May 5, 1959 O. P. FRANKERT 2,885,155

GRINDING MILLS WITH CLASSIFYING LININGS

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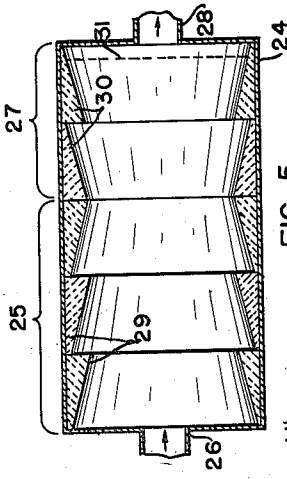


FIG. 5

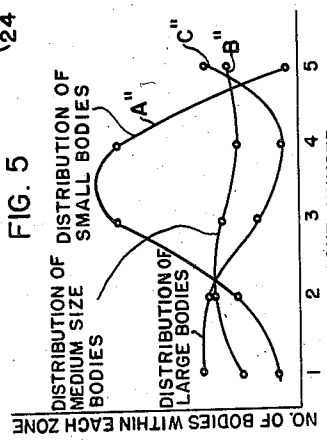


FIG. 6

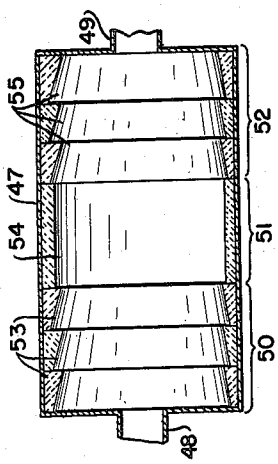


FIG. 8

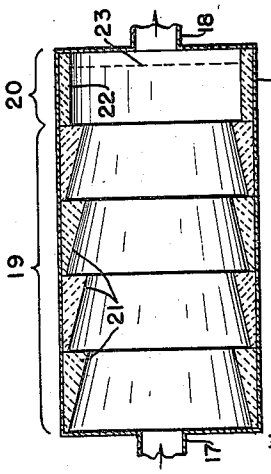


FIG. 3

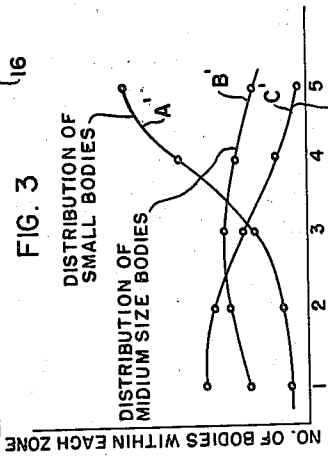


FIG. 4

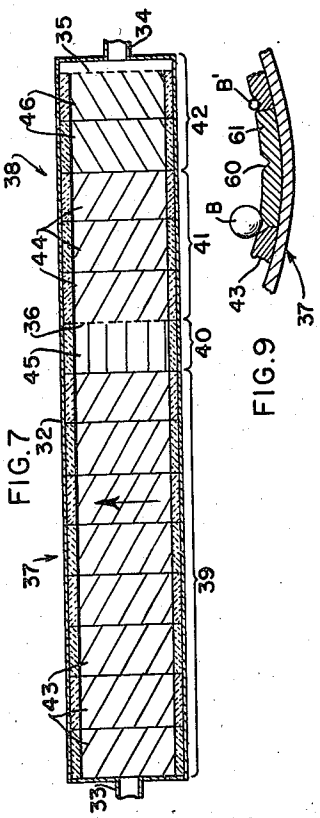
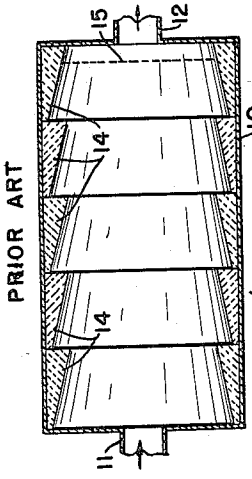


