April 15, 1941. H. G. LYKKEN 2,238,743

BOWL MILL

Filed May 13, 1938

3 Sheets-Sheet 1

FIG. 1

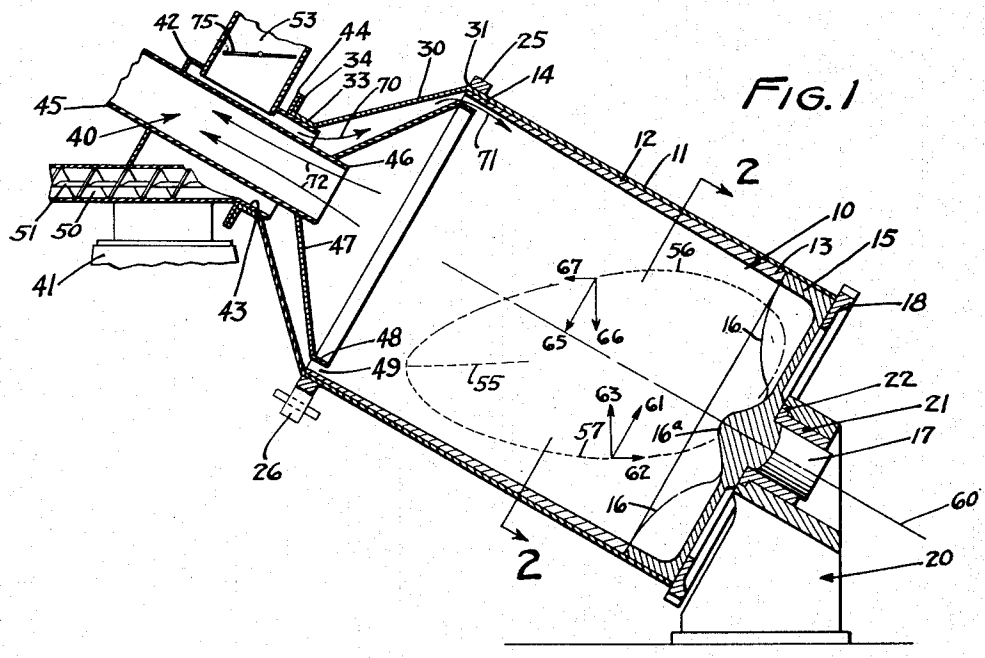
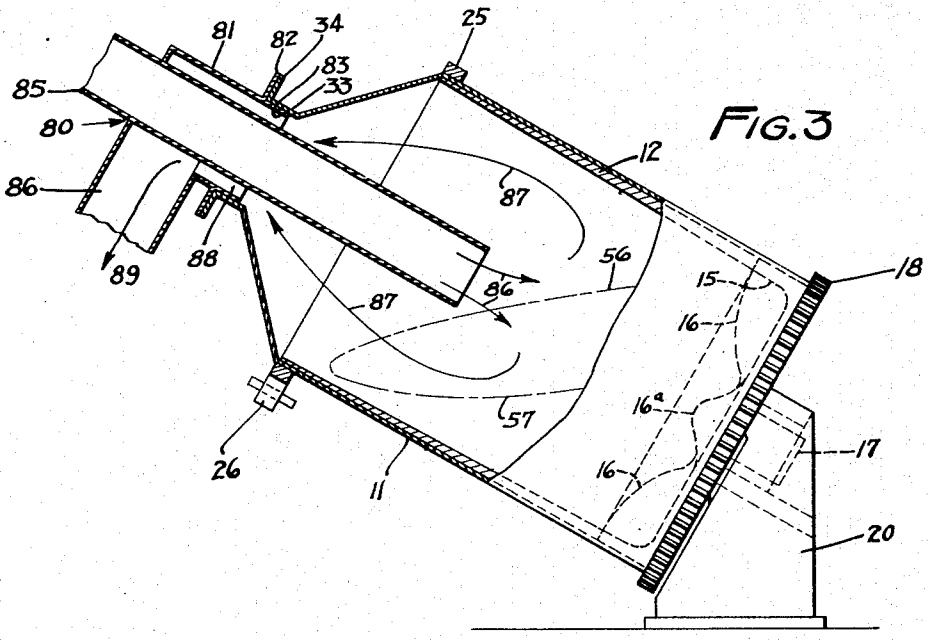


