March 16, 1965 A. R. BRYAN 3,173,619

BALL MILLS

Filed April 12, 1963 4 Sheets-Sheet 1

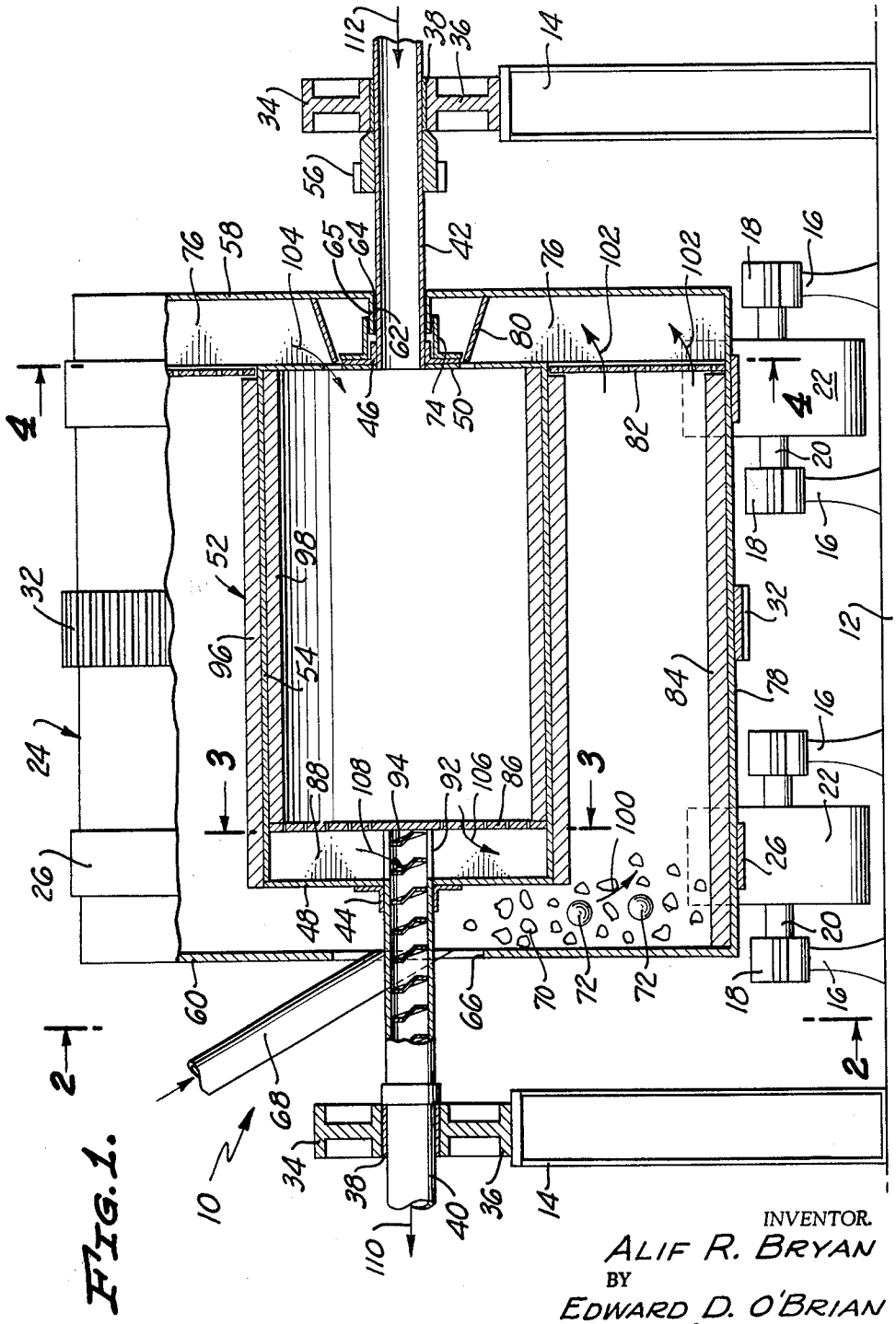


FIG. 1.

INVENTOR.
ALIF R. BRYAN
BY
EDWARD D. O'BRIAN
ATTORNEY

March 16, 1965 A. R. BRYAN 3,173,619

BALL MILLS

Filed April 12, 1963 4 Sheets-Sheet 2

FIG. 2.

