

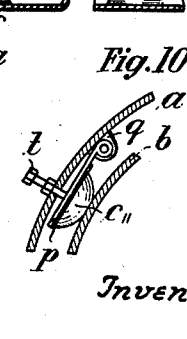
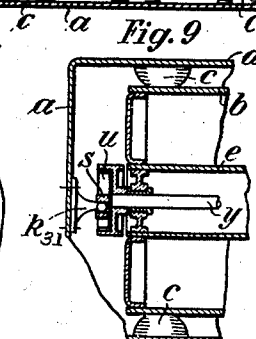
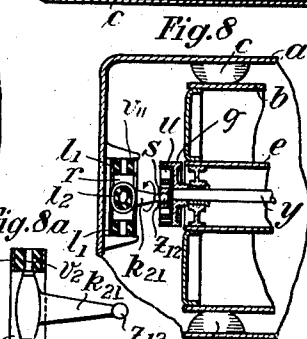
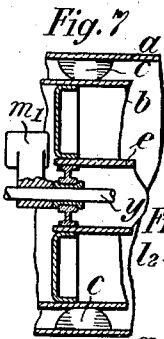
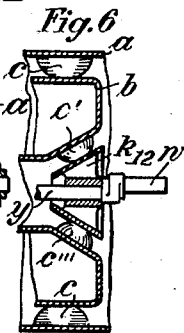
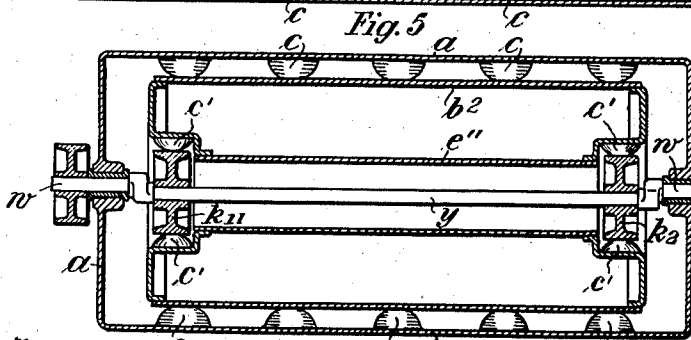
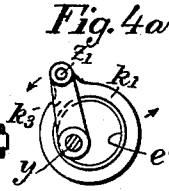
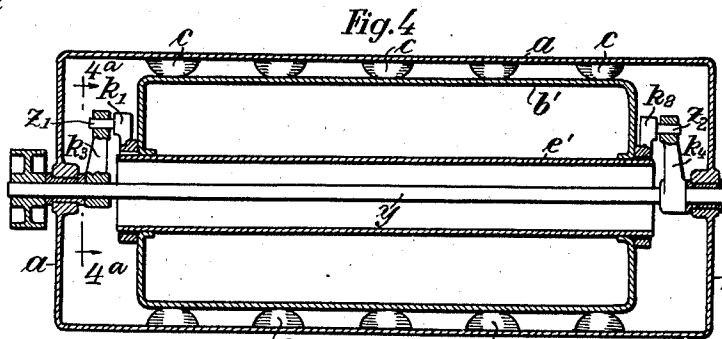
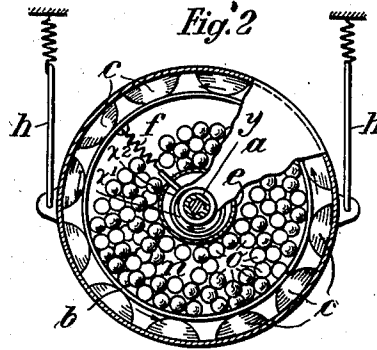
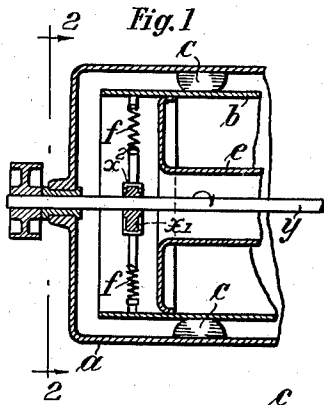
Aug. 22, 1939.

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2,170,768

GRINDING AND THE LIKE APPARATUS

Filed Oct. 19, 1936



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UNITED STATES PATENT OFFICE

2,170,768

GRINDING AND THE LIKE APPARATUS

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Charlottenburg, GermanyApplication October 19, 1936, Serial No. 106,464
In Germany June 16, 1936

9 Claims. (Cl. 83—9)

This invention relates to grinding and the like apparatus for comminuting materials.

