July 7, 1970 T. D. DAVIS ET AL 3,519,212

CRUSHER FEEDING METHOD

Original Filed March 24, 1964

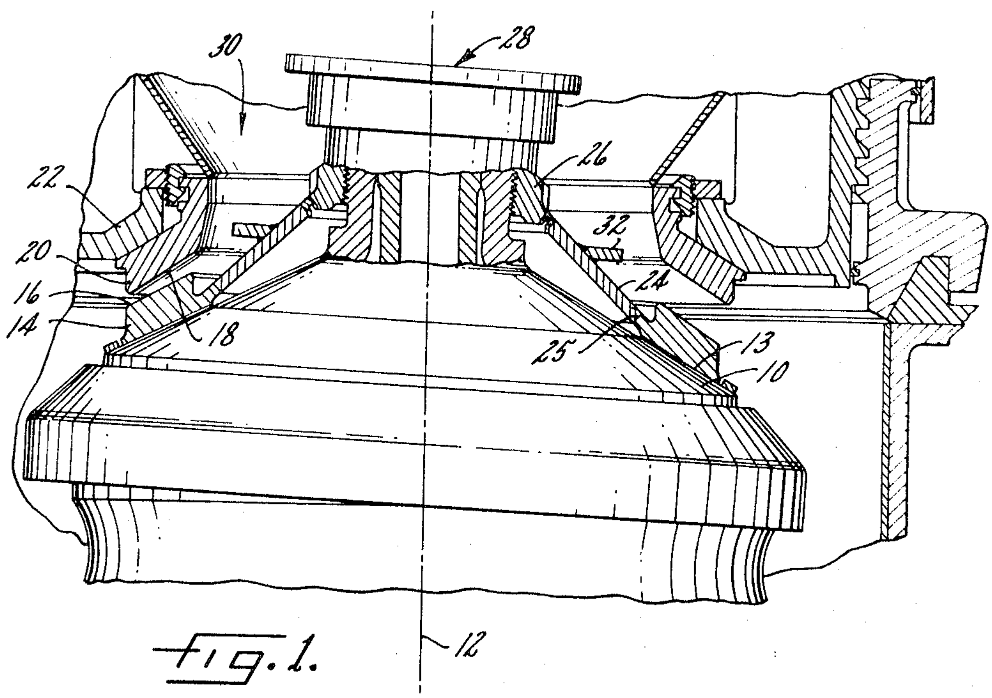



Fig. 1.

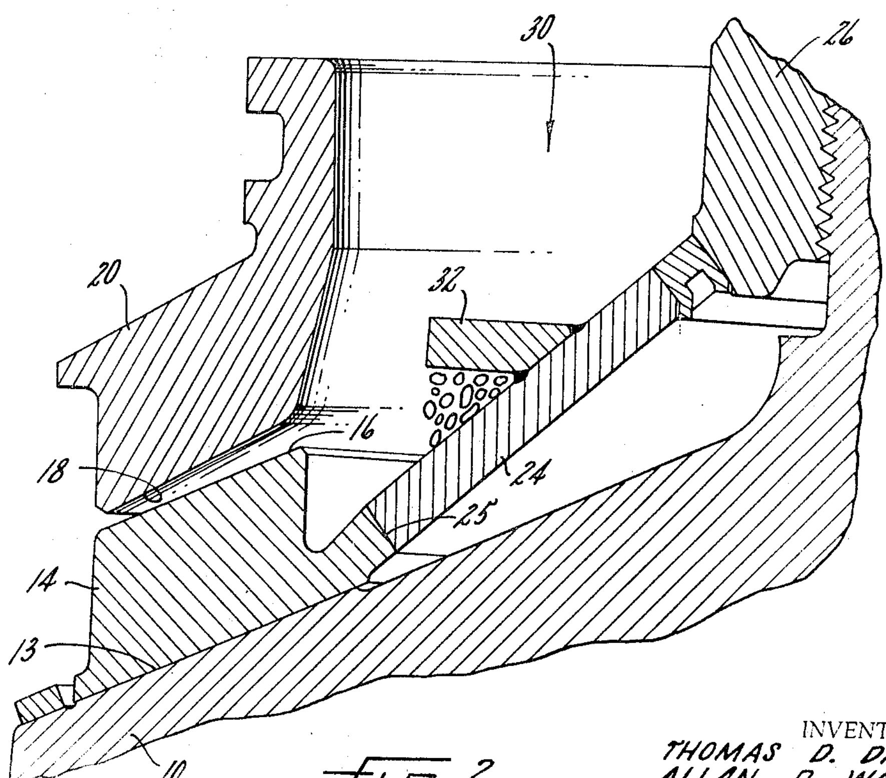



Fig. 2.


INVENTORS.
THOMAS D. DAVIS
ALLAN D. WATSON
BY
Parker & Carter
ATTORNEYS.

United States Patent Office 3,519,212
Patented July 7, 1970



# 3,519,212
# CRUSHER FEEDING METHOD

Thomas D. Davis, Hillsborough, and Allan D. Watson, San Diego, Calif., assignors to Nordberg Manufacturing Company, Milwaukee, Wis., a corporation of Wisconsin

Application Mar. 24, 1964, Ser. No. 354,216, now Patent No. 3,329,356, dated July 4, 1967, which is a continuation-in-part of application Ser. No. 232,843, Oct. 24, 1962. Divided and this application Apr. 10, 1967, Ser. No. 629,715
Int. Cl. B02c 2/04
U.S. Cl. 241—30 6 Claims

## ABSTRACT OF THE DISCLOSURE

A method of operating a gyratory crusher by applying a positive congesting pressure to the material within the crushing zone as the gyrating member of the crusher is moving away from the stationary crushing member, and agitating the material above the crushing cavity as the gyrating member is moving toward the stationary member. The areas of pressure application and material agitation are diametrically opposed. A frictional force is applied to drag material into the crushing cavity as the gyrating crushing member is moving away from the stationary crushing member. The combination of positive pressure and frictional force applied to the material moves the material at a speed greater than that of gravity into the crushing zone.

