Nov. 27, 1928. 1,692,974

W. M. BARKER

BALANCED BALL MILL

Filed Sept. 1, 1926 5 Sheets-Sheet 1

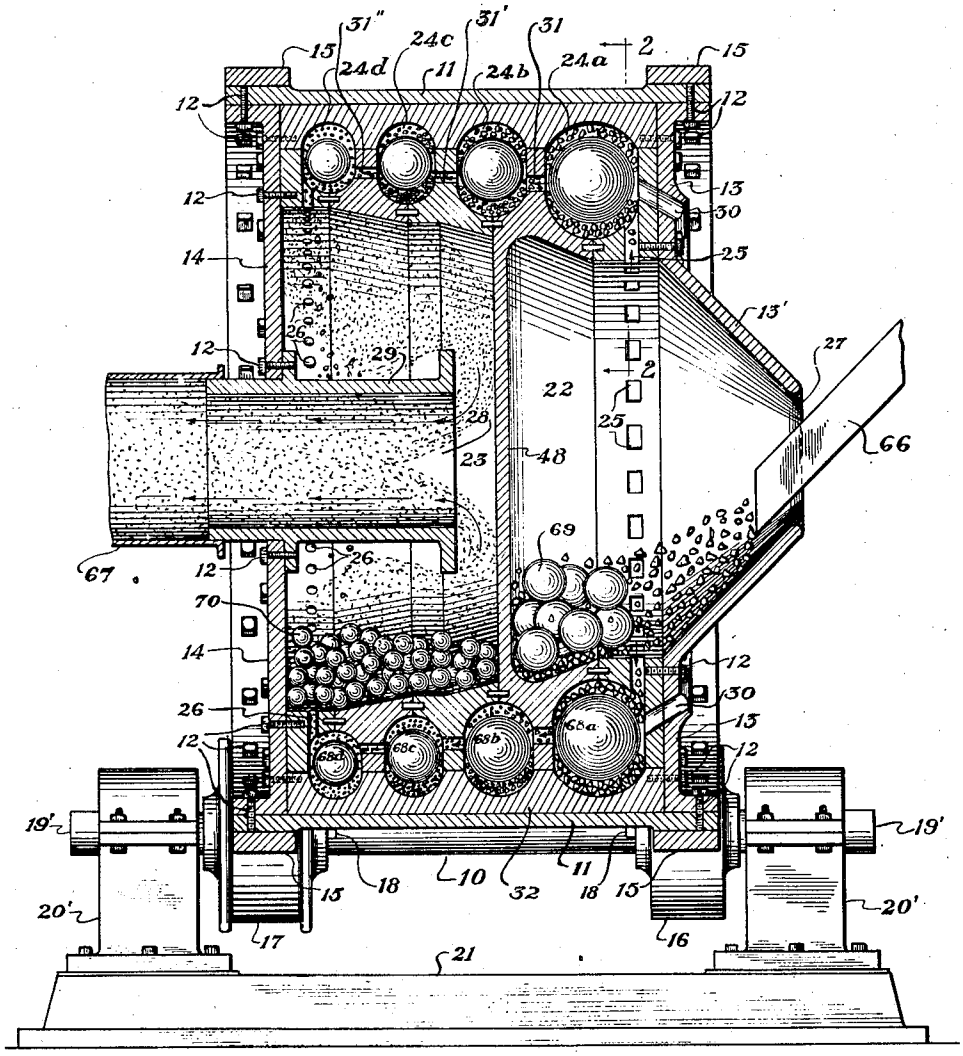


Fig. 1

Inventor

William M. Barker

By Treask and Bond

Attorneys

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W. M. BARKER

BALANCED BALL MILL