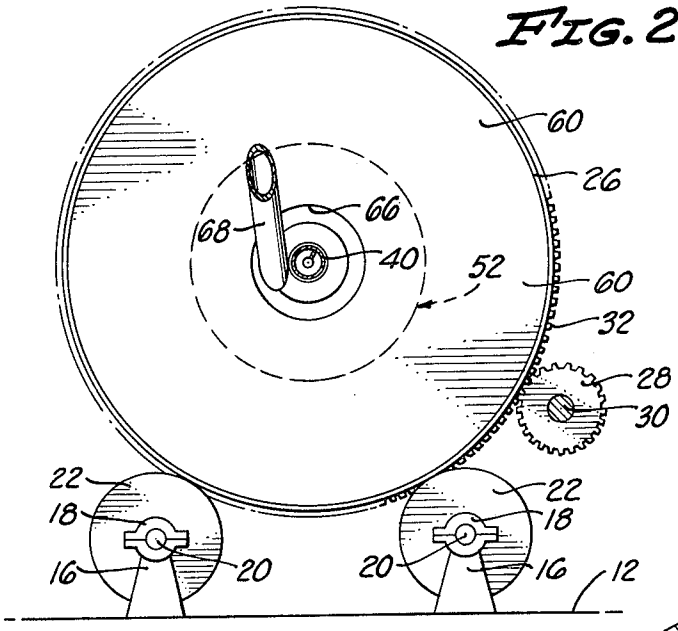


FIG. 3.

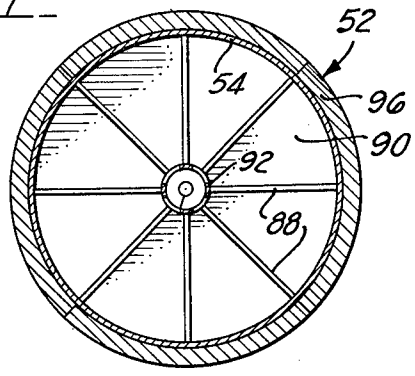
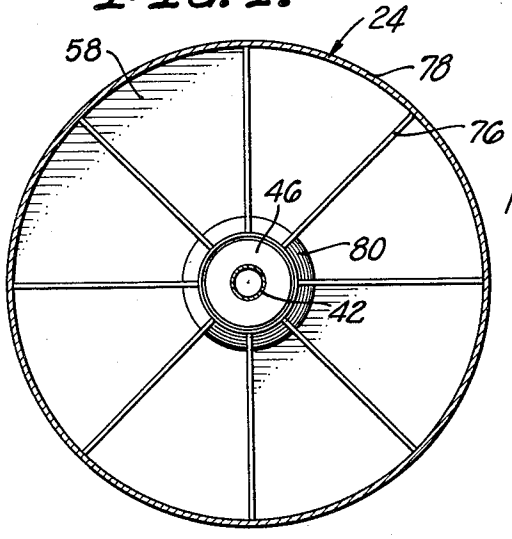


FIG. 4.



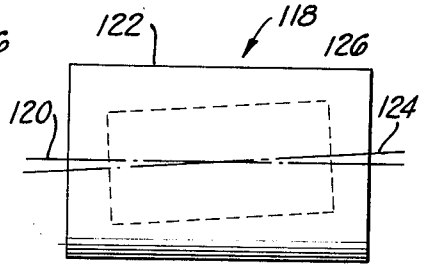


FIG. 5.