This invention relates to gyratory crushers, and in particular to a method for increasing the material feed to and through a crushing cavity. This is a division of our copending application Ser. No. 354,216, filed Mar. 24, 1064, now Pat. No. 3,329,356, issued July 4, 1967, which was a continuation-in-part of Ser. No. 232,843, filed Oct. 24, 1962, now abandoned.

One purpose of the invention is a method of the type described in which a positive congesting pressure is applied to the material feed to pack the crushing cavity.

Another purpose is a method of the type described in which the material feed is driven at a velocity, greater than that caused by gravity alone, into the crushing cavity.

Another purpose is a method of operating a gyrating crusher which increases the maximum amount of product of a desired size.

Another purpose is a method of the type described in which the material above the crushing cavity is agitated or loosened to provide a free flow into the crushing cavity.

Another purpose is a method of the type described including the step of frictionally dragging material to be crushed into the crushing cavity.

Another purpose is a method of operating a gyrating crusher in which the crushing cavity is opened, above its optimum, and a downwardly directed positive pressure is applied to the material feed to increase the amount of usable product moved through the crushing cavity.

Another purpose is a method of operating a gyratory crusher by applying a positive congesting pressure to the material in the crushing cavity and agitating the material above the crushing cavity to keep it in a freely flowing condition.

Other purposes will appear in the ensuing specification, drawings and claims.

The invention is illustrated diagrammatically in the following drawings wherein:

FIG. 1 is a partial vertical section through a crusher of the type described, and

FIG. 2 is an enlarged section illustrating the crushing



cavity and the means for applying a congesting pressure to the material feed.

This invention is usable for example with a crusher of the type shown in U.S. Pats. 2,670,142 and 2,917,247. The invention should not be limited to this particular type of crusher, as it may be applicable to other gyratory crushers.

Considering a crusher of the type disclosed in the above two patents, it should be noted that the crushing cavity forms a smaller angle with the horizontal than in other types of gyratory crushers. For example, the crushing cavity may form an angle of on the order of 25 to 30 degrees with the horizontal, as contrasted to an angle of about 45 degrees in other types of gyratory crushers. Crushers of this type may be used on limestone or similar materials. For each desired size of product there is an optimum setting of the crushing cavity discharge opening. As an example, if the desired product size is —⅛ inch, a crushing cavity opening of 5⁄16 inch might be the optimum. The size of the cavity can be increased, for example to one-half inch, and the total tonnage through the crusher will substantially increase. However, the amount of usable product will be below the amount of usable product with a 5⁄16-inch setting. In other words, the size of the crushing cavity can be increased, but the amount of usable product does not increase, and may fall off. There is therefore an optimum setting for the crushing cavity for each size of desired product. It should be understood that the figures given above are merely examples or illustrations, and do not necessarily apply to any particular type or size of machine.

It has been found that the capacity of a crusher for producing a desired size of product can in some cases be increased as much as 50 percent if a positive pressure is applied to the material feed to compact it and to drive it into the crushing cavity at a speed greater than its velocity from free fall. This positive pressure may be combined with a crushing cavity opening above the optimum. Merely opening the cavity above the optimum is not sufficient. The material feed must be driven into the cavity at a velocity greater than that attained merely by free fall or through gravity so that the cavity is congested and the material is packed in the cavity. Although it is preferred that the cavity be enlarged in size and the material be driven with a positive pressure, in some applications merely the use of a positive pressure is sufficient.

Considering FIG. 1, the conical head of a gyratory crusher is indicated at **10** and it will rotate and gyrate about an axis **12** as is conventional. Details of the crusher can be found in either of the above-mentioned U.S. patents. The head **10** which has an outer surface **13** that slants downwardly and outwardly and mounts a mantle **14** having an upper surface **16** that defines a crushing cavity with the lower surface **18** of a bowl liner **20**. The bowl liner is attached to the bowl **22** as is conventional. It should be noted that the angle of the crushing cavity is on the order of 25 to 30 degrees, or is much flatter than in many types of gyratory crushers. In operation, as the head and mantle gyrate, the head will move the material in the crushing cavity generally normally toward the bowl liner.

Mounted on the head above the mantle **14** is a conic thrust member or sleeve **24** which abuts the upper edge **25** of the mantle and applies a downward thrust thereto. The upper end of the thrust member **24** is held in position by a securing nut **26** which is threaded to the head. Mounted above the securing nut **26** is a feed plate assembly indicated generally at **28** which is not important to this invention. In operation, the feed plate assembly will rotate and will distribute material into the zone **30** above the crushing cavity proper.

Mounted on the thrust member **24** is an annular ring **32**, which as shown herein, is separate and welded to the thrust member. The ring may be integral with the thrust member. Either form is satisfactory. The ring **32** extends laterally into the zone **30** above the crushing cavity. It is important that the area between the outer circumferential or peripheral edge of the ring and the opposing surface of the bowl liner be no less than the area of the opening into the crushing cavity. This is necessary in order not to restrict the material flow into the crushing cavity. In operation, the head will gyrate and the mantle will move toward and away from the bowl liner. The mantle is moved toward the bowl liner in a defined zone which rapidly circumferentially moves about the crushing cavity. As the mantle moves away from the bowl liner, ring **32** will move downwardly into the mass of material and will drive it toward the crushing cavity. The ring **32** congests the material in the cavity at a greater rate than it would merely by falling through gravity. The ring **32** may accelerate movement of the material feed into the cavity at a rate approximately twice that of gravity.

In addition to the downwardly directed congesting pressure which is applied as the mantle is moving away from the bowl liner, when the mantle moves toward the bowl liner, the ring **32** will apply an upwardly directed force which will have a tendency to loosen or agitate the material in the space **30**. In certain types of material, for example limestone or the like, there may be a tendency to pack or bridge. This may be due to clay in the material, particle size and shape, moisture content, etc. It is therefore desirable to continually agitate and loosen the material so that it can freely flow into the crushing cavity. The ring **32** performs this function and maintains the material as individual particles rather than as an adhered mass of particles.