Filed Sept. 1, 1926 5 Sheets-Sheet 2

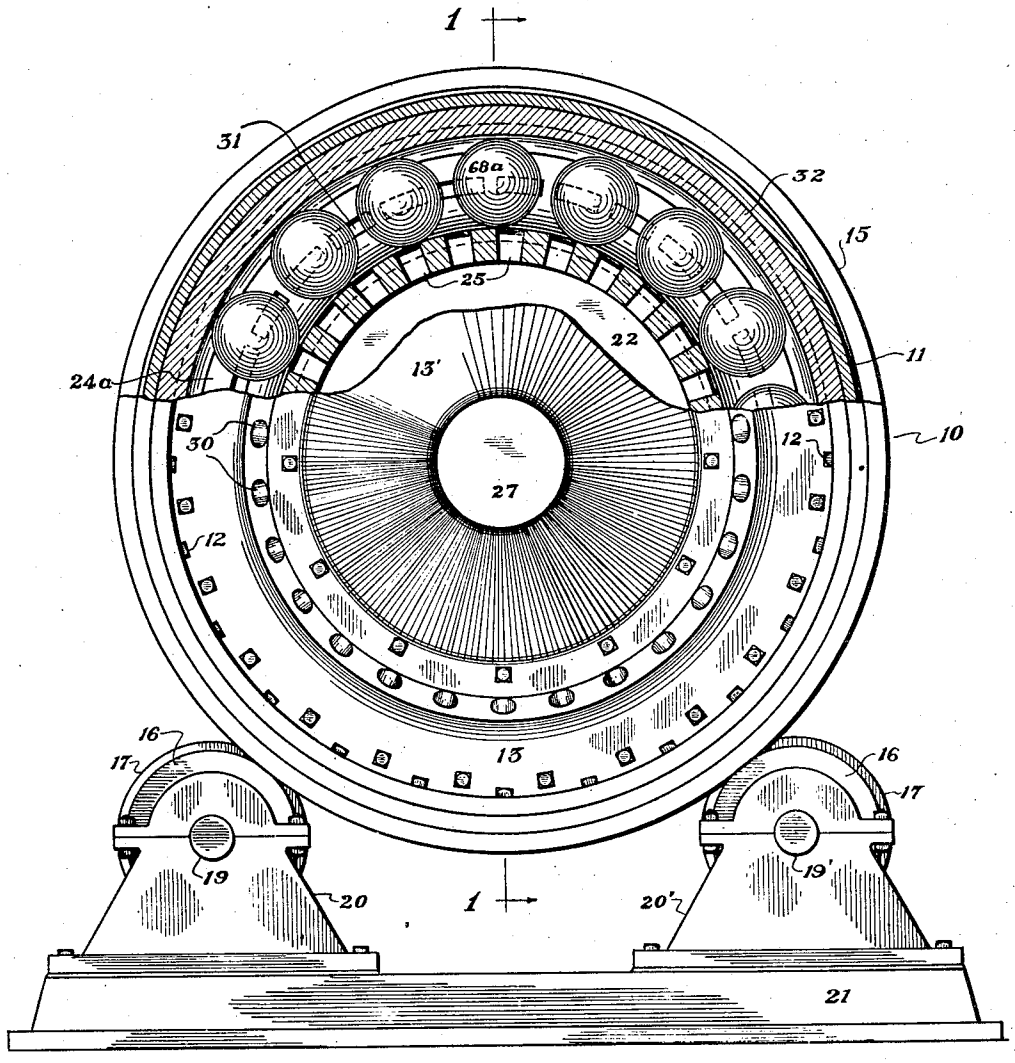


Fig. 2

Inventor

William M. Barker

By Fraser and Bond

Attorneys

Nov. 27, 1928. 1,692,974

W. M. BARKER

BALANCED BALL MILL

Filed Sept. 1, 1926 5 Sheets-Sheet 3

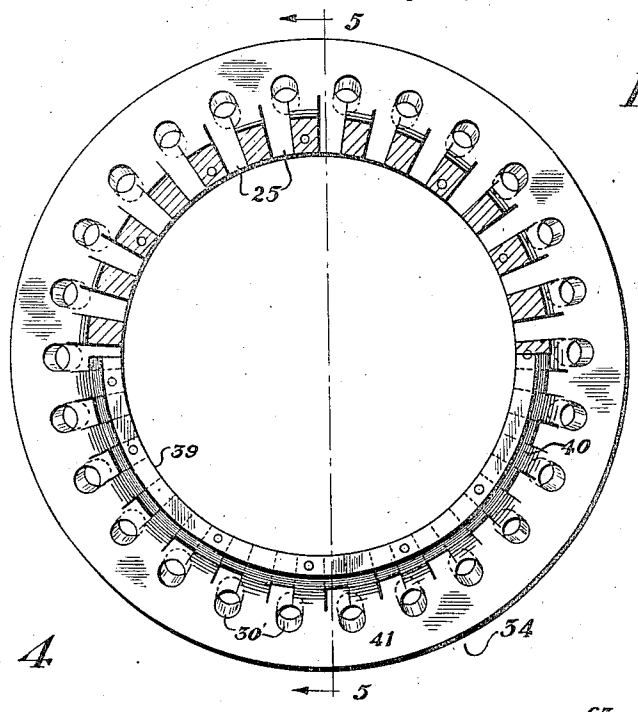


Fig. 4.