INVENTOR.
ALIF R. BRYAN
BY
EDWARD D. O'BRIAN
ATTORNEY

March 16, 1965 A. R. BRYAN 3,173,619

BALL MILLS

Filed April 12, 1963 4 Sheets-Sheet 3

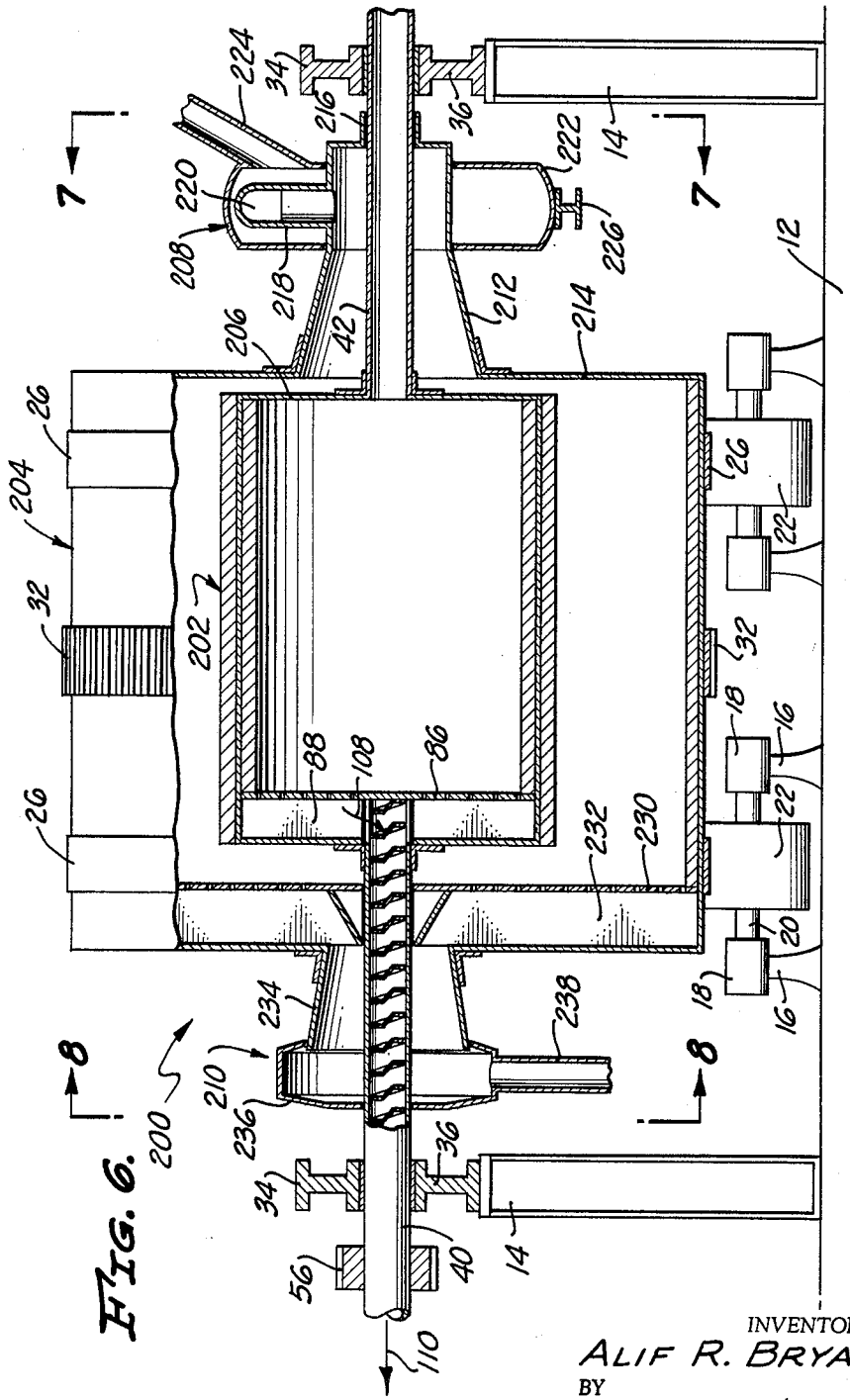


FIG. 6.

INVENTOR.
ALIF R. BRYAN
BY
EDWARD D. O'BRIAN
ATTORNEY

March 16, 1965 A. R. BRYAN 3,173,619

BALL MILLS

Filed April 12, 1963 4 Sheets-Sheet 4

FIG. 7.

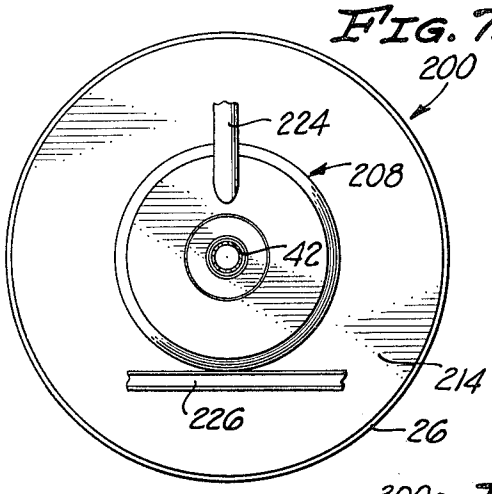


FIG. 8.

