

**Nov. 12, 1940.**

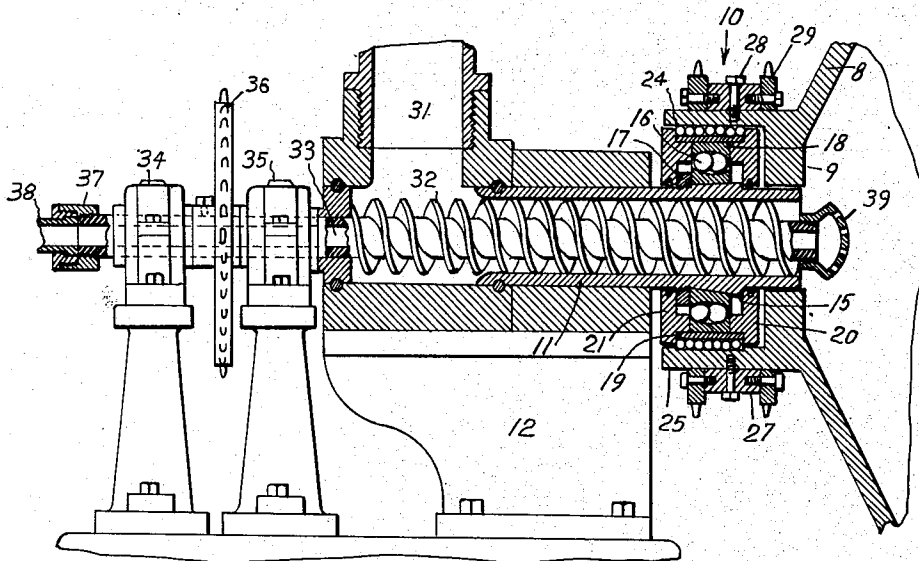
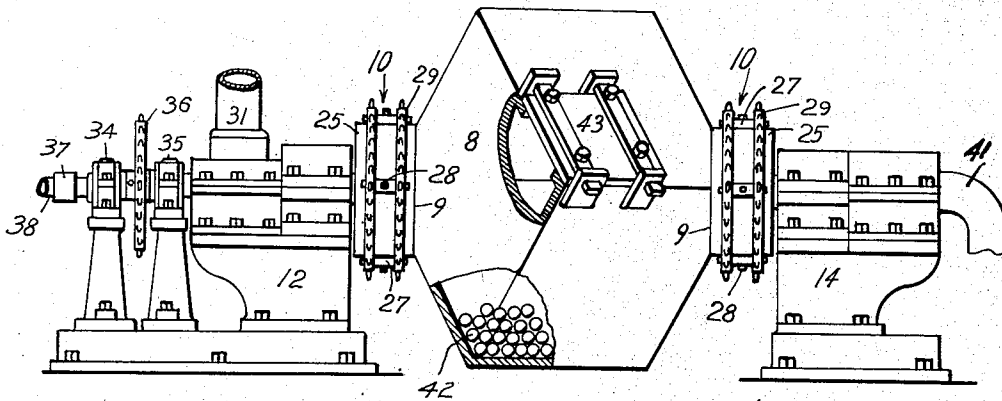
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**2,221,176**

