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VIBRATING GRINDING MILL HAVING A MEANS FOR PREVENTING GRINDING MEDIA TRACKING AND EXCESSIVE MILL WEAR

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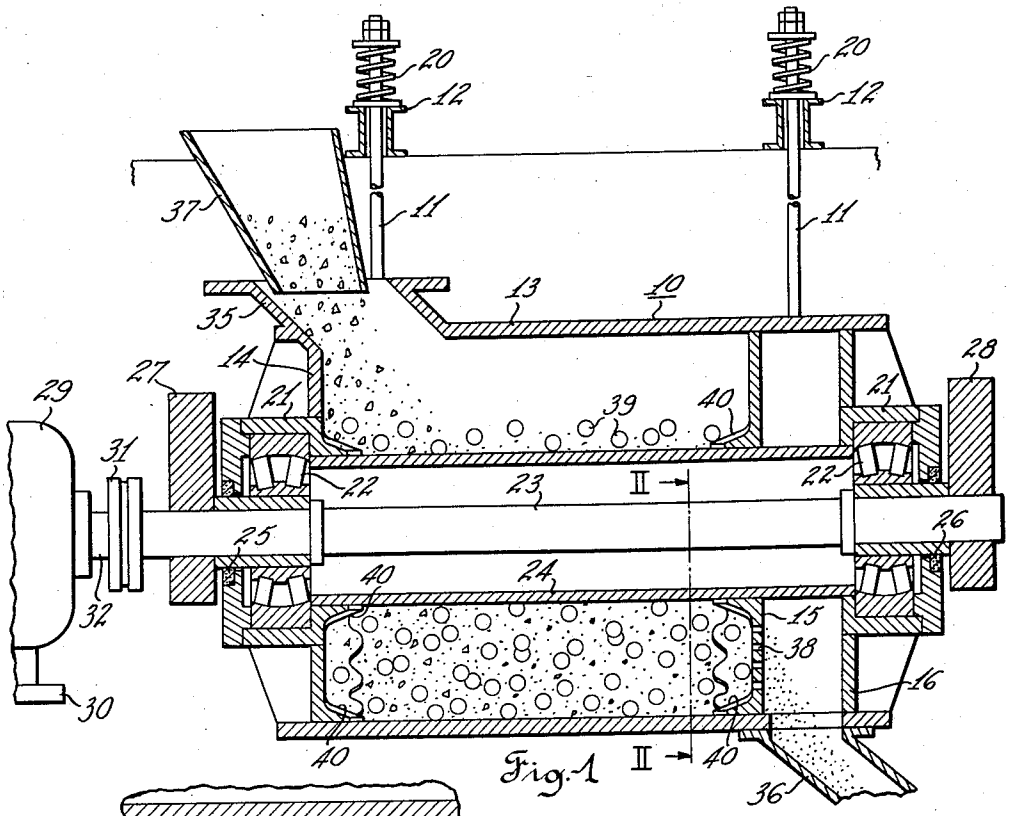


