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GYRATORY BALL MILL HAVING A GYRATED CHAMBER WITH A PERIPHERAL DISCHARGE

Filed July 31, 1948 2 Sheets-Sheet 1

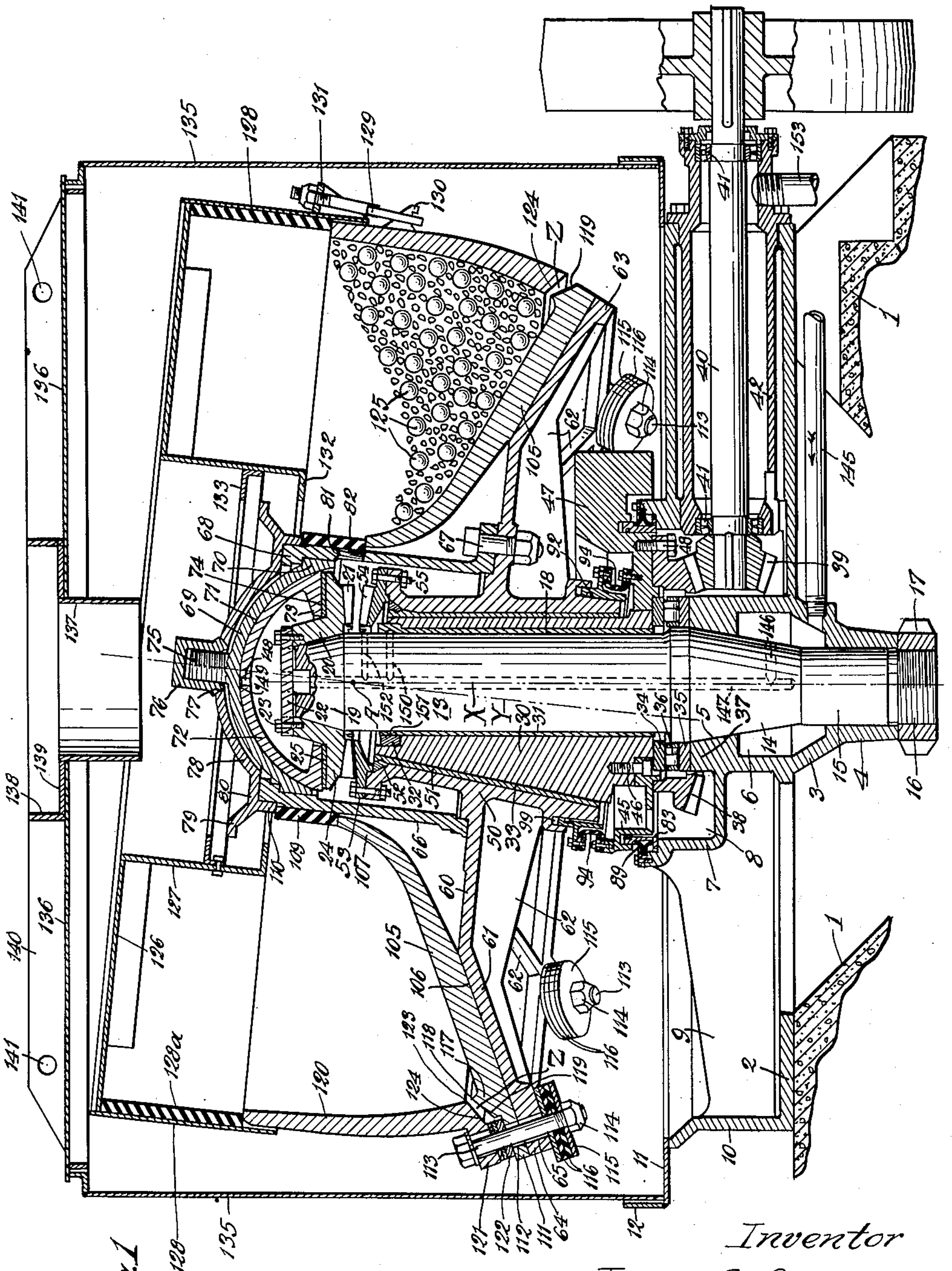

Fig. 1

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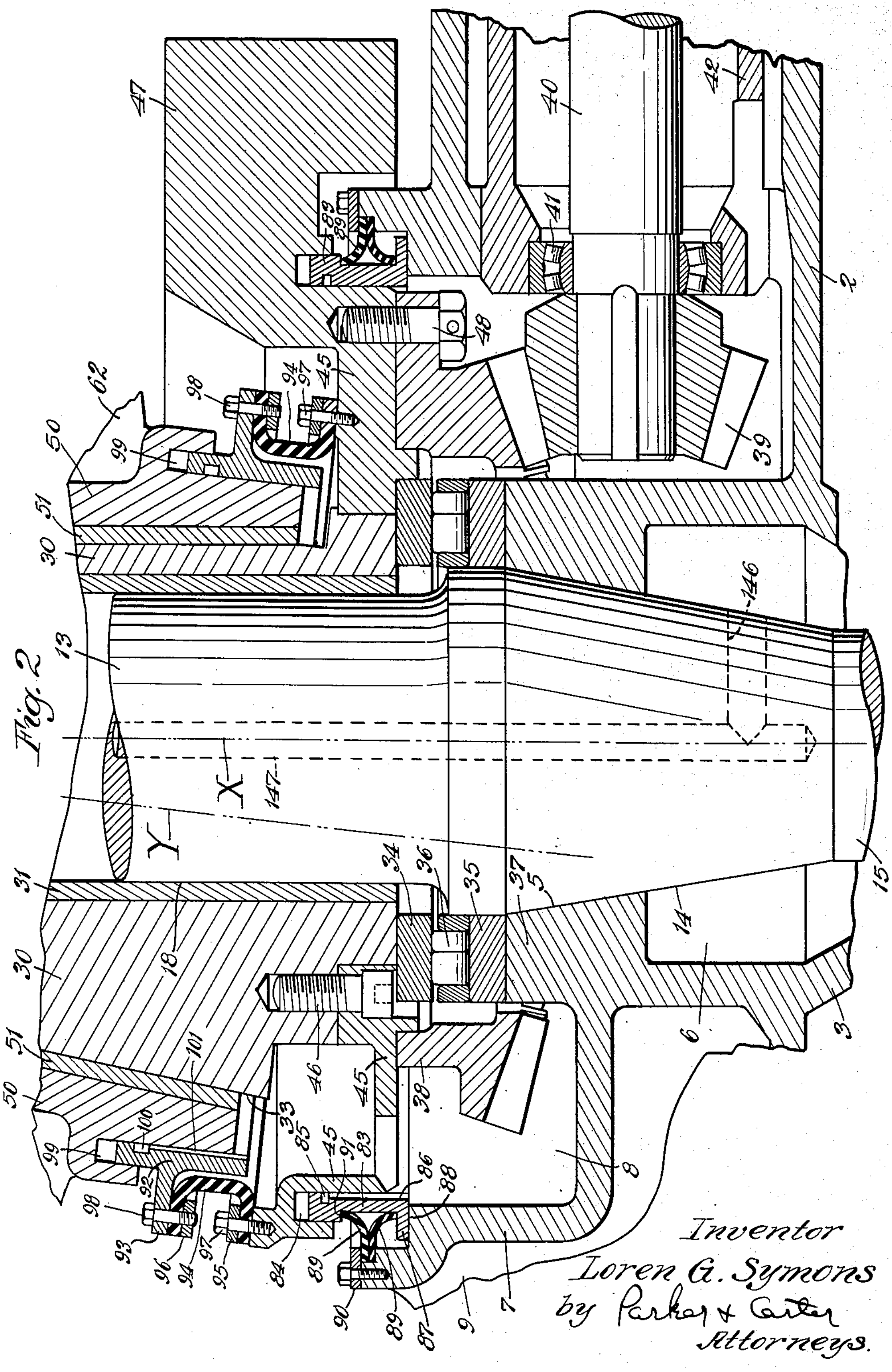