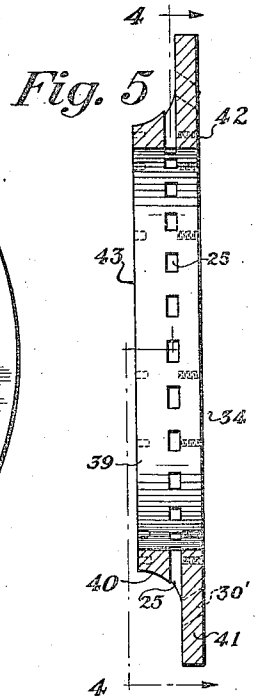


Fig. 5

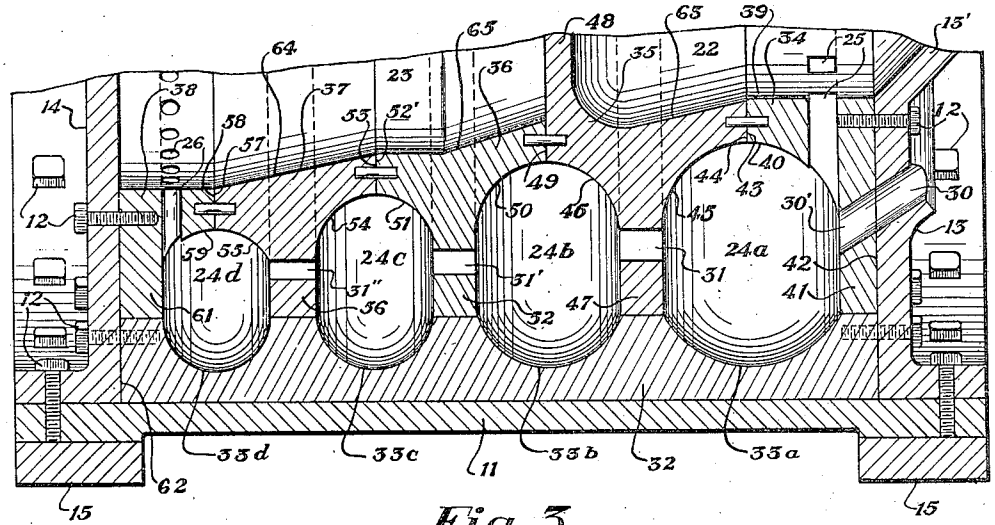


Fig. 3

Inventor

William M. Barker.