ATTRITION MILL

Filed March 28, 1938

2 Sheets-Sheet 1



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ATTRITION MILL

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2 Sheets-Sheet 2

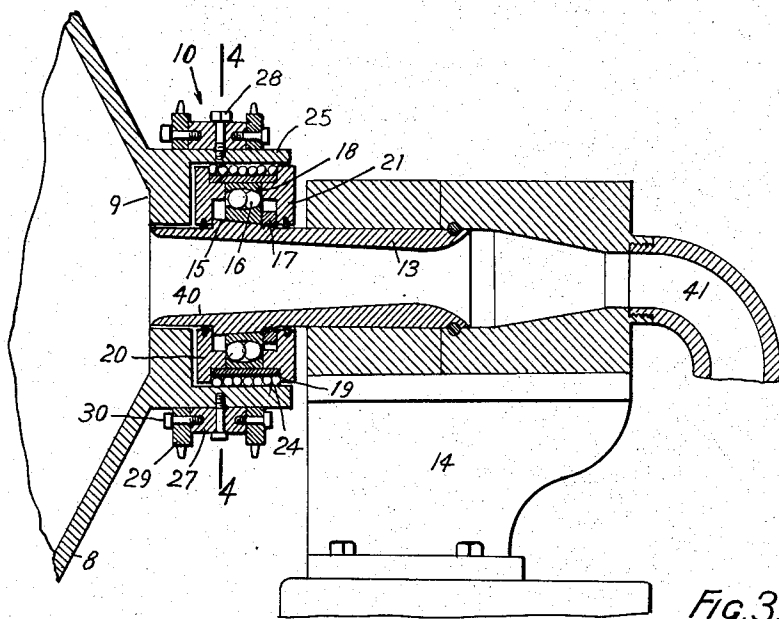


Fig. 3.

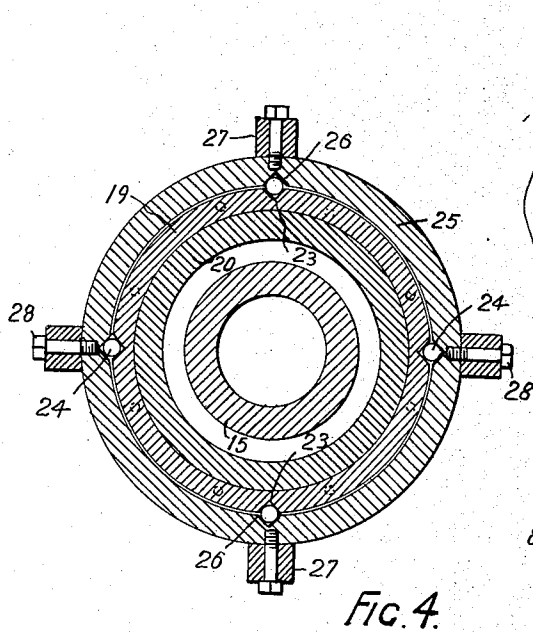


Fig. 4.

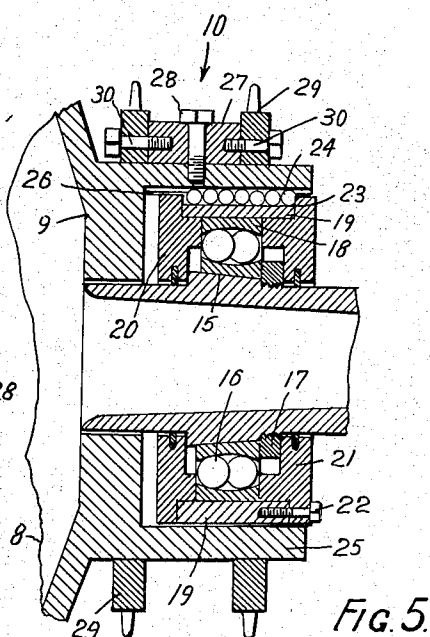


Fig. 5.

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## UNITED STATES PATENT OFFICE

2,221,176

## ATTRITION MILL

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Application March 28, 1938, Serial No. 198,361  
In Australia June 12, 1937

## 1 Claim. (Cl. 83—9)

This invention relates to rotary grinding or attrition mills, for the preliminary reduction of substances, or the grinding or attrition thereof, or the intimate blending of two or more substances.

The principal object of the invention is to provide a rotary mill which will grind substances to a finer and more uniform degree, or which will cause a more intimate blending of two or more substances, than is possible with mills hitherto employed.

The mill according to the invention includes a chamber of cube shape, containing a plurality of polished balls, which is mounted by its diagonally opposed corners for rotation in suitable bearings. The mill may be used for the treatment of various substances, such as metal-bearing ores, grain, cork, straw, silica, pulp, ceramic materials, moulding powders and others.