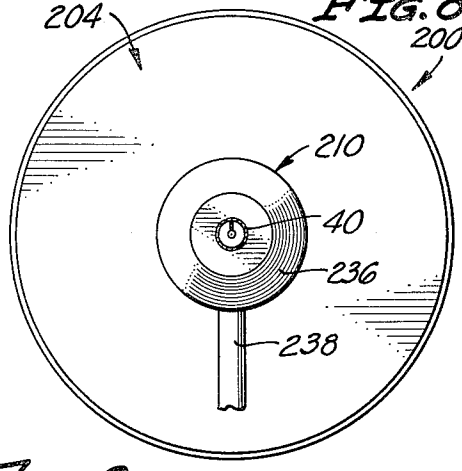
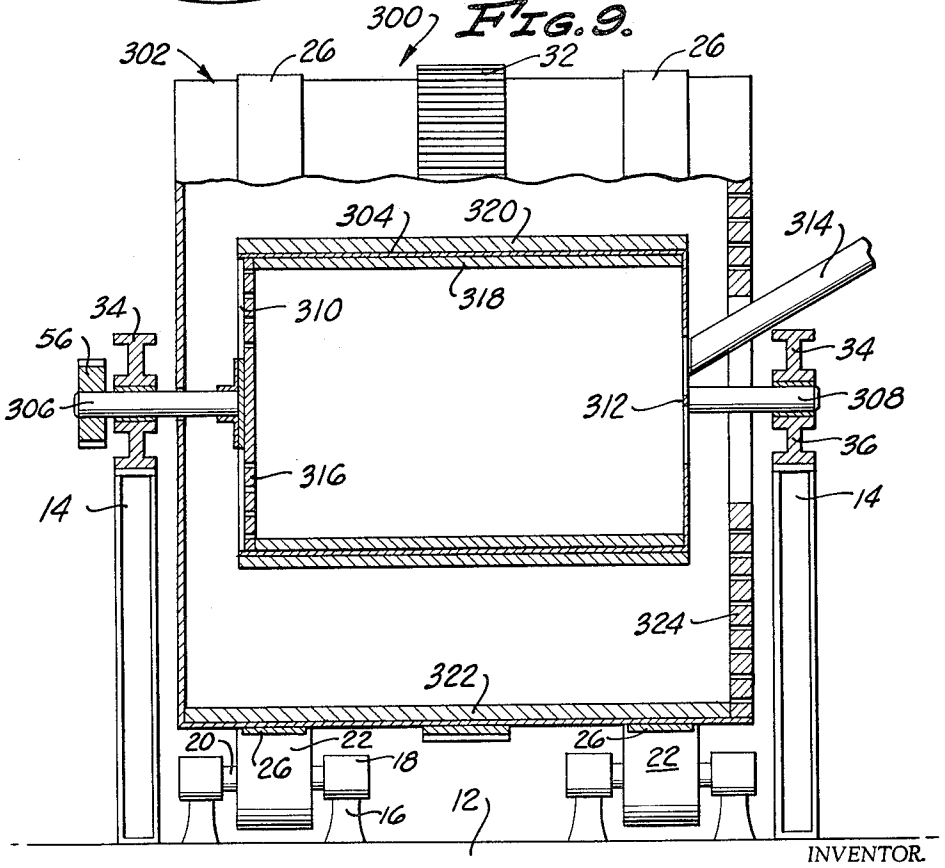


FIG. 9.



INVENTOR.
ALIF R. BRYAN
BY
EDWARD D. O'BRIAN
ATTORNEY

United States Patent Office 3,173,619 Patented Mar. 16, 1965

3,173,619

BALL MILLS

Alif R. Bryan, Tehachapi, Calif., assignor to Monolith Portland Cement Co., Los Angeles, Calif., a corporation of Nevada

Filed Apr. 12, 1963, Ser. No. 272,694
13 Claims. (Cl. 241—153)

This invention pertains to new and improved ball mills and to methods utilizing the same.

The term "ball mill" is commonly employed to designate a grinding mill which includes a shell having an axis, means for rotating this shell about its axis and a charge of material located within the shell. Such a charge of material normally consists of a plurality of particles serving to facilitate grinding as well as a charge of material to beg round. Commonly balls, pebbles, rods or the like are utilized as the grinding media in a mill of this type. The shell in a mill of this type is normally of a cylindrical configuration, however, various conically shaped shells and shells of other configurations are used in grinding mills falling within the broad classification of ball mills. Frequently such mills are referred to by other terms such as rod mills, tube mills, compartment mills and the like, depending upon the manners in which they are designed and the material used as a grinding media in them.

When a ball mill is operated the material being ground as well as the particles of the grinding media generally abrade against one another so as to accomplish a certain amount of grinding. Normally a ball mill is operated so that such abrasion while important in grinding is secondary to the grinding achieved by cascading the particles used as grinding media and some of the charge across the interior of the ball mill by operating it so that its shell is rotated at such speed as to impart sufficient movement to the contents of the shell so as to cause these contents to be lifted and thrown or dropped down against the bottom portion of the shell so as to hit against the shell and any material already accumulated in this bottom portion.

Mills of the general category indicated in the preceding are probably employed for the vast majority of industrial grinding operations. It is well known that conventional ball mills are comparatively inefficient in virtually every imaginary sense of the term "efficiency." Thus, for example, the power consumption in grinding with a ball mill is normally exceedingly high. Further, a conventional ball mill is a comparatively slow piece of equipment to utilize in grinding any specific material. Another factor is that conventional ball mills occupy an undue amount of space considering the output in terms of fineness and quantity from such mills. Conventional ball mills can also be considered inefficient in that economically it is advantageous to employ such mills so that the grinding achieved in them is related to the size of the mill.

