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2,332,701

SYSTEM AND METHOD OF GRINDING

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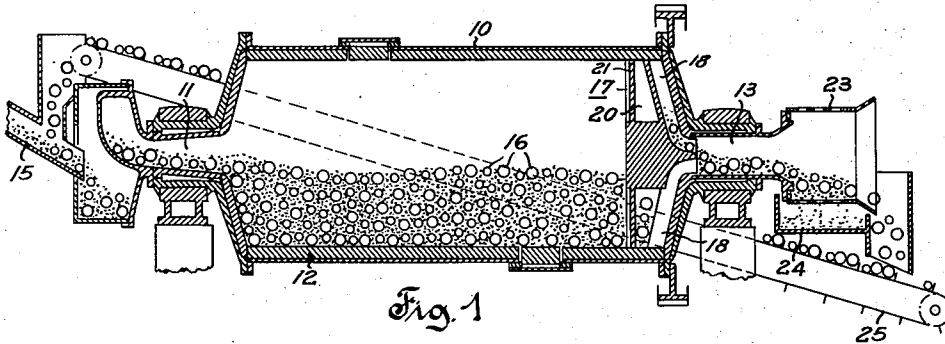


Fig. 1

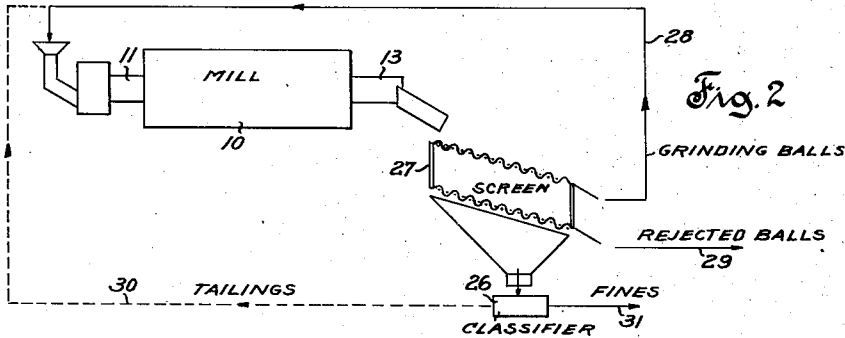


Fig. 2

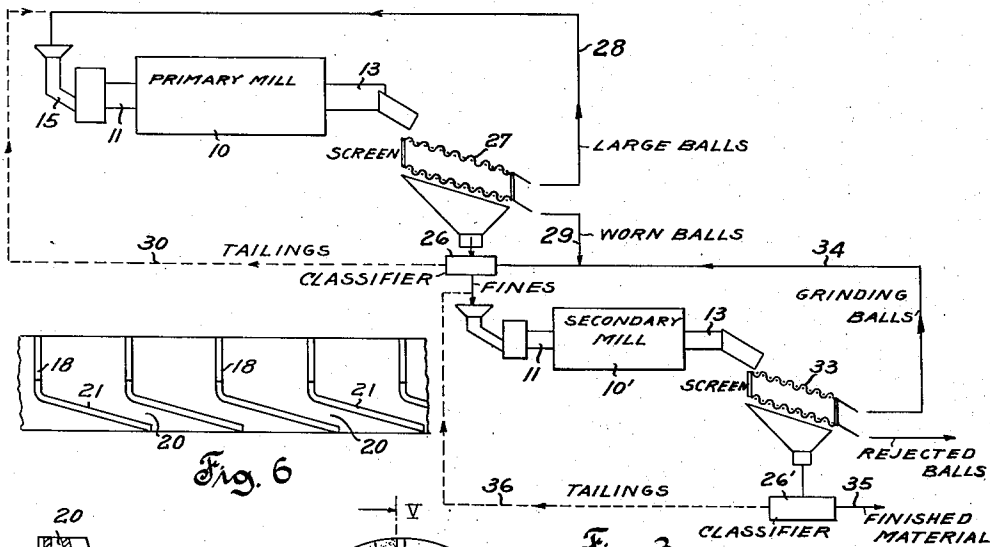


Fig. 3

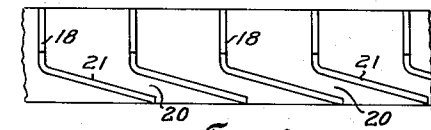


Fig. 6

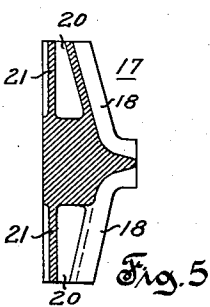


Fig. 5

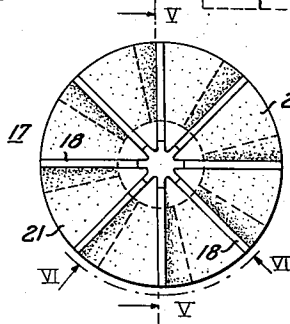


Fig. 4

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## UNITED STATES PATENT OFFICE