FIG. 3



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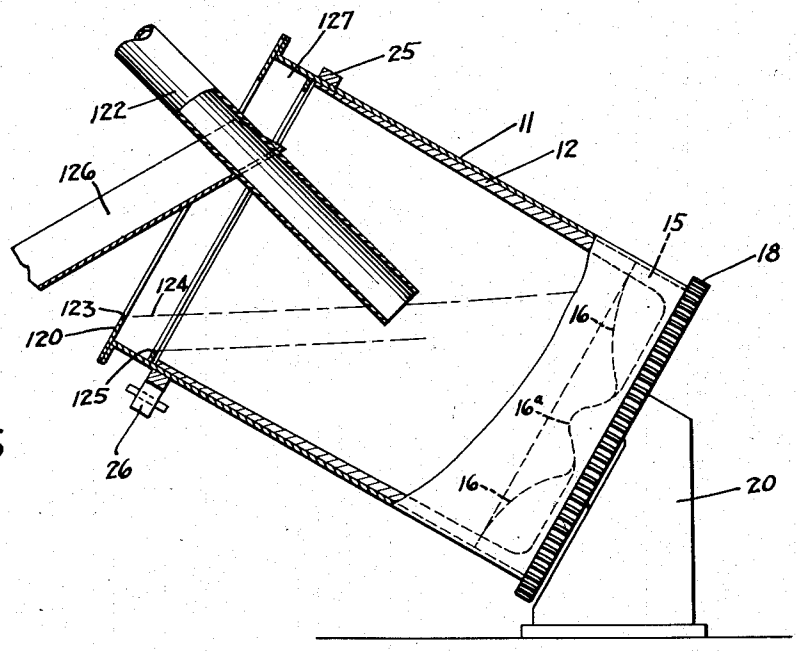