Material may be trapped beneath ring **32**, as illustrated particularly in FIG. 2, with the result that the ring and the material trapped beneath it form a generally vertical rough and uneven surface which will frictionally drag material to be crushed from the space **30** down into the crushing cavity. The height and lateral extent of ring **32** determines the extent of the vertical frictional face. In this connection, the size and position of ring **32** may vary with different materials and the size of the finished product.

The thrust member **24** is conventionally made of a steel which is abrasive resistant. There is very little impact of the material feed upon this member, but it will be subject to considerable abrasion. Accordingly, a steel which is satisfactory to resist abrasion is customarily used. The thrust member **24** is a replaceable wear part in that even though made of an abrasive-resistant steel, it will need replacement after a period of use. Accordingly, it may be desirable to form the thrust ring **24** integral with the ring **32**. For example, these two members may be cast as a single unit. The ring **32** may be separate, and welded or otherwise secured to the thrust member **24**.

The use, operation and function of the invention are as follows:

By utilizing the present invention, the capacity of a gyratory crusher may be increased as much as 50 percent, both in total tonnage and in the maximum amount of usable product. The material may be accelerated or pushed toward the crushing cavity at a speed approximately twice that of gravity. A downward congesting pressure is applied by the ring **32** to positively move the material toward the crushing zone. The material is congested or compacted so there is sufficient attrition crushing to reduce the material to size. With crushers of the type referred to above there is attraition reduction as well as impact reduction. In many gyratory crushers there is only impact. By congesting the material in the crushing cavity there is additional attrition and therefore faster reduction of the material feed. Because there is additional attrition crushing, the cavity can be opened to let more material pass through it without any reduction in the amount of usable product of a desired size. It is the combination of the downwardly applied pressure and the opening of the crushing cavity above the optimum which permits increased capacity. However, the capacity should never be increased to the point where the crusher is overloaded.

Not only does the ring perform the function of driving more material into the crushing cavity, but it has an additional function in applying an upwardly directed agitating force to keep the material in the zone above the crushing cavity free and loosely packed so that it can flow easily into the crushing zone. Also, material is dragged into the crushing cavity by the frictional force provided by the material caught beneath the ring **32**. It is the combination of all three functions that makes the ring **32** advantageous.

It should be noted that the congesting pressure will be applied to the material as the head moves away from the bowl liner. At one point around the crushing cavity the mantle or head will be moving toward the bowl liner to crush the material while on the opposite side of the cavity the head will be moving away. It is at this latter point that the downwardly applied pressure will congest the material within the cavity, to pack it for subsequent upward movement of the mantle to crush it. It should also be noted that while one side of the cavity is receiving a downwardly directed pressure to pack the material, the area above the opposite side of the cavity is receiving an upwardly directed agitating pressure or force to loosen the material so that it may freely flow into the cavity.

The invention is not practically useful with all types of material or with all crushers. As stated above, it is particularly useful with crushers which have a rather low angle for the crushing cavity, for example on the order of 25 to 30 degrees with the horizontal. A ring of this type is generally useful with particles which have an affinity for each other, preventing free flow. A crusher as described herein can be used on any material which has a very high angle of repose, for example greater than about 45 degrees. By the angle of repose it is meant the angle that a pile of material will form with the horizontal. A low angle of repose means that the particles have very little clogging or sticking tendency and the pile will tend to flatten out. A high angle of repose means that the particles have a great sticking tendency and they will not slide over each other but will tend to pyramid up. Generally speaking, coarser materials will have a high angle of repose. There will be many voids in a mass of coarse particles enabling the crushing cavity to be effectively packed.

Whereas the preferred form of the invention has been shown and described herein, it should be realized that there are many modifications, substitutions and alterations thereto within the scope of the following claims.

We claim:

**1.** A method of operating a gyrating crusher having a crushing zone defined by a stationary crushing member and a gyrating crusher member in which the gyrating crusher member moves material in the crushing zone generally normally towards the stationary crushing member, including the steps of applying a positive congesting pressure to the material within the crushing zone as the gyrating crushing member is moving away from the stationary crushing material, and agitating the member above the crushing cavity as the gyrating member is moving toward the stationary member.

**2.** The method of claim **1** further characterized in that the area of pressure application and material agitation rapidly circumferentially moves about the crushing zone, with the area of pressure application being generally diametrically opposed to the area of material agitation.

**3.** The method of claim **1** further characterized in that the material to be crushed is moved, by said positive pressure, at an acceleration greater than that of gravity, into the crushing zone.

4. The method of claim 1 further characterized in that the application of congesting pressure includes the application of a frictional force to move material toward the crushing zone as the gyrating member moves away from the stationary crushing member.

5. A method of operating a gyrating crusher having a crushing zone defined by a stationary crushing member and a gyrating crushing member in which the gyrating crushing member moves material in a crushing zone generally normally towards the stationary crushing member, including the steps of applying a positive congesting pressure to the material within the crushing zone as the gyrating member is moving away from the stationary crushing member, with the area of pressure application rapidly circumferentially moving about the crushing zone, agitating the material above the crushing cavity as the gyrating crusher member is moving toward the stationary crushing member, with the areas of pressure application and the material agitation being diametrically opposed, and applying a frictional force to drag material into the crushing cavity as the gyrating crushing member is moving away from the stationary crushing member, the combination of the positive pressure applied to the material as well as the frictional force applied to the material, moving the material at a speed greater than that of gravity into the crushing zone.



6. The method of claim 5 further characterized in that the material used in the crushing operation has an angle of repose greater than about 45 degrees.