An object of the present invention is to provide new and improved ball mills. A related object of the present invention is to provide ball mills which overcome many of the disadvantages and limitations of prior related structures such as are briefly described in the preceding. A closely related object of the present invention is to provide ball mills which are more efficient than prior structures in a number of different manners.

These and various other objects and advantages of the present invention will be more fully apparent from a detailed consideration of the remainder of this specification including the appended claims and the accompanying drawings in which:

FIG. 1 is a partially cross-sectioned view of one embodiment of a complete ball mill of the present invention;

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 1;

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 1;

FIG. 5 is a reduced diagrammatical showing of another embodiment of the ball mill of this invention;

FIG. 6 is a partially cross-sectioned view of still another embodiment of a complete ball mill of the present invention;

FIG. 7 is a cross-sectional view taken along line 7—7 of FIG. 6;

FIG. 8 is a cross-sectional view taken along line 8—8 of FIG. 6; and

FIG. 9 is a partial cross-section of another embodiment.

The accompanying drawings are primarily intended so as to clearly illustrate for explanatory purposes presently preferred embodiments of this invention. From a careful consideration of these drawings and of this specification those skilled in the grinding field will realize that a number of changes may be made in the precise ball mills illustrated through the use or exercise of routine engineering skill or ability without departing from the inventive features embodied in the ball mills shown in the drawings and described in this specification. Such features are considered to be defined and summarized by the appended claims.

However, as an aid toward understanding this invention it can be stated in essentially summary form that it concerns ball mills featuring constructions that include first and second shells so arranged that the first shell is disposed within the second shell and both shells are disposed on substantially the same axis of rotation. In one embodiment of a ball mill of this invention comprises a pair of such concentrically mounted shells wherein means are provided for rotating these shells independently of one another and preferably in opposite directions of rotation. In this embodiment means are also provided to introduce grinding balls or pebbles along with raw material to be ground into the outer of these shells and then for introducing material ground within the outer shell into the interior of the inner shell which is supplied separately with grinding balls, and thence from the interior of the inner shell out of the mill. In a second embodiment of the present invention two separate shells are concentrically arranged for relative rotation with respect to each other with an outer shell containing an inner shell. Means are provided whereby these shells may be rotated in the same or opposite directions independently of each other and whereby raw material and grinding balls or pebbles can be separately introduced into each of the shells and the ground material of each shell can be separately discharged so that the two shells operation as separate but cooperatively related ball mills.

The actual details of this invention will be more fully apparent in considering the accompanying drawings. Here there is shown in FIG. 1 a ball mill **10** comprising one form of this invention which includes a foundation **12** supporting a pair of end bearing support pedestals **14** and four pairs of intermediate bearing support pedestals **16**. The intermediate pairs of bearing supports **16** each are provided with conventional split bearing caps **18** which house sleeve bearings that rotatively support the axles **20** of guide and support rollers **22**. These rollers **22** are disposed in aligned confronting pairs in a manner shown in FIGS. 1 and 2 to enable them to rotatively support an outer cylindrical shell **24** of the ball mill on the circumferential tracks **26** disposed on the outer periphery of the outer shell **24**. These roller assemblies comprise idlers and serve to support the outer shell rotatively as it is rotatably driven by a conventionally powered pinion **28** suitably supported on a shaft **30** in cooperation with a girt gear **32** fixedly attached in a suitable manner on

the outer periphery of the shell 24. The end bearing support pedestals 14 are utilized to support the upper and lower bearing shells 34 and 36 which in turn rotatively support by means of sleeve bearings 38 aligned tubular shafts 40 and 42. The confronting ends of the hollow tubular shafts 40 and 42 are secured by flanges 44 and 46 to the end closure plates 48 and 50 of inner hollow shell 52 further defined by the cylindrical wall 54. Preferably the shells 24 and 52 are located so as to have a common axis and the tubular shafts 40 and 42 are located so as to also extend along this axis from the extremities of the inner shell 52. In order to cause the inner shell to rotate the shaft 42 may be provided with a girt gear 56 which cooperates with a drive pinion in a conventional manner. With this arrangement the shells 24 and 52 may be rotated at different angular velocities.