FIG. 6

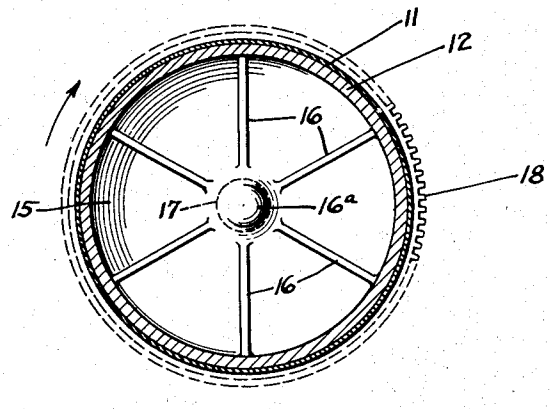


FIG. 2

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3 Sheets-Sheet 3

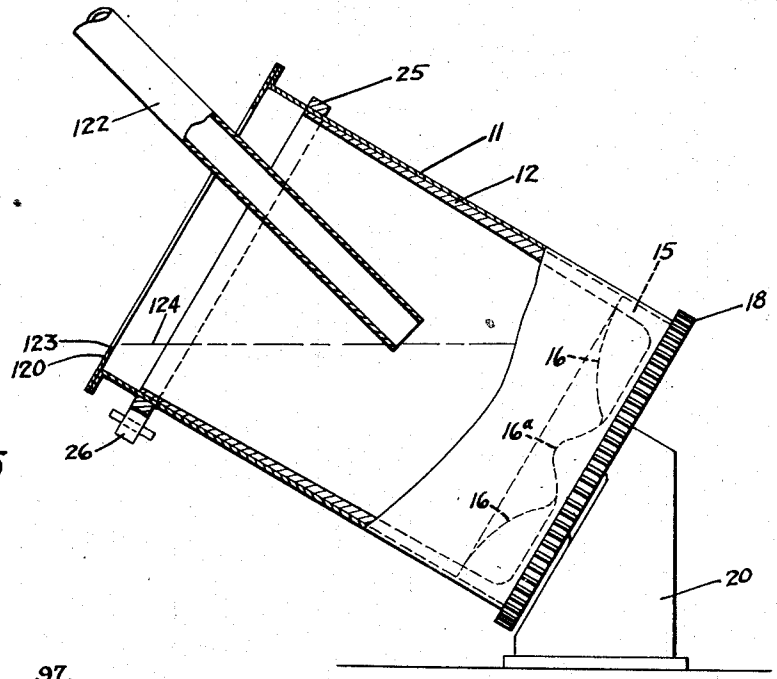


FIG. 5

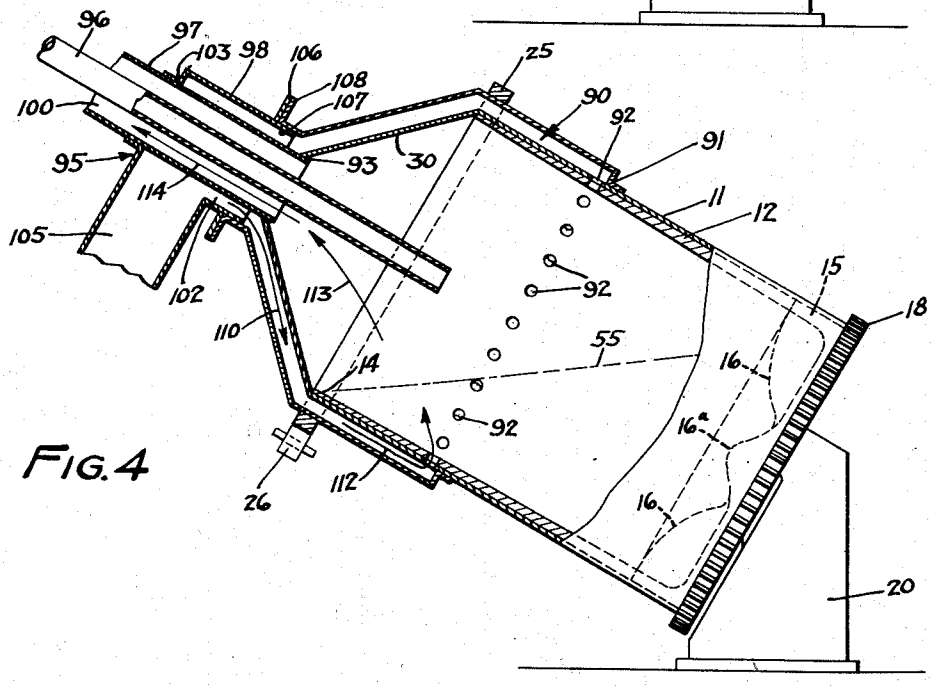


FIG. 4

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UNITED STATES PATENT OFFICE

2,238,743

BOWL MILL

Henry G. Lykken, Minneapolis, Minn.

Application May 13, 1938, Serial No. 207,859

1 Claim. (Cl. 83—9)

This invention relates to pulverizing and grinding mills of the type in which material to be reduced in size is subjected to the interaction of an activated mass of metallic balls, flint pebbles, or the like, into which the material is fed and subsequently removed when sufficiently reduced in size.

The interaction and activation of the mass has heretofore been accomplished by revolving the mass in a tubular container, about a substantially horizontal axis.

In the standard ball or tube mill the ball charge moves only in the direction of rotation, and there is no axial movement or displacement of the ball charge itself. As a result there is a lack of lengthwise distribution of the material to be reduced in the ball charge, too much material being present at the feed end and too little at the discharge end. The movement of the charge is a minimum distance in the plane perpendicular to the axis of rotation, or otherwise stated, the axis of the cascading of the charge is parallel to the axis of rotation.