**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,999,756 | 4/1935 | Goldberg | 241—209 |
| 2,296,281 | 9/1942 | Gruender | 241—30 |
| 2,917,247 | 12/1959 | Gruender | 241—202 |
| 2,971,705 | 2/1961 | Werner | 241—202 |



LESTER M. SWINGLE, Primary Examiner

D. G. KELLY, Assistant Examiner

# United States Patent

[11] **3,625,440**

[72] Inventor **Irving Bond**
**Newton Highlands, Mass.**
[21] Appl. No. **852,554**
[22] Filed **Aug. 25, 1969**
[45] Patented **Dec. 7, 1971**
[73] Assignee **Bay State Smelting Co., Inc.**
**Somerville, Mass.**

[54] **METHOD FOR RECOVERING COPPER BASE METAL FROM COPPER BASE ASHES AND RESIDUES**
**1 Claim, 1 Drawing Fig.**

[52] **U.S. Cl.** .......... **241/21,** 241/24, 241/30
[51] **Int. Cl.** .......... **B02c 21/00,** B02c 17/10
[50] **Field of Search** .......... 241/15, 20, 21, 24, 30, 80

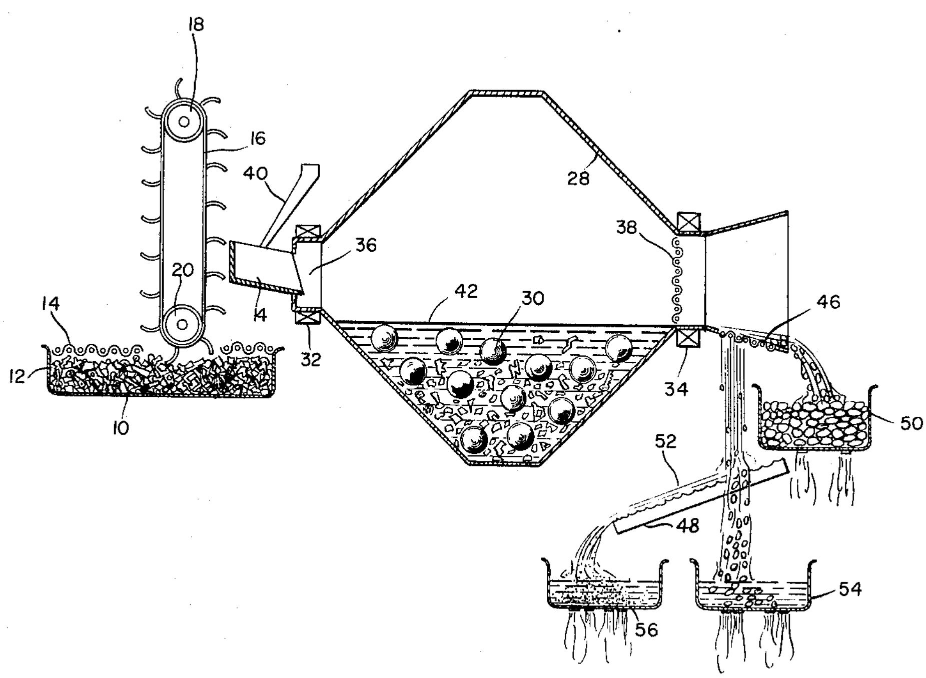
[56] **References Cited**

UNITED STATES PATENTS

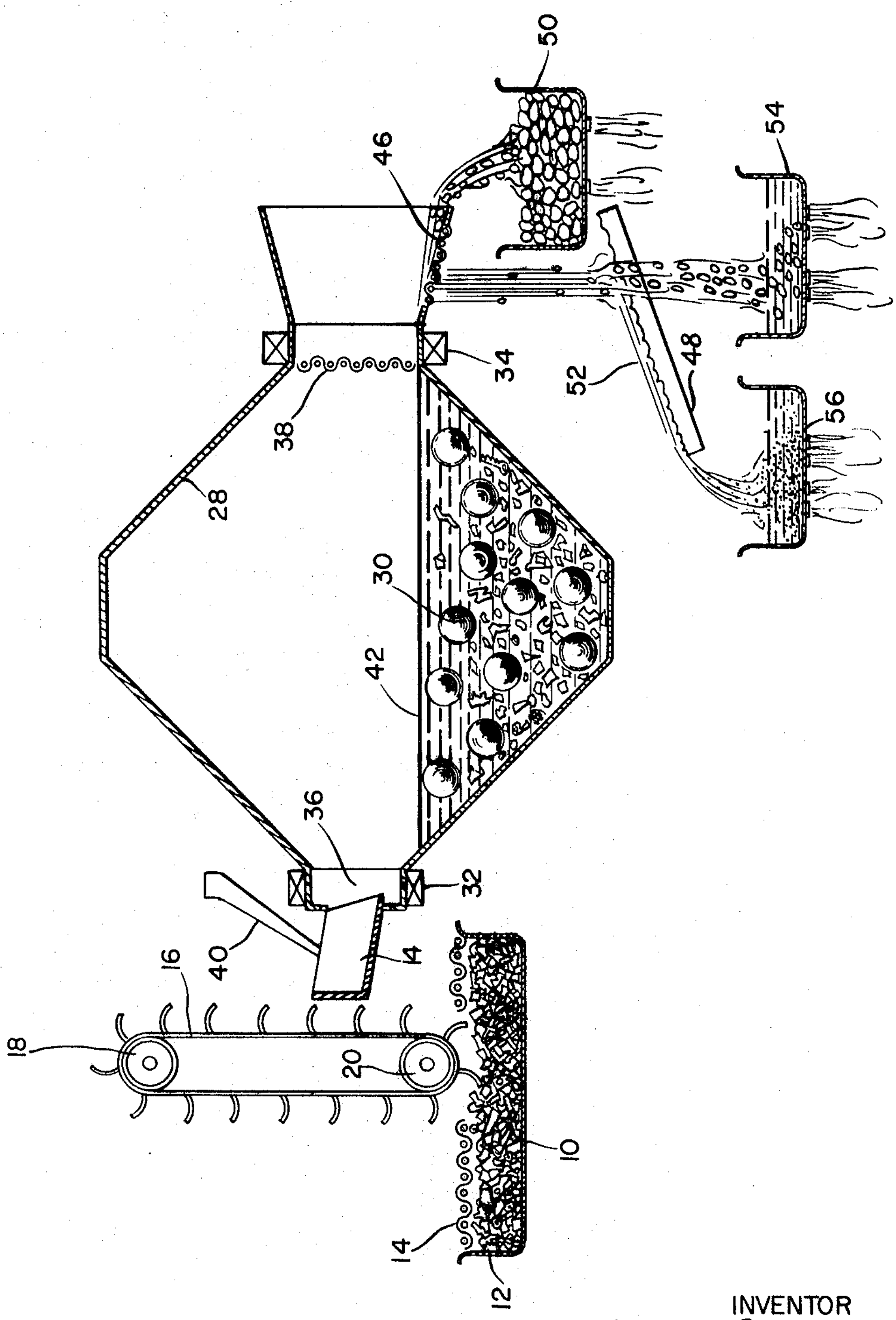
| | | | |
|---|---|---|---|
| 2,072,063 | 2/1937 | Alton | 241/80 UX |
| 2,675,966 | 4/1954 | Kihlstedt | 241/20 |
| 3,086,718 | 4/1963 | Lukas | 241/24 |