By Dreas and Bond

Attorneys

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W. M. BARKER

BALANCED BALL MILL

Filed Sept. 1, 1926 5 Sheets-Sheet 4

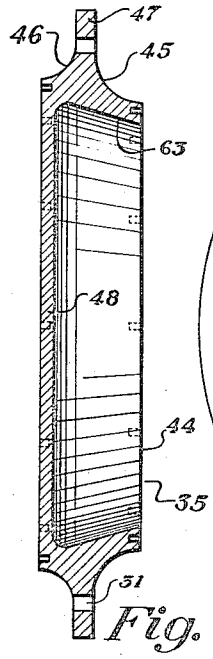


Fig. 7

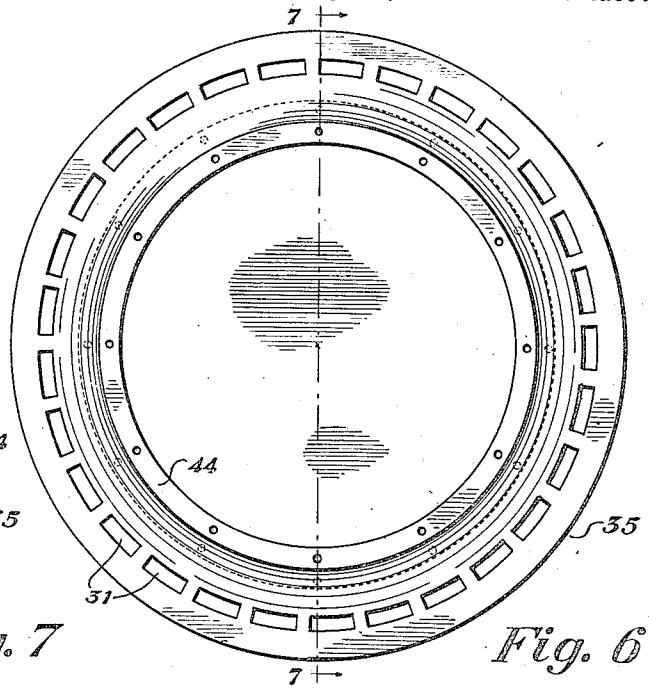


Fig. 6

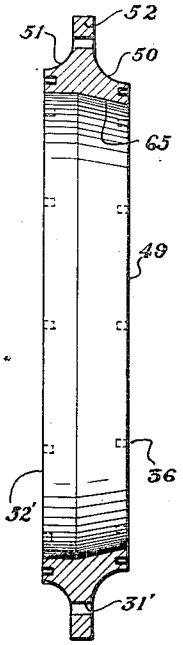


Fig. 9

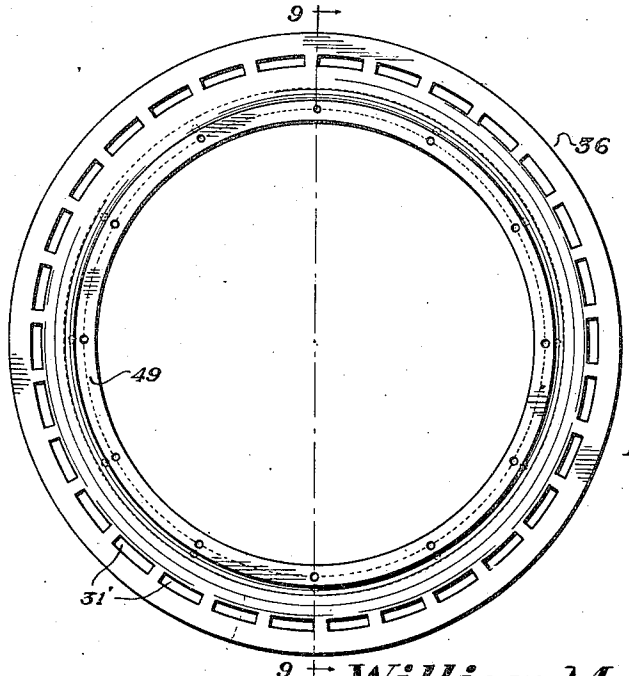


Fig. 8

Inventor

William M. Barker.

By Treat and Boud

Attorneys

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W. M. BARKER

BALANCED BALL MILL

Filed Sept. 1, 1926 5 Sheets-Sheet 5

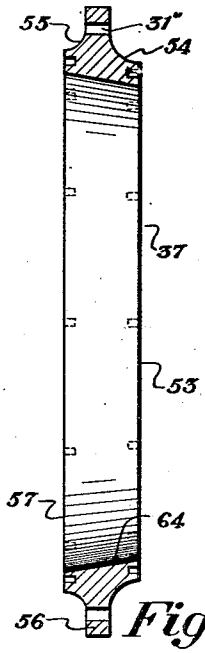


Fig. 11

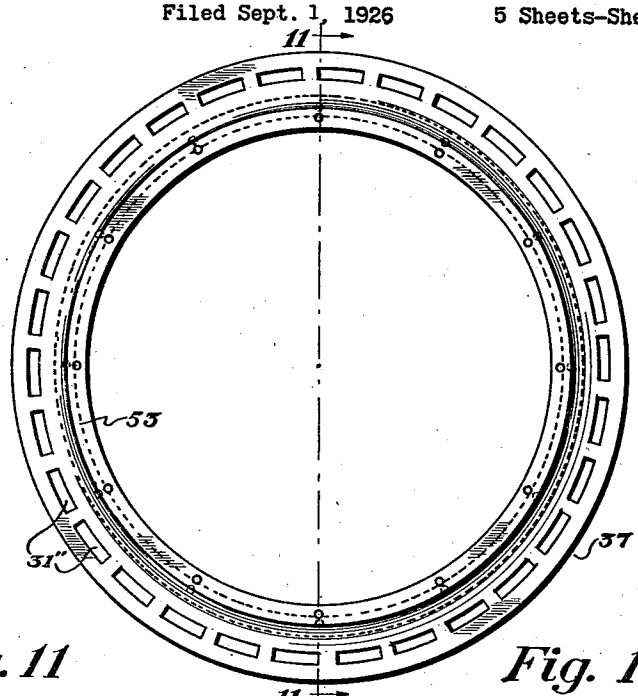


Fig. 10

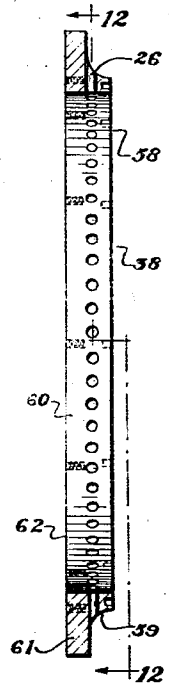


Fig. 13

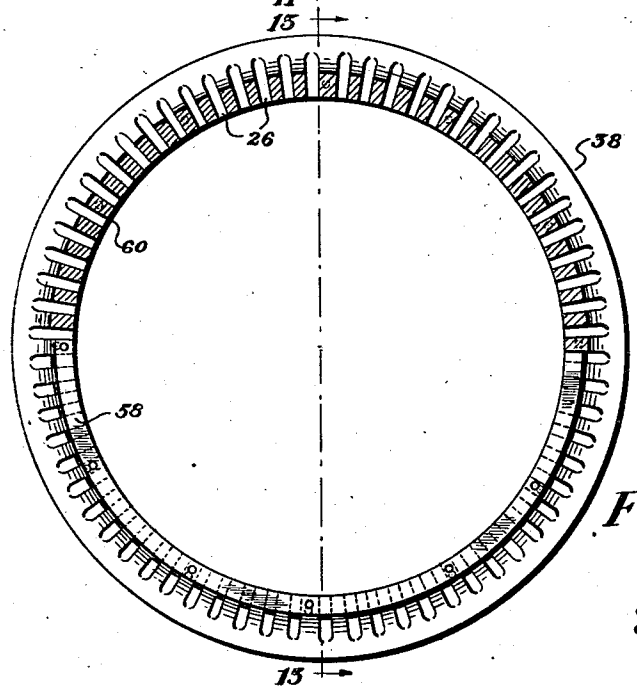


Fig. 12

Inventor

William M. Barker.