I have discovered that superior results from the standpoint of quality of grind, capacity of the mill, and amount of power consumed in grinding can be accomplished if each particle of the mass and the mass is caused to move in a closed path which lies across the mill and at the same time caused to move axially of the mill. In order to obtain this motion I cause the activation of the mass to be carried out in a bowl-shaped mill, such as a closed bottom cylinder, which is revolved about an axis inclined to the horizontal. It is, therefore, an object of the present invention to provide an improved mill in which the activation of the mass is about a closed path of motion across and lengthwise of the mill.

In the present invention the activation of the charge is carried out in a bowl-shaped container which is revolved about an inclined axis. The bowl is loaded nearly full at the bottom, and the loading tapers off to zero at the upper or open end. As the axis of rotation is inclined substantially to the horizontal, the rotation produces a circulating cascading effect of the material by which the individual particles are moved endwise of the mill as well as transversely. In this way the charge is continuously cascaded from end to end as well as transversely of the mill.

The continuous and uniform circulation of all of the material in the charge, greatly increases the grinding efficiency and capacity of the mill. This makes possible increased loading of a given size mill as compared with ordinary ball mills, and the increased movement of the material per revolution increases the grinding action and efficiency.

There is better liberation of the finished product from the charge, due to the axial movement which avoids excessive reduction, and since the center of gravity of the mill is closer to the axis of rotation than is the usual ball or tube mill, decreased power is necessary for starting and running. There is also a material saving in wear on the grinding media due to the greater percentage of material which may be used, and less metal to metal wear upon the grinding media and liner and less impact between balls and between balls and liner.

It is therefore an object of the invention to provide a milling apparatus having these objects and advantages, and in which the activation is carried out in a bowl-shaped or closed end mill which is rotated about an inclined axis.

I have also discovered that if a fluid such as air or water is conducted into and out of a mill of the type described, that a classification of the material being processed will take place and the material may be divided thereby into particles of various sizes and grades. It is therefore a further object of the invention to provide a combined mill and classifier, and to provide a method and means of grinding and classifying material.

Other and further objects are those inherent and implied by the invention set forth in the specification, claim and drawings.

The invention is illustrated with reference to the drawings in which—

Figure 1 is a cross-sectional view in elevation of one modification of the present invention.

Figure 2 is a cross-sectional view along the line 2—2 of Figure 1.

Figure 3 is an elevational view partly in section of a modified form of the invention.

Figure 4 is an elevational view partly in section of another modification of the invention.

Figure 5 is an elevational view partly in section of a modification of the invention in which a liquid is used as the classifying medium.

Figure 6 is an elevational view partly in section showing another modification of the invention in which a liquid is used as the classifying medium.

The milling and classifying machine of the present invention, illustrated in Figure 1, comprises a bowl-shaped chamber generally designated 10, which is mounted for rotation upon an angularly positioned journal generally designated 20. The bowl-shaped chamber 10 is preferably of circular cross-section, as shown in Figure 2,

but in some instances it is desirable to make the chamber of polygonal cross-section as hereinafter pointed out.

The chamber 10 is constructed of an outer shell 11 of steel plate or other suitable material, and a cylindrical liner 12 of wear-resistant material. Liner 12 may be of one piece or a number of segments and may be of thick cross-section toward the lower end 13 of the chamber and gradually decreased in thickness toward the upper end 14. The liner 12 does not extend to the bottom of the shell 11 but is joined by a cast end-closure plate 15 which serves to close the end of shell 11 so as to form the bowl-shaped chamber 10.

