Sept. 12, 1967 K. E. STETTINIUS 3,341,136

GYRATORY GRINDER

Filed Aug. 16, 1965 2 Sheets-Sheet 1

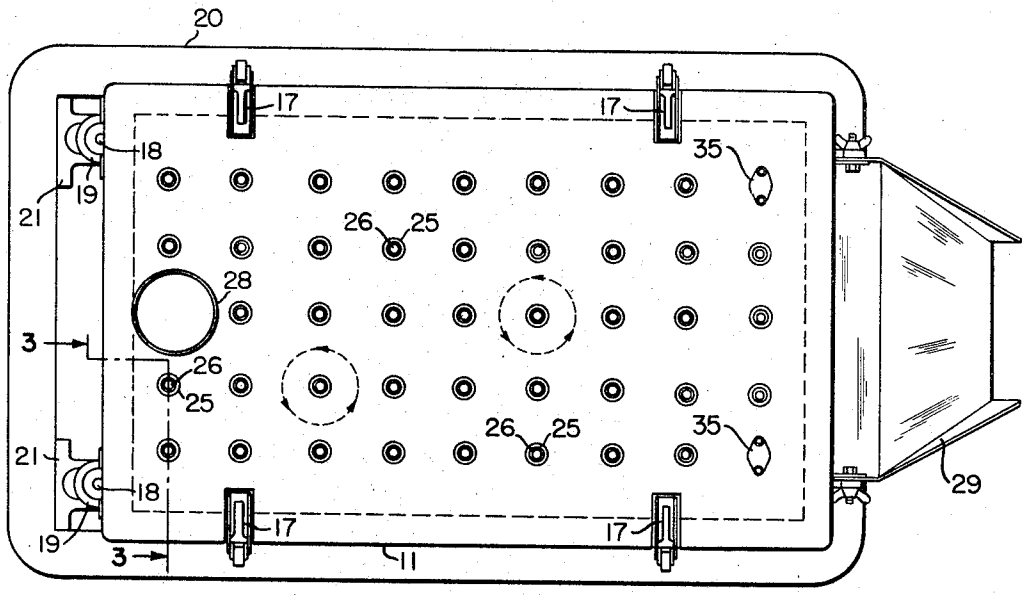


FIG. 1

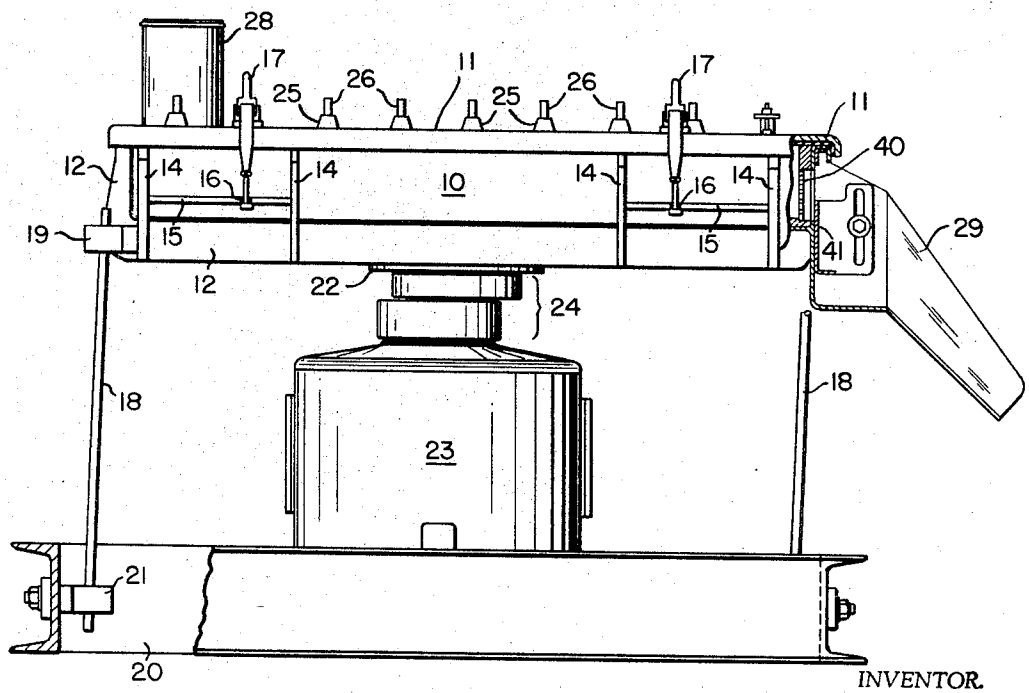


FIG. 2

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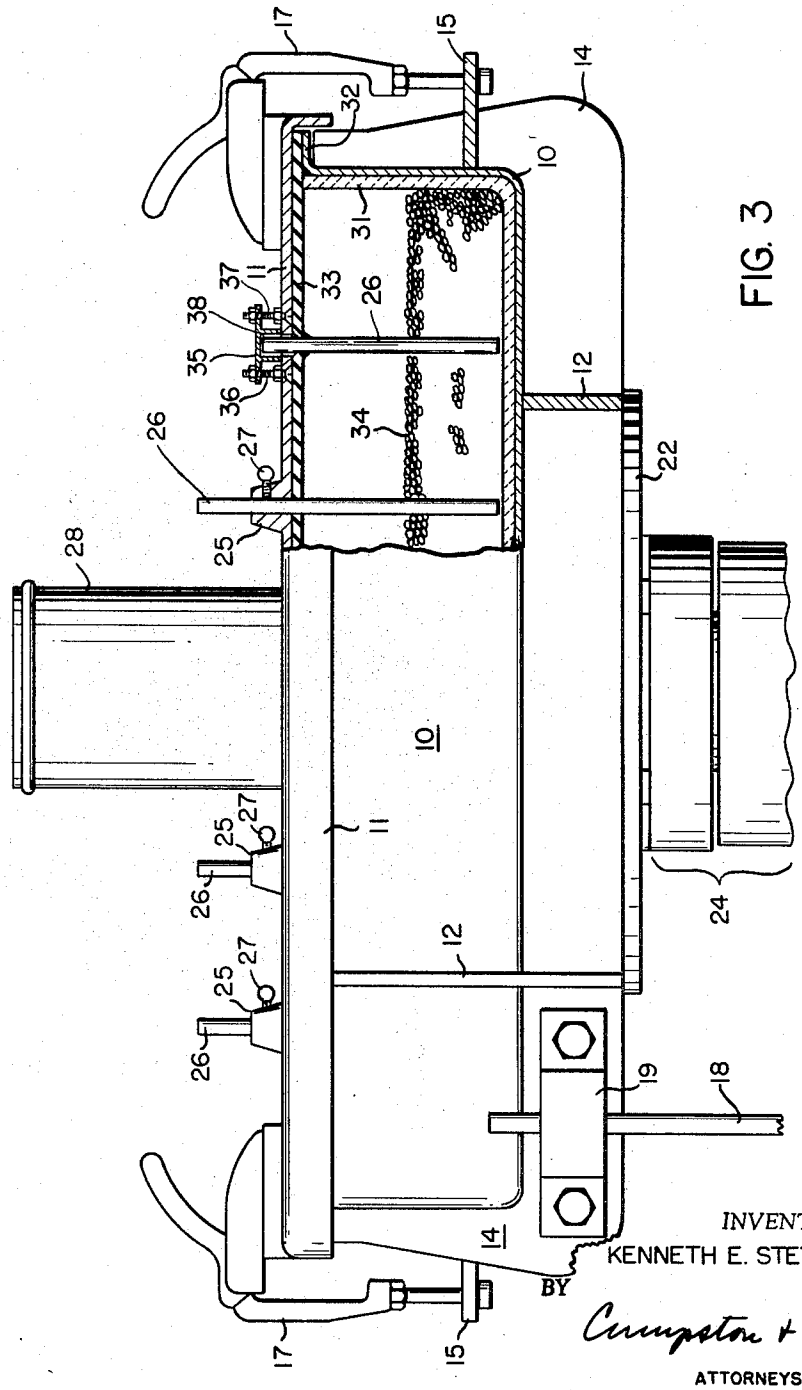


FIG. 3

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GYRATORY GRINDER

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The present invention relates to gyratory grinders or mills and more particularly to mills driven in a horizontal gyratory motion and containing a charge of pebbles or balls which grind material by impact and attrition.

