Dec. 20, 1955 W. K. STONE 2,727,697

VIBRATORY BALL MILLS

Filed Oct. 5, 1951 2 Sheets-Sheet 1

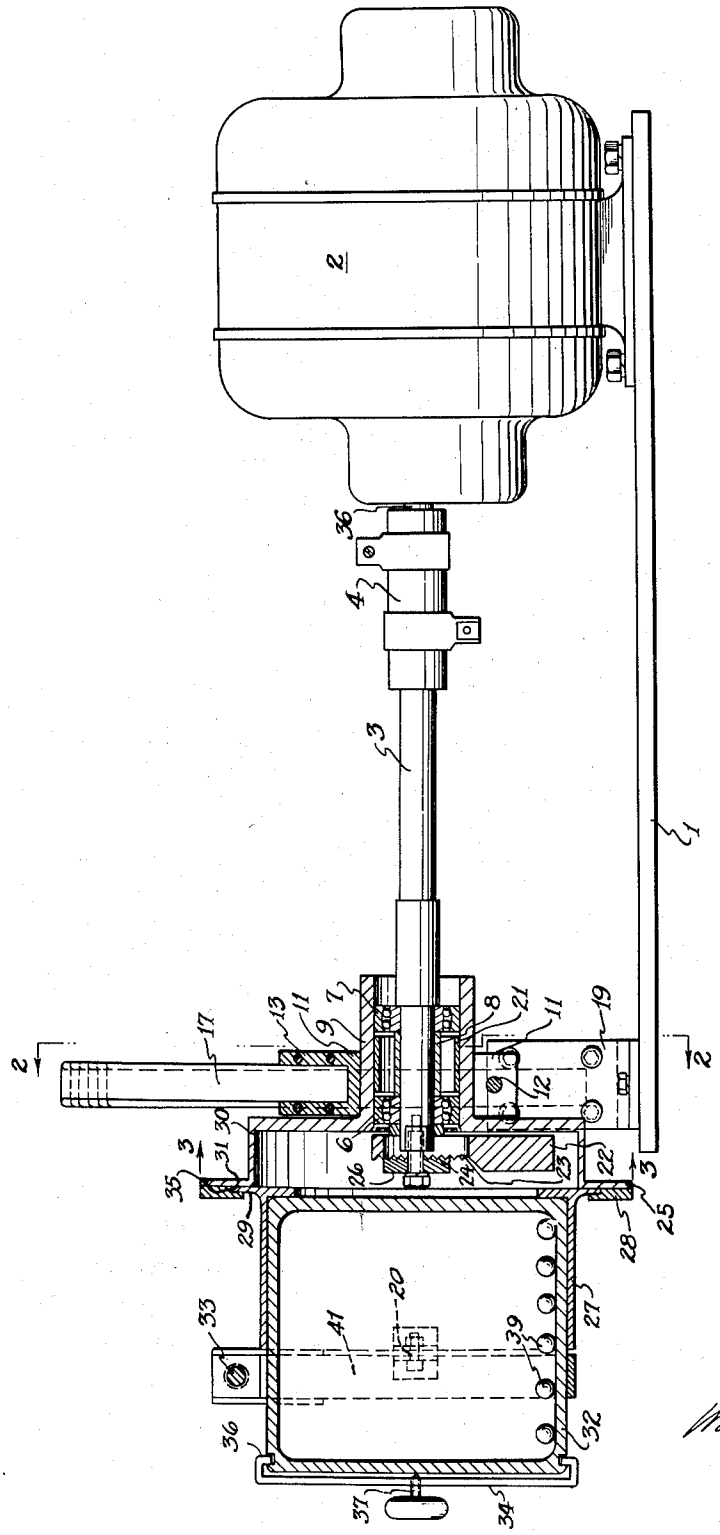

Fig. 1

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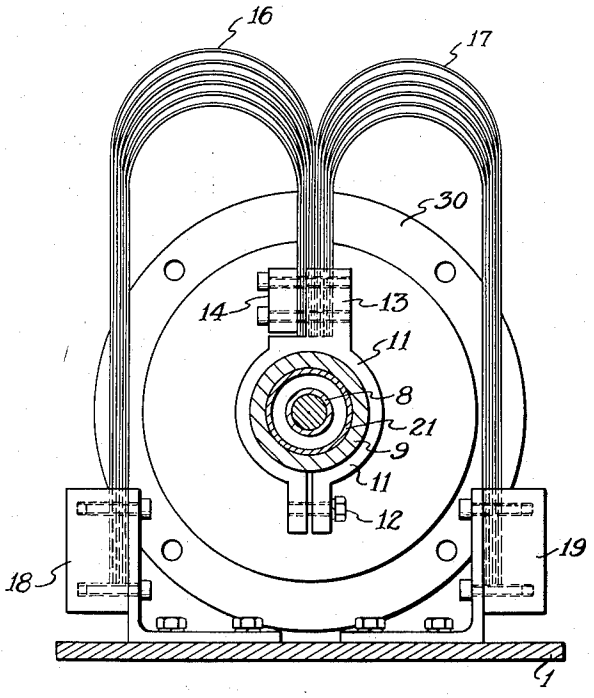

