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2,398,989

AIR SWEEP BALL MILL SYSTEM

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2 Sheets-Sheet 1

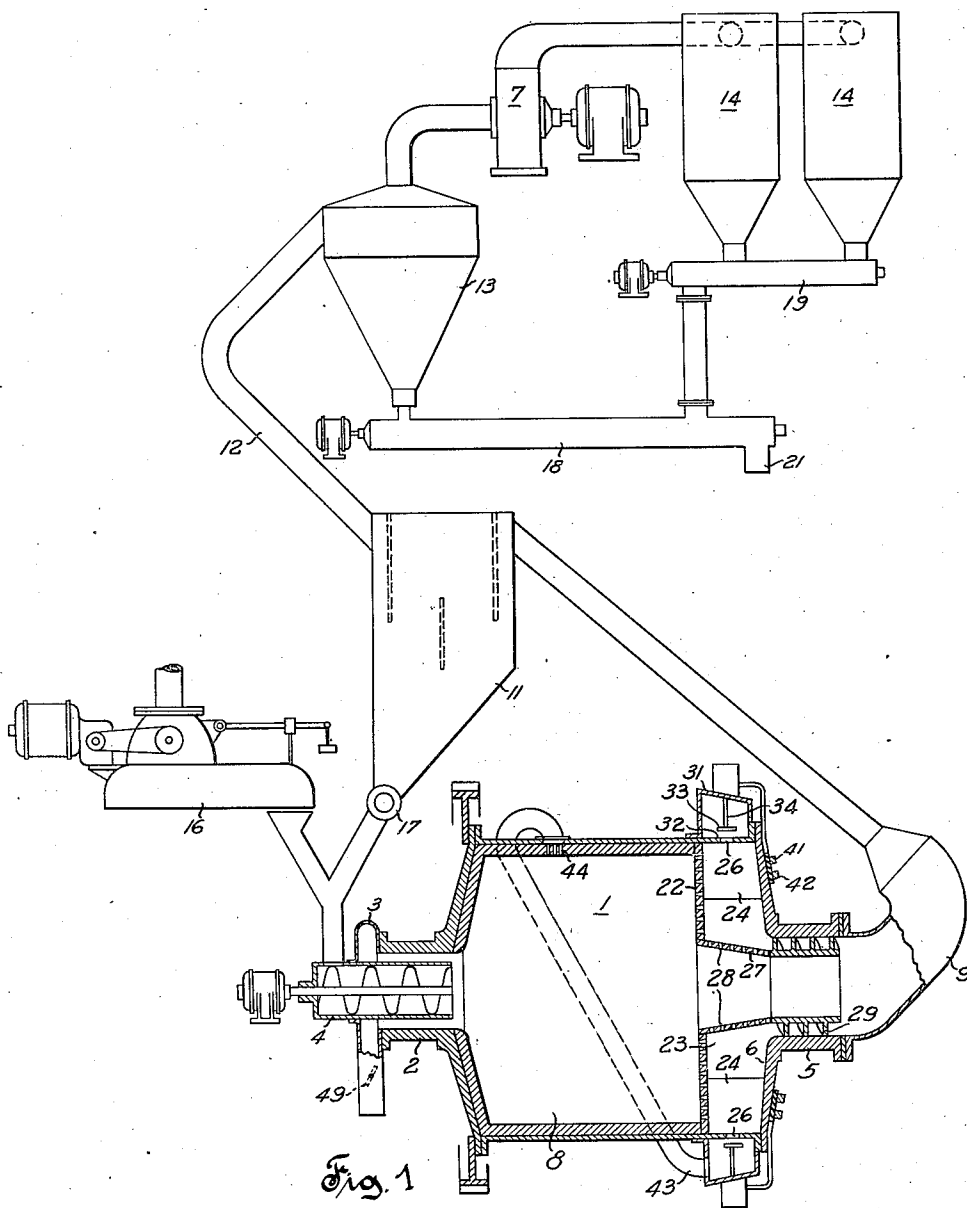


Fig. 1

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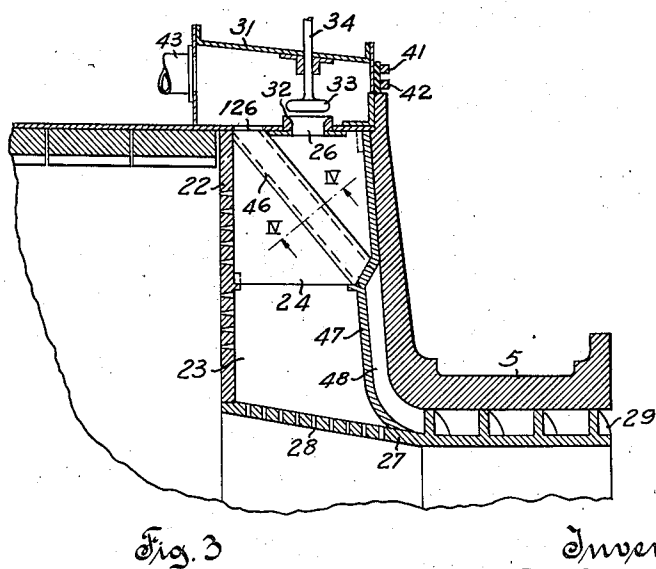
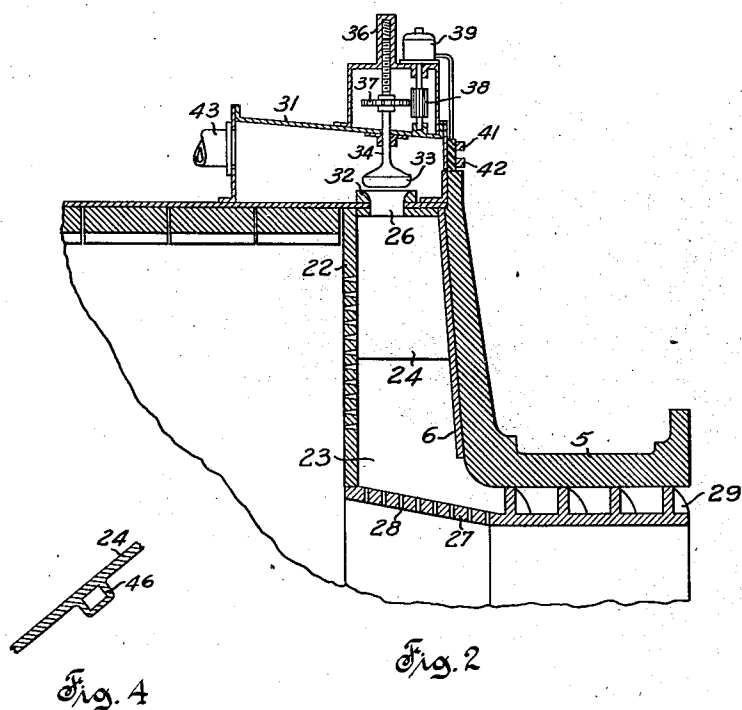
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AIR SWEEP BALL MILL SYSTEM

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2 Sheets-Sheet 2



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AIR SWEEPED BALL MILL SYSTEM

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4 Claims. (Cl. 241—52)

This invention relates to air swept tube and ball mills for dry grinding to obtain a fine product.

Ordinarily material discharged from the mill is a mixture of finished material of the requisite size and coarser insufficiently ground materials. This discharged material is classified or separated into finished product and tailings to be returned to the mill for further grinding.

It is known to carry on a portion of the classification process within the mill by causing the material being ground to fall through a current of air which carries off the finer ground particles.

It is also known to return particles too coarse to be carried by the current of air to the grinding space for further grinding.

This invention concerns a specific internal classifying and discharge chamber construction in which material passes through a grid in the mill into a cascading space, is showered over a coaxial screen and through it into a current of air being drawn axially through the screen.

An object of the invention is to provide for improved classification capacity in an air swept mill.

Another object is to provide a control of coarse material returned to the grinding space from the cascading space.

Still another object is to provide for a return of coarse material settling in an upcast duct to the grinding space through the discharge trunnion but out of contact with the air current in the mill.

Still other objects will be apparent from the following description with reference to the accompanying drawings, in which:

Fig. 1 is largely a diagrammatic view of a dry grinding plant embodying the invention, the mill being shown in longitudinal section;

Fig. 2 is a fragmentary enlarged section of a portion of the mill of Fig. 1;

Fig. 3 is a fragmentary enlarged section similar to Fig. 2 showing a modified form of circulating load control and coarse material return; and

Fig. 4 is a fragmentary cross section taken on line IV—IV of Fig. 3.