*Primary Examiner*—Donald G. Kelly
*Attorney*—Morse, Altman & Oates

**ABSTRACT:** Copper base aggregates are washed with water to remove dust, are ball milled to separate oxides by shock, are screened to remove lumps for reprocessing and are cleaned by flowing with water over a vibrating table, to produce an intermediate copper base product for remelting.



PATENTED DEC 7 1971 3,625,440




INVENTOR
Irving Bond
BY
Morse, Altman & Oates
ATTORNEYS

# METHOD FOR RECOVERING COPPER BASE METAL FROM COPPER BASE ASHES AND RESIDUES

## BACKGROUND AND SUMMARY

The present invention relates to the recovery of copper base metal from copper base aggregates, particularly copper base ashes and residues from other copper base metal production and fabrication processes and more particularly to such recovery in an efficaciously and economically. Difficulties have been encountered particularly in removing oxygen economically in order to leave a copper base intermediate product useful as a copper melt or copper melt additive.

The primary object of the present invention is to provide a process and a device for providing such an intermediate copper base product by washing with water to remove dust, ball milling to separate oxides by shock, screening to remove lumps for reprocessing, and cleaning by flowing with water over a vibrating table. It has been found that, under the contemplated circumstances, it is more economical to dispose of the oxides separated in the foregoing manner than to attempt to recover useful copper base materials from the oxides by various techniques.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the process and device, together with their steps, parts and interrelationships, which are exemplified in the present disclosure, the scope of which will be indicated in the appended claims.

## BRIEF DESCRIPTION OF DRAWING

For a fuller understanding of the nature and objects of the present invention, reference is made to the following detailed specification, taken in connection with the accompanying drawing which is a diagrammatic view of an apparatus embodying the present invention.

## DETAILED DESCRIPTION

With reference to the drawing, the starting material is copper base ashes and residues **10**, commonly called grisley, which is supplied to a well **12** through a coarse screen **14**. Generally the copper base ashes are composed of one or more of a member of the class consisting of brass, cupronickel and bronze, containing at least 40 percent copper and a remainder of other constituents.

This starting material is elevated to a chute **14** by a vertical bucket conveyor **16**, which has driven pulley wheels **18**, **20** for controlling an endless belt **22** having a series of bucket scoops **24**. The lower extremity of conveyor **16** projects into well **12** so that bucket scoops **24** continuously **16** projects the starting material to chute **14**.

The starting material from conveyor **16** is guided by chute **14** to a rotating drum **28**, which, in conjunction with steel balls **30**, constitutes a mill. Drum **28** is journaled at bearings **32**, **34** for rotation about an axis, at the opposite ends of which are an inlet **36** and an outlet **38**. A stream of water, introduced at **40**, flows through inlet **36** to form a pool of water **42** in mill **28**, and through outlet **38**, which is associated with a series of screens to be described below. Generally the volume occupied by steel balls **30** ranges from one-third to one-half the volume of drum **28**. Steel balls **30** range in diameter from 1.5 to 5 inches.

Outlet **38** communicates with a series of a vertical screen **44** and an inclined screen **46**. Screen **44**, which is located in outlet **38** and is characterized by 1 to 2 inch openings, retains the copper base material within the mill for a sufficiently long period for the balls to remove metallic oxide particles from larger agglomerates by shock. Screen **46**, which is characterized by openings one-sixteenth to one-fourth inch openings, serves to pass fines to an inclined vibrating table **48** and to guide coarse agglomerates to a container **50**. Vibrating table **48** is riffled as at **52**. As the aqueous slurry of fines flows over the vibrating table, which is inclined, the heavier metal bearing particles tend to be retained by the riffles in such a way as to flow transversely along the riffles for capture in a suitable container **54** and the lighter oxidized particles flow transversely of the riffles in the direction of inclination of the vibrating table for capture in a suitable container **56**.