Fig. 2

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GYRATORY BALL MILL HAVING A GYRATED CHAMBER WITH A PERIPHERAL DISCHARGE

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5 Claims. (Cl. 241—84)

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My invention relates to an improvement in fine reduction or fine grinding of materials, such as rock and ore. One purpose is to provide an improved chamber for receiving the charge of material in a gyratory ball mill.

Another purpose is to provide improved adjusting means for the circumferential outlet slot of the gyrated chamber of a gyratory ball mill.

Another purpose is to provide improved wear taking parts for direct contact with the charge and the material undergoing crushing.

Other purposes will appear from time to time in the course of the specification and claims.

I illustrate my invention more or less diagrammatically in the accompanying drawings wherein:

Figure 1 is a vertical axial section; and

Figure 2 is a partial vertical axial section on an enlarged scale.

Like parts are indicated by like symbols throughout the specification and drawings.

Referring to the drawings, 1 generally indicates any suitable base or support, herein shown as of concrete. Positioned upon it is a machine base 2 having a generally central downward extension 3, terminating in a cylindrical sleeve 4. It will be noted also that an upper part of the central portion defines an upwardly and inwardly tapered surface 5, beneath which is a circumferential enlargement 6 of the central cavity of the downward extension or hub 3. 7 is an integral, circumferential wall which defines a space 8. The wall 7 may be connected by ribs 9 which extend to a circumferential outside flange 10. Extending outwardly from the outside flange is an annulus 11, shown as welded to the flange 10, and as having an upwardly extending circumferential flange 12, the purpose of which will later appear.

Seated in the hub or enlargement 3 is a normally fixed, vertical shaft, generally indicated as 13. It has an enlarged and tapered portion 14 which seats against and conforms to the inner surface 5 of the hub 3. It also has a bottom cylindrical portion 15 received within the cylindrical sleeve 4 and terminating in a screw-threaded portion 16 adapted to receive a locking nut 17. It will be understood that the nut 17 is tightened up sufficiently to position the shaft 13 firmly in relation to the base, and may then be suitably secured against retrograde rotation, for example, by spot-welding. The shaft 13 has an external bearing surface 18, herein shown as cylindrical. It has an upper tapered portion 19 to which may be secured a gear assembly 20 having formed on its bottom a circumferentially extending set of

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gear teeth 21, the purpose of which will later appear. The member 20 may be suitably secured to the upper end of the shaft 13 as by a crosspiece 22 and bolts 23. The member 20 has an outwardly extending shelf 24 which carries any suitable bearing ring 25, the upper surface of which is preferably located in a single horizontal plane.

Rotatable about the shaft 13 is the eccentrically apertured sleeve 30. It has an inner bore within which is positioned any suitable bearing sleeve 31 which may, for example, be of lead bronze, and which is locked against rotation in relation to the sleeve 30, for example, by the metal body 32. The axis about which the bearing surface 18 is described is indicated at X. The eccentric sleeve 30 has an outer bearing surface 33 described about the axis Y, which is inclined to the axis X, the two axes intersecting at A. In the device as herein shown the outer bearing surface 33 is shown as upwardly reduced or generally slightly conic. The eccentric sleeve 30 is shown as supported at its lower end upon a bearing assembly including an upper race 34, a lower race 35 and any suitable rollers or balls 36. The lower race rests upon the upper end 37 of the hub 3.