The end-closure plate 15 is provided with a plurality of radial protuberances 16 which as subsequently described, serve to lift the mass of grinding media and material to be ground, and thus activate the mass. The end-closure plate 15 is also provided with an integrally cast boss 16A which protrudes into the chamber, and a stub shaft 17 upon which the entire device rotates. A large ring gear 18 is attached to the bottom of the bowl 10 and meshes with a pinion gear (not illustrated) which serves to rotate the chamber. The angularly shaped journal bracket 20 is provided with an anti-friction bearing 21 having a thrust section 22 which carries the axial load during the rotation of the mill.

The upper end of cylindrical shell 11 is provided with a tire 25 which rotates upon a plurality of rollers 26 only one of which is illustrated. It is understood that a number of rollers are provided as required, in order adequately to distribute the load and steady the mill.

The upper end of the cylindrical shell 11 is closed by a conically shaped cap 30 which is preferably welded to the shell 11 at the junction 31. The small end of conically shaped cap 30 is provided with a cylindrically shaped extension 33 which has an outwardly extending flange 34. All of these parts rotate with the mill.

Adjacent the upper end of the mill there is mounted a unit generally designated 40, which serves to introduce the material to be comminuted and the classified fluid into the mill and to remove the classified comminuted material from the mill. Unit 40 is mounted on a pedestal 41 and is stationary with respect to the mill.

Unit 40 comprises a jacket 42 which has a protruding cylindrically shaped section 43 fitted to the cylindrical extension 33 of the mill. The two parts 33 and 43 are fitted with small clearance so that when the mill is rotated the outward passage of the classifying fluid and the comminuted material will be prevented. The sealing effect between cylindrical section 33 of the mill is enhanced by a flange 44 which is mounted on cylinder 43 so as to overlie flange 34 of the mill. Any other seal may obviously be used between the unit 40 and the mill section, the object being to provide a rotating fit between the two units and at the same time maintain the clearance sufficiently small so as to prevent the outward flow of classifying fluid and material at that point.

A central tube 45 is mounted in the cylindrical housing 42 and projects into the mill. The inner projecting end 46 of the tube 45 carries a conically shaped classifier head 47 having a flange 48 which parallels shell 11 but is spaced from it so as to provide an annular passageway 49 between the upper end 14 of liner 12 and the flange 48. Passageway 49 is continued toward the apex of the mill, and increases in width.

Unit 41 is provided with a horizontal tube 50 and feed screw 51 for the introduction of solid material into the mill, and also with a duct 53 for the introduction of classifying fluid which in this instance is a gas such as air.

During operation the mill is loaded with a charge of grinding media such as hardened steel balls, flint pebbles, or the like, and the material to be comminuted is introduced by means of feed screw 51 until a sufficient mass of material and grinding media is present in the mill so that it fills the bowl portion 10 to level 55 when the mill is at rest. It is assumed that the mill is rotated clockwise as viewed in Figure 2, or so that the top of the mill approaches the observer in the view Figure 1. When the mill is thus rotated the charge of grinding media and material is lifted due to its contact with the liner 12 of the mill and particularly due to the contact with radial lifting vanes 16. The material is carried upward until it reaches a high level away from the observer (as viewed in Figure 1), represented by the line 56, and a low level toward the observer, represented by the line 57.

When the material and grinding media are rotated upwardly with the mill the motion of an individual particle is in a plane perpendicular to axis 60. This motion may be represented by the vector 61 and may be considered as having a horizontal component of motion 62 and a vertical component of motion 63. Hence as the mass is being lifted each particle of material and grinding media moves toward the right in an amount represented vectorially by the arrow 62. As the particles of material and grinding media reach the level of line 56 (away from the observer, as viewed in Figure 1) they fall downward to the left. This motion may be represented by vector 65 and may be considered as having a downward movement represented by the vector 66, and a horizontal movement to the left, as represented by the vector 67. Thus for each rotation of the mill the mass of media and material is moved axially of the bowl about a closed path. The material is hence circulated axially of the mill as it is tumbled upon itself within the mill. This effect results from the inclination of the mill.