It is well known that material to be ground is mixed with balls, rollers or other rigid bodies and the whole is placed in a hollow chamber and is then set in a rotating, swinging or rocking motion. This involves in all cases a device which is positively driven at a certain speed or with a limited stroke mechanism with a relatively poor efficiency.

It is further old to agitate such a mixture in mixture chambers which lie parallel to the axis of the swinging motion, which are positively driven by rotating masses, in such manner that a rubbing motion is created between the material to be ground and the grinding bodies. This grinding process gives poor mechanical efficiency, because the rotating motion is produced by forced high bearing pressure and a grinding operation results which is sufficient for grinding fine materials only, while comparatively little force is transmitted to the material to be ground. Consequently, it is impossible in using these methods to increase the size of the chambers profitably, neither is it possible to increase the force or grinding output to any great extent. Besides, in this method the mixture of the material to be ground and the grinding bodies are not evenly distributed over the entire chamber, since through the force of gravity the material to be ground forces its way downward through the circular rotations and thus accumulates in increasing quantities in the bottom of the chamber.

According to the present invention the above disadvantages are eliminated by coupling a second body to the swinging body of the grinding chamber, which second body serves as counterweight and has the same heavy axis. This device operates by interposing elastic means between the bodies and swingingly motivating the inner chamber by means of a loose coupling. In this manner any necessary contact pressure between the material to be ground and the grinding bodies is obtained, which with 180° rotating motion against each other around the common axis in this two chamber system, guarantees a vibration-free working, and a better mixture of the material to be ground with the grinding bodies results aided by the elastic means on which the grinding chamber rolls.

In order more clearly to understand the invention, reference is made to the accompanying drawings, which illustrate diagrammatically and by way of example, various embodiments of

grinding apparatus in accordance therewith, and in which:

Fig. 1 is an axial section of part of one embodiment;

Fig. 2 is on the line 2—2 of Fig. 1 and with parts of the outer cylinder *a* broken away and with but one of the supports *f* shown;

Fig. 3 is a detail; showing a modified resilient support between the outer and inner cylinders;

Fig. 4 is an axial section through a second embodiment;

Fig. 4a is a vertical section taken on the line 4a—4a of Fig. 4 with the receptacle *b* removed;

Fig. 5 is an axial section through a third embodiment;

Fig. 6 is a fragmentary vertical longitudinal section showing a modified form of drive;

Fig. 7 is a fragmentary vertical longitudinal section showing a modified form of drive;

Fig. 8 is a fragmentary vertical longitudinal section showing a modified form of drive;

Fig. 8a is an elevation partly in section of a detail of Fig. 8;

Fig. 9 is a fragmentary vertical longitudinal section showing a modified form of drive; and

Fig. 10 is a detail showing an adjustable resilient support between the outer and inner cylinders.

In said drawing, like parts are denoted by like reference characters.

Referring to Fig. 1, a hollow receptacle *b* is disposed within a cylinder *a* closed at both ends. The cylindrical hollow receptacle *b* having closed ends is pierced axially by a tube *e*, so that the resulting hollow space in the cylinder *b* is of annular cross-section. A shaft *y* rotates two eccentrics *x*₁, only one of which is shown and which are mounted on said shaft *y* adjacent the ends of the hollow receptacle *b*. The shaft *y* passes through the tube *e*. The eccentrics *x*₁ are mounted in annular bearings *x*₂ which are connected to the outer jacket of the hollow receptacle *b* by any desired number of radially mounted resilient members *f*. If the shaft *y* be rotated, circular oscillations are imparted to the hollow body *b*, through the eccentrics *x*₁, bearings *x*₂ and resilient members *f*. Such oscillations are transmitted through a plurality of interposed and substantially hemispherical elastic members *c* to the outer hollow cylinder *a*. In Fig. 3, instead of a plurality of members *c* an elastic cylinder *d* is positioned between the cylinders *a* and *b*. The elastic cylinder *d* functions in the same manner as do the members *c*.

