United States Patent

Slegten

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[54] AUTOMATIC GRADING LININGS FOR CYLINDRICAL TUBE OR SIMILAR MILLS

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[52] **U.S. Cl.** **241/183**

[51] **Int. Cl.** **B02c 17/22**

[58] **Field of Search** 241/70, 71, 72, 153, 172, 176, 241/179–183; 51/164

[56] **References Cited**

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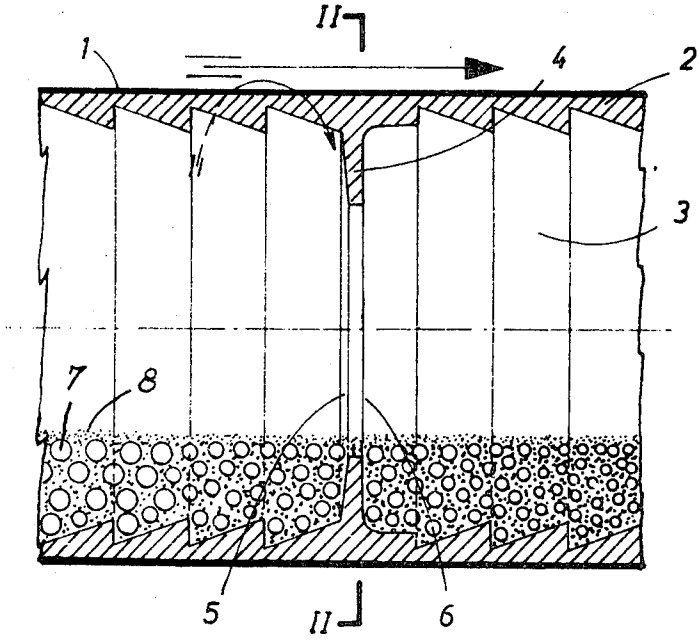
[57] **ABSTRACT**

The invention relates to an automatic grading lining for a cylindrical tube or a similar mill, the inner surface in the mill bounding a series of trunco-conical volumes which are flared towards the mill entry and which lining further comprises one or more diaphragms having a central aperture of smaller diameter than the narrowest diameter portions of the trunco-conical volumes and being disposed in a plane substantially perpendicular to the mill axis.