I have discovered that numerous advantages result when using a mill of the present invention, among which are the following: First, the ratio of the weight of the material to the weight of the grinding media is much higher than in previous ball mills, and there is accordingly much less wear on the mill and power consumed per pound of finished material. Second, the quality of the ground material is enhanced because the grinding effect is largely due to attrition. Third, the power necessary to start the mill is less than in horizontal ball mills.

As the material is reduced in size by the action of the grinding media, it is removed from the mill by a current of classifying fluid which in Figure 1 may be air or other gas. The gas is introduced through the duct 53 and it then travels in the direction of arrow 70, through the space between stationary cylindrical member 43 and the member 33 of the mill, and thence through the space 49 and into the mill, as shown by arrow 71. The gas then sluices through the mill and raises the fine particles of material and carries them upwardly through cylinder 40, in the direction of arrows 72. The only material which

is removed from the mill is that which is fine enough to be carried by the current of classifying gas, the coarse material being left in the mill for further reduction.

The influx of classifying gas may be regulated in any desired amount by a vane 75 in the inlet duct 53 and the introduction of material to be ground may likewise be regulated by the rate of rotation of feed screw 51. The rate of flow of the classifying fluid through the mill in part determines the size of the particles of reduced material which may be lifted upwardly and through tube 40. By changing the rate of feed of material and classifying fluid to the mill it is thus possible to vary the size of the grind within wide limits.

In Figure 3 there is illustrated a modification of the mill shown in Figure 1 which is the same in all respects except for the means of introducing the material to be comminuted and the classifying fluid. In Figure 3 a unit generally designated 80 replaces the unit 40 of Figure 1 and consists of an elbow-shaped tube 81 having a stationary flange 82 and a cylindrical portion 83 which cooperate to form a fluid-tight connection with the rotated flange 34 and cylindrical portion 33 of the mill. Unit 80 includes an axial tube 85 through which the classifying fluid and material are introduced into the bowl mill and a side tube 86 for the out-flow of classifying fluid and reduced material.

The operation of this modification of the invention is analogous to that described above with reference to Figure 1, particularly as to the circulation of material and the charge of grinding media within the mill. As the material to be comminuted is reduced in size it is picked up by the classifying fluid which impinges upon the activated mass in the direction of arrows 86. The fine particles are lifted like dust and carried upwardly in the direction of arrows 87, through the space 88 between members 83 and tube 85 and thence outwardly in the direction of 89 through the outlet port 86.

In this modification, as in the modification shown in Figure 1, the rate at which the material and classifying fluid are introduced into the mill may be regulated by any suitable means and the amount of reduction of the material accordingly regulated as desired.

In the modification shown in Figure 4 the upper portion of the bowl is provided with an air jacket, generally designated 90, which extends downwardly along the cylindrical shell 11 to any point 91, as desired. The cylindrical shell 11 and liner 12 are pierced by a number of air inlet ports 92 for the passage of air from the jacket into the bowl. In this modification of the mill the conical section 30 which rotates with the mill is terminated at the point 93 where it joins stationary cylindrical tube 97 of the unit, generally designated 95.

Unit 95 consists of three concentric tubes 96, 97 and 98. Tube 96 is of small diameter and is provided for the introduction of material to be comminuted. Tube 97 is of a diameter sufficiently large that a space 100 is provided for the outward flow of the classifying fluid and reduced material. Tube 98 is likewise sized so as to provide a space 102 for the inflow of classifying fluid. It will be noted that tube 98 is joined at point 103 to member 97 and that inlet tube 105 is provided for inflow of classifying fluid. Tube 98 and flange 106, which is mounted upon it, fit snugly with the cylindrical portion 107 and flange 108 which rotate with the mill and thus prevent the outflow of the classifying fluid at the junction of these elements.