The outer shell 24 has its ends enclosed by means of end plates 58 and 60. End plate 58 is provided with a centrally located opening 62 which is spaced from the tubular shaft 42 by means of a sleeve bearing 64 interposed between the tubular shaft and an inwardly turned flange 65 on the end plate 58. The end plate 60 is provided with a larger central opening 66 which is spaced from the tubular shaft 40 a sufficient distance so as to allow passage of a conveyor tube 68 past the tubular shaft 40 to the interior of the outer shell, 24. This conveyor tube is utilized to charge the interior of the outer shell with material 70 to be pulverized and a supply of grinding balls 72. Such material and grinding balls may be supplied to the conveyor tube in any number of conventional manners such as by means of an attached hopper which is in turn supplied from a belt type conveyor. To prevent passage of finely ground material to the sleeve bearing 64 a closely spaced annular cover 74 is attached to the flange 46 on the end plate 50 of the inner shell 52 and disposed to extend over the inwardly turned flange 65 on the end wall 58 of the outer shell 24. This outer shell 24 is further defined by a plurality of radially disposed lifter vanes 76, as shown more clearly in FIG. 4, that are evenly spaced perpendicularly inwardly from the end plate 58. The lifter vanes 76 extend between the outer cylindrical wall 78 of the shell 24 to an annular conically shaped barrier 80 integrally attached to both the vanes 76 and the end plate 58. A scoop feeder rotating with the inner mill could be substituted for the lifter vanes 76. The lifter vanes 76 are covered by a screen plate 82 which is annular in shape and is secured at its outer edge to the wall 78 and closely clears the cylindrical wall 54 of the shell 52 at its inner edge. To withstand the abuse inflicted by the tumbling balls 72 and material 70 the interior of the cylindrical wall 78 is lined with a durable abrasive resistant wear plate or liner 84.

The inner shell 52 further comprises a dividing screen plate 86 located adjacent the end plate 48. Lifter vanes 88 similar to the lifter vanes 76 are radially disposed in the space between the end plate 48 and dividing screen plate 86 and secured thereto as shown in FIG. 3. The spaces 90 between the lifter vanes 88 communicate through openings 92 in the end of the tubular shaft 40 to a screw flight 94 fixedly secured within the tubular shaft 40. In order to prevent damage to the exterior of the inner shell 52 another abrasive resistant wear liner 96 is preferably located completely around its exterior. A further liner 98 of the same character is preferably located with the interior of the inner shell 52. These liners 96 and 98 as well as the liner 84 may be secured in place in accordance with conventional practice by means of bolts or other type fasteners which are recessed so that there is no danger of the means holding these liners in place becoming inoperative during the operation of the complete ball mill 10.

During the operation of the ball mill 10 preferably grinding balls 72 or media of different sizes are located within the interior of each of the shells 24 and 52. Also during the operation of this ball mill 10 material to be

ground is supplied along with replacement grinding balls through the supply or feed conveyor tube 68 to the interior of the outer shell 24 as shown by the arrow 100. As the two shells 24 and 52 are simultaneously rotated the charge of material in the outer shell 24 will become crushed and abraded to fine enough consistency to pass through the mesh of the screen plate 82 as indicated by the arrows 102 where the rotation of the lifter vanes 76 will pick up the finely divided material and cause it to fall by gravity at the top of the cycle against the end plate 50 of the inner shell 52 and pass in the direction of the arrow 104 through mesh holes provided in the plate 50 to the interior of the inner shell 52. The material at this stage will be of rather coarse grade. When within the inner shell 52 the material will be further pulverized by the crushing and grinding action of the grinding balls contained therein to a much finer grade. As the material becomes sufficiently pulverized it will pass through the mesh of the divider screen 86 in the direction of arrow 106 and be picked up by the rotating lifter vanes 88. As the vanes 88 rotate past the top of their cycle the finely divided material will fall by gravity as indicated by the arrow 108 onto the screw flight which is attached to and rotating with the tubular shaft 40. The action of the screw flight 94 will convey the finely divided material through the tubular shaft 40 in the direction of the arrow 110. The tubular shaft 40 may be directed to another treatment stage either directly or by means of a conventional conveyor not shown.

In utilizing the ball mill 10 in the manner described relatively coarse grinding is accomplished in the area between the inner and outer shells 52 and 24, respectively, and finer grinding is accomplished within the inner shell 52. Because of this, in order to promote grinding efficiency it is considered preferable to utilize larger particles for grinding operations or as a grinding media in the outer shell 24 than in the inner shell 52. Also the openings in the screen 82 are preferably of larger dimension than the openings provided in the divider screen 86 within the inner shell 24. It is to be pointed out that the supply of grinding balls or media within the inner shell 24 may be conventionally supplied through the interior of the tubular shaft 42 as indicated by the arrow 112. Normally, in the operation of this ball mill, there is no significant problem in the structure shown of particles of grinding media becoming lodged between close fitting relatively moving parts, such as between the screen 82 and liners 96 and 84, because the rotation of the mill will tend to throw out any particles which will tend to become so lodged. Also the spacing between adjacent parts is preferably significantly greater than the larger dimensions of any particles of materials pulverized so as to negate any reasonable danger of the material or grinding media becoming jammed therebetween in such a manner as to impede the normal rotation of the shells 24 and 52.