At present, two basic types of ball mills are known, tumbling ball mills that generally rotate about a horizontal axis and gyratory mills. Each contains a charge of impact objects referred to throughout the specification and claims interchangeably as either "pebbles" or "balls." Such impact objects can be any of a variety of sizes, shapes and masses depending upon the mill in which they are used and the material which they are grinding. In tumbling ball mills, the balls must be of relatively large mass because they are raised up and allowed to cascade downward over one another and accomplish grinding by impact from the force of their fall. In gyratory mills, the grinding chamber is normally in the shape of an annulus, the pebble size of the pebble charge is generally smaller, and the pebbles are jiggled by a gyratory motion in a horizontal plane which causes the pebbles to tend to congregate around the periphery of the mill, rising at the outside of the chamber, spilling over the top toward the inside and traveling outward again. Grinding in such a device is accomplished by milling about and rubbing together of the shaken pebbles.

It is an object of this invention to increase the speed, capacity, and efficiency of a gyratory ball mill.

Another object of the invention is to grind materials, either wet or dry, to a finer and more uniform size more quickly and less expensively than was possible with previously known grinders.

These and other objects of the invention will be apparent hereinafter from the specification, the drawings, and from the subject matter claimed. Specific preferred embodiments of the invention will hereinafter be more fully described, the inventive subject matter being claimed at the end of this specification.

In the drawings:

FIG. 1 is a top view of one embodiment of an improved gyratory mill according to the present invention;

FIG. 2 is a side view, partly in section, of the improved gyratory mill of FIG. 1.

FIG. 3 is an end view, partly in section, of the improved gyratory mill of FIG. 1.

Generally, the improved gyratory grinder according to the invention has a grinding chamber which can be any convenient shape and size and which is filled about one-half full with a charge of pebbles that are preferably relatively small for greater contact with each other. Instead of jiggling these pebbles about in the usual way, impact rods or bats are arranged to extend into the grinding chamber and move with the chamber for batting the pebbles about to impart great energy to them. In operation, the pebbles are knocked about such a chamber violently and substantially uniformly so that grinding is accomplished rapidly and continuously throughout substantially the entire volume of the chamber.

Referring to the drawings throughout which corresponding parts are given the same reference numerals, one preferred embodiment of the inventive gyratory mill is formed with a generally rectangular grinding box **10** with an associated cover **11**. Grinding chamber **10** can be any convenient size or shape, and the illustrated rectangular shape functions quite well. Grinding chamber **10** is supported for gyratory motion in any convenient manner, and in the illustrated mill, chamber **10** is supported on a cradle-like structure. This support structure includes a pair of elongated U-shaped cradle arms **12** (see FIGS. 2 and 3) which extend longitudinally underneath the box **10**. A plurality of L-shaped side cradle pieces **14** are secured in pairs to the outer surface of each of the longitudinal cradle arms and are adapted to engage the sides of the box **10** adjacent each of its four corners. As shown in FIG. 2, each pair of side cradle pieces **14** has a plate member **15** secured horizontally therebetween and formed with a notch **16** into which the lower, enlarged end of a suitable cover toggle **17** is adapted to engage, for fastening the cover **11** securely onto the top of the grinding box **10**.

As best shown in FIGS. 2 and 3, each of the corners of cradle-like frame preferably has a stabilizer rod **18** movably connected thereto in any suitable manner, for example, by the bolted brackets **19** attached to the outermost side cradle members **14**. The bottom ends of the stabilizer rods **18** are similarly connected to the respective corners of a rectangular support frame **20** as by bolted clamps **21**. Stabilizer rods **18** are preferred for helping to maintain box **10** in uniform level orientation and for preventing any rotation as it is gyrated.

