a rotating mill having at least one partially confined grinding zone. The material is fed through a constricted opening into one end of this grinding zone, atmospheric air being permitted to enter in the same way. The coarse material is gradually ground down into finely divided form and is discharged through a constricted opening into an adjoining collection zone and thence discharged from the mill. The rate of feed of the coarse material into the grinding zone and the rate of discharge of the ground material therefrom are so controlled that a pool of the finely ground material is maintained in the grinding zone which is so fluidized that it behaves like a liquid.

The apparatus is a tube mill having one or more grinding compartments. If there is only one grinding compartment a narrow collection compartment is located on the downstream side and if there are two grinding compartments the second one is on the downstream side of the narrow compartment. The wall of this compartment adjacent the grinding compartment includes a screen section, and the opposite wall a dam ring and overflow opening.

7 Claims, 8 Drawing Figures



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SHEET 1 OF 2

FIG. 1

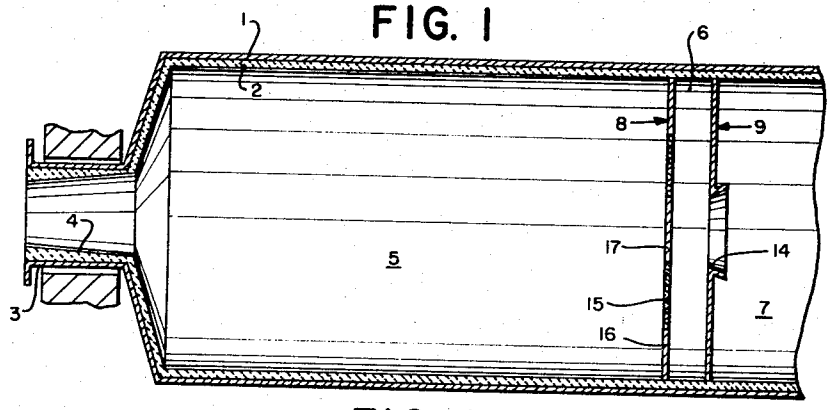


FIG. 2

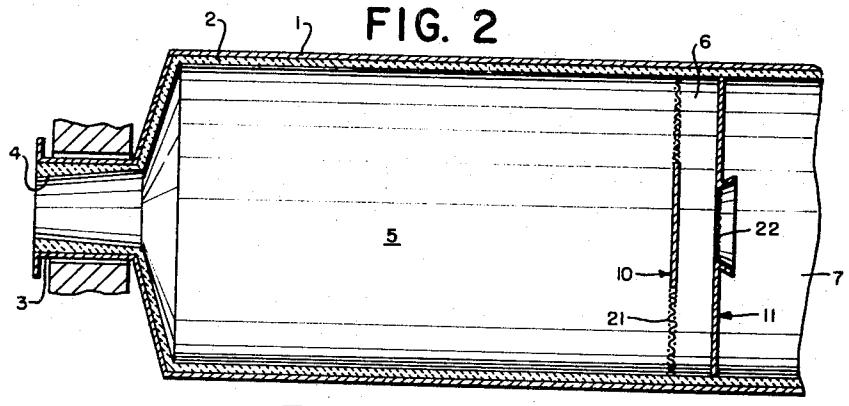


FIG. 3

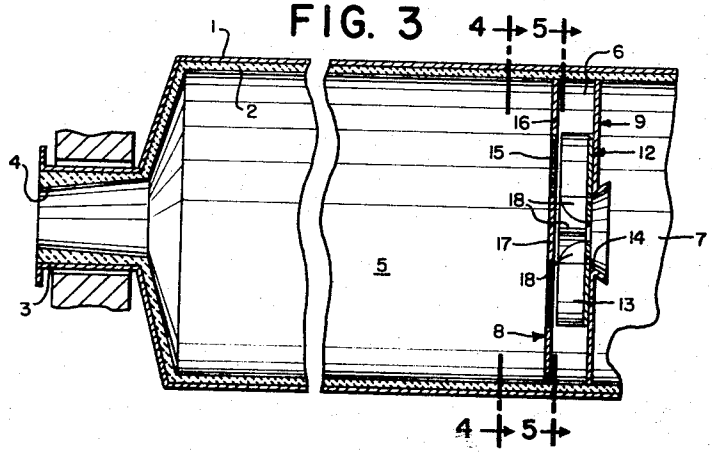


FIG. 4

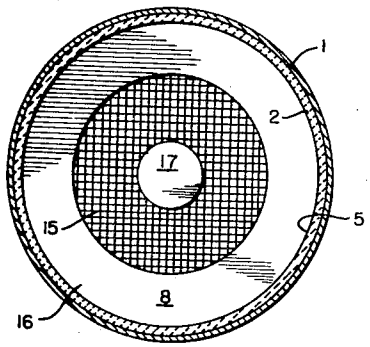


FIG. 5

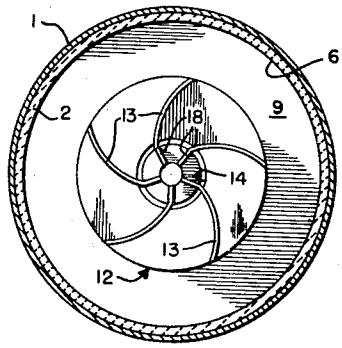


FIG. 6

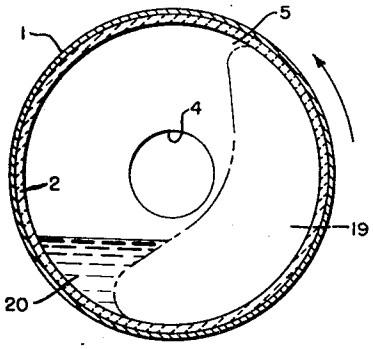


FIG. 8

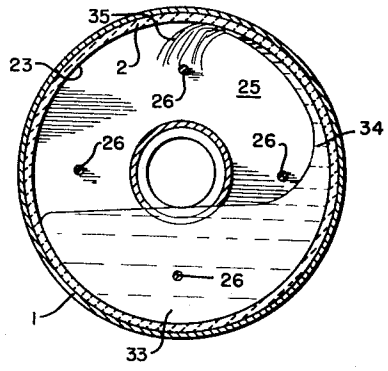
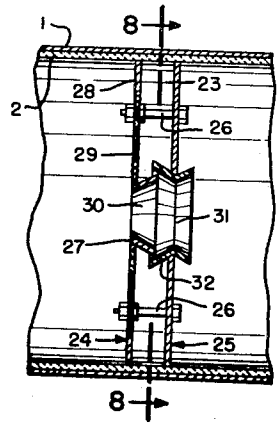


FIG. 7



METHOD AND APPARATUS FOR GRINDING MINERAL MATERIALS

This is a dividional application of my copending application, Ser. No. 790,020 filed Jan. 9, 1969, now U.S. Pat. No. 3,633,832, issued Jan. 11, 1972.

BACKGROUND OF THE INVENTION

The dry grinding of coarse granular materials, such for instance as cement clinker, is commonly effected in tube mills containing grinding bodies. Such a mill may have only one grinding compartment, but more often it has two or more grinding compartments each separated from the next by a diaphragm through which sufficiently ground material can pass. It has hitherto been considered important to insure that material sufficiently ground to pass through the diaphragm provided between the first compartment and the next is removed as fast as it is produced by the impact of the grinding bodies. Otherwise the fine ground material is thought to interfere with the grinding by building up a protective layer on the grinding bodies and the coarse material.