In operation material to be ground is introduced through small tube 96 in a regulated amount and classifying fluid such as air or other gas is introduced through tube 105 and flows through the space 102 and along the path of the arrows 110 and 112 into the mill. Since the mill is loaded to a level 55 which extends to near the upper edge 14 of liner 12, some of the air or other classifying gas is forced through the activated mass at the upper portion of the mill and raises a cloud of reduced material which is then driven along the path of arrows 113 and 114 through outlet space 100. By this means it is possible to drive larger particles from the mill than is possible in the modifications illustrated in Figures 1, 2 and 3. In the mill illustrated in Figure 4 the circulation of the mass of grinding media and material within the mill is substantially the same as that described with reference to Figure 1.

In the modification shown in Figure 5 the mill is adapted to be used with a liquid classification media and the mill is accordingly not closed at the top as shown in Figures 1, 3 and 4 but is provided with a weir plate 120 by which the outflow of classifying liquid is regulated. In this modification the mill is provided with a stationary tube 122 which extends into the body of the mill. The classification liquid and material to be comminuted are introduced through tube 122 and the material is reduced in the presence of the liquid, the circulation within the mill being analogous to that described with reference to the previous modifications except that the difference between the high and low levels of the activated mass is not usually as great as when the reduction is carried on under dry conditions. This, however, depends upon the cohesiveness of the material being comminuted.

As the material is reduced in size it is more readily maintained in suspension and as a consequence is carried over the lip 123 of weir plate 120 with the outflow of classifying fluid. The larger particles of material settle more rapidly and are accordingly returned to the activated mass of grinding media and material. The particles of material remain in the mass of grinding media until they are sufficiently reduced in size to be carried over the weir plate by the classifying liquid. It is understood, of course, that a steady flow of classifying fluid and material is maintained through the mill. The rate of flow and the proportion of classifying medium to material may be regulated as desired to vary the size of the grind.

In the modification shown in Figure 6, the mill is provided with a weir plate 120 which is the same as that described in Figure 5 and with an internal classification plate 125. The mill is also provided with a stationary sluiceway 126 in addition to tube 122.

In this modification of the invention the reduced material is classified and removed from the mill in two flows as follows: The lighter portions of the material which remain suspended at the surface level 124 of the classifying fluid are carried over the edge 123 of weir plate 120 as described with reference to the modification in Figure 5. The somewhat coarser material settles between weir plate 120 and the classification plate 125 and is carried upwardly as the mill rotates until it reaches an elevated position 127 at

which point it falls into sluiceway 126, whence it drains downwardly from the mill. In this way the material is automatically classified into the fine and coarse sizes as it is removed from the mill. The circulation of the activated mass of grinding media and material within the mill is in this modification substantially the same as that described with reference to Figures 1, 3 and 4 except that the difference between the high and low levels is not as great as in the dry grinding procedures. If desired a plurality of vanes (not shown) may be provided between the weir plate 120 and classification plate 125 so more readily to lift the material to a position above sluiceway 126.

In all of the foregoing mills the angle of inclination of the bowl may be varied as desired to suit conditions. The more nearly horizontal the mill is mounted the less will be the amount of axial circulation, and the greater the inclination the less will be the transverse circulation. I have found that good results are obtained when the axis of the mill is substantially thirty degrees to the horizontal but I do not wish to restrict myself to this angularity.

As previously stated, the cross-section of the mill may be circular or polygonal, as desired. In some instances it is desirable to use a triangular or square cross-section, or a cross-section having 6, 8 or 10 sides.

Other modifications may obviously be made without departing from the spirit of the invention described, and claimed as follows.

I claim as my invention:

A mill for grinding and pulverizing of material introduced thereinto, and for classifying and separating of such pulverized material comprising a bowl-shaped chamber having a closed bottom and upwardly extending walls, means mounting said chamber for rotation about an inclined axis with the open side of the chamber directed upwardly, and means for supplying a fluid to the chamber and for withdrawing the fluid laden with pulverized material from the chamber, the bottom of the chamber being provided with a central upwardly extending dome-shaped protuberance and a plurality of radial vanes around and extending from said protuberance.

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