7 Claims, 7 Drawing Figures



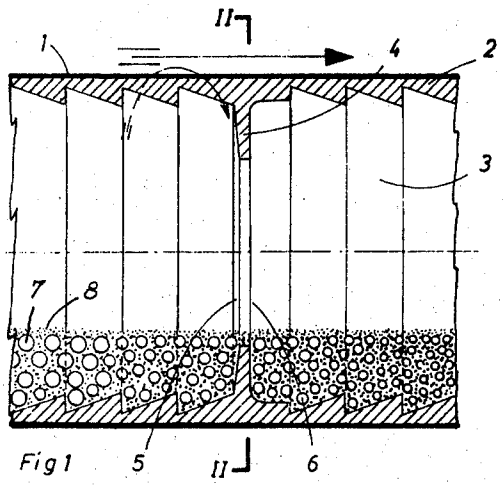


Fig 1

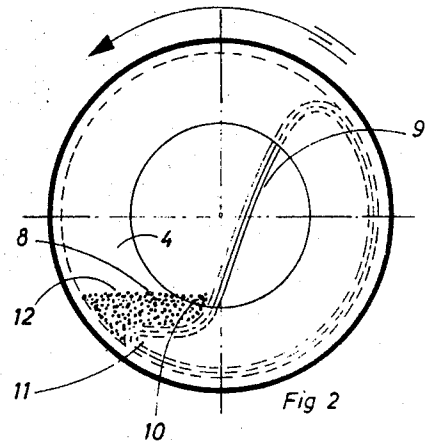


Fig 2

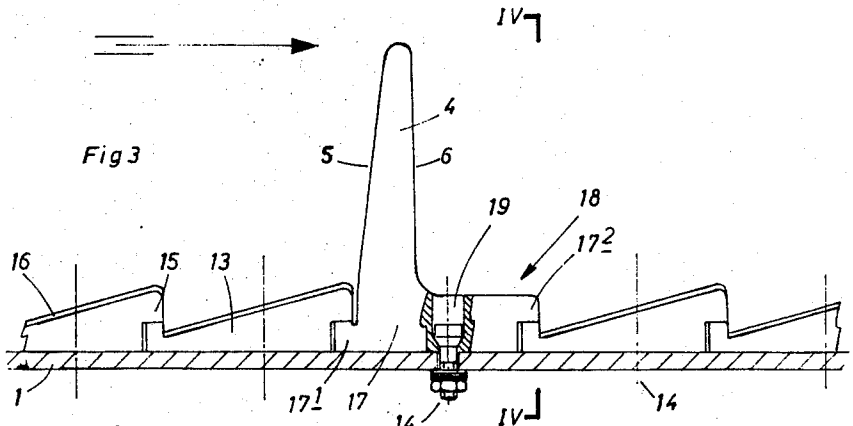


Fig 3

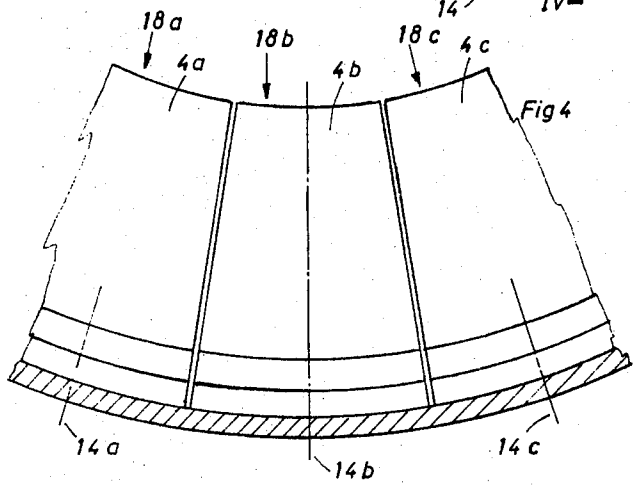


Fig 4

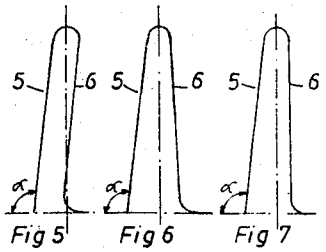


Fig 5

Fig 6

Fig 7

AUTOMATIC GRADING LININGS FOR CYLINDRICAL TUBE OR SIMILAR MILLS

This invention relates to a lining for a cylindrical tube or similar mill.

Linings of the kind are known which comprise formed plates whose inner surface in the mill bounds a series of trunco-conical volumes which are flared towards the mill entry. Linings of this kind are used to produce automatic grading of the grinding media in decreasing order of magnitude from the entry to the exit of the grinding chamber housing such media.

With this kind of lining, the dimensions of the grinding media decrease proportionally as the fineness of the material being ground increases. It has been found in a very large number of industrial constructions that this feature increases efficiency considerably.

However, it has been found that the grading effect of such linings acts on the grains of material being ground in the same way as on the grinding media ; since, as a rule the material being ground is finer than the grinding media, it is strongly pushed in the direction of the outlet, so that the flow speed of the material is accelerated.

For certain applications, inter alia for the wet grinding in an open circuit of the raw material for cement making, such acceleration of the flow is a serious disadvantage. Although the material is relatively soft and may quickly be ground, and thus the time which it spends in the mill is generally short, any reduction in such time increases the amount of grains which are not sufficiently ground and this can cause difficulties in the burning.

Acceleration of the flow speed is all the more dangerous since in using automatic grading linings, some, if at all, of the partitions which separate the mill into different compartments and form an obstacle to unground material are removed. Moreover, in large-scale industrial mills as built at the present time, the tendency, for manufacturing reasons, is to reduce the length to diameter ratio of the mill, thus further reducing the time spent by the material in the mill during grinding.

It is an object of the invention to provide a lining for a cylindrical mill producing an automatic grading of the grinding media with additional means for decelerating the flow of the material.

According to the present invention there is provided an automatic grading lining for a cylindrical mill, whose inner surface in the mill bounds a series of trunco-conical volumes which are flared towards the mill entry and which lining further comprises one or more diaphragms having a central aperture of smaller diameter than the narrowest diameter portions of the trunco-conical volumes and being disposed in a plane substantially perpendicular to the mill axis, the side of each diaphragm which is to face the mill inlet forming an obtuse angle with the mill barrel on the mill inlet side, the side which is to face the mill outlet being preferably vertical. The invention also provides a lining for a cylindrical mill, which lining has a substantially cylindrical inner surface, and which lining further comprises one or more diaphragms being disposed in a plane substantially perpendicular to the mill axis, the side of each diaphragm which is to face the mill inlet forming an obtuse angle with the mill barrel on the mill inlet side, the side which is to face the mill outlet being preferably vertical. The invention further provides a cylindrical mill having a lining as defined above.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing, in which:

FIG. 1 shows a partial vertical section, taken along the longitudinal axis, of a mill having a lining according to the invention.