When the first grinding compartment is overfilled, caused either by an increased feed of coarse material or by a decrease in the discharge of ground material from the mill, backspill may occur. On the other hand, if the feed is too slow, less finished product is produced, and the wear on the grinding bodies and mill lining, which is always considerable, is increased. There is an optimum rate of feed which should be maintained.

The mill produces a great deal of noise in operation, so much in fact as frequently to be a nuisance to the mill operators and attendants and may even by dangerous to their health. In some cases the noise problem may be solved by insulating the mill proper, for example by interposing insulating material between the mill shell and the lining, or by making a separate building enclosing the mill and isolating it from the surroundings. The noise serves a useful purpose, however, in that it increases if the feed is too slow and decreases if it is too fast. An experienced mill operator is capable of controlling the feed to the mill according to the grinding noise emitted from the mill. Moreover, the control can be made automatic by equipping the grinding plant with a microphone, a transmitter and an amplifier by means of which the sound is converted into a suitable control signal which alone or in combination with other signals is used to control the feed to the mill.

SUMMARY OF THE INVENTION

According to the invention the rate of feed to the mill through a constricted opening in one end wall of the mill and the rate of discharge from the first or sole grinding zone or compartment are so controlled that part of the ground product, although ground to such an extent as to be capable of passing out of the grinding zone, is prevented from leaving it, with the result that a permanent pool of ground material forms and is maintained at the bottom portion of the confined grinding zone. This pool is so aerated and fluidized during the motion of the charge by air already in and entering the grinding zone as to behave as a liquid. The finely ground material from the pool is gradually screened out at the discharge end of the grinding zone and collected in the adjoining narrow compartment or collection zone. The material is gradually removed from the collection zone through a constricted discharge opening. This rate of discharges controls the rate of feed of coarse material to confined grinding zone.

We find that the wear is reduced because of the high proportion of fine material that is present in the grinding zone or compartment, and that there is an increase in the efficiency as measured by the power consumption. In addition the noise is reduced, and the grinding process can be carried on with a grinding noise lower than was previously considered desirable, and yet the feed to the mill can still be controlled by the noise.