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

A rotating mill 1 is provided with a hollow feed trunnion 2 at one end. A controllable stationary fluid inlet hood 3 and a feeder 4 of suitable known construction are arranged to introduce fluid and material to be ground through the trunnion 2. A hollow discharge trunnion 5 on discharge end plate 6 supports the other end of the mill. Trunnions 2 and 5 rest in suitable bearings of any known type (not shown) to support the mill

for rotation. A blower 7 draws air through hood 3, trunnion 2, grinding space 8, trunnion 5, an upcast duct 9, a settling chamber 11, a duct 12, and a cyclone product separator 13, and discharges the air through bag type filters 14 of suitable design which remove any residual product from the blower discharge before releasing the air to the atmosphere. The settling chamber 11, cyclone separator 13, blower 7 and bag type filters 14 may be of any known suitable type and form no part of the present invention. The action of these devices is well known and will be readily apparent to any person skilled in the art.

A constant weight feeder 16 of any suitable known type is arranged to feed raw material to feeder 4, and settled coarse material from settling chamber 11 may be withdrawn through a suitable air seal valve 17 of any known type and transmitted to join the stream of raw material moving to feeder 4. Conveyors 18 and 19 of any known type convey the finished ground product to a product outlet 21.

The invention resides in the internal structure of mill 1 and its relation to upcast duct 9 as hereinafter described.

The ball or tube mill 1 is provided with an annular, foraminous grid or screen 22 axially spaced from the discharge end plate 6 to form a division between the grinding space 8 and a constant discharge chamber or cascading space 23. Lifters 24 of any known suitable type, such as the radial plates shown in the drawings, are spaced around the periphery of the mill between grid 22 and the end plate 6. Openings 26 are provided in the periphery of the mill between the lifters 24 for reasons hereinafter disclosed. A foraminous tubular liner 27 which may be flared or funnel-like as shown is attached at one end to the annular grid 22 adjacent its central opening and extends through trunnion 5 in coaxial, radially spaced relation thereto. The portion of the tubular liner 27 axially within the space 23 is provided with perforations as shown at 28. A helical fin 29 which may be formed integrally with liner 27 is arranged to occupy the space between the inner surface of trunnion 5 and liner 27 to serve as a material conveying means as hereinafter further described. Fin 29 may also support liner 27 within trunnion 5. The pitch and direction of helical fin 29 are so designed as to feed material into the space 23 when the mill 1 is revolving in its normal direction. The stationary upcast duct 9 is arranged to have an area somewhat larger than the discharge end of liner 27,

and to seal in any known manner with the end of rotating trunnion 5.

Surrounding the mill 1 adjacent openings 26 is an annular box or collector 31 secured to the periphery of mill 1. Each opening 26 is provided with a seat 32 for a valve 33, and these seats and valves, or either of them, may be formed of or covered with resilient, tough, wear-resistant material such as rubber. The valve 33 may be carried on a threaded stem 34 passing in sealing relation through the box 31. The stem 34 may engage a stationary, threaded guide or nut 36 and may be provided with any known means for adjustment to variably position valve 33 with relation to its seat 32, such as a gear 37. A pinion 38 may be turned by hand or may be controlled during mill operation by an electric motor 39 mounted on box 31 and energized by connection to slip rings 41 and 42 which may be energized in an obvious manner. A helical conduit 43 connects box 31 with an opening 44 in the mill 1, and communicates with the grinding space 8 for reasons to appear hereinafter.

In the modification shown in Fig. 3 a second set of openings 126 is provided, opening into box 31. Conduits 46, which may be formed integrally with lifters 24 on the trailing sides thereof, connect holes 126 with an annular breast or diaphragm 47 separating the space 23 surrounding the perforated portion of liner 27 within the mill, from a space 48 freely communicating with the annular space between the unperforated portion of the liner 27 and the inner surface of trunnion 5.

The system according to the invention operates as follows:

Constant weight feeder 16 feeds raw material to be ground into mill feeder 4 which conveys the material through trunnion 2 into grinding space 8. Here the material is tumbled about, with or without a charge of steel balls or other grinding media, being comminuted or ground as in known ball and tube mills. As the material reaches grid 22, such material as is fine enough to pass the apertures is passed into space 23. Air or other gaseous fluid medium is drawn into the mill through hood 3. The current of fluid entrains particles in the space 8 which are fine enough to be suspended in the current of fluid and passes at an increased velocity through the central opening of grid 22 and liner 27. A minor flow through the apertures of grid 22, space 23 and perforations 28 may also occur. The mixture of finished and insufficiently ground material passing the apertures of grid 22 into space 23 will be lifted by lifters 24 and showered over the perforated portion of tube or liner 27. Some, particularly the finest of this partially ground material, will be dispersed in streams through the perforations 28 and will fall into the rapid main current of fluid passing through the restricted passage within liner 27. Here the rapidly moving fluid will entrain substantially all sufficiently ground material and carry it out of the mill 1 into upcast duct 9. As the stream changes direction and also is decreased in velocity due to the fact that the area of duct 9 is larger than that of liner 27, some coarser material will settle in duct 9 and tend to build up at the joint with trunnion 5. Material gathering here will be conveyed by the helical fin 29 back to space 23.