FIG. 2 shows a section of the mill of FIG. 1 along the line II—II thereof.

FIG. 3 shows an enlarged partial view of the mill of FIG. 1.

FIG. 4 shows a section of the mill of FIG. 1 along the line IV—IV of FIG. 3.

FIGS. 5 to 7 show alternative diaphragm sections.

Referring now to the drawing, FIG. 1 shows a rotatable cylindrical mill comprising a barrel 1 having an internal lining 2. The inner surface of the lining bounds a series of contiguous trunco-conical volumes 3, which are flared towards the mill inlet. The material for grinding will move as shown by the straight arrow.

According to the invention, the lining comprises at least one annular diaphragm 4. In the described embodiment, the diaphragm 4 has an upstream surface 5 disposed on the mill inlet side, and a downstream surface 6 disposed on the mill outlet side.

The mill is rotatable in the direction indicated by the arcuate arrow and is partly filled with grinding media 7, which are usually round, and material 8 being ground. The grinding media 7 are graded automatically so that their dimensions diminish regularly from the mill inlet towards the mill outlet.

FIG. 2 shows trajectories 9 of the grinding media 7 during rotation of the mill. The diaphragms 4 form a series of barriers holding back the material 8 being ground, each diaphragm separating two groups of contiguous volumes 3.

The material cannot cross such barriers except in a central zone 10 where the grinding media are particularly active since such zone lies substantially in the trajectories 9. The amount of material escaping the action of the grinding media is, therefore reduced, since the material can no longer circulate freely in the mill, advancing above zone 11 of the base of the trajectories. Moreover, in successive basins 12 formed by the barriers, the larger material has a tendency to descend and, therefore, move more slowly in the direction of the outlet than the finer material. The larger material is, therefore, subjected for a longer time to the action of the grinding media than the fine material, such selective action improving the grinding of the coarsest material.

The height of the diaphragms 4 is determined in relation to the diameter of the mill and its coefficient of filling with grinding media, and also on the required dwell time of the material. For instance, for the wet grinding of the raw material for cement making, satisfactory results are obtained by giving the barriers a height of 18–20 percent of the inside diameter of the mill barrel, for a coefficient of filling with grinding media of 30 percent. The height of the barriers is generally reduced or raised in proportion with a reduction or increase in the coefficient of filling.

The grinding media are graded on the one hand in each trunco-conical volume 3 bounded by the lining, but also from one volume 3 or one group of volumes 3 to the next, inter alia to make the grinding media move towards the outlet as they become worn. If their shape is unsuitable, the diaphragms impede grading from one group of volumes to the next, and thus have an adverse effect on the automatic classification action of the lining, more particularly if their height is enough to effectively decelerate the material.

The classification disturbances caused by the diaphragms 4 can be avoided by so inclining their upstream surfaces 5 as to form an obtuse angle with the mill barrel on the mill inlet side, the downstream surface 6 of the diaphragms being inclined substantially parallel with the upstream face as shown in FIG. 5 (this arrangement is the most advantageous as regards the weight of the diaphragm). Still better results are obtained by inclining the downstream surface oppositely from the upstream surface, the angle formed with the mill barrel on the mill outlet side by the downstream surface being however less than that formed by the upstream face with the mill barrel on the mill inlet side (FIG. 6), but the best classification results have been obtained with the downstream face vertical (FIG. 7). In the majority of cases, a satisfactory grading effect is obtained by so inclining the upstream face that it forms an angle α of about 97° with the mill barrel on the mill inlet side.

Referring now to FIGS. 3 and 4, the mill barrel is drilled, and each of the plates 13 forming the lining 1 is attached to the barrel by a bolt. The inner surface of a ring of plates bounds in the mill a trunco-conical volume 3 (FIG. 1) flared in the direction of the mill inlet, the successive rings of plates

forming a succession of contiguous trunco-conical volumes. The downstream portion **15** of each ring overlaps the adjoining ring to prevent the material being ground to circulate between the plates during rotation, thus wearing the barrel. The plates are formed with corrugations **16** to raise the grinding media suitably. The diaphragms **4** are interposed at suitable intervals between two trunco-conical volumes. To make sure that the plating is continuous, foot **17** of the diaphragm extends beneath the upstream plate ring and overhangs the downstream ring.