Fig. 2

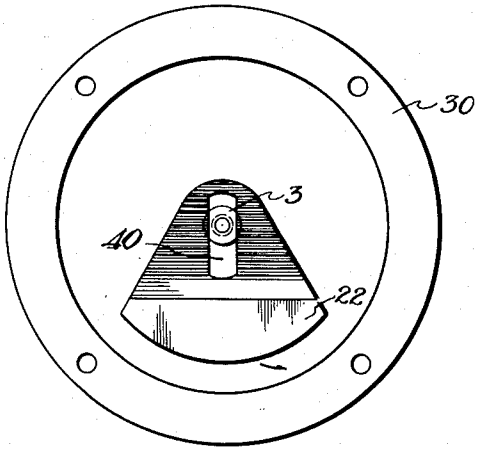

Fig. 3

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VIBRATORY BALL MILLS

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7 Claims. (Cl. 241—175)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of March 3, 1883, as amended (45 Stat. 467; 35 U. S. C. 45).

The present invention is concerned with improvements in vibratory ball mills of the type constructed by Dr. P. H. Hermans of Utrecht, Holland. In this type of mill a mass of hard balls is contained in a jar which is revolved but not normally rotated. The invention relates more specifically to a means for also rotating the jar containing the balls so as to prevent settlement to the bottom of the jar of the material to be ground by the movement of the balls.

In vibratory ball mills of the general type with which the present invention is concerned the settlement of the material to be ground to the bottom of the jar in which the grinding takes place has always presented a serious problem. In the original mill of this type it was necessary to periodically stop the mill, loosen the jar, rotate it, tighten it up and then start up the mill again. This, of course, is not practical in a commercial operation. Other attempts to overcome this difficulty have been only partially successful and usually require a number of additional parts which greatly complicate the machine.

The primary object of the invention is to provide a vibratory ball mill in which the jar is automatically rotated.

Another object of the invention is to provide for automatic rotation of the jar without the use of a number of extra parts.

Another object of the invention is to obtain automatic rotation of the jar as a result of a very simple modification of the prior art device.

Other uses and advantages of the invention will become apparent upon reference to the specification and drawings.

Figure 1 is a cross-sectional view taken along the length of the machine.

Figure 2 is a sectional view taken along line 2—2 of Figure 1.

Figure 3 is a view taken along line 3—3 of Figure 1 showing the arrangement between the weight and the shaft.

Referring to Figures 1 and 2, the vibratory ball mill is mounted on the base plate **1**. A motor **2** drives the shaft **3** through the flexible coupling **4**. The far end of of the shaft **3** is journaled in the bearings **6** and **7** which are supported in the bearing housing **9**. The bearings are kept properly spaced by means of the spacer **8**. The suspension yoke **11** is clamped about the bearing housing and is drawn tight by means of the bolt **12**. One side of the yoke is extended vertically upward and this vertical extension **13**, together with the metal plate **14** form a jaw for clamping one end of the springs **16** and **17**. The other ends of the springs **16** and **17** are clamped in the clamps **18** and **19** respectively which are in turn rigidly

mounted on the base **1**. This assembly, including the flexible coupling **4**, allows the shaft **3** and all parts mounted on it to float on the springs **16** and **17** for reasons to be explained subsequently. The bearing housing and all parts mounted on it are not rigidly secured to the bearings and therefore are allowed horizontal motion limited only by the travel limit sleeve **21** which is riveted to the bearing housing. However, this allowance for horizontal movement is not necessary, and the bearing housing can be rigidly fastened to the bearings.

The free end of the shaft **3** is flattened on opposite sides so as to receive the eccentric weight **22** as shown in Figure 3. The upper portion of the weight has teeth **23** which contact the teeth **24** on the weight-adjusting plate **26**. This arrangement in conjunction with the slot **40**, in the weight **22**, allows for adjustment of the weight with respect to the shaft **3**.

The jar holder **27** is secured to the flange **25** of the weight housing **30** by means of the slip ring **28**. The flange and the weight housing are merely a continuation of the piece forming the bearing housing **9**. The outside diameter and thickness of the flange **29** of the jar holder **27** are dimensioned so as to provide sufficient clearance relative to the weight housing **30** to permit rotation of the jar holder in the weight housing. The clearance between the horizontal face **31** of the jar holder and the face **35** of slip ring **28** determines the speed of rotation of the jar holder **27**, for reasons to be explained below. Speeds from one to four revolutions per minute have been used.