In each embodiment illustrated, the outer hol-

low cylinder *a* is fastened to resilient suspension members *h* in such a way that it is able to perform small oscillations but is unable to turn freely around the axis *y*. On the other hand, the inner hollow receptacle *b*, when the eccentrics *x*₁ are rotated in the clockwise direction in bearings *x*₂, rotates slowly in the anti-clockwise direction. This is caused by the fact that the resilient members *c* are slightly compressed radially by the eccentric agitation, so that the hollow receptacle *b* being of smaller radius must roll over the supporting resilient members, between which there is a space of greater radius. This action is in the nature of that of a pinion gear rotated on the end of a crank arm and in engagement with the inner teeth of a ring gear. In this case the constant drag of the members *c* on the periphery of the cylinder *b* causes the latter to rotate in a counter-clockwise direction even though the path of travel of the cylinder *b* is in a clockwise direction. During this movement, the outer cylinder *a* is tilted slightly in a clockwise direction against the tension of the spring supports *h* by the clockwise direction of travel of the inner drum *b*. This tensioning of the supports causes slight intermittent oscillations of the outer cylinder *a* in a counter-clockwise direction, thereby slightly increasing the speed of rotation of the inner drum *b* in that direction and also setting up in harmonic vibrations which are transmitted to drum *b* and which are helpful in the grinding. The result of this action is to produce a certain loss of travel for every revolution of the eccentrics, i. e., a revolution in the opposite direction to that of the rotation of the eccentrics.

If such a tube mill be charged in known manner through closable openings, not shown, with material to be ground *n* and grinding bodies *o*, which latter may consist of cylindrical metal rollers, metal balls or other suitable material (quartz sand or the like), and if the whole system be agitated in the manner described in the foregoing so as to perform circular oscillations, then both the hollow receptacle *b* and also all the auxiliary bodies *o* in the interior thereof will perform circular oscillations, i. e., each individual auxiliary body describes a circle corresponding to the amplitude of the circular oscillations and is thus caused to roll over the surrounding material.

Since material to be ground is now between the individual spherical or cylindrical grinding bodies, said material is ground under very favourable conditions by the aforesaid rolling process.

In such a device, it is possible through the throw of the circular oscillations (the amplitude), which is variable within wide limits, or through the frequency, which can also be readily varied to a large extent, to vary the contact pressure of the grinding bodies against each other, i. e., the grinding itself, to an extreme degree. This produces a grinding machine which is not merely extremely adaptable to the materials to be treated, but in which it is possible to determine the optimum efficiency for each size of machine and kind of material.

Apart from this, however, owing to the fact that the grinding chamber rotates slowly during the grinding process together with all the auxiliary bodies, the grinding machine of the present invention affords an excellent mixing and distribution of the material to be ground, said material being constantly conveyed from the lower layers to the top and after passing between the

grinding bodies rolling over each other being again subjected to the grinding process.

Instead of using the loose coupling described in the foregoing, the agitation of the grinding cylinder with circular oscillations can be carried out with the aid of any other desired coupling device. Thus for example, in the embodiment shown in Fig. 4, the driving shaft *y* can be passed through a hollow tube *e'* in the middle of the grinding cylinder *b'*. At both ends of the latter (*b'*) are disposed cranks *k*₁ and *k*₂, the pins *z*₁ and *z*₂ of which engage cranks *k*₃ and *k*₄ respectively on the driving shaft *y*. The cranks *k*₁ and *k*₂ are rotatably mounted on the tube *e'* and the inner ends of the pins *z*₁ and *z*₂ are rotatably secured in said cranks. The outer ends of the pins *z*₁ and *z*₂ are rigidly secured in the outer ends of the cranks *k*₃ and *k*₄. The cranks *k*₃ and *k*₄ are rigidly mounted at their inner ends on the shaft *y*. This arrangement permits the inner drum *b'* to travel in a clockwise path and rotate in a counterclockwise direction as does the drum *b* of Figs. 1 and 2. If the shaft *y* be rotated, the resiliently mounted grinding cylinder *b'* will at first lag behind somewhat owing to its inertia and to the fact that it gives to the forces acting on the crank pins *z*₁ and *z*₂, i. e., it will move eccentrically around the shaft *y* owing to the fact that its gravitational axis describes a cylindrical path around the axis of the shaft *y*, see Fig. 4a. The radius of this path increases in length as the frequency of the circular oscillations increases and consequently the centrifugal force acting on the grinding cylinder also increases.