## OPERATION AND CONCLUSION

In the process of the present invention, in one example, screen **46** has openings that are 1¼ inch in diameter and screen **46** has openings that are one-eighth inch in diameter. Agglomerates from well **12** are transferred to chute **14** by conveyor **16** and immersed in a steady flow of water through inlet **40**. Within mill **28**, which rotates continuously, the agglomerates are impacted by steel balls **30** and the slurry produced by water **42** is flowed toward screen **38**, which retains balls **30** and the larger agglomerates and transmits that portion of the slurry containing particles less than 1¼ inch in diameter. This portion of the slurry flows over inclined screen **46**, which transmits that portion of the slurry containing the smaller particles and guides that portion of the slurry containing the larger particles. The larger particles, which are at least one-eighth inch in diameter, are caught by container **50**. The smaller particles, which are less than one-eighth inch in diameter, are flowed onto inclined vibrating table **48**, where the metal bearing particles are caught in container **54** and the residue is caught in container **56**. Containers **50**, **54** and **56** all have lower openings, through which water escapes. Since certain changes may be made in the foregoing disclosure without departing from the scope hereof it is intended that all matter contained in the foregoing description and shown in the accompanying drawing be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. A process for recovering copper base metal from copper base aggregates, said process comprising the steps of washing said aggregates with water to remove dust, ball milling said aggregates in an aqueous slurry to separate oxides by shock, screening said aqueous slurry to remove lumps for reprocessing, screening to separate a slurry component containing larger particles and a slurry component containing smaller particles, and flowing said slurry component containing smaller particles over a riffled vibrating support to separate metal bearing particles from oxidized residue, said copper base metal being selected from the class consisting of brass, cupronickel and bronze, said ball milling being effected with steel balls that range in diameter from 1.5 to 5 inches in a rotating mill having an axis, an inlet at one end of said axis receiving said copper base aggregates, an outlet at the other end of said axis discharging a slurry formed in said rotating mill, said axis being slightly inclined from said inlet to said outlet, said screening being effected by a first screen at said outlet for retaining predeterminedly large particles in said mill and a second inclined screen at said outlet for receiving a flow of slurry from said outlet in order to separate finer particles from coarser particles, the volume of said steel balls ranging from one-third to one-half the volume of said rotating mill, said screening including obstructing at said outlet with a screen having openings ranging from 1 to 2 inches.

* * * * *

# United States Patent [19]

**Mortenson**

[11] **3,987,969**

[45] **Oct. 26, 1976**


[54] **METHOD AND DISC MILL FOR GRINDING OF MATERIAL**


[75] Inventor: **Magne Mortenson,** Trondheim, Norway

[73] Assignee: **Kvaerner Brug A/S,** Oslo, Norway



[22] Filed: **Mar. 10, 1975**

[21] Appl. No.: **557,176**

[52] **U.S. Cl.** .................................... **241/30;** 241/176

[51] **Int. Cl.²** ........................................ **B02C 17/10**

[58] **Field of Search** .............. 241/30, 172, 176, 178


[56] **References Cited**

UNITED STATES PATENTS

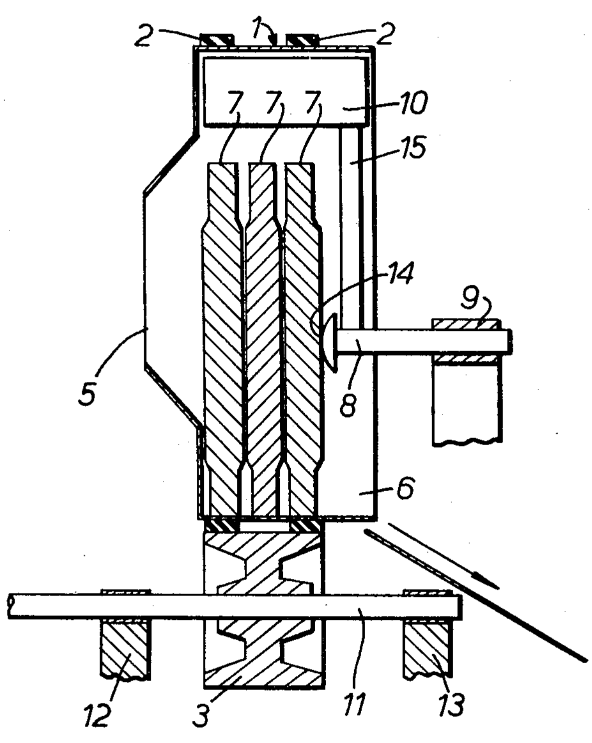

| | | | |
|---|---|---|---|
| 178,564 | 6/1876 | Smith | 241/178 |
| 478,252 | 7/1892 | Cullingworth | 241/178 X |
| 810,904 | 1/1906 | Bonvillain | 241/172 |
| 1,363,990 | 12/1920 | Morthland | 241/176 |
| 2,014,640 | 9/1935 | Wales | 241/172 |
| 2,482,740 | 9/1949 | Brown | 241/176 X |


*Primary Examiner*—Granville Y. Custer, Jr.
*Attorney, Agent, or Firm*—Young & Thompson

[57] **ABSTRACT**


A method of grinding material in a disc mill, the mill being operated at maximum r.p.m. corresponding to three to four times the critical velocity and is restricted only by injurious vibrations due to unbalanced masses so that the grinding material is centrifuged and forms a layer on the internal surface of the mill cylinder, the thickness of this layer being restricted by a suitable member. A disc mill for carrying out the method is also disclosed, the mill having free grinding discs of the same diameter, equal to about two thirds of the diameter of the mill cylinder, the discs being collected in an effective grinding area with a length about two thirds of the diameter of the cylinder.


**5 Claims, 2 Drawing Figures**



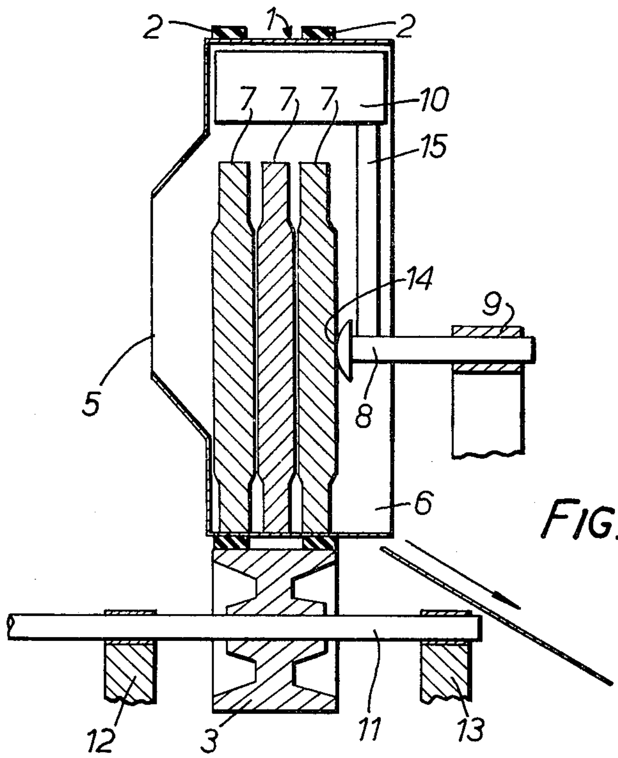



FIG. 1.