Fig. 1

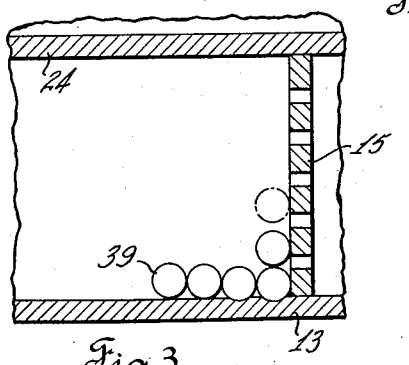


Fig. 3

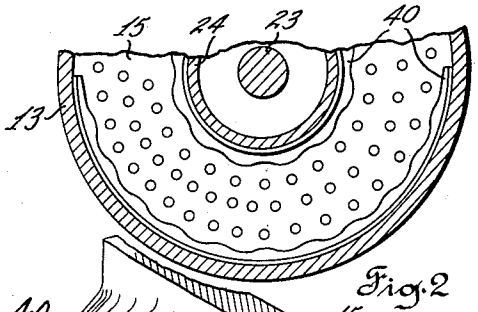


Fig. 2

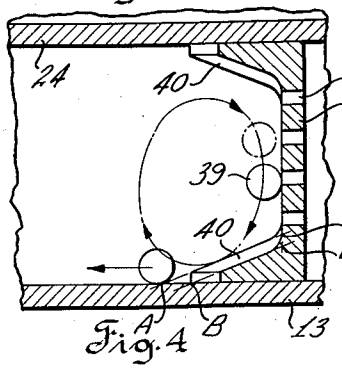


Fig. 4

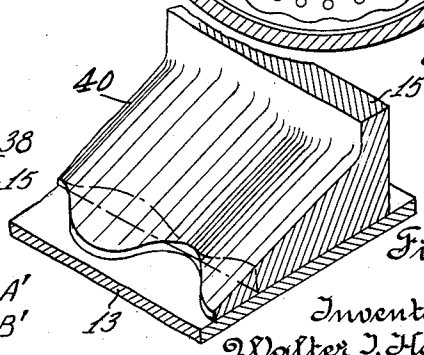


Fig. 5

Inventor
Walter J. Hartwig
By Arthur M. Streich
Attorney

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VIBRATING GRINDING MILL HAVING A MEANS FOR PREVENTING GRINDING MEDIA TRACKING AND EXCESSIVE MILL WEAR

Walter J. Hartwig, Milwaukee, Wis., assignor to Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

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7 Claims. (Cl. 241—175)

The present invention relates to material comminuting mills of the type known as vibrating grinding mills. In such a mill materials are comminuted in a vibrating container by the action of loose grinding bodies to which motion is imparted by the vibratory movement of the container.

A vibrating mill has a container which is commonly of a cylindrical shape which is adapted to be resiliently mounted for vibratory movement. The container is usually supported so that the longitudinal axis thereof is in a horizontal position. Power driven means are provided for imparting vibratory movement to the container. The nature of the vibratory movement is that of a gyratory motion transversely of the longitudinal axis. This motion effects grinding of material within the container by virtue of the grinding action of the loose grinding bodies moving through the material to be ground in the container.

As a result of the gyrating movement of the container, the grinding bodies and the material being ground in the container revolve as a whole in a direction opposite from the direction of the gyration of the container. In addition to the movement of the entire mass within the container the individual grinding bodies are in motion within this mass. It has been determined that throughout the greater part of the container the movement of individual grinding bodies, within the rotating mass, does not follow any definite or fixed pattern of movements. However, in an area closely adjacent to a vertical wall such as an end wall of the container or a grate wall having openings for permitting ground material to pass from the container, it has been found that the grinding media have a tendency to follow more definitely prescribed patterns of movement. For a distance of approximately the diameter of two or three of the grinding media inward of such a vertical wall the grinding media has a very definite tendency to track. That is, the grinding media has a tendency to get into a path adjacent an end wall and to stay there. The vertical component of motion applied to the grinding media has been found to result in subjecting portions of the container adjacent to a vertical wall to a pounding action by individual tracking elements of the grinding media. This pounding is somewhat like repeated hammer blows directed in an approximately perpendicular manner upon the container wall close to the vertical wall. This tracking and hammering action by the grinding media has resulted in failure of portions of the longitudinal walls of the container close to a vertical wall. Although all portions of the walls of the container are subjected to some wearing action of the grinding media, it has been found that the wear of portions of the longitudinal walls closely adjacent to vertical walls has resulted in container failures when the rest of the container is still in

very good condition and suitable for continued use for a substantial period of time. If, therefore, the tracking and concentrated wear of the longitudinally extending walls of the container can be eliminated or reduced, the life expentancy of the machine will be substantially increased.

It is therefore the principal object of the present invention to provide an improved vibrating grinding mill which will eliminate the tendency of the grinding media to prematurely wear through portions of longitudinal wall structure in areas closely adjacent vertical wall members.

Another object of the present invention is to provide an improved vibrating grinding mill in which the tendency of grinding media to track along portions of longitudinal wall structure adjacent vertical wall members is substantially reduced or eliminated.

Another object of the present invention is to provide an improved vibrating grinding mill in which the tendency for the grinding media to impart repeated perpendicularly directed blows to particular portions of longitudinal wall structure adjacent vertical walls is eliminated and at the same time the grinding media in this location will be deflected in an inwardly direction to prevent its making repetitious impacts on approximately the same spot or area and to so direct such grinding media that in moving away from such a vertical wall they further contribute to breaking up any regular pattern of movement of grinding media in this area.

According to a preferred embodiment of the present invention a media deflecting fillet is provided between a portion of longitudinal wall structure and an adjoining end wall. The end wall may be a wall enclosing a portion of the container or be a perforated or apertured wall for defining the end of the grinding chamber and acting as a grate to permit ground material to pass through. The fillet is provided with an undulated surface comprising alternate wave crests and troughs. If a first line is considered to indicate or represent the crest of such a wave and a second line is taken to represent the bottom of a trough adjacent to the first line, the undulated surface is so formed that the first and second lines are parallel to each other and intersect with the longitudinal wall structure at respective points that are respective distances from the adjacent end wall that are greater than the diameter of the largest of the grinding media within the container and that these distances are also greater than the respective distances between the longitudinal wall structure and the points at which the lines intersect with the vertical wall structure.