From space 23 a portion of the partially ground material will pass through openings 26 into box 31 and be conveyed through conduit 43 and opening 44 back to the grinding space 8 for further grinding. The amount of the circulating load

passing openings 26 can be controlled according to the invention by adjustment of valves 33. Such control will cause more or less material to be carried in the cascading space or constant discharge chamber 23, which will influence the passage of material through grid 22 and thus control the fineness of grinding in the mill. Control of valves 33 may be coordinated in any known manner with control of feed by feeder 16, and control of volume of air by control of blower 7 or an inlet control valve as shown at 49 in hood 3.

The operation of the form of the invention shown in Fig. 3 differs only in that material settling in upcast duct 9 is returned directly to box 31 through space 48, conduits 46 and openings 126, bypassing the constant discharge chamber 23 and valved openings 26, thus permitting a return of coarse material without further contact with the stream of air in chamber 23.

It will be noted that in either form of the invention as disclosed, material settling in duct 9 is returned to the mill out of contact with the main stream of fluid sweeping through tubular liner 27, as in the form of Figs. 1 and 2 the fin 29 will impede if not altogether prevent any flow of fluid at any appreciable velocity through the space in trunnion 5 surrounding liner 27.

Use of the flared liner 27 will permit some coarser materials entering perforations 28 to be deflected back into the grinding space 8 against the stream of air.

The above described mill construction affords a great advantage over prior constructions in that all ground product is cascaded through and contacted by the fluid stream at substantially its maximum velocity and good product removal is obtained with a minimum of power consumed in fluid blowing as compared with fluid swept mills in which the air must entrain the product particles in the grinding space when its velocity is low.

It will be understood that the specific structure shown is susceptible to modification by substitution of equivalents within the scope of the invention, for instance by use of other well known types of valves at openings 26, other known types of valve control for motors 39, and other well known devices for the product classifying and collecting devices 11, 13, 14, 18 and 19, etc. It is intended that such modifications and others which will readily occur to persons skilled in the art be included within the scope of the invention, which is limited only by the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. In an air swept ball mill, having a grinding space and a hollow discharge trunnion, a tubular liner for said trunnion having an imperforate portion extending through said trunnion and coaxially spaced therefrom and a foraminous portion extending within said mill, an annular grid dividing the space within said mill surrounding said foraminous portion from said grinding space, a wall dividing the annular space between said imperforate portion of said liner and the inner surface of said trunnion from direct communication with the interior of said mill surrounding said foraminous portion, and conduit means in said mill for conducting materials from the inner end of said annular space to said grinding space.

2. A ball mill comprising a grinding chamber, feed and discharge trunnions, an annular grid dividing said grinding space from the discharge

end wall of said mill, a perforated tubular member circumferentially connected with said grid and extending coaxially through said discharge trunnion, said grid and tubular member defining with said end wall an annular ground material discharge chamber radially surrounding said perforated tubular member, lifters in said discharge chamber for showering ground material over said perforated tubular member, a conduit arranged to conduct ground material from the periphery of said discharge chamber to said grinding space, and load control means comprising a valve adjustable to control the flow of material through said conduit.

3. In a ball mill having a discharge end wall and a discharge trunnion, a grid spaced from said discharge end wall to form a discharge chamber in said mill, a perforated tubular member extending from said grid into said discharge trunnion and having an imperforate section extending coaxially through said trunnion in radially spaced relation, means for depositing insufficiently ground material discharged from said tubular member in the outer end of the space between said trunnion and said tubular member, a material returning helix arranged in and extending through said space, a conduit connect-

ing said discharge chamber with the grinding space of said mill, a valve arranged to restrict flow of material from said discharge chamber to said conduit, and means for conducting into said conduit material which is returned into said mill by said helix, said last means bypassing said valve.

4. In a ball mill having a discharge end wall and a discharge trunnion, a grid spaced from said end wall to define a discharge chamber in said mill, a perforated tubular member extending from said grid through said discharge chamber into said discharge trunnion and having an imperforate section extending through said trunnion in coaxially spaced relation, means for depositing insufficiently ground material discharged from said tubular member in the outer end of the space between said trunnion and the imperforate section of said tubular member, a material returning helix arranged in said space, means for drawing a current of gaseous fluid through said mill and out through said tubular member and means in said discharge chamber for lifting and showering materials therein over the perforated surface of said tubular member.

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