In order to facilitate the flow of material through the ball mill, if desired the axis of the two shells can be canted in the direction of desired flow to a slight degree. Such an arrangement is shown diagrammatically in the embodiment of this invention shown in FIG. 5. If such canting is effected, it will of course, be necessary to cut the angles of the support rollers 22 to maintain the desired position of the ball mill with respect to these roller supports. As shown in FIG. 5, the ball mill 118 is diagrammatically shown with the axis 120 of the outer shell 122 canted downwardly to the right and the direction of the axis 124 of the inner shell 126 canted downwardly to the left. It is to be understood that otherwise the construction of the embodiment of the ball mill 118 is the same as the ball mill 10 and the operation of each ball mill 10 and 118 is the same as described in conjunction with the ball mill 10.

FIGS. 6–8 show still another embodiment of a ball mill 200 falling within the scope of the present invention.

The ball mill 200 differs from the ball mills 10 and 118,

previously described, in that it comprises two separate ball mills that are independently supplied with charges of raw material to be ground and supplies of grinding balls or pebbles. This embodiment comprises the same support arrangement including the members **14** and drive gear **56** for the inner shell member **202**, and the same drive gear **28** and supporting rollers and guide tracks **26** are utilized to support and drive the outer shell **204**. Also, the same bearing shells **34** are utilized to support the tubular shafts **40** and **42** of the inner shell **202**. Essentially, the inner shell **202** differs from the shell **52** of the ball mill **10** in that it is provided with a solid entrance end plate **206** which is provided with a central opening communicating with the entrance tubular shaft **42** that is utilized to supply both raw material to be ground and grinding balls to the interior of the inner shell **202** in the manner previously described in conjunction with the ball mill **10**. Otherwise, the inner shell **202** is of the same construction as that of ball mill **10** as represented by the common reference characters shown in FIG. 6.

The outer shell of the ball mill **200** is similar to the outer shell **24** of the ball mill **10** shown in FIGS. 1–4 as represented by the common reference characters. However, the outer shell **204** includes a scoop feed assembly **208** and a separate discharge assembly **210**. The scoop feed assembly **208** comprises a truncated conical extension **212** on a solid end wall **214** which includes a rotatable connection **216** with the tubular shaft **42** of the inner shell **202**. This scoop feed assembly includes a tubular scoop extension **218** having an open end **220** disposed in a raw material and grinding ball housing **222** which is supplied with raw material and grinding balls through an input conduit **224**. The housing **222** is suitably supported in a fixed position on a support beam **226**. With this arrangement raw material and grinding balls or pebbles entering the housing **222** through the input conduit **224** are scooped up by the scoop **218** as the outer shell is rotated whereby they are led by the conical shape of the extension **212** to the interior of the outer shell **204**.

The discharge assembly **210** of the outer shell **204** comprises an interior end screen **230** and lifters **232** similar to those utilized in the outer shell **24** of the ball mill **10** and a conical discharge extension **234** which communicates with a stationary collector housing **236** that is provided with a discharge conduit **238**.

By virtue of the above arrangement, the ball mill **200** can be utilized to grind separate raw materials in the two shells **202** and **204** or the material discharged from the larger mill shell **204** can be led from the discharge conduit **238** to the input conduit **42** of the smaller mill shell **202** for further reduction in particle size.

It has been found that when the inner and outer shells of the ball mills **10**, **118** and **200** are driven in reverse rotary directions that an unexpected advantage is realized in that the grinding balls or pebbles of the outer shells of these mills are randomly scattered along with the material being ground in such a manner as to vastly improve the grinding efficiency of the outer shells. However, if desired the inner and outer shells of these ball mills may be rotated in the same direction.

Another embodiment is shown in FIGURE 9 where the ball mill **300** has an outer shell **302** rotatably mounted on support rollers **22** and driven by ring gear **32** as is described hereinbefore. Contained within the outer shell **302** is an inner shell **304** which is supported on shafts **306** and **308** which in turn are supported in the pedestal bearings **34**. Shaft **306** carries the drive gear **56** for rotation of the inner shell **304**. The inner shell **304** is supported on the shafts **306** and **308** by means of spiders **310** and **312** so that material may enter through spider **312** from loading chute **314** and may pass out through spider **310** after passing screen **316**. The inner shell **304** is provided with wear resistant lining and covering **318** and **320**, respectively.