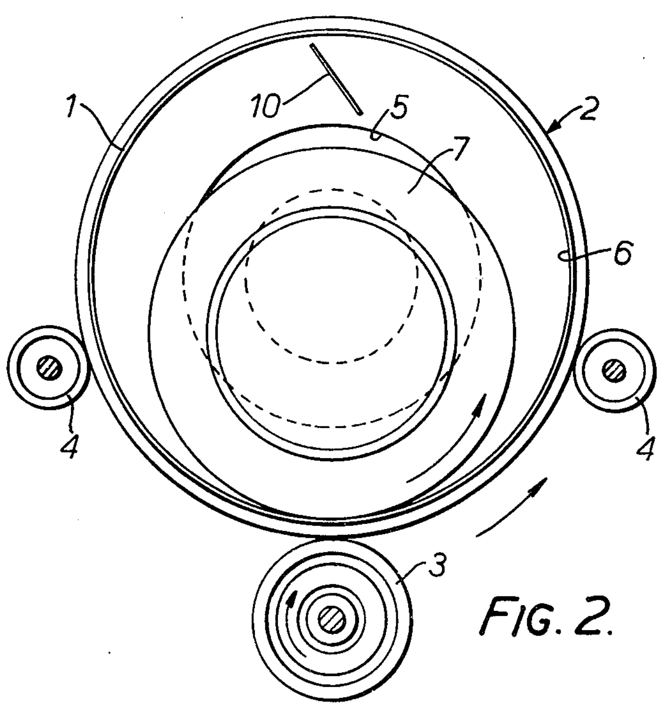



FIG. 2.

## METHOD AND DISC MILL FOR GRINDING OF MATERIAL

For almost a hundred years, work has been carried out on the construction of disc mills. None of the many proposals protected by patent has been used in practice, however. This is due to the fact that these mill constructions have not been particularly utilizable nor have they offered much competition to ball mills. The reason for this is that the constructors have not understood the special properties of the disc mill. It seems obvious to point out that analogical conclusions from construction and operation of ball mills would lead to disc mill constructions which are not particularly effective.

By investigation, a number of previously unknown factors have been discovered. On this basis, a special disc mill having great crushing effect has been constructed.

In order to achieve a simple characteristic and comparison of mills of various diameters and various r.p.m.'s, it is reasonable to indicate the r.p.m. of the mill in relation to the position assumed by the material in the mill drum under the influence of centrifugal force. If D signifies the internal diameter of a horizontally mounted cylinder rotating with an r.p.m. of $n$, a centrifuging of particles within the drum will take place, in accordance with the known formula

$$a = \frac{\pi^2 n^2 D}{1800}$$

in which $a$ is acceleration, $n$ is r.p.m., and D is the mill drum diameter in meters. Thus, when $a$ is the acceleration of gravity, or 9.81m/sec.$^2$, then the particles are carried with the cylinder, and do not fall, when $n_K$ is greater than $42.2/\sqrt{D}$. Vertically positioned, freely operating discs will not be centrifuged and carried with the cylinder, however, regardless of the r.p.m. thereof.

In the operation of a disc mill, therefore, there is no maximum, critical r.p.m. corresponding to the said formula which applies only to the ball mill.

If a disc mill is operated at a lower r.p.m. than $n_K$, a greater part of the raw material fed into the cylinder will remain on the inlet side of the discs and pass through without crushing. In such case the mill is not very effective.

If the r.p.m. is increased to above $n_K$, the raw material will be introduced between disc and drum and will be crushed. A substantial part of the material is carried with the disc and is released at the top thereof in a return flow toward the cylinder. With increasing r.p.m., the crushing capability of the mill is greatly increased. Experiments have shown that it is expedient to restrict the r.p.m. of the mill to about three to four times $n_K$, inter alia, on the grounds of vibration of unbalanced masses in a rapidly rotating machine.

If the mill is operated at an r.p.m. greater than $n_K$, a portion of the material particles which have passed between the disc and drum will be centrifuged towards the mill cylinder and form an internal layer therein, and the mill gradually becomes filled with material. If this is to be avoided, the mill must be provided with a suitable member which determines the thickness of centrifuged layers. This can be carried out by means of a scraper or in any suitable manner, for example, high pressure water scavenging. If the thickness of the centrifuged material layer is controlled, the mill achieves a self-constructing wear-lining within the cylinder.



Experiments with disc mill grinding show that it is of great importance for effective grinding that the volume of the raw material within the cylinder for grinding is relatively small. Maximum raw material filling should not be above 15% of the cylinder volume. Great energy of conversion is thereby achieved concentrated on small volume of raw material and subsequent great grinding effect.

In order to operate with small amounts in the mill, the cylinder must ot be appreciably constricted at the outlet opening, otherwise it must be provided with a suitable member for discharging the material. On dry grinding in the mill, suitable air suction means are arranged at the outlet opening. A mill having a centrally arranged outlet for overflow for pulp, as in a conventional ball mill, provides an ineffective grinding process.

If the disc mill is operated with wet grinding, addition of water can be reduced to about 50% of that necessary in a corresponding ball mill. This permits improved grinding condition and energy effect in the disc mill.