Gyratory motion is preferably imparted to grinding box **10** through the support cradle structure. In the illustrated embodiment, cradle members **12** are secured to drive plate member **22** which in turn is connected to drive mechanism **23** through an eccentric coupling **24** which translates shaft rotation into a horizontal orbital or gyratory motion. The path of a point traveling in such gyratory motion is illustrated by the broken-line arrows in FIG. 1. Drive means **23** is preferably variable speed from about 200 to 300 r.p.m. to adjust the grinding operation to various specific applications, but no specific speeds or gyration sizes are essential to the invention.

Impact rods or bats **26**, extending preferably vertically into grinding box **10**, are preferably fastened to cover **11**. Rods **26** can be secured to cover **11** in any convenient way, and two ways of securing rods **26** in place are shown in FIG. 3. Rods **26** can be made vertically adjustable within tubular projections **25** extending upwardly from the upper surface of cover **11**. With such an arrangement, thumb screws **27** are threaded through projections **25** and engage rods **26** to secure them in place. Rods **26** can also be secured permanently in place on cover **11** by being cemented within individual housings **35** each of which is preferably removably secured to cover **11** by means such as bolts **36** and **37**. Any of a variety of cements **38** such as lead alloy or portland cements can be used to secure a rod **26** within a housing **35**, and new rods can replace worn ones within removable housings **35**.

With either method of securing rods **26** to cover **11**, it is preferred that rods **26** be substantially uniformly spaced over the surface area of cover **11** so as to extend downward into grinding box **10** at uniform intervals throughout box **10**. The spacing between adjacent rods **26**

is preferably made substantially equal to the diameter of the gyratory motion of the grinding chamber as indicated by the dotted arrows in FIG. 1. The rods or bats **26** are preferably made of ceramic material and preferably extend to near the bottom of box **10**. However, rods may also be made of cermet materials such as tungsten carbide and can extend all the way to the bottom of box **10**.

Referring to FIG. 3, grinding box **10** is preferably lined with a material for increasing its grinding efficiency. On the one hand, a resilient liner such as rubber can assist in keeping the pebbles flying violently about, and on the other hand, a hard liner can be used to accomplish some grinding in contacts between pebbles and the liner. In the illustrated embodiment, the side and bottom walls of box **10** are provided with a liner **31** preferably made of high density alumina ceramic material, and the underside of cover **11** is provided with a liner **33** of neoprene, rubber, or other resilient material. Liner **33**, in the illustrated embodiment forms a gasket between cover **11** and outturned flange **32** of the side walls of box **10**. Of course, other liner materials including other ceramic or cermet materials can be used, or liners can be omitted within the spirit of the invention.

Grinding box **10** is preferably about half filled with a charge of balls or pebbles **34** as shown in FIG. 3. Since the pebbles **34** are batted violently about by bats **26** and use kinetic energy thus acquired for their grinding force rather than relying upon their mass and the force of gravity, pebbles **34** are preferably of relatively small size so as to be more numerous and to have more frequent contact with each other resulting in a greater area of effective contact per unit of time in operation. Thus, one very successful grinder according to the invention has used ceramic pebbles of approximately one-quarter inch diameter and bats of approximately one inch diameter. Of course, pebbles of materials other than ceramic can be used, including metallic or cermet materials.

The inventive mill is adapted for continuous grinding of either wet or dry materials and continuous input and output of materials preferably through inlet duct **28** in cover **11** and output chute **29** at the opposite end of box **10** as best shown in FIG. 2. A perforated discharge grid **40** is preferably removably arranged over the output end of box **10** as shown in the sectioned portion of FIG. 2 to retain pebbles within the box. Perforations in the output grid **40** are preferably relatively large compared to the fineness of the ground product, and output grid **40** is preferably easily removable and replaceable to remedy plugged or worn perforations. Any worn pebbles passing through discharge grid **40** are preferably removed by a screening after the grinding operation.

In operation, grinding box **10** is driven in a relatively rapid circular horizontal gyratory motion preferably of approximately 200 to 300 r.p.m. in an orbit such as indicated by the dotted arrows in FIG. 1. This imparts rapid circular motion to the rods **26** as well as box **10**, and rods **26** thus repeatedly bat pebbles **34** violently about the inside of box **10**. Pebbles **34** are driven substantially uniformly throughout the volume of box **10** with high speed and energy and collide with each other, the bats **26**, and the inside surfaces of box **10** repeatedly and rapidly to grind material thoroughly and quickly.