FIG. 7

FIG. 9



PRIOR ART

FIG. 1

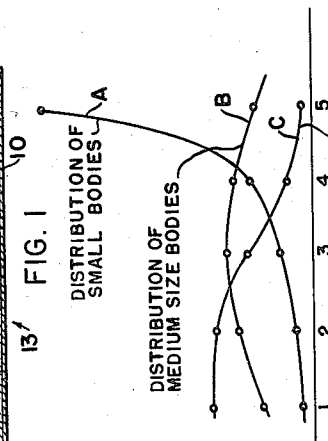


FIG. 2

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GRINDING MILLS WITH CLASSIFYING LININGS

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Application June 22, 1955, Serial No. 517,343

4 Claims. (Cl. 241—153)

This invention relates to grinding mills of the type employing a tubular shell having an inlet at one end and an outlet at the other and adapted to contain a charge of grinding bodies, which are classified according to size, as the mill rotates, by the internal lining of the shell. More specifically, the present invention is directed to grinding mills in which the lining effecting classification of the grinding bodies is of such construction that the grinding bodies are kept in the zones of the shell, where they will operate most efficiently, and, at the same time, the small grinding bodies are kept from clogging grate openings in mills having such grates.

Heretofore, classifying linings employed in grinding mills have commonly extended the full length of the mill shell and have acted on the large grinding bodies to move them toward the inlet end of the shell, the small bodies then moving toward the outlet. Classification of this sort is highly desirable, but, in a mill having a grate at the outlet end or at the outlet end of a compartment, the small grinding bodies may clog the grate openings and thus reduce the efficiency of the mill and increase the frequency of the cleaning of the mill.

The mill of the present invention provides a distribution of the grinding bodies, which insures efficient grinding in mills with grates as well as those of the air-swept type, and the novel features of the mill prevent the clogging of grate openings and also make possible selective grinding of materials differing in hardness. The desired effects are achieved by providing the mill shell with a classifying lining divided into zones and acting differently in different zones according to the location of the zones. By proper formation of the lining in the various zones, distribution of the grinding bodies in the charge may be maintained in any desired manner.

For a better understanding of the following invention, reference is made to the following drawings, in which:

Fig. 1 is an axial sectional view of the shell of a grinding mill of the prior art;

Fig. 2 is a graph showing the distribution of small, medium, and large grinding bodies along the length of the shell of Fig. 1;

Fig. 3 is a view similar to that of Fig. 1, showing one form of grinding mill of the present invention;

Fig. 4 is a graph similar to Fig. 2 showing the distribution of grinding bodies of various sizes within the mill shell of Fig. 3;

Fig. 5 is an axial sectional view of another form of mill of the invention;

Fig. 6 is a graph similar to Fig. 2 showing the distribution of grinding bodies of various sizes within the mill shell of Fig. 5;

Fig. 7 is an axial sectional view of a two-compartment mill of the invention;

Fig. 8 is an axial sectional view of another form of mill of the invention; and

Fig. 9 is a cross-sectional view on an enlarged scale showing the structure of the lining members of the mill of Fig. 7.

The mill shown in Fig. 1 is typical of the prior art and it includes a cylindrical shell **10** having an inlet opening **11** at one end and an outlet opening **12** at the other. The mill is provided with a lining **13** made up of a plurality of sections **14** with frusto-conical internal surfaces. Adjacent the outlet **12** there is a grate **15** to prevent the loss of grinding bodies from the shell **10** as the ground product advances to outlet **12**. The grinding bodies may be balls, small cylinders, pebbles, etc., and the bodies in a charge vary substantially in size.

As the mill of Fig. 1 is rotated, the frusto-conical lining members act to advance the larger grinding bodies toward the inlet of the shell and the smaller bodies then move toward the outlet. The distribution of the bodies, after a period of operation of the mill, is shown in Fig. 2, where curve A represents the number of relatively small bodies in zones at different distances along the shell from the inlet, and curves B and C show the distribution along the shell of the bodies of medium and large size, respectively. The curves show that the small bodies tend to accumulate at the outlet end of the mill immediately adjacent the grate, whereas the bodies of medium size form the major proportion of the charge at the middle of the shell and the large bodies accumulate at the inlet end. The small bodies are liable to clog the grate and thus interfere with the passage of the ground product, and the continued reduction in size of the small bodies increases the clogging action, so that relatively frequent cleaning of the mill may be required.