By Fraser and Bond

Attorneys

Patented Nov. 27, 1928. 1,692,974

UNITED STATES PATENT OFFICE.

WILLIAM M. BARKER, OF CANTON, OHIO.

BALANCED BALL MILL.

Application filed September 1, 1926. Serial No. 132,987.

The invention relates to ball mills preferably of the horizontal rotating type for use in grinding and pulverizing materials in the chemical, mineral, and metallurgical industries, and the like.

In my prior U. S. patent for balanced ball mills, No. 1,594,990, dated August 3, 1926, I disclose an improved construction and arrangement for a horizontal rotating ball mill which may be used to grind or pulverize material, either in a dry or wet state, and provided with means for approximately balancing the ball load of the mill by maintaining a nearly equal weight of balls on each side of the mill drum axis, and adapted for grinding material passing from the mill feed chamber to the discharge chamber by true rolling action and attrition between freely moving means, as balls and the like, and hard metal tracks, and the tracks being shaped to form continuous ball race annular grinding chambers entirely around the shell of the mill drum, and there being means for keeping the balls in these peripheral grinding chambers and away from the axial part of the drum, and there being means as an air suction draft, for positively forcing material being processed through the mill to pass in succession between the entire series of balls and ball tracks.

The objects of the present invention are in general to provide improvements in the construction and arrangement of the balanced ball mill of my prior patent; and, specifically, are:

First, to provide auxiliary air inlets for the annular grinding chambers in addition to the material inlets therefor;

Second, to provide a plurality of ball race annular grinding chambers for the mill, and intervening partitions between the chambers, and a plurality of ports in each of the several partitions communicating between adjacent annular grinding chambers, the several annular grinding chambers being of different sizes and preferably successively decreasing in size from the feed end to the discharge end of the mill, and the several different size annular grinding chambers having sets of grinding means as balls and the like therein, and the balls of a set in one chamber differing in size from the balls in a set in another chamber, and the size of the ports in the several partitions likewise differing from each other;

Third, to provide deflecting means in the discharge chamber of the mill preventing any tramp or oversize material which may have accidentally passed through the annular grinding chambers from being immediately drawn out of the mill through its discharge orifice without being subject to the final grinding action of the grinding means as balls preferably provided in the discharge chamber of the mill.

Fourth, to provide means for increasing the useful life of the grinding means such as balls, by utilizing the balls successively, as their diameters are reduced by wear, in annular grinding chambers of successively reduced size.

A preferred embodiment of the invention is illustrated in the accompanying drawings forming part hereof, in which—

Figure 1 is a longitudinal vertical axial cross-section of one form of the improved balanced ball mill as on line 1—1, Fig. 2;

Fig. 2, an end elevation thereof, portions of the mill drum being shown in section as on line 2—2, Fig. 1;

Fig. 3, a detached fragmentary enlargement of the lower portions of the mill drum of Fig. 1, the grinding balls being removed;

Fig. 4, a detached detail elevation view of the first and feed end liner ring, portions being shown in section as on line 4—4, Fig. 5;

Fig. 5, a cross-section thereof as on line 5—5, Fig. 4;

Fig. 6, a detached detail elevation view of the second liner ring;

Fig. 7, a cross-section thereof as on line 7—7, Fig. 6;

Fig. 8, a detached detail elevation view of the third liner ring;

Fig. 9, a cross-section thereof as on line 9—9, Fig. 8;

Fig. 10, a detached detail elevation view of the fourth liner ring;

Fig. 11, a cross-section thereof as on line 11—11, Fig. 10;

Fig. 12, a detached detail elevation view of the fifth and discharge end liner ring, portions being shown in section as on line 12—12, Fig. 13; and

Fig. 13, a cross-section thereof as on line 13—13, Fig. 12.

Similar numerals refer to similar parts throughout the several figures of the drawings.

The improved balanced ball mill indicated generally at 10, includes an outer drum shell 11, secured as by cap screws 12 to the preferably flanged and orificed feed head 13 and

discharge head 14 to form a preferably cylindric outer drum case for the ball mill.

Preferably at its ends, the shell 11 is provided with tires 15 for riding upon the carrying rolls 16 and the flanged carrying and thrust rolls 17, one carrying roll 16 and one carrying and thrust roll 17 being secured as by tapered keys 18 upon each of a pair of longitudinally extending and laterally spaced shafts 19 and 19′, and the shafts 19 and 19′ are journalled respectively in suitable bearing blocks 20 and 20′ mounted upon a suitable base 21.