Depending from the lower end of the eccentric sleeve 30 is a gear 38 in mesh with a pinion 39 on a drive shaft 40, mounted in suitable bearings 41 in a tubular element 42 which, in turn, is mounted in the base 1. The shaft 40 may be driven by any suitable mechanism, not shown, it being understood that as the shaft 40 is rotated, it rotates the eccentric sleeve 30 about the central column or post 13. In order to counterweight the eccentric 30 I provide a circumferentially extending member 45, to which the gear 38 may be directly secured. The member 45 may be anchored or secured to the eccentric 30, as by suitable screws or bolts 46. The annulus 45 also carries, or includes, any suitable counterweight 47 which rotates in unison with and counterbalances the eccentric 30 and the below described structures which surround the eccentric. The gear 38 may be secured to the annulus 45, for example, by screws 48.

Surrounding the eccentric 30 is a bowl assembly which includes a central sleeve 50. Within this central sleeve is a bearing sleeve 51 of lead bronze or other suitable material, which is anchored, as by the metal body 52, against rotation in relation to the sleeve 50. To the upper end of the sleeve 50 is secured a gear 53 having teeth 54 meshing with the teeth 21 of the gear

24. The opposed gear teeth are of such form and number as to prevent rotation of the sleeve 50 in relation to the post or central shaft 13. The gear 53 is shown as secured to the sleeve 50, for example, by any suitable bolts 55. Extending outwardly from the sleeve 50, intermediate its upper and lower ends, is a bowl supporting flange 60 having an outer and generally conic portion 61 and integral reinforcing ribs 62 which extend to a circumferential reinforcement or enlargement 63. About the periphery of the bowl support are a plurality of lugs 64 apertured as at 65. Extending upwardly from the portion or web 60 is a generally cylindrical sleeve 66 which may be secured to the web 60 as by bolts 67. The member 66 has an inwardly reduced upper portion or flange 68 which rests upon and overhangs the circumferential enlargement or step 70 of the concave and broadly spherical bearing member 69.

The inner bearing surface 71 of the member 69 rests upon and conforms to the upwardly convex, partly spherical bearing or support 72 which may be made of lead bronze or other suitable material. The member 72 is shown as having inward extensions 73 having lower bearing surfaces 74 resting upon and conforming to the upper surface of the bearing ring 25. Thus a limited lateral movement of the member 72 is permitted, in a plane at right angles to the axis X of the central post 13. It will be noted that the bowl supporting structure is thus suspended from the partly spherical bearing 69 and may move thereupon about the center indicated at A.

The member 69 is shown as having an upwardly extending, generally central, outwardly screw-threaded stud 75 which receives a nut 76 having a conic bottom surface 77 adapted to exert a thrust against the feed plate 78. The plate 78 has an upwardly and outwardly extending feed lip 79 and an intermediate portion 80 resting upon and surrounding the upper end of the sleeve 66. 81 is an access aperture in the sleeve 66 which is normally closed by the screw-threaded plug 82.

In order to seal the above described bearing surfaces I provide a sealing ring 83, the upper portion of which is received in a circumferential slot 84 in the member 45. The ring 83 may have an entry sealing slot 85 in connection with one or more vertical oil channels 86. The lower end of the sealing ring 83 is shown as having an outward extension or flange 87 resting upon a horizontal surface or ledge 88 formed adjacent the upper edge of the wall 7. A pair of sealing members 89 are gripped by a locking ring 90, and are oppositely bent to seat against the flange 87 and against an outer step 91 formed in the outer surface of the ring 83. Thus an efficient seal is provided which will adapt itself to some slight measure of relative displacement of the parts.

Between the upper part of the member 45 and the sleeve 50 I provide an additional sealing ring 92 having an outwardly extending flange 93 intermediate its ends. The flange 93 is connected to the member 45 by a generally U-shaped seal 94 of a suitable flexible oil-resistant material, such as neoprene. The seal may be locked by gripping rings 95, 96, through which pass locking screws 97, 98. The upper end of the sealing ring 92 extends into a slot 99 in the member 50. The ring is shown as having a circumferential oiling slot 100 with which communicate one or more vertical oiling passages or channels 101.