In accordance with the present invention, the problem of clogging the grate openings is avoided in a variety of ways, one of which is illustrated in Fig. 3. The mill of Fig. 3 has a generally cylindrical shell **16** with an inlet opening **17** at one end and an outlet opening **18** at the other and it is provided with a lining divided into zones **19** and **20**. The lining **21** of zone **19** is made up of sections with frusto-conical inner surfaces and these sections have the classifying effect of advancing the larger grinding bodies toward the inlet of the shell so that the small bodies then move toward the outlet. The lining **22** of zone **20** is formed with a cylindrical inner surface which has no such classifying action and a grate **23** is provided immediately before the outlet to prevent the escape of grinding bodies. As a consequence of the use of the different kinds of lining in the two zones, the distribution of the grinding bodies in the mill of Fig. 3 is different from that in the mill of Fig. 1.

The distribution of grinding bodies in the mill of Fig. 3 is shown by the curves in Fig. 4. Of these curves, curve A′ shows the distribution of the small bodies at different distances along the shell from the inlet and makes clear by comparison with curve A in Fig. 2 that there are substantially less small bodies adjacent the grate **23** than adjacent the grate **15** in the mill of Fig. 1. Curves B′ and C′ of Fig. 4 show that the distribution along the shell of bodies of medium and large size, respectively, is approximately the same in the mills of Figs. 1 and 3.

Another form of the new mill is shown in Fig. 5 as including a shell **24** with a lining in two zones, of which zone **25** is adjacent the inlet **26** and zone **27** adjacent the outlet **28**. The lining members **29** and **30** in zones **25** and **27**, respectively, are formed with oppositely oriented frusto-conical inner surfaces and the lining of zone **25** thus tends to cause large bodies to move toward the inlet with the small bodies then moving toward the outlet, while the lining of zone **27** acts on the bodies with the reverse effect. Adjacent the outlet **28**, the grate **31** prevents the escape of grinding bodies from the mill.

Curve A″ of Fig. 6 shows that combined classifying effects of the lining members in the zones **25** and **27** on the small grinding bodies cause a large proportion of these bodies to accumulate at the boundary of zones **25**

and 27 with relatively smaller proportions adjacent the inlet and the outlet. Curve B'' shows that the distribution of medium sized bodies is substantially uniform throughout the mill and curve C'' shows that the large bodies accumulate in about equal numbers adjacent the inlet and the outlet.

Mills of the invention may be of multi-compartment types and one such mill is shown in Fig. 7 as including a shell 32 with an inlet 33 and an outlet 34. A grate 35 is mounted within the shell adjacent the outlet, while a second grate 36 subdivides the shell into compartments 37 and 38. Compartment 37 may contain a charge of grinding bodies in the form of balls of various sizes, while the grinding bodies in compartment 38 may contain cylindrical bodies varying in size but generally smaller than the smallest balls in compartment 37. The lining in each compartment is divided into a plurality of zones with the lining members in the different zones acting differently on the grinding bodies. In compartment 37, there are two zones 39 and 40 and, in compartment 38, there are two zones 41 and 42. The lining members 43 and 44 in the zones 39 and 41, respectively, are of the classifying type and are constructed to cause the small grinding bodies to move toward the outlet 34 while the large grinding bodies are moved in the opposite direction and, for this purpose, the members 43 and 44 may be of the type shown in Fig. 9 and more fully disclosed in my copending application, Serial No. 507,218, filed May 10, 1955, now Patent No. 2,801,804. The lining members 45 in zone 40 are of the non-classifying type and may have projections parallel to the axis, while the members 46 in zone 42 are similar to the members 43 and 44 but oppositely disposed, so they act to advance the small grinding bodies toward the inlet 33, while the large bodies in the zone move toward the outlet 34.

The lining members 43 and 44 are plates formed with depressions 60 separated by projections or lands 61. The projections are wide in relation to the depressions and are preferably more than twice as wide as the depressions. The depressions may be of V-section, as shown, and the depth of the projections measured from their top to the bottom of a depression is such that a large grinding body B cannot penetrate to the bottom of a depression, while a small grinding body B' may do so. The projections are sections of helices of a pitch between 30° and 60° with a pitch of 45° preferred and the plates are so mounted in the shell that the projections form continuous helical channels from one end of the shell to the other, although the helices may be interrupted. The helices are of a hand opposite to the direction of rotation of the shell viewed from the inlet end. Since the large grinding bodies cannot penetrate to the bottom of the depressions, the latter have little lifting effect on such bodies, but the small grinding bodies entering the depressions are moved lengthwise of the mill toward the outlet end thereof as the mill rotates. The movement of the smaller grinding bodies toward the mill outlet results in the larger bodies accumulating near the inlet, as is desirable.