It has been determined by tests that a fillet without the undulated surface described is not effective to eliminate tracking and localized excessive wearing of the longitudinal wall structure. Without the undulated surface, the only effect of the fillet is to move the place of tracking and wear from the area adjacent the end wall to the area adjacent the fillet because the grinding media then tracks in the crotch between the fillet and the longitudinal wall structure.

A deflecting fillet according to this invention has been found to be completely effective in elimination tracking of the grinding media and in causing an effective dispersion of the grinding media to prevent both tracking and repeated hammerlike blows on particular localized portions of the longitudinal wall structure. The undulated formation and angular disposition of such a deflecting surface reduces a hammerlike blow of the grinding media from an otherwise approximately perpendicular blow to one of a glancing nature that both reduces damage to the structure that is hit and, by virtue of the

grinding media rebounding inwardly at a variety of angles, grinding media is effectively dispersed in this area. The grinding media in this area do not rotate with the charge of material to be ground.

Other objects and advantages will become apparent from the following detailed description of the invention and the accompanying drawing which shows an embodiment of the invention.

In the drawings:

Fig. 1 is a vertical sectional view through the longitudinal axis of the vibrating mill embodying the present invention;

Fig. 2 is a partial cross sectional view taken on line II—II of Fig. 1;

Fig. 3 is a portion of a vertical sectional view of a vibrating mill illustrating the action of grinding media in a mill that does not embody the present invention;

Fig. 4 is a portion of a vertical sectional view similar to Fig. 3 but illustrating the action of grinding media in a mill that does embody the present invention; and

Fig. 5 is a fragmentary view in perspective of the corner of the mill shown in Figs. 2 and 4, with a phantom section shown thereupon showing the undulating contour thereof.

Referring to Fig. 1, a suitably shaped container **10** is shown suspended by cables **11** from a stationary overhead supporting structure **12**. The container **10** has longitudinally extending wall structure **13** forming a cylindrical body portion of container **10**. The container is also provided with an end wall **14** on the feed end of the mill and an apertured end wall **15** and an imperforate end wall **16**, both on the discharge end of the mill. The pair of end walls **15**, **16** on the discharge end of the mill are provided to divide the container into two chambers for a purpose that will appear as the description of the invention proceeds.

The container **10** is supported with its longitudinal axis in a horizontal plane and resilient means such as springs **20** are provided between the cables **11** and the supporting structure **12** to allow the container to have a vibrational movement in any direction relative to the supporting structure.

End walls **14** and **16** are provided with suitably positioned bearing housings **21** in which bearings **22** are mounted. As shown, bearing housings **21** are mounted coaxially relative to the longitudinal axis of the container **10**. Rotatably journaled in the bearings **22** is a shaft **23** and additional longitudinally extending wall structure **24** concentrically spaced within the wall structure **13** to provide a protective tube surrounding the shaft **23** that extends between the walls **14** and **16** of the container. Suitable sealing means **25**, **26** are provided respectively between the shaft **23** and bearing housings **21**.

Weight means **27**, **28** are rigidly attached, preferably in phase with each other, at opposite ends of the shaft **23** and each of the weight means has a center of gravity disposed eccentrically of the axis of the shaft. Upon rotating the shaft **23** the centrifugal forces imparted to the shaft by the weight means **27**, **28** are transmitted through the bearings **22** so as to cause the container **10** to gyrate in a direction transversely of its axis.

A motor **29** mounted on a stationary support **30** is provided for driving the shaft **23** of the vibrating mill. As the container **10** is vibratable relative to the motor **29**, a flexible coupling **31** is provided between the shaft **32** of the motor **29** and the shaft **23** of the mill.

A feed inlet **35** is provided at the top at one end of the container **10** and a discharge outlet **36** is provided at the bottom of the opposite end of the container. Means for feeding the material to be ground to the mill such as a hopper **37** is also provided and the material to be ground is continually fed to the mill through the inlet **35** and ground material is continuously withdrawn from the mill through the discharge outlet **36**.

The intermediate end wall **15**, that divides the container into two chambers, is provided with apertures **38**. The chamber defined by the end wall **14** and the apertured wall **15** is the grinding chamber. This chamber is provided with a plurality of grinding media or balls **39**. Normally the grinding chamber is about four-fifths full of grinding balls and material to be ground. The apertures **38** in the wall **15** are large enough to allow ground material to pass freely therethrough but small enough to prevent the escape of the grinding balls.

The second chamber within the container **10**, as defined by the apertured wall **15** and the imperforate end wall **16**, serves to confine and collect the ground material that has passed through the apertured wall **15** and to direct such material into the discharge outlet **36**.