Another type of loose coupling is obtained by enlarging the inner tubes *e''*, *e'''* of the grinding device at their ends, as shown respectively in Figs. 5 and 6, and allowing a cylindrical or conical body *k*₁₁, *k*₁₂ to roll in the resulting enlarged space at both ends over elastic members *c'* through the rotation of the shaft *y* and of an eccentric shaft *w*. If this be done on both sides of the grinding machine, the latter will be agitated so as to perform circular oscillations in planes which may be regarded as passing vertically through the grinding machine or the driving shaft *y*.

Figure 7 shows a modification which illustrates an actuation of the device by means of loose coupling which is formed by mounting an eccentric swinging mass *m*₁ on both outer ends of the rotatably mounted shaft *y*. In the rotation of the shaft *y*, which can be accomplished in any manner, such as by a belt pulley (Fig. 4) or by means of a flexible shaft, the force created by the rotating swinging mass *m*₁ is transferred to the hollow cylinder *b* with a 90° phase displacement. As said cylinder is resiliently supported by the elastic means *c*, it travels in an orbital clockwise path while rotating in a counterclockwise direction. The force aforesaid is relayed with a 180° phase displacement to the outer swingingly mounted cylinder *a* which acts as a counterweight, by which a mass adjustment takes place between the hollow cylinder *b* and the cylinder *a*.

Figs. 8 and 8a show another actuation of the device by means of a loose coupling. This loose coupling is formed by providing a disk *g* on both outer ends of the shaft *y* on which is mounted a diametrical slide-guide *u* which receives a sliding shoe *s* that is provided on the free end with a ball socket. In this ball socket is received the ball-shaped end *z*₁₂ of a lever arm *k*₂₁ which is

connected to the counter-weight mass *a* by a double cardan joint. The double cardan joint is formed in a known manner. It comprises pins *v'* and *v²* which are arranged at right angles to each other and which are mounted on the outer end of the lever arm *k₂₁*. The ends of the pins *v'*, *v²* are seated in a ring *r*. The pins *v'* and *v²* are elliptical in shape and are engaged in elliptical bearings *l₁* and *l₂*. The space between the pins *v'* and *v²* and the bearings *l₁*, *l₂* is furnished with a rubber filling *v₁₁* which offers resistance to any yielding in the axial direction. In contrast to the cardanic mounting with round plugs and frictionless beds as is known in the art, the pins *v'* and *v²* and their bearings *l₁* and *l₂* are shaped elliptically and are provided with a similar shaped rubber filling between plug and bearing, which creates a resistance to each deviation of the lever arm *k₂₁* from the axial direction, which resistance is reflected in the counter-weight mass *a*. Cardan joints of this kind thus transmit elastic forces between the two oscillating masses, just like other loose couplings. These forces increase with the deflection (amplitude), so that the energy transmitted per oscillation, i. e., the output per second also varies with the deflection of the coupling.

As the degree of the deflection is in turn dependent on the frequency, it is at once evident that in the present embodiment and in those described in the foregoing the transmitted power and thus also the effective grinding output increases with the frequency on account of the increase of the centrifugal force.

It will also be seen that the sliding track *u* in the present embodiment is not absolutely essential because asymmetry of the hollow receptacle *b*, necessary for the rotation, can be expected in all cases, on account of the weight of the receptacle *b* and the distortion thereof by centrifugal force so that the coupling (Fig. 8) can also be set in motion without an eccentric sliding track. The eccentric sliding track merely affords the advantage that the starting up or the transmission of power is immediately and more energetically established by the coupling.

Finally, Fig. 9 illustrates a loose coupling that can be used to drive the apparatus of the present invention. The sliding track *u*, the sliding shoe *s* and the eccentric lever *k₃₁* correspond exactly to the loose coupling described in Fig. 8. On the other hand, the lever *k₃₁* is not connected to the outer mass *a* by an elastic universal joint but is connected rigidly thereto. Consequently relative displacement of the masses *a* and *b* can occur only in the direction of the sliding track *u*, whereas the loose coupling described in Fig. 8 permits phase displacements in every direction. The loose couplings as illustrated in Figs. 1, 2, 5, 6, 7 and 8 can yield in the direction of both the space axes applicable to the circular oscillations and thus represent the best possible working systems, while the couplings shown in Figs. 4 and 9 are prevented from yielding in respect of one axis. In the case of circular oscillations of the present kind, however, the loose couplings shown in Figs. 4 and 9 can also be used with good results.