After the material is preliminarily ground in the inner mill **304** by being rotated with grinding balls or the like, it passes through screen **316**, spider **310**, and is gravity discharged into the inside of outer shell **302**. Outer shell **302** is provided with a wear resistant lining **322**. After the material is ground even more finely within the outer shell **302**, it is discharged through a screen **324**. After discharge it may be picked up by lifting vanes, or scoop means and discharged into an outlet conveyor as is hereinbefore disclosed.

From the foregoing it is apparent that new ball mill devices have been provided which by virtue of the flow of material to be ground into the outer shells and thence to the inner shells, in the case of the ball mills **10** and **118** and if desired in the ball mill **200**, so as to effect a much higher efficiency than other types of unitary ball mill constructions. It is also to be realized that the ball mills disclosed above also effect higher operating efficiencies when the inner and outer shells are rotated in opposite directions of rotation.

It will be realized by those skilled in the art to which this invention pertains that by ordinary skills a variety of differently appearing ball mill constructions may be designed and constructed utilizing the features of the invention as embodied in the above described example of the device of this invention. Accordingly, since the structures of this invention are susceptible to such modification the invention is to be considered as being limited only by the appended claims.

I claim:

1. A ball mill which includes:
first and second ball mill shells having different diameters, each of said shells having an axis, said shells being located concentrically about the same axis, the interior of the larger of said shells being spaced from the exterior of the other of said shells;
means for turning said shells independently of one another;
means for introducing material to be ground into the outer of said shells;
means for introducing ground material from the outer of said shells into the inner of said shells; and
means for removing the ground material from the inner of said shells.

2. A ball mill as defined in claim 1 wherein:
the axis of the said first ball mill shell and the axis of said second ball mill shell are canted in opposite directions to facilitate the flow of material through said shells.

3. A ball mill as defined in claim 1 wherein:
said means for turning said shells functions to turn said shells in the same direction of rotation.

4. A ball mill as defined in claim 1 wherein:
said means for turning said shells functions to turn said shells in opposite directions of rotation.

5. A ball mill as defined in claim 1 wherein:
said means for turning said shells functions to turn said shells at the same angular velocity.

6. A ball mill as defined in claim 1 wherein:
said means for turning said shells functions to turn said shells at different angular velocities.

7. A ball mill as defined in claim 6 wherein:
the smaller of said shells is turned by said means for turning said shells at a faster angular velocity than the angular velocity of said larger of said shells.

8. A ball mill which includes:
first and second cylinders having different diameters, said cylinders being concentrically located about the same axis;
means for turning said cylinders independently of one another;
means for introducing material to be ground into the outer of said cylinders;
means for introducing ground material from the outer of said cylinders into the inner of said cylinders; and
means for removing ground material from the inner of said cylinders.

9. A ball mill as defined in claim 8 wherein:
the axes of said first and second cylinders are canted in different directions to facilitate the flow of material through said cylinders; and
said means for turning said cylinders functioning to turn said cylinders in opposite directions of rotation and wherein the angular velocities of said cylinders are different.

10. A ball mill which includes:
rotable support means;
a first cylindrical mill rotatably mounted about a horizontal axis on said rotable support means;
bearing means;
a second cylindrical mill rotatably mounted about said horizontal axis on said bearing means, said second cylindrical mill being of smaller diameter than said first cylindrical mill and being located within the interior of said first cylindrical mill;
means for introducing material to be ground into the interior of said first cylindrical mill;
means for conveying ground material from the interior of said first cylindrical mill into the interior of said second cylindrical mill;
means for conveying ground material from the interior of said second cylindrical mill to the exterior of said ball mill;
first means for rotating said first cylindrical mill around about its axis; and
other means for rotating said second cylindrical mill about its axis independently of said first means within the interior of said first cylindrical mill.

11. A ball mill which includes:
first and second ball mill shells having different diameters, each of said shells having an axis, said shells being located concentrically about the same axis with the first shell located within the second shell and wherein the exterior of the first shell is spaced from the inner wall of the second shell;
means for rotating said shells independently of one another;
separate means for introducing raw material to be ground and grinding media separately into each of said shells; and
separate discharge means for separately discharging ground raw material from each of said shells.

12. A ball mill as defined in claim 11 wherein:
said means for rotating said shells independently of one another operates to rotate said shells in opposite directions of rotation.

13. A ball mill as defined in claim 11 wherein:
said means for rotating said shells independently of one another operates to rotate said shells in the same direction of rotation.

References Cited in the file of this patent

UNITED STATES PATENTS

1,520,537 De Markus ---------- Dec. 23, 1924
1,710,659 Griesen ---------- Apr. 23, 1929