Spacing of the bats **26** by a distance approximately equal to the diameter of the gyratory motion has been found to produce the desired violent agitation of the pebbles and very effective and improved grinding action. However, the invention is not limited to any particular spacing of bats, amplitude of gyratory motion, or size of grinding chamber.

Other features, advantages, and other specific embodiments of this invention will be apparent to those exercising ordinary skill in the pertinent art after reading the foregoing disclosure. In this regard, while specific preferred embodiments of my invention have been described in considerable detail, such disclosure is intended in an illustrative, rather than a limiting sense, and other embodiments, variations, and modifications can be effected within the spirit of the invention and the scope of the subject matter as disclosed and claimed.

I claim:

1. In a gyratory ball mill having a grinding chamber containing a charge of grinding pebbles and drive means connected to said chamber for driving said chamber in a gyratory motion in a horizontal plane, the improvement comprising: a plurality of rod members extending rigidly within said chamber, said rods being spaced throughout said chamber and being movable with said chamber for repeatedly batting said pebbles about as said chamber is gyrated by said drive means.

2. The gyratory ball mill of claim **1** wherein said rod members are releasably secured to said grinding chamber and extend vertically therein.

3. The gyratory ball mill of claim **2** wherein said rod members are adjustable vertically within said chamber.

4. The gyratory ball mill of claim **1** wherein said chamber comprises substantially uninterrupted open space, and said rod members are spaced substantially uniformy throughout said chamber.

5. The gyratory ball mill of claim **4** wherein the diameter of said gyratory motion is substantially equal to the distance between adjacent ones of said plurality of rod members.

6. The gyratory ball mill of claim **1** wherein said pebbles and said rod members are formed of ceramic material.

7. The gyratory ball mill of claim **1** including means for continuously introducing material to be ground into said chamber and means for continuously removing ground material from said chamber.

8. In a gyratory ball mill driven in a horizontal gyratory motion, the combination comprising:

(a) a grinding box enclosing a volume substantially all of which is adapted for grinding;

(b) a charge of grinding pebbles disposed in said box;

(c) a cover fastened to said grinding box and configured to define a plurality of apertures spaced substantially uniformly over said cover; and

(d) a plurality of rods disposed in said apertures and extending rigidly downward into said volume for continually batting said pebbles about as said grinding box is gyrated.

9. The gyratory ball mill of claim **8** including means on said cover arranged for securing said rods removably in place.

10. The gyratory ball mill of claim **8** wherein said pebbles and said rods are formed of ceramic material.

11. The gyratory ball mill of claim **8** wherein the diameter of said gyratory motion is substantially equal to the distance between adjacent ones of said plurality of rods.

12. The gyratory ball mill of claim **8** including means for continuously introducing material to be ground into said chamber and means for continuously removing ground material from said chamber.

13. The gyratory ball mill of claim **8** wherein said cover member is releasably secured atop said grinding box.

14. A gyratory ball mill comprising:

(a) an open top, substantially rectangular grinding box;

(b) a charge of ceramic grinding pebbles disposed within said grinding box;

(c) a cover member adapted to be releasably secured atop said grinding box and having a plurality of apertures therethrough substantially uniformly spaced over the surface of said cover member;

(d) means for driving said box in a gyratory motion in a horizontal plane;

(e) a plurality of ceramic rods one of which is disposed in each of said apertures so as to extend rigidly downward into said grinding box, said rods being

adapted for repeatedly batting said pebbles about as said grinding box is gyrated by said drive means; and

(f) means for removably securing said rods in place in said apertures.

15. The gyratory ball mill of claim **14** wherein said grinding box is lined with a ceramic material, and the bottom surface of said cover member is lined with a resilient material.

16. The gyratory ball mill of claim **14** wherein said diameter of said gyratory motion is substantially equal to the distance between adjacent ones of said plurality of rods.

17. The gyratory ball mill of claim **14** including means

for continuously introducing material to be ground into said chamber and means for continuously removing ground material from said chamber.

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