Fig. 10 illustrates a mechanism for adjusting the resilient members *c*. The resilient spherical buffer *c₁₁* is in this case secured to a lever-like support *p*, which is pivoted to a bearing *q*. By adjusting the screws *t* the resilient member secured to the outer mass *a* is brought near to the inner mass *b*, i. e., the initial elastic tension is

increased. In contradistinction to the increase of power obtained by raising the frequency, in the present case an increase of power is obtained by increasing the potential energy.

The present invention also includes the case where double mass systems coupled in a manner different from that described in the foregoing are used or where other known types of coupling are employed. It is, however, advantageous for the hollow body *a* that does not participate in the grinding process to be prevented from performing a rotary movement by tangential forces, for example by the suspension means *h* or resilient supports acting in a similar manner, while the grinding chamber *b* may perform a slow rotary movement facilitating the grinding process, in addition to the circular oscillation, for the purpose of loosening and mixing the material under treatment.

Moreover, the invention also includes the case where the non-rotating hollow body acting as the second mass is secured on elastically yielding supporting devices, and where the counter or second mass *a* consists not of a cylinder jacket but of separate rings or other composite constructional arrangements.

Although the shape of the auxiliary bodies used for the grinding may affect the grinding operation to some extent depending on whether they are of cylindrical, oval or spherical shape, and similarly the curved surfaces of the hollow receptacle, depending on how they vary between the cylindrical and prismatic form, such variations are immaterial for the purpose of the present invention.

I claim:

1. A device for grinding material including a swingable receptacle for containing loose grinding bodies having their axes parallel to the axis of said receptacle, a swingable body surrounding said receptacle and having its axis parallel to that of said receptacle, means mounting said body for limited swinging movement, said mounting means causing said body to serve as a counter-weight for the said receptacle, said receptacle being positioned within said body and elastic means spacing said receptacle and body apart.

2. The structure of claim 1, elastic means for preventing the rotation of said body, and means for moving said receptacle in a circle within said body.

3. The structure of claim 1, a rotatable shaft arranged axially of said body and said receptacle, cranks carried by said receptacle and freely rotatable on the same at either end thereof, cranks on said shaft and rotatable therewith, a rigid connection between each crank on said shaft and the corresponding crank on said receptacle whereby to swing said receptacle in a circle around said shaft.

4. The structure of claim 1, a rotatable shaft arranged axially of said body and said receptacle, cranks carried by said receptacle and freely rotatable on the same at either end thereof, cranks on said shaft and rotatable therewith, a rigid connection between each crank on said shaft and the corresponding crank on said receptacle whereby to swing said receptacle in a circle around said shaft, and elastic means for preventing the rotation of said body.

5. The structure of claim 1, elastic means for preventing the rotation of said body, a rotatable crank shaft arranged axially of said receptacle and said body, and a resilient connection between

said shaft and said receptacle, said shaft being freely rotatable in said connection.

6. The structure of claim 1, elastic means for preventing the rotation of said body, a rotatable crank shaft arranged axially of said receptacle and said body, and a resilient connection between said shaft and said receptacle, said shaft being freely rotatable in said connection, said connection comprising circular members freely rotatable on said shaft adjacent said receptacle, and resilient buffer members carried by said receptacle and engaging the peripheries of said circular members.

7. The structure of claim 1, a rotatable shaft arranged axially of said receptacle and said body, means for preventing the rotation of said body, means for swinging said receptacle in a circle within said body, said means comprising a pair of plates fixed on said shaft adjacent each end of said receptacle, sliding tracks on said plates, shoes adapted to slide in said tracks, and means

carried by said body eccentrically of said shaft and engageable with said slides.

8. The structure of claim 1, a rotatable shaft arranged axially of said receptacle and said body, means for preventing the rotation of said body, means for swinging said receptacle in a circle within said body, said means comprising a pair of plates fixed on said shaft adjacent each end of said receptacle, sliding tracks on said plates, shoes adapted to slide in said tracks, and means carried by said body eccentrically of said shaft and engageable with said slides, said means connecting said body to said slides and comprising a Cardan joint.

9. The structure of claim 1, means for preventing the rotation of said body, means for swinging said receptacle in a circle within said body, and the stretching of said elastic means during said swinging being variable.

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