In order to maintain the pool of ground material in the first or sole grinding compartment, it is necessary to construct the mill appropriately. The invention includes novel tube mill constructions suitable for carrying out the method and including a relatively narrow compartment located downstream of the first or sole grinding zone or compartment and adapted to serve as a reservoir of fluidized ground material. The partition between the first or sole grinding zone or compartment and the narrow reservoir compartment is constructed to enable the fluidized ground material to flow from either compartment to the other. The narrow reservoir compartment is bounded downstream by a wall having one or more openings through which the ground material can pass and which are so located that the continued grinding operation produces a permanent pool of substantial depth which is maintained in the narrow reservoir compartment.

If there is only one grinding zone or compartment, the wall bounding the narrow reservoir compartment downstream is constituted by the end wall of the mill containing the discharge opening which is through a hollow supporting trunnion for the mill tube. More commonly, however, tube mills have more than one grinding zone or compartment, and in this case the narrow reservoir compartment is preferably intermediate the first and second grinding zones or compartments and is bounded downstream as well as upstream by a partition.

The provision of an intermediate compartment in a mill is known, but hitherto the reason for providing it has been to improve the movement of the ground product through the mill, and lifters or the equivalent have been provided for discharging the intermediate compartment as fully and quickly as possible. In the present invention there are no such lifters, but there may advantageously be scoops working in a central area to limit the depth of the reservoir of fluidized material.

It is found in practice that there is sometimes a tendency for the pool in the narrow compartment to be undesirably reduced as a result of discharge of material at a greater rate than that of entry, and indeed the narrow compartment is sometimes emptied. The reason is that some material is positively lifted above the opening in the downstream wall or partition wall and on falling down again passes through the opening. The wall or partition is of course built up from individual elements, and bolt heads or other projections tend to lift the material, particularly when this is sticky, for example lime.

Such undesired discharge from the narrow compartment may be prevented by shrouding the central opening through which the discharge takes place so that

material falling downwards is deflected and so prevented from passing through the opening. The tendency to the undesired discharge may be reduced also by increasing the fluidization of the pool in the intermediate compartment. This may be done by providing stirrers or by introducing fluidizing air through air-permeable plates at the peripheral wall of the intermediate compartment.

BRIEF DESCRIPTION OF THE DRAWINGS

Several embodiments of the invention are shown by way of example in the accompanying diagrammatic drawings, in which

FIG. 1 is a vertical section through the inlet end and the first grinding compartment of one multi-compartment mill;

FIG. 2 shows a vertical section through the inlet end and the first grinding compartment of another mill;

FIG. 3 shows a modification of the mill of FIG. 1;

FIG. 4 is a section on the line 4—4 of FIG. 3;

FIG. 5 is a section on the line 5—5 of FIG. 3;

FIG. 6 shows the distribution of the charge and material in the grinding compartment diagrammatically;

FIG. 7 is a vertical section similar to FIG. 1 through a modified mill; and

FIG. 8 is a section on the line 8—8 of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment shown in FIG. 1 includes a mill shell 1 or tube 1 with a wear-resistant lining 2 and is carried by hollow trunnions, of which only the trunnion 3 at the inlet end is shown. These hollow trunnions form constricted inlet and discharge openings for the material. Material to be treated in the mill is fed through the central opening 4 of one of the trunnions into a first grinding zone or compartment 5, which is separated from a second grinding zone or compartment 7 by a narrow intermediate reservoir compartment 6 bounded by two partitions 8 and 9. The partition 8 comprises an imperforate rim portion 16 and a center portion 17 with an annular screen portion 15 between them. The partition 9 is a dam ring with a single central opening 14. The meshes of the screen 15 allow ground material but not grinding bodies to pass.

Coarse material to be ground is fed substantially continuously through the opening 4 to the first grinding zone or compartment 5, which contains a suitable amount of grinding bodies (not shown). The ground material can leave the grinding zone or compartment 5 through the screen 15 in partition 8, and pass into the intermediate reservoir compartment 6. As it can leave this only by overflow through the central opening 14 of dam ring 9, a reservoir of ground material is maintained in the intermediate compartment 6. The charge in the grinding zone or compartment 5 is composed of two parts as indicated in FIG. 6. One part 19 comprises a mixture of grinding bodies and of material being treated in various stages of reduction. Because of the rotation of the mill, indicated by the arrow, and the friction between the lining 2 and the charge, this part 19 is in continuous motion, being lifted above the axis of the mill and then sliding and tumbling downwards.