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## SYSTEM AND METHOD OF GRINDING

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9 Claims. (Cl. 83—94)

This invention relates to a method and system of grinding ores, cement materials, and the like by means of ball or pebble mills. Usually these mills are of the cylindrical drum type, mounted for rotation about a substantially horizontal axis. The invention is of particular utility in the art of fine grinding, by which is meant grinding to obtain product passing through 200 mesh or even finer. The term "ball mill" as used in the specification and claims shall also be deemed to include pebble mills and mills utilizing other grinding media.

It is an object of this invention to provide a method and system of grinding in which a considerable portion of the grinding media, such as steel balls or non-ferrous pebbles, is passed through the mill together with the material being ground, at least some of the grinding media being returned to the mill with the feed.

A further object of the invention is to provide a method and system of grinding in which grinding media are discharged from the mill with the material being ground, and are thereafter separated, the larger grinding media only being returned to the mill with the feed. In this way grinding media which are too small to grind efficiently are removed from the mill.

A still further object of the invention is to provide a method and system of grinding in which grinding media are discharged from a primary mill together with the material being treated, and the discharge is divided into four parts of which the first, constituting the larger balls, is returned to the primary mill with the feed; a second, constituting smaller balls, is fed to a secondary mill; a third part, consisting of the larger particles of ground material, is fed into the primary mill together with said first portion; and the fourth, consisting of finer particles of ground material, is fed to the secondary mill.

A still further object of this invention is to provide a grinding system and method involving a primary grinding mill and a secondary grinding mill provided with means for discharging both grinding media and material therefrom; means for separating the discharge of the primary mill into large and small grinding media and coarse and fine material; means for returning the larger grinding media and coarse particles to the feed end of the primary mill; means for conveying the small grinding media and fines into the feed end of the secondary mill; means for discharging pulp and grinding media from the secondary mill; and means for separating said discharge into (a) grinding media of useful

dimensions which are returned to the feed end of said secondary mill, (b) grinding media and pieces of lining of dimensions too small for efficient use, which are rejected from the circuit, and (c) ground material.

A further object of this invention is to provide a discharge grid which is particularly adapted for the system and method of grinding described herein.

Other objects will appear from the following detailed description, taken in connection with the attached drawing and the claims appended hereto.

In the drawing:

Fig. 1 is a horizontal, vertical section through a ball or pebble mill in accordance with this invention;

Fig. 2 is a diagrammatic showing of a mill circuit comprising a single grinding mill;

Fig. 3 is a diagrammatic showing of a mill circuit comprising a primary grinding mill in circuit with a secondary grinding mill;

Fig. 4 is an elevation view of a ball mill grate peculiarly adapted for use in a ball mill in accordance with the present invention;

Fig. 5 is a sectional view of the grate taken along the line V—V of Fig. 4; and

Fig. 6 is a developed view of the periphery of the grate taken along the line VI—VI of Fig. 4.

In grinding ore, cement clinker and the like in ball mills, it is well known that the steel balls or pebbles which do the grinding become worn during use. This wear of the balls or pebbles reduces the size thereof. Since it is desirable to maintain the size of the grinding media within certain limits, and especially so for fine grinding, operators of grinding mills are faced with one of two alternatives: either to shut down the mill and remove the grinding media which are smaller than that required for maximum efficiency; or to leave the small and broken grinding media in the mill, thereby reducing the efficiency of the grinding. In accordance with the present invention the grinding media are continuously discharged from the mill together with the ground material, and only that portion of the grinding media which is still in good condition and of the correct size is returned to the feed end of the mill.

Furthermore, it has been found in practice that, within limits, the finer the material being ground the smaller should be the grinding media. This means that, in fine grinding, the balls or pebbles should have a diameter ranging about  $\frac{3}{4}$ " to 1.5", the smaller diameters being suitable

for steel balls and the larger for pebbles. In order to use grinding media of such dimensions in a ball mill of standard type, the grate at the discharge end of the ball mill must be provided with openings fine enough to prevent these small grinding media from passing therethrough. This results in grate openings so small that they easily become stopped up with pulp and small pieces of liner or grinding media, thus greatly limiting the capacity of these mills. In accordance with this invention, this difficulty is entirely eliminated, since the openings in the grates may be made large enough to permit even the largest balls or pebbles in the mill to pass therethrough.