One of the shafts, as the shaft 19, may be extended beyond one of its bearing blocks for connection with a suitable motor or the like, not shown, for rotating the shaft, to provide a friction drive for rotating the cylindric shell 11 and connected parts.

The outer shell 11 and the heads 13 and 14 form a cylindric chamber in which are located walls forming a feed chamber 22, a discharge chamber 23, and a plurality of ball race annular grinding chambers 24^a, 24^b, 24^c, and 24^d, a plurality of inlet ports 25 communicating between the feed chamber 22 and the first annular grinding chamber 24^a, and a plurality of outlet ports 26 communicating between the last annular grinding chamber 24^d and the discharge chamber 23.

The feed head 13 is preferably provided with an outwardly projecting central conical extension 13′, having a preferably axial feed orifice 27 therein for providing entrance for material to be ground into the feed chamber of the mill.

The discharge head 14 is likewise provided with a preferably axial discharge orifice 28 located and secured as by cap screws 12, in the head 14 and preferably consisting of a flanged discharge orifice deflector tube 29 longitudinally extending into the discharge chamber 23 for a purpose to be hereinafter set forth in detail.

For providing auxiliary air inlets to the annular grinding chambers, a plurality of preferably angled air inlet ports 30 are peripherally spaced and located in the feed head 13 and communicate through the walls thereof with the annular grinding chamber 24^a.

The several annular toroidal grinding chambers 24^a, 24^b, 24^c, and 24^d are all preferably of different sizes or volumes, and preferably decrease in size from the feed end of the mill to the discharge end; that is to say, chamber 24^b is smaller than chamber 24^a, chamber 24^c is smaller than chamber 24^b, and chamber 24^d is smaller than chamber 24^c.

In the partition wall separating annular grinding chamber 24^a from the adjacent grinding chamber 24^b, a plurality of communicating side ports 31 are located and provide communication between the chambers 24^a and 24^b.

Likewise communication between the chambers 24^b and 24^c, and 24^c and 24^d, are provided by side ports 31′ and 31″ located in the partition walls separating the respective chambers.

The area of the ports 31 communicating between chambers 24^a and 24^b, is preferably larger than the area of the ports 31′ communicating between the chambers 24^b and 24^c, and the area of ports 31″ communicating between the chambers 24^c and 24^d may be likewise smaller than the area of the ports 31′.

While the aforesaid feed chamber, discharge chamber, annular grinding chambers, and the inlet, outlet, auxiliary air inlet, and communicating ports therefor, may be formed by walls of any desired construction having the general outline indicated, a preferred construction and arrangement for forming the chambers and ports includes an outer cylindric liner 32 having its outer surface fitting and abutting the inner surface of the shell 11, and being preferably secured to the heads 13 and 14 as by cap screws 12.

The liner 32 is provided with annular grooves 33^a, 33^b, 33^c, and 33^d forming the outer walls of the annular chambers 24^a, 24^b, 24^c and 24^d respectively, and outer ball race tracks therein.

The remaining walls of the chambers are formed by liner rings 34, 35, 36, 37 and 38, carrying the inlet, outlet, communicating and auxiliary air inlet, ports therein as hereinafter described in detail.

The liner ring 34 is provided with the peripherally spaced and radially extending inlet ports 25 for communicating between the feed chamber 22 and the first grinding chamber 24^a. The ports 25 extend from the inner cylindric peripheral face 39 of the ring 34 to a peripheral side groove 40 in the outer peripheral face of the ring.

The side grooved outer peripheral face of the ring 34 extends outwardly at the feed end side of the ring to form a laterally extending ring flange 41, whose outer surface fits against the inner surface of the filler 32 at the feed end side of the first peripheral groove 33^a therein.

The feed end face 42 of the ring 34 preferably abuts against the inner surface of the feed head, and the ring 34 is secured to the feed head as by peripherally spaced cap screws 12.

The ring 34 is also provided with a plurality of angled and peripherally spaced apertures 30′ registering with and being extensions of the apertures 30 in the feed head for providing auxiliary air inlets to the annular grinding chamber 24^a. The discharge end face 43 of the ring 34 is adapted to abut with the feed end face 44 of the ring 35.

The ring 35 is also provided with a feed end peripheral side groove 45, a discharge end peripheral side groove 46, and an outwardly ex-

tending peripheral flange 47 between the side grooves, and in which are located the communicating ports 31. The ring 35 is also provided with the transverse, imperforate, disk wall 48 for separating the feed chamber 22 from the discharge chamber 23 and which abuts at its outer peripheral edge with the feed end side face 49 of the ring 36.