The second part of the charge in compartment 5 consists almost exclusively of ground product which is fluidized by air during the violent agitation of the charge. The fluidization is assisted by ventilating air which is drawn through the mill as usual. The fluidized mass of ground product forms a pool 20 which behaves like a liquid, and if it could pass freely out of the grinding zone or compartment 5 it would do so. However the reservoir of material in intermediate compartment 6 inhibits the passage of the ground material into the intermediate compartment, except at the same rate as ground material passes through the opening 14 in the dam ring 9, and causes ground material to build up to the same level against the partition 8 in the grinding compartment 5. Thus, contrary to conventional practice, the first grinding zone or compartment 5 is permanently overfilled.

The existence of the pool 20 of fluidized ground material in grinding zone or compartment 5 is advantageous as it protects the wearing plates at the toe of the mixture 19 of grinding bodies and coarse material against the impact of the grinding bodies. Part of the ground material is continually lifted or pumped out of pool 20 so as to form a constituent of the part 19 and partake in the continuous movement of this part. Ground material continuously leaves this part 19 to enter the intermediate reservoir compartment 6. In addition the pool reduces the noise.

In FIG. 2 two different partitions 10 and 11 bounding the intermediate reservoir compartment 6 are shown. The partition 10 includes a screen 21 that extends as close as is feasible to the mill lining 2, and the partition 11 is a dam ring with a screen 22 over its central opening. This screen 22 serves to prevent grinding bodies in the second grinding zone or compartment 7 from entering the intermediate reservoir compartment 6.

If it is desired to increase the ease of flow of ventilating air through the mill, it is desirable to use a partition such as 10 with its increased area of opening, rather than that shown at 8, and to use a partition such as dam ring 9 which has no screen.

Increased control over the level of the fluidized material in the intermediate compartment 6, and therefore over the volume of the pool 20 of fluidized material, can be obtained by the provision of apparatus for discharging material from a central zone in the intermediate compartment 6. One such apparatus is shown at 12 in FIGS. 3 and 5 and comprises scoops 13 carried by radial vanes 18 which are mounted on supports not shown and which guide the scooped material to the opening 14 in the partition or dam ring 9. These scoops 13 cannot empty the intermediate compartment 6 of ground material, but in practice they maintain it at a desired level. Their outer ends should be located at a substantial distance from the wall of the mill, and the desired level can be adjusted by cutting off part of the end of each scoop after the apparatus has been installed in the mill.

FIGS. 7 and 8 diagrammatically show a construction by which the tendency for the pool of fluidized material in the intermediate compartment 6 to be undesirably reduced or even emptied is effectively eliminated. In this construction there is an intermediate compartment 23 bounded by partitions 24 and 25 which are joined by staybolts 26. The partition 24 has a solid center portion

27 and rim portion 28 with an annular screen 29 between them. The center 27 carries a frusto-conical ring 30. The partition 25 has a central opening 31, which is surrounded within the compartment 23 by a frusto-conical ring 32 which embraces the ring 30.

FIG. 8 shows a fluidized pool 33 from which material tends to be carried upwards as shown at 34 to fall downwards as shown at 35. It will be seen that the rings 32 and 30 effectively shroud the opening 31, while allowing material from the surface of the pool to pass. The staybolts 26 stir the pool and help to keep it fluidized.

I claim:

1. A method for dry grinding material in a rotary mill of the type having a grinding zone with free falling grinding bodies disposed therein comprising the steps of:

a. grinding the material in a grinding zone of the mill into finely divided granular material;

b. forming a permanent pool of said granular material in said grinding zone;

c. collecting a portion of said granular material in a collecting zone of the mill to maintain said permanent pool of said material in the grinding zone;

d. moving the granular material in a continuous stream successively through the grinding and collection zones;

e. controlling the rate at which material is fed into the mill such that said rate of feed is consistent with maintenance of said pool; and

f. controlling the rate of flow of said granular material through the grinding and collection to thereby control the rate of discharge from the mill.

2. The method according to claim 1 wherein:

a. the rate of flow of said granular material is controlled by fluidizing the finely divided granular material contained within the grinding and collection zones to form a common pool of fluidized granular material within the mill whereby said finely divided granular material in the collection zone can move backward into the grinding zone via the common pool.

3. The method according to claim 2 wherein the step of:

a. controlling the level of fluidized granular material in the collection zone to finely adjust the rate of flow of granular material through the mill.

4. The method according to claim 3 wherein:

a. the level of fluidized granular material in the collection zone is controlled by controlling the rate of discharge of fluidized granular material from the collection zone.

5. The method according to claim 4 wherein the rate of discharge of fluidized granular material from the collection zone is controlled by moving at least a portion of said granular material disposed within the collection zone in a path of travel removed from the discharge path of travel of the granular material therefrom.

6. The method according to claim 5 wherein moving said fluidized granular material out of said discharge path is accomplished by deflecting the flow of said portion of granular material away from the discharge opening in the collection zone.

7. The method according to claim 6 wherein the deflection of the fluidized granular material flow occurs at a point along the discharge path of travel located in close proximity to the discharge opening in the collection zone.

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