With the construction above described, the classifying action in the compartment 37 is similar to that in the mill of Fig. 3, and the classifying action in compartment 38 is similar to that in the mill of Fig. 5. Accordingly, the distribution of the grinding bodies within the compartments 37 and 38 will be similar to the distribution within the mills of Figs. 3 and 5, respectively, and as shown in Figs. 4 and 6. In a mill provided with lining members of the construction and arrangement shown in Fig. 7, it is possible to use smaller grinding bodies and thus obtain a finer ground product than would otherwise be feasible.

In some instances, it may be desirable to grind materials containing components differing in hardness and, for this purpose, the mill of Fig. 8 may be used. The mill is of the air-swept type and has a tubular shell 47 with an inlet 48 and an outlet 49 and it is divided into zones 50, 51, and 52. The lining members 53 and 55 in the zones 50 and 52, respectively, are formed to provide a plurality of frusto-conical internal surfaces effecting a classification, in which the large grinding bodies move toward the inlet 48 and the small bodies toward the outlet 49. The lining 54 in the central zone 51 is cylindrical and without classifying effect. Initially, zone 50 is filled with large grinding bodies, zone 52 with small grinding bodies, and the central zone 51 with a mixture of large and small bodies. In operation, hard material, which is not ground close to the inlet by the large grinding bodies in zone 50, will be ground in the central zone 51 and, at the same time, the small grinding bodies in zone 51 will grind the softer material already ground to a substantial extent in zone 50. Some of the softer material will be ground to final size by the small grinding bodies in zone 51 and will be carried out of the mill by the air flowing through the mill from the inlet to the outlet. The material, which has not been sufficiently ground in the central zone 51 and is mainly of a hard nature, will enter zone 52 and receive its final grinding there.

If desired, that part of the mill containing zone 50 may be omitted and the pre-grinding normally taking place in the zone may be carried out in a separate crusher. If the materials crushed vary in hardness, the softer materials will be delivered by the crusher in a more finely divided state and such materials may best be introduced into a mill having a zone at the inlet end, such as zone 51, which contains a mixture of large and small grinding bodies and has no classifying action, followed by a classifying zone, such as zone 52, having a lining made up of members 55.

I claim:

1. A grinding mill which comprises a cylindrical shell having an inlet at one end and an outlet at the other, and a charge of grinding bodies within the shell, the bodies in the charge varying in size, and a lining within the shell made up of a plurality of zones, the lining in less than all the zones being formed to classify the grinding bodies and causing the large grinding bodies to advance toward the inlet and the small grinding bodies to advance toward the outlet, said classifying lining having projections on its inner surface separated by depressions and of an average width greater than the average width of the depressions, the projections having the shape of sections of helices of a hand opposite to the direction of rotation of the mill shell, when viewed from the inlet end.

2. The grinding mill of claim 1 in which the cylindrical shell is divided into two compartments by a grate, each compartment having a zone with said classifying lining formed to advance the large grinding bodies toward the inlet and the small grinding bodies toward the outlet, the first of the compartments having a zone adjacent the grate with a non-classifying lining and the second of the compartments having a zone adjacent the outlet with said classifying lining installed in the shell in such manner as to advance the large grinding bodies toward the outlet and the small grinding bodies toward the inlet.

3. The grinding mill of claim 1 in which the lining in at least one zone is said classifying lining formed to advance the large grinding bodies toward the inlet and the small grinding bodies toward the outlet and the lining in at least one other zone is said classifying lining installed in the shell in such manner as to advance the large grinding bodies toward the outlet and the small grinding bodies toward the inlet.

4. The grinding mill of claim 3 in which the zone adjacent the outlet end has said classifying lining effective to move large grinding bodies toward the outlet and small bodies toward the inlet.

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