A metal band **41** is clamped tightly about the jar **32** by means of the clamp **33**. The band is then bolted to the jar holder **27** by means of the bolts **20**.

The material to be ground and about 3700 small metal balls **39** which do the grinding are put into the jar **32**. The motor **2** drives the shaft **3** and the eccentric weight **22** through the flexible coupling **4**. Rotation of the weight about the axis of the shaft **3** and the restraining action of the springs **16** and **17** cause the weight and the shaft **3** to move in a complex path, which has a circular component, about the axis of revolution of the armature shaft **36** of the motor **2**. The complex motion of the shaft **3** is transmitted to the weight and bearing housings **30** and **9**, respectively, through the ball bearings **6** and **7**. This high speed motion of the weight and bearing housings and therefore of the jar holder **27** and the jar **32** sets the balls in the jar into very rapid motion and causes a minimum of 100,000 collisions per second between the balls. This permits materials to be ground to sizes of a few microns in length or less.

This much of the action of the mill is old and well known in the art. However, when the mill was operated as originally built, which was with the jar holder bolted to the weight housing, the material being ground settled to the bottom of the jar making it desirable to periodically stop the mill, manually rotate the jar, and then start the mill up again. This is obviously inconvenient.

In the device of the present invention the rotation of the jar is accomplished by employing the principles of the standard internal differential gear. This is accomplished by the modification of the jar holder assembly. Formerly the jar holder was bolted to the weight housing. However, in the present device, as previously pointed out, the jar holder is secured to the weight housing by means of the slip ring **28**. As a result of the internal differential gear action between the surface **31** of the jar holder flange **29** and the surface **35** of the slip ring **28**, the circular component of the complex motion of the weight housing is transmitted to the jar holder and the jar holder is made to rotate in a direction opposite to the direction of rotation of the weight housing. The speed of rotation of the jar holder is dependent upon the relative diameters

of the faces 31 and 35 and the speed of revolution of the weight housing.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of my invention as defined in the appended claims.

I claim:

1. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, bearing means for supporting the last-mentioned end of said shaft, a bearing housing spring supported for relatively free movement thereof and a holder for said container being supported by said bearing housing; the improvement comprising slip-ring means for providing an internal differential friction gear coupling between said holder and said bearing housing.

2. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, bearing means for supporting the last-mentioned end of said shaft, a bearing housing spring supported for relatively free movement thereof, a holder for said container, said holder having a circular flange which is supported by said bearing housing; the improvement comprising slip-ring means for providing an internal differential friction gear coupling between said flange and said bearing housing.

3. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, bearing means for supporting the last-mentioned end of said shaft, a bearing housing spring supported for relatively free movement thereof and a holder for said container, said holder having a circular flange which is supported by said bearing housing; the improvement comprising slip-ring means fastened to said bearing housing for providing an internal differential friction gear coupling between said flange and said bearing housing.

4. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, bearing means for supporting the last-mentioned end of said shaft, a bearing housing spring supported for relatively free movement thereof and a holder for said container, said holder having a circular flange which is supported by said bearing housing; the improvement comprising a slip ring having a circular groove, said slip ring being fastened to said bearing housing, the circular groove receiving said circular flange of said holder, the diameter of the groove being larger than the outside diameter of said flange.

5. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, bearing means for supporting the last mentioned end of said shaft, a bearing housing spring supported for relatively free movement thereof and a holder for said container having a flange and being supported by said bearing housing; the improvement comprising slip-ring means on said bearing housing engaging said holder flange for providing an internal differential friction gear coupling between said holder and said housing.

6. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, bearing means for supporting the last mentioned end of said shaft, a bearing housing having a flange spring supported for relatively free movement thereof and a holder for said container, said holder having a circular flange which is supported by said bearing housing; the improvement comprising the combination of slip-ring means having a first portion with a first internal diameter and a second portion with a second internal diameter, said holder flange having an outer diameter smaller than the diameter of the second portion of said slip-ring means, and means for retaining said holder flange between the bearing housing flange and the first portion of said slip-ring means.

7. In a vibratory ball mill of the type comprising a container and means for vibrating said container including a shaft, means for rotating said shaft from one end thereof, an eccentric weight on the other end of said shaft, a bearing housing spring supported for relatively free movement thereof and a holder for said container being supported by said bearing housing; and means for rotating said container comprising internal differential friction gear coupling means between said bearing housing and said container holder.

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