For use in grinding or mixing finer materials, such as moulding powders or rice for cosmetic purposes, the grinding or mixing may be carried on in batches. For heavier materials, such as metal-bearing ores, but also for fine materials, the material is charged and discharged (either continuously or in batches) through feed and discharge tubes entering it through the chamber bearings. This continuous removal of milled material, during grinding, facilitates the grinding of the material remaining in the chamber, and renders the mill particularly efficient.

The milling chamber is of cube shape, and on account of its particular mounting with the diagonally opposed corners of the chamber (as distinguished from the diagonally opposite corners of any one side) disposed in its axis of rotation, the material and the balls therein follow an unusual path and set up a novel and effective grinding operation. As the chamber revolves in its bearings, the various corners thereof (other than the corners held in the bearings) assume the lowest position in succession, and the balls and the material are continually sliding down one or more sides of the chamber towards the instantaneous lowest point, repeatedly changing their direction during each rotation of the chamber. The contents generally slide, across the width and length of the chamber, in streams which cross and recross and intermingle in a manner resulting in a complete intermixture or grinding of the material(s). The reduction of the material, and/or the intermixture of two or more materials, is caused by the constant frictional movement of the particles over each other. The polished steel balls are not for the purpose

of pulverising by impact, but are for the purpose of adding to the weight of the mass, and causing it to slide freely over the interior of the chamber during rotation.

After the chamber has been in motion for a few cycles, the material and the balls are distributed generally around the interior of the chamber, and consequently the mill is substantially balanced. Owing to this fact, the power required to keep the mill in rotation is particularly low.

In order to fully describe the invention reference is made to the accompanying drawings, in which:

Fig. 1 is a side elevation, in part cross-section, of the permanently mounted form of the milling chamber and bearings,

Fig. 2 is a cross-sectional elevation of one end bearing of the milling chamber of Fig. 1, and the feed thereto,

Fig. 3 is a cross-sectional elevation of the other end bearing, and the discharge means,

Fig. 4 is an enlarged vertical section on line 4—4 of Fig. 3, and

Fig. 5 is an enlarged view of the bearing of Fig. 3.

The hollow milling chamber 8 is of cube form, which is mounted by its diagonally opposite corners, 9, 9 (as distinguished from the diagonally opposite corners of any one side) in expansion bearings 10, 10. The bearing 10 at either side is the same, and is illustrated in Figs. 2, 3, 4 and 5. The bearing 10 at the feed side of the mill is formed about a feed tube 11 secured in a pedestal 12, and the bearing 10 at the discharge side of the tube is formed about a discharge tube 13 mounted in a pedestal 14.

Each bearing 10 comprises a tapered collar 15 formed about the tube 11 (or tube 13) and upon which a ball race 16 is clamped by a ring nut 17 threaded on the tube. The rolling (outer) ring 18 of the ball race 16 carries an annular sleeve 19 into which an inner closure disc 20 and an outer closure disc 21 are pressed. As shown in Fig. 5, the closure disc 21 may be secured to the sleeve 19 by set screws 22, 22. Thus it will be observed that the outer ring 18 of the ball race, the sleeve 19 and the closure discs 20 and 21 revolve on the ball race 16 about the tube 11 (or the tube 13).

Sleeve 19 is formed with four symmetrically spaced longitudinal grooves 23, 23 (Figs. 4 and 5) in its outer periphery, to form a seating for a plurality of balls 24, 24.

Each mounting corner 9 of the chamber 8 is

formed with a hollow bearing sleeve 25 which is an easy fit over the sleeve 19. The inner surface of sleeve 25 is formed with four longitudinal grooves 26, 26 (Figs. 4 and 5) which register with grooves 23, 23 and which receive the balls 24, 24, as shown in Fig. 4. By means of the balls 24 mounted between the registering grooves 23 and 26 of the sleeves 19 and 25 respectively, the sleeve 25 is constrained to rotate with sleeve 19, but it may slide axially thereon to permit expansion of the milling chamber 8 due to the heat engendered in milling.

The outer surface of each sleeve 25 is fitted with four equally spaced blocks 27, 27 secured by set screws 28, and to these blocks two spaced sprockets 29, 29 are secured by set screws 30.