Referring more particularly to Fig. 1, 10 illustrates a cylindrical ball mill provided with a feed trunnion 11, liners 12 and discharge trunnion 13. Material to be ground, such as ore or cement clinker, either wet or dry, is introduced at 15, and passes into the mill by way of feed trunnion 11, where it is ground by the cascading action of grinding media 16.

Adjacent the discharge end of the mill is a grate 17, which may be constructed as more particularly illustrated in Figs. 4, 5 and 6. It will be noted that on the discharge side, grate 17 is provided with a discharge cone having radial ribs 18 extending from the center to the periphery of the grate. A plurality of inclined radial shots 20, of such size as to permit grinding media 16 to pass therethrough, are provided in grate 17 adjacent the periphery thereof. The vanes 21 defined by slots 20 are arranged so that, during rotation of the mill, as best shown in Fig. 6, the vanes tend to shed the larger balls back into the interior of the mill, while the pulp and the smaller grinding media easily pass through the grate. Part of the larger media also passes through the grate, which serves only to deter, but not to prevent, the passage of the larger grinding media therethrough. While a specific grate construction is illustrated, it is obvious that other grate constructions, arranged for passage of grinding media and pulp therethrough, may be utilized.

After passing through the grate, the pulp and grinding media are elevated by means of radial ribs 18 and pass out through discharge trunnion 13, and through some separating means which is illustrated in this case as being a trommel screen 23, although any other type of separating means may be used. In the arrangement shown in Fig. 1, the ground materials and finer grinding media pass through the trommel screen into chute 24, while the oversize, consisting of grinding media which are still sufficiently large for further use, is conducted by elevator 25 back to the feed end of the mill.

It will be noted that this arrangement results in continuous removal from the mill of grinding media which are smaller than those which are effective for efficient grinding, and at the same time permits free passage of the pulp (and grinding media) through the mill. This results both in increased efficiency of grinding and in increased capacity of the mill.

Referring now to Fig. 2, a ball mill 10 is shown, as in Fig. 1, but the mill discharges to a separator which is here shown as a double deck vibrating screen 27 which is provided with an upper deck having a coarse screen cloth and a lower deck having a fine screen cloth. The upper deck serves to scalp off the large grinding media, which are discharged as oversize and fed back to the feed end of the mill, as shown at 28. The lower fine screen separates the pulp from the smaller grind-

ing media which, together with broken segments of grinding media and liners, are discharged at 29. The pulp, which passes through the lower screen, may be divided by any desired means, such as classifier 26, the coarser fraction of the pulp being fed back to the mill, as shown at 30, while the finer ground material, indicated at 31, may be discharged from the circuit either as finished material or for further treatment. The division of the pulp into coarse fraction 30 and fine fraction 31 may be effected by means of a classifier, air separator, or other desired means.

The circuit illustrated in Fig. 3 is similar to that of Fig. 2, but includes a secondary mill 10' in circuit with primary mill 10. In this case the fines passing through the lower deck of vibrating screen 27 are separated as by means of a classifier 26, the coarser portion being returned to the feed end of the primary mill 10, as shown by dotted line 30, while the finer portion of the slurry is conveyed to the feed end of the secondary mill 10'. The smaller grinding media discharged from primary mill 10 are scalped off by the fine meshed lower deck of screen 27 and serve as grinding media for the secondary mill 10'. Since the material being ground in secondary mill 10' is finer than that in the primary mill, it can utilize the smaller grinding media efficiently.

The discharge from secondary mill 10' passes to a separator 33, which in this case is a vibrating screen similar to that shown at 27. Here the larger, useful grinding media are scalped off and returned to the feed of the secondary mill, as shown by path 34. The lower deck of screen 33 serves to scalp off the small and broken grinding media and pieces of liner, which are discarded. The continuous removal of this useless media and spalls greatly increases the efficiency of the operation of the secondary grinding mill. The slurry passing through the lower deck of screen 33 may be further separated, as by means of a classifier 26', the fines being removed from the circuit as finished material at 35, while the coarser fraction is returned to the secondary mill feed, as shown at 36. It will be noted that classifier tailings circuits 30 and 36 are shown in dotted lines, to indicate that this part of the circuit, together with classifiers 26 and 26', may be omitted if no circulating load is desired.