Supported on the bowl structure 60, 61, and resting on the portion 61, is a bottom bowl member, generally indicated as 105. It has a lower surface 106 which may conform to or be received upon the corresponding upper surface of the bowl member 61. It is shown as having an inner portion 107 which may extend upwardly at a progressively steeper angle, but which is shown as out of contact with the sleeve 66. I may employ a ring 109, of rubber or a rubber substitute, which fills the gap between the upper edge of the member 107 and the lower flange 110 of the feed plate element 78. I preferably use rubber or a rubber substitute to provide for variations in distance between the opposed metallic surfaces which are bridged or closed by the member 109. The member or ring 109 may be tightly fitted upon an upper portion of the outer surface of the sleeve 66.

The member 105 is shown as having outer securing lugs 111, apertured as at 112 to receive securing bolts 113. 114 indicates any suitable locking nut. In order to prevent a direct metal-to-metal contact between the bolts 113 and the lugs 64 and 111 I provide disks 115 separated by disks or bodies 116 of rubber or of a suitable rubber substitute. Extending about the outer edge of the member 105 I illustrate an enlargement 117 which defines a relatively sharp discharge lip 118, from which outwardly extends a conic discharge surface 119.

Mounted upon the lugs 111 I position the circumferentially extending side member or annulus 120. It is shown as being progressively reduced in thickness, and as being slightly arcuate or rounded in vertical radial section. It is provided with a plurality of lugs 121, there being, preferably, the same number of lugs as the lugs 64 on the bowl support 61, and the lugs 111 of the members 105. The member 120 may be positioned at the proper elevation in relation to the member 105, as by the use of any suitable shims 122. When the parts are locked in position by running up the nuts 114 on the bolts 113, the bottom, inner angle 123 of the side plate or annulus 120 is at the desired distance from the discharge lip 118 of the bowl member 105. It will be noted that the lower surface 124 of the member 120 diverges from the upper, outer surface 119 of the member 105, thus providing a discharge slot or outlet which will have a minimum tendency to clog. The number of bolts 113 is insufficient to block any substantial length of the discharge slot thus provided, which, for convenience, I will indicate as Z.

In the use of the device I maintain a charge of balls, or their equivalent, which work upon material introduced to the crushing space defined between the members 105 and 120. I indicate such balls at 125. It will be understood that the charge of balls may be widely varied, both as to the shape of the balls or charge elements, and as to their size and bulk. It is practical, for example, to use balls of various sizes, or of a range of sizes.

In order to further enclose and mask the crushing space I provide a top lid 126 having an inner cylindrical wall 127 and an outer cylindrical wall 128. The latter outwardly overlaps the upper edge of the member 120 and is held downwardly thereagainst by any suitable member, such as the screw eyes 129, the eyes of which extend about outwardly extending lugs 130, formed in the outer face of the member 120. The shanks of the screw eyes might pass through any suitable lugs or brackets 131, outwardly extending from the wall 128. Inwardly extending from the wall 127 I illustrate a lower flange 132 and an upper flange 133 which, with the lip 79 of the feed plate 78, define a tortuous entry passage for material being fed to the crushing space within the members 105 and 120.

Surrounding the above described mill I illustrate an upwardly removable housing which includes the circumferential side wall 135 with its connected top wall 136, having a central downspout 137. 138 is a feed receiving ring which may be connected to the downspout 137 by the flat ring 139. Any suitable feed limiting or control means may be employed for delivering feed to the downspout 137. The ring 138 may be provided with outwardly extending reinforcing ribs 140 which extend upwardly from the top wall 136. Some of these ribs may be apertured, as at 141, to receive any suitable hooks or connections when it is wished to lift the outer housing upwardly out of position. The lower edge of the wall 135 is surrounded by the frame flange 12.