Feed tube 11 (Fig. 2) communicates with a feed pipe 31 through which the material to be milled is fed. A helical screw conveyor 32, formed about a hollow shaft 33, extends from below pipe 31 and through feed tube 11. Shaft 33 extends from pedestal 12 and is carried in two spaced bearings 34 and 35, between which the shaft is fitted with a driving sprocket 36 by means of which it is rotated. Externally of bearing 34 the shaft is connected by means of a rotatable coupling 37 with an air supply pipe 38. The inner end of hollow shaft 33 (within chamber 8) is fitted with a spray head 39.

The discharge tube 13 is internally formed as a Venturi tube 40 (Fig. 3) and it communicates with a delivery pipe 41 mounted on pedestal 14.

The milling chamber 8 is provided with a number of polished steel balls 42, 42 (Fig. 1) and access to the interior of the chamber is had through any suitable detachable door 43.

The operation of the mill is as follows:

The material (or materials) to be milled, either by way of attrition or intermixture, or both, is fed through pipe 31, and conveyor shaft 33 is revolved from sprocket 36 to convey this material through feed tube 11 and into milling chamber 8. This feeding of the material into the milling chamber may be continuous or intermittent, and it may occur with the chamber 8 in rotation or stationary.

The milling chamber 8 is revolved from a source of power through chains reeved about sprockets 29, 29 and during the rotation of the chamber the various corners thereof (other than the pivot corners 9, 9) assume in succession the instantaneously lowest position, causing the material and balls to follow an unusual path resulting in a novel and effective grinding operation. The balls 42 cause the material to freely and continuously cascade over the interior surfaces of the chamber towards the instantaneously lowest corner in separate streams which cross and recross and intermingle with each other. This peculiar movement of the material causes a high degree of frictional movement of the particles of the material over each other, which frictional movement results in particularly fine grinding

and/or a very intimate intermixture of the materials.

The lighter particles of the milled material may be continuously blown from chamber 8 by compressed air admitted to air pipe 38, whence the air passes through hollow shaft 33, through the milling chamber, and out through discharge pipe 13, carrying the lighter particles with it. The material discharged with the air may be the required product, as in grain milling, or it may be refuse, as when milling metal-bearing ores. In the former case a very fine control over the size of the material recovered can be exercised by varying the pressure of the compressed air. Where metal-bearing ores are being treated, fine metal particles deposited in the downward sloping bore 40 of tube 13 are returned to the chamber 8 by the natural vibration of the mill. The continuous removal of milled material facilitates the efficient grinding of the remaining material.

Expansion of chamber 8, due to the heat engendered by milling, is made possible by the axial displacement of the sleeves 25 on the balls 24 which also permits the chamber to effect its natural axial vibration. The material remaining in chamber 8 after milling is completed, together with balls 42, are removed through detachable door 43.

The invention provides a mill which will, owing to its peculiar action, perform the reduction or intermixture of materials to a degree hitherto unobtainable in a mill, and moreover provides a mill which has an extremely long life and which requires but a fraction of the power usually taken by ball mills. The mill also reduces the material to a particularly uniform degree of fineness.

I claim:

A mill comprising a rotatable cube-shaped chamber supported at two diagonally opposite corners, a plurality of grinding balls in said chamber, driving means causing the chamber to rotate and individual corners of the chamber to assume in succession the instantaneously lowest position and the balls to roll during each rotation to such instantaneously lowest corners of the chamber in a series of zig-zag lines at angles to one another, hollow supports at the diagonally opposite corners connecting the chamber to tubes through which the material to be milled is fed into and discharged from the chamber, and bearings on said supports which permit a limited axial displacement of the chamber and expansion or contraction thereof, each bearing including the bearing proper carried by the support, a sleeve on said bearing proper, a second sleeve projecting from the chamber and surrounding said first sleeve, and longitudinally extending ball races disposed in registering grooves of both sleeves, which ball races constrain the sleeves to rotate with one another but permit their relative axial displacement.

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