The term "grinding media" as used herein is generic to steel balls, "Concavex" grinding media, pebbles and other types of bodies used in grinding; while the term "raw material" refers to the material which is to be ground.

The terms "primary mill" and "secondary mill" are not limited to independent mills, but may refer to successive grinding chambers in a compartment mill. Furthermore, the terms refer to two successive mills, in which the "primary" mill treats coarser material than the "secondary" mill, but the mills are not necessarily the first and second mills to grind raw material; for example, the "primary" and "secondary" mill may in fact be the tertiary and quarternary mills, respectively, in a circuit.

While specific applications of this invention have been described above, it is to be understood that these do not limit the scope of the invention, since modifications and equivalents within the scope of this invention will readily occur to those skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. A grinding system comprising a ball mill, a double deck vibrating screen and a classifier,

means for discharging ground material and grinding media from said ball mill to said screen, means for returning the grinding media passing over the coarse mesh upper deck of said vibrating screen to said ball mill, means for discharging the fines passing through the finer mesh lower deck of said vibrating screen to said classifier, and means for conveying the tailings of said classifier to said mill for further grinding.

2. A grinding system comprising primary and secondary ball mills, means for continuously discharging grinding media and ground material from said primary mill during normal grinding operation of said mill, means for separating said primary mill discharge into three parts comprising relatively large grinding media, relatively small grinding media, and ground material, means for continuously returning said relatively large grinding media to said primary mill, during normal grinding operation thereof, and means for feeding said relatively small grinding media to said secondary mill.

3. A grinding system as defined in claim 2, and means for feeding said ground material to said secondary mill.

4. A grinding system comprising a primary ball mill and a secondary ball mill, means for continuously discharging grinding media and ground material from each mill, means for separating the discharge of each mill into three parts comprising relatively large grinding media, relatively small grinding media, and ground material, means for returning said relatively large grinding media from each mill to the mill from which it was discharged, means for conveying said primary mill relatively small grinding media to said secondary mill, means for separating the ground material discharged by each mill into fine and oversize fractions, means for returning the oversize fraction of each mill into its respective mill for further grinding, and means for conducting said primary mill fines to said secondary mill.

5. A grinding system comprising a primary and a secondary ball mill in series, grinding media of various sizes in each mill, means for continuously circulating the larger of said grinding media through each mill, means for continuously feeding the smaller of said grinding media from said primary to said secondary mill, and means for continuously rejecting from said secondary mill the smaller of said grinding media contained therein.

6. A grinding system comprising primary and secondary ball mills, means for continuously dis-

charging grinding media and ground material from said primary mill, means for separating said primary mill discharge into three parts comprising relatively large grinding media, relatively small grinding media, and ground material, means for continuously returning said relatively large grinding media to said primary mill, means for feeding said relatively small grinding media to said secondary mill, means for separating said ground material to fines and oversize, means for returning said oversize to said primary mill for further grinding, and means for feeding said fines to said secondary mill.

7. A grinding system comprising primary and secondary ball mills, means for continuously discharging grinding media and ground material from said primary mill, means for separating said primary mill discharge into three parts comprising relatively large grinding media, relatively small grinding media, and ground material, means for continuously returning said relatively large grinding media to said primary mill, means for feeding said relatively small grinding media to said secondary mill, means for feeding at least a portion of said ground material to said secondary mill, means for continuously charging reground material and grinding media from said secondary mill, means for separating the discharge of said secondary mill into three parts comprising relatively large grinding media, relatively small grinding media, and reground material, and means for returning said relatively large grinding media to said secondary mill.

8. The method of grinding in a ball mill system comprising primary and secondary mills which comprises continuously circulating relatively large grinding media through said primary mill during normal grinding operation thereof and continuously conveying from said primary to said secondary mill grinding media which are too small for effective grinding in said primary mill.

9. The method of grinding in a ball mill system comprising primary and secondary mills which comprises circulating through each mill grinding media of sufficient size to grind effectively in said mill, continuously conveying from said primary to said secondary mill grinding media of lesser diameter than that required for effective grinding in said primary mill, and continuously rejecting from said secondary mill grinding media of lesser diameter than that required for effective grinding in said secondary mill.

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CERTIFICATE OF CORRECTION.

Patent No. 2,332,701

October 26, 1943.

CHARLES W. DOWSETT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 19, claim 2, after "mill" strike out the comma; and second column, line 27, claim 7, for "charging" read --discharging--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of December, A. D. 1943.

(Seal)

Henry Van Arsdale,  
Acting Commissioner of Patents.