In order to lubricate the above described mill I may use any suitable lubricant delivering pump or means, not herein shown. It will be understood, however, that a suitable liquid lubricant is supplied through the inlet duct 145, whence the lubricant flows to the space 6 within the hub 3. From the space 6 it may pass through the entry duct 146 which extends radially to the center of the post 13 to communicate with the axial passage 147. This passage extends clear to the top of the post and delivers oil to the space within the spherical bearing 72. It may pass through the spherical bearing 72 through the passage 148, the outer wall of the bearing 72 being cut back, as at 149, to assist in distributing oil to the spherical bearing surface between the members 69 and 72. Oil from the axial duct 146 also passes by the outlet duct 150 to the circumferential recess 151 in the bearing sleeve 31, to lubricate the exterior bearing surface 18 of the post 13. The upper oil outlet 152 delivers oil to the gears 21 and 54 and to the outer bearing surface 33 of the eccentrically apertured sleeve 30. Oil flows down along the outer post surface 18 to the bearing rollers 36. Oil also flows down the surface 33 to the space defined by the wall 7 and lubricates the gears 38 and 39. This flow of oil also is available for lubrication of the sealing rings 83 and 92. The oil finally escapes about the shaft 40, within the tubular member 42, and is withdrawn through the oil outlet pipe 153.

It will be realized that, whereas, I have described and illustrated a practical and operative device, nevertheless many changes may be made in the size, shape, number and disposition of parts without departing from the spirit of my invention. I therefore wish my description and drawings to be taken as in a broad sense illustrative or diagrammatic, rather than as limiting me to my precise showing. For example, the size, shape and proportions of the members 105 and 120 may be widely varied, and, in particular, the slope of the member 105 may be varied, as well as the nature of the charge used in the mill. The length of the stroke may be varied within a substantial range by varying the angle between the axes X and Y, or, in general, by varying the eccentricity of the sleeve 33.

The use and operation of the invention are as follows:

I provide a gyratory mill in which a charge of balls or suitably shaped media is employed to reduce, by impact, material delivered to the crushing or grinding cavity. The material is fed through the downspout 137, when the device is operated dry, and passes about the lip 79. When it is desired to crush wet, it may, under some circumstances, be practical to remove, bodily, the cover plate 136. The crushing action is as follows: I build up a mixed mass in the impacting chamber, which includes the charge of balls and the material to be crushed. This mass is subjected to a series of impacts resulting from the rapid gyration of the above described bowl or plate structure. In effect, a wave of elevation moves circumferentially about the impact chamber. The result of the wave of elevation is to project bodily upwardly that part of the mass beneath which the wave of elevation passes. The resulting length of stroke and speed of stroke of the ring or bowl against the mass are such that the balls or impacting members, such as 125, and the particles undergoing reduction, or grinding, are thrust upwardly from and by the bowl far enough and high enough so that when the balls or impacting members and the particles fall, they do not contact the surface of the bowl until the underlying part of the bowl has again been down to its lowest level and is advancing upwardly. The result is that when any particular part of the bowl is traveling upwardly, it will contact the downwardly falling particles and impacting members after they have received a substantial degree of gravital acceleration. The result is an impact of maximum force and effect. It should be noted that the mass of any individual impact element or ball is so small, in relation to the mass of the bowl, that the factor of inertia of the individual ball or impact element is unimportant. The result is the subjection of the particles to violent impact when the balls or impact elements contact and are contacted by the bowl. The force of this impact is distributed through the mass of impact elements and material undergoing grinding so that the faces of the individual balls or elements serve as impacting faces which exercise a sharp impact against material trapped between adjacent balls and in the line of the blow delivered by the bowl. In effect, I obtain a multiple impact, because the mass of balls and particles separate out or scatter on the upward and downward stroke. This effect is particularly marked if the machine is operated wet, with water supplied to the interior of the impacting chamber. The final or bottom particles are struck first and the result is an instant and complete reversal of direction of movement of the particles and impact members. These, in turn, are carried upwardly to impact the still falling upward part of the mass. This action is entirely unlike anything found in prior art ball mills, and involves a multiplication or sequence of impacts at a single movement of the bowl. Each ball or impact member, which has just changed its direction of movement, will strike against the mass above it just as hard as did the bowl itself. This is necessarily so because it is now traveling in reverse direction at the same speed as the speed of travel of the bowl. The mass of the bowl is so great, in relation to the mass of any individual particle or impacting member, that it is not perceptibly slowed down by the successive impacts against individual impact members and it continues to multiply its breaking effect by carrying the already impacted members and particles upwardly against the still downwardly falling balls and particles. As a result, the theoretical slowing down of the bowl or plate by its impact against the particles and impacting members is unimportant. It is a simple matter so to relate the length and the speed of gyration under load as to obtain the desired impacting effect.