The total height of each diaphragm **4** is approximately 20 percent of the inside diameter of the mill barrel. The upstream surface **5** of the diaphragm forms an angle of 97° with the mill barrel on the mill inlet side, the downstream surface **6** being perpendicular to the mill barrel.

The length of the foot of the diaphragm is equal to the length of the plates forming the trunco-conical volumes, so that each of the rings can readily be interchanged with a diaphragm.

Each diaphragm is divided into elements **18** (FIG. **4**), each of which is attached by a bolt **14**.

Each element **18** forms a part of a diaphragm **4** (i.e., **4***a*, **4***b*, **4***c*, ... **4***n* for each element **18***a*, **18***b*, **18***c*, ... **18***n* as shown in FIG. **4**) unitary with a foot **17**. The upstream portion 17^1 of each foot extends beneath the plating element **13** immediately upstream, while the downstream portion 17^2 overlaps a portion of the plating element **13** immediately downstream. The diaphragm proper **4** is disposed downstream of the foot **17** portion 17^1 and upstream of the foot 17^2 which is formed immediately downstream of such portion **4** with a hole **19** through which a bolt **14** extends for attaching the element **18** to the mill barrel **1**.

The plating can be made of cast iron, steel, rubber or any other suitable material.

The number of diaphragms is selected in relation to the decelerating effect desired ; in most cases such effect will be adequate with one ring disposed at about every 2 meters. For some applications, a single ring will be enough to hold back the material.

It has been found that the diaphragms shown in FIGS. **3** and **4** not only have no adverse effect on grading, but themselves have automatic classification properties.

If very accurate classification is unnecessary, therefore, diaphragms having their own grading effect, like those shown in FIGS. **3** and **4**, can perfectly well be used, disposing between the diaphragms plates whose inner surface does not form successive trunco-conical volumes but is substantially cylindrical.

According to the desired lifting effect for the grinding media, the inner surface of the plates disposed between the diaphragms can be either smooth or formed with corrugations of which the crest lines and valley lines converge towards the mill axis, are parallel to the mill axis or diverge from the mill axis, or with any roughnesses or hollows adapted to raise the grinding media suitably.

What I claim is:

1. In a cylindrical mill, a mill barrel having an inner lining, the inner surface of the lining comprising an axial series of contiguous truncated conical annular portions each of which is flared towards the mill inlet end; and at least one diaphragm being positioned between two adjacent of said conical portions, said diaphragm having a central aperture of smaller diameter than the narrowest diameter of each of said truncated conical lining portions, and being disposed in a plane extending generally transversely to the mill axis, the surface of the diaphragm facing the mill inlet end forming an obtuse angle with the mill barrel, and the surface of the diaphragm facing the mill outlet end forming an angle with the mill barrel which is always smaller than said obtuse angle formed between the surface of the diaphragm facing the mill inlet end and the mill barrel.

2. A mill as claimed in claim **1**, wherein the surface of the diaphragm facing the mill outlet end is normal to the mill axis.

3. A mill as claimed in claim **1**, wherein the surface of the diaphragm facing the mill outlet end extends parallel to the surface facing the mill inlet end.

4. A mill as claimed in claim **1**, wherein the surface of the diaphragm facing the mill outlet end forms an obtuse angle with the mill barrel, said last-mentioned obtuse angle being in opposition to and less than the obtuse angle formed between the surface of the diaphragm facing the mill inlet and the mill barrel on the mill inlet side.

5. A mill as claimed in claim **1**, wherein said diaphragm comprises a plurality of peripheric segments, each said segment including an outer foot portion in contact with the peripheral inner surface of said mill barrel, aperture means in each of said foot portions, and fastener means adapted to extend through said aperture means for fastening said segments to said mill barrel.

6. A mill as claimed in claim **5**, wherein the axial length of said foot portions in said mill barrel corresponds to the axial length of one of the truncated conical portions of said lining.

7. A mill as claimed in claim **1**, including a plurality of said diaphragms being positioned in said mill barrel at predetermined axial intervals.

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