As shown in Fig. 1 and Fig. 2, a grinding ball deflecting fillet **40** is provided between portions of longitudinal wall structure **13**, **24** and an adjoining end wall such as the imperforate end wall **14** or the apertured end wall **15**. For convenience of explanation the fillet **40** between the apertured end wall **15** and the outer container shell **13** will be referred to specifically and it is this portion of the mill that is illustrated in greater detail in Figs. 2, 4 and 5.

The fillet **40** is provided with an undulated surface comprising alternate wave crests and troughs, as shown in the phantom section of Fig. 5. If a first line A—A′ is considered to indicate or represent the crest of such a wave and a second line B—B′ is taken to represent the bottom of a trough adjacent to such a crest then the undulated surface, as shown, may be described as being so formed that the first and second lines A—A′ and B—B′ are parallel to each other. It is also desirable that these two lines intersect with the longitudinal wall structure **13** at respective points A and B that are respective distances from the end wall **15** that are greater than the diameter of the largest of the grinding balls **39** within the grinding chamber of the container.

Another desirable feature is that the distances of the points A and B from the end wall **15** are also greater than the respective distances between the longitudinal wall structure **13** and the points A′ and B′ at which the lines intersect with the vertical wall **15**.

Fig. 3 illustrates the action of a grinding ball in the area where the longitudinal wall structure joins a vertical wall, such as the apertured wall **15**, and in which a fillet **40** of the type described is not provided. As previously stated as a result of the gyrating movement of the container **10**, the mass of the material being ground and the grinding balls **39** revolve as a whole in a direction opposite from the gyration of the container **10**. Within this mass individual grinding balls have a motion which includes a vertical component as illustrated in Fig. 3. In this area close to the vertical wall the grinding balls have a tendency to track as previously stated. The action of the grinding balls illustrated in Fig. 3 shows how the tracking of grinding balls in this area results in repeated hammer-like blows being directed in approximately perpendicular manner upon the longitudinal wall structure **13**. It is such an action of the grinding balls that the present invention will eliminate.

The manner in which the present invention functions to eliminate all tracking and excessive and concentrated localized damage to the container wall is illustrated in Fig. 4. Fig. 4 illustrates how a grinding ball moving perpendicular to the longitudinally extending wall structure **13** will strike the undulated surface of the fillet **40** a glancing blow and be directed inwardly of the apertured wall **15**. Thus the undulated surface of the fillet eliminates the possibility of the grinding ball striking a direct and substantially perpendicular blow and also causes grinding balls to glance off the surface of the fillet in an inward direction to break up any tendency of the grinding balls to track in a fixed pattern in this area as previously resulted in excessive and localized damage to the container of the mill.

It will be understood that the scope of the present invention is not limited to the precise details of the vibrating ball mill embodying the invention that is herein illustrated but that within the scope of the appended claims other embodiments of the invention may readily occur to persons skilled in this art.

What is claimed is:

1. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines being parallel to each other.

2. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines intersecting with said longitudinal wall at respective points that are respective distances from said end wall that are greater than the diameter of the largest of said grinding media.

3. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines being parallel to each other and intersecting with said longitudinal wall at respective points that are respective distances from said end wall that are greater than the diameter of the largest of said grinding media.

4. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines intersecting with said longitudinal wall at respective points that are respective distances from said end wall that are greater than respective distances between said longitudinal wall and points at which said lines intersect said end wall.

5. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines being parallel to each other and intersecting with said longitudinal wall at respective points that are respective distances from said end wall that are greater than respective distances between said longitudinal wall and points at which said lines intersect said end wall.

6. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines intersecting with said longitudinal wall at respective points that are respective distances from said end wall that are greater than the diameter of the largest of said grinding media and greater than respective distances between said longitudinal wall and points at which said lines intersect said end wall.

7. In a vibrating grinding mill comprising a container with a substantially horizontally disposed longitudinal axis passing through the approximate center of said container, said container having longitudinally extending wall portions and at least one end wall perpendicular to said axis, a plurality of grinding media partially filling said container, and power driven means for imparting vibratory movement to said container, means for protecting at least a portion of said longitudinal wall portions from excessive and concentrated wear in an area adjacent to said end wall, comprising, a media deflecting fillet between said portion of said longitudinal wall portion and said end wall, said fillet having an undulated surface, a first line in said undulated surface representing the crest of a wave in said surface, a second line in said undulated surface representing the bottom of a trough adjacent said first line, and said first and second lines being parallel to

each other and intersecting with said longitudinal wall at respective points that are respective distances from said end wall that are greater than the diameter of the largest of said grinding media and greater than respective distances between said longitudinal wall and points at which said lines intersect said end wall.

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