The ring 36 is likewise provided with feed end peripheral side groove 50, discharge end peripheral side groove 51, and an outwardly extending peripheral flange 52 between the side grooves, and in which are located the communicating ports 31'. The discharge end side face 52' of the ring 36 abuts with the feed end side face 53 of the ring 37.

The ring 37 is likewise provided with feed end peripheral side groove 54, discharge end peripheral side groove 55, and outwardly extending peripheral flange 56 between the grooves and having located therein the communicating ports 31''. The discharge end side face 57 of the ring 37 abuts with the feed end side face 58 of the ring 38.

The ring 38 is provided with feed end peripheral side groove 59, and the outlet ports 26 extend in the ring 38 from the side groove 59 to the inner cylindric peripheral face 60 of the ring 38.

The side grooved outer peripheral face of the ring 38 extends outwardly at the discharge end side of the ring to form a laterally extending ring flange 61, whose outer surface fits against the inner surface of the filler 32 at the discharge end side of the peripheral groove 33^d therein.

The discharge end face 62 of the ring 38 preferably abuts against the inner surface of the discharge head, and the ring 38 is secured to the discharge head as by peripherally spaced cap screws 12.

The ring 35 is provided with an inner conical peripheral face 63 connecting at the feed end of the ring 35 with the inner cylindric peripheral face 39 of the ring 34, and joining at the discharge end of the ring 35 with the feed end disk face of the wall 48, to form the feed chamber 22.

The discharge chamber 23 is formed by the inner face of the discharge head 14, the inner cylindric peripheral face 60 of the ring 38, the inner conical peripheral face 64 of the ring 37, the cylindric and conical peripheral face 65 of the ring 36, and the discharge end disk face of the wall 48.

In operating the improved balanced ball mill herein set forth, material to be ground is first fed into the feed head orifice 27 as from a chute 66.

The discharge orifice tube 29 is connected as by duct 67 with an exhauster, not shown, which sets up a suction draft crosswise of the annular grinding chambers 24^a, 24^b, 24^c, and 24^d, by drawing air into the first grinding chamber 24^a through the peripherally spaced auxiliary air inlets 30 and the feed inlet ports 25, thence from the chamber 24^a into the chamber 24^b through the ports 31, thence from the chamber 24^b into the chamber 24^c through the ports 31', thence from the chamber 24^c into the chamber 24^d through the ports 31'', thence from the chamber 24^d into the discharge chamber 23 through the outlet ports 26, and finally from the discharge chamber into the discharge orifice 28.

The air thus drawn cross-wise through the annular grinding chambers of successively decreasing size or volume, draws with it through the inlet ports 25, and thence through grinding chambers and into the discharge chamber the material which has been fed into the feed chamber.

The mill drum case being rotated, the material thus drawn by the suction draft through annular grinding chambers is subject in the grinding chambers to the grinding action of the successive sets of grinding means such as balls 68^a, 68^b, 68^c, and 68^d, located respectively in and substantially filling the annular grinding chambers 24^a, 24^b, 24^c, and 24^d.

The balls 68^a of the set in the first chamber 24^a are preferably the largest and heaviest of the balls of any of the sets, and a substantial portion of the total grinding action of the mill is accomplished by the balls 68^a rolling against the track groove faces of the chamber 24^a.

The successive sets of balls 68^b, 68^c, and 68^d, are all preferably successively smaller in size and weight than the next preceding set, and subject the material passing between them and track groove faces of their respective grinding chambers 24^b, 24^c, and 24^d, with a successively decreasing grinding action.

A relatively few medium size balls 69 are preferably placed in the feed chamber 22 for the purpose of breaking up oversize pieces in the feed too large to pass through the inlet ports 25.

A relatively few small balls 70 are likewise placed in the discharge chamber 23 for the purpose of grinding to proper size any oversize or "tramp" material that may happen to pass through grinding chambers.

The discharge orifice deflector tube 29 extending into the discharge chamber 23 is for the purpose of deflecting downwards into the discharge chamber any such "tramp" material that may be drawn from the outlet ports 26, and the end of the tube 29 is preferably closely adjacent the wall 48 so that the "tramp" material must be reduced to proper size by the balls 70 before it is drawn into the discharge orifice.

The mill requires no cyclone or other separator for connection with it for making a uniform grade of ground product or fines. The size of the fines discharged by the mill is governed by the suction and speed of the exhauster fan.

When the balls 68^a, 68^b, and 68^c becomes reduced in size by wear, they may be taken out of their chambers 24^a, 24^b, and 24^c and placed in chambers 24^b, 24^c, and 24^d, respectively, becoming then balls 68^b, 68^c, and 68^d, and the worn out balls 68^d removed from the chamber 24^d may become balls 70 for use in the discharge chamber 23.