An advantage of my structure is that the subjection of the bowl to impact is always localized. For example, only about one-eighth of the bottom of the bowl will, at any instant, have material in contact with it which is being accelerated, if the general proportions of the drawings of the present application are followed.

The rest of the bowl area will not be under strain, as the material will be clear of the bottom of the bowl. In other words, no more than one eighth of the circumference of the bowl is performing work at the same time. And the zone of simultaneous strain is moving rapidly around the bowl, so that no part of the bowl is subjected to a continuing strain due to impacting the charge. While this may not be necessary for the practice of the invention, it is helpful in connection with the design and employment of commercially acceptable machines for carrying out the invention.

The width of the discharge aperture Z may readily be varied or controlled by changing the shims **122**. This may be necessary for handling different substances or for obtaining different reductions, but, in the main, the size of the product is independent of and not controlled by the opening of the discharge slot. It is advantageous to be able to vary or control the opening, in the event that manganese steel is used for the wearing parts, and the parts peen or float in a direction to reduce or change the opening. As will be clear from the drawings, I prefer to position the aperture between the lips **118** and **123** slightly above the lowest level of the upper surface of the bowl member **105**. I find this advantageous, since the balls, when the material is upwardly tossed, move across the opening and tend to keep it clear. It should be understood that, in the main, the member **120** does not perform a crushing function. Its primary purpose is to confine the movement of the material and charge. In the main, the material does not rise many inches from the surface of the bowl member **105**. However, I find it advantageous to protect the interior of the wall **128** by an inner ring **128***a* of rubber or some equivalent substance.

The device is readily disassembled. The entire outer housing may be removed for inspection or servicing of the mill proper.

I claim:

1. In a ball grinder, a base, a normally fixed and generally upright post on said base, having an exterior circumferential bearing surface, an eccentrically apertured sleeve rotatable about

said outer bearing surface and a drive connection for rotating it about said post, said sleeve having an exterior bearing surface, the axis of which is at an angle to the axis of said post, a bowl body having a central hub conforming to and rotatable about the exterior bearing surface of said sleeve, a connection for said bowl body formed and adapted to prevent its rotation in relation to said post and a material receiving bowl structure removably mounted on said bowl body, said bowl body having a generally conic, removable bottom member and a circumferential wall extending upwardly from the lower outer edge thereof and spaced therefrom, said wall and conic member being mounted for unitary movement with the rest of the bowl body and defining, by their opposed edges, a discharge slot.

2. The structure of claim 1, characterized by and including a ball and socket connection between said upright post and said bowl body.

3. The structure of claim 1, characterized by and including a ball and socket connection between said upright post and said bowl body, including an upwardly convex ball member mounted upon the upper end of said post and transversely movable in relation to said post.

4. The structure of claim 1, characterized by and including a feed plate mounted on said bowl body and extending above said post and eccentric sleeve.

5. The structure of claim 1, characterized by and including a feed receiving box mounted for unitary movement with said bowl body and having a circumferential outer discharge slot in communication with the interior of said material receiving bowl structure.

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