I claim:

1. A ball mill and the like including walls forming a feed chamber, a discharge chamber and an annular grinding chamber, a plurality of material inlet ports communicating between the feed chamber and the grinding chamber, a plurality of outlet ports communicating between the grinding chamber and the discharge chamber, a plurality of auxiliary inlet ports in the end wall of the grinding chamber for admitting air and the like thereto, and grinding means as balls and the like movable in the grinding chamber for grinding material passing therethrough.

2. A ball mill and the like including rotatable walls forming a feed chamber, a discharge chamber and an annular grinding chamber, a plurality of material inlet ports communicating between the feed chamber and the grinding chamber, a plurality of outlet ports communicating between the grinding chamber and the discharge chamber, a plurality of auxiliary inlet ports in the end wall of the grinding chamber for admitting air and the like thereto, and grinding means as balls and the like movable in the grinding chamber for grinding material passing therethrough.

3. A ball mill and the like including horizontally rotatable walls forming a feed chamber, a discharge chamber and an annular grinding chamber, a plurality of material inlet ports communicating between the feed chamber and the grinding chamber, a plurality of outlet ports communicating between the grinding chamber and the discharge chamber, a plurality of auxiliary inlet ports in the end wall of the grinding chamber for admitting air and the like thereto, and grinding means as balls and the like movable in the grinding chamber for grinding material passing therethrough.

4. A ball mill and the like including walls forming an annular grinding chamber, a plurality of material inlet ports for the chamber, and a plurality of auxiliary inlet ports in the end wall of the chamber for admitting air and the like thereto.

5. A ball mill and the like including walls forming an annular grinding chamber, a plurality of material inlet ports for the chamber, and a plurality of auxiliary inlet ports in the end wall of the chamber for admitting air and the like thereto, and grinding means as balls and the like movable in the grinding chamber for grinding material passing therethrough.

6. A ball mill and the like including walls forming a plurality of toroidal grinding chambers, inlet ports, outlet ports and communicating ports therefor, and one of the chambers having a different volume than another chamber.

7. A ball mill and the like including walls forming a plurality of toroidal grinding chambers, inlet ports, outlet ports and communicating ports therefor, and successive chambers having successively different volumes.

8. A ball mill and the like including walls forming a plurality of toroidal grinding chambers, inlet ports, outlet ports and communicating ports therefor, one of the chambers having a different volume than another chamber, and grinding means as balls and the like movable in the grinding chambers for grinding material passing therethrough.

9. A ball mill and the like including walls forming a plurality of toroidal grinding chambers, inlet ports, outlet ports and communicating ports therefor, successive chambers having successively different volumes, and grinding means as balls and the like movable in the grinding chambers for grinding material passing therethrough.

10. A ball mill and the like including walls forming a plurality of toroidal grinding chambers, inlet ports, outlet ports and communicating ports therefor, one of the chambers having a different volume than another chamber, and a set of grinding means as balls and the like of one size in one grinding chamber, and a set of grinding means as balls and the like of another size in another grinding chamber.

11. A ball mill and the like including walls forming a plurality of toroidal grinding chambers, inlet ports, outlet ports and communicating ports therefor, successive chambers having successively different volumes, and successive sets of grinding means as balls and the like in the successive grinding chambers, the successive sets of grinding means having successively different sizes.

12. A ball mill and the like including walls forming a feed chamber and a discharge chamber, a disk wall separating the feed chamber and discharge chamber, ports communicating between the feed chamber and the discharge chamber, and an outwardly flanged deflector extending into the discharge chamber and ending closely adjacent to the disk wall.

13. A ball mill and the like including walls forming a feed chamber and a discharge chamber, a disk wall separating the feed chamber and discharge chamber, ports communicating between the feed chamber and the discharge chamber, and a tubular deflector extending into the discharge chamber and ending closely adjacent to the disk wall.

14. A ball mill and the like including walls

forming a feed chamber, a discharge chamber and an annular grinding chamber, a plurality of material inlet ports communicating between the feed chamber and the grinding chamber, a plurality of outlet ports communicating between the grinding chamber and the discharge chamber, a plurality of auxiliary inlet ports in the end wall of the grinding chamber for admitting air and the like thereto, and grinding means as balls and the like movable in the grinding chamber for grinding material passing therethrough, and a deflector extending into the discharge chamber.

15. A ball mill and the like including walls forming a feed chamber, a discharge chamber and an annular grinding chamber, a plurality of material inlet ports communicating between the feed chamber and the grinding chamber, a plurality of outlet ports communicating between the grinding chamber and the discharge chamber, a plurality of auxiliary inlet ports in the end wall of the grinding chamber for admitting air and the like thereto, and grinding means as balls and the like movable in the grinding chamber for grinding material passing therethrough, and a tubular deflector extending into the discharge chamber.

In testimony that I claim the above, I have hereunto subscribed my name.

WILLIAM M. BARKER.