The size of the disc in relation to the diameter of the cylinder is of great importance to the grinding effect. Experiments with grinding of special types of raw material show that the disc size can be more than two thirds of the diameter of the cylinder. When using discs of such a diameter, the discs will fill up to 50 to 60% of the cylinder volume.

A mill constructed on these principles should operate in closed circuit with a classifying apparatus which separates the crushed material and returns coarse material for regrinding in the mill. The circulating mass through the mill is great, therefore, in comparison with the raw material addition. An extremely rational grinding process is achieved hereby, distinguished by minimum crushing to below the particle size determined by the classifying apparatus in a closed circuit.

If the mill is operated in open circuit without return, it will yield a selective grinding such that resistant minerals in the raw material are not crushed to a great extent and can, therefore, be separated selectively in a suitable subsequent process.

In addition to crushing of mineral raw material, a disc mill constructed on these principles has proved well adapted for treating a number of industrial products, for example, grinding of batches of tree limbs in cellulose digestion. By means of the disc mill grinding, a fibrous product is produced from the said branches which yields a stronger paper than is yielded by a conventional refining.

If the mill is provided with a series of discs - all of the same diameter, but of various thicknesses - it is possible, by disposing the thickest, i.e. the heaviest disc at the material inlet in the cylinder, to subject the coarse additive material to the greatest crushing load. An expedient crushing process is thereby achieved which is not possible in other mills. This process has been the unattainable aim of mill constructors.

The invention is further explained hereinbelow with reference to an embodiment example illustrated in the diagrammatic FIGS. 1 and 2.

FIG. 1 is a longitudinal section through a disc mill, and

FIG. 2 is an end view with some parts omitted for clarity's sake.

The disc mill consists substantially of a mill drum **1**, which, on one end side thereof, has a mill inlet **5**. The mill drum is rotatably mounted by means of two guide rollers **4** and a support and drive disc **3** which is in frictional operational co-operation with the mill drum, more specifically with two external support bearing rings **2** on the exterior of the mill drum **1**. The support and drive disc **3** is mounted on a shaft **11** which, in suitable manner, is mounted in bearings **12, 13** and is connected with drive means (not illustrated).

The right-hand end side of the mill in FIG. **1** is open and forms an outlet **6**.

Within the mill drum, three grinding discs **7** are arranged in this case. In a mounting **9**, a rod **8** is mounted having a rounded head **14** which acts as guide member for the grinding discs **7**. From the rod **8**, an arm **15** projects as the support of a scraper **10**. In the end view in FIG. **2**, the rod **8**, arm **15** and mounting **9** are omitted in order to facilitate understanding of the Figure.

In place of the support means **8, 9, 14** the mill can of course be provided with other members, for example, a diaphragm to prevent discharge of the grinding discs. The mill can of course also be mounted and operated in different ways from those illustrated in the drawing.

I claim:

**1.** A method of grinding material in a disc mill comprising a hollow cylinder and at least one disc in the cylinder, said at least one disc having a diameter that occupies most of the inside diameter of said cylinder, comprising introducing a charge of material to be ground into a said cylinder, rotating the cylinder at a



speed such that centrifugal force holds the material in a layer on the inner surface of a wall of the cylinder throughout rotation, and removing a portion only of the thickness of said layer of material after said layer has passed between said wall and said disc.

**2.** A method as claimed in claim **1**, in which said disc has more than two-thirds the diameter of the cylinder and fills up to 50 to 60 percent of the cylinder volume.

**3.** A disc mill for grinding material, comprising a hollow cylinder having at least one disc therein, the cylinder and disc having horizontal non-coincidental axes, said at least one disc being adapted to rest on the bottom of the inner side wall of the cylinder and having a diameter that occupies most of the inside diameter of said cylinder, an inlet for introducing material to be ground into the cylinder, an outlet for removing ground material from the cylinder, means to rotate the cylinder at a speed at least as great as the speed at which the material clings in a layer by centrifugal force to the inner wall of the cylinder throughout rotation, and means to remove a portion only of the thickness of said layer and to divert ground material from said layer to said outlet.

**4.** A disc mill as claimed in claim **3**, said at least one disc having a diameter about two-thirds the diameter of the cylinder.

**5.** A disc mill as claimed in claim **3**, said at least one disc filling up to 50 to 60 percent of the cylinder volume.

* * * * *

United States Patent [19] | [11] 4,057,191
Ohno | [45] Nov. 8, 1977

# [54] GRINDING METHOD

[76] Inventor: Ietatsu Ohno, 1-2, 1-chome Kasuya, Setagaya, Tokyo, Japan

[21] Appl. No.: 717,010

[22] Filed: Aug. 23, 1976

[51] Int. Cl.² .............................................. B02C 17/14

[52] U.S. Cl. ........................................ 241/30; 51/164; 241/175

[58] Field of Search ................... 241/26, 30, 175, 176, 241/177; 51/164; 259/72

[56] References Cited

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 3,030,082 | 4/1962 | Matzen et al. | 259/72 |
| 3,164,328 | 1/1965 | Van Dornick | 241/30 X |
| 3,206,128 | 9/1965 | MacPherson et al. | 241/26 |
| 3,392,925 | 7/1968 | Moore | 241/175 |
| 3,981,488 | 9/1976 | Ratowsky | 259/72 |

*Primary Examiner*—Roy Lake
*Assistant Examiner*—Howard N. Goldberg
*Attorney, Agent, or Firm*—Laurence R. Brown

[57] ABSTRACT

A grinding method wherein a cylindrical or polygonal tank of any material and a proper length is lined on the inside surface with any of such materials as a rubber, synthetic resin, brush, fiber and paper pulp. The tank is held in a universal joint at one end and is rotated at the other end. Thus, grinding agents and materials to be ground are put into the tank at the held end. A centrifugal motion is generated on the inner peripheral surface of the tank and the materials will flow to the other end and be ground while rotating spirally due to the centrifugal force on the inner peripheral surface of the tank while in contact with grinding agents.

2 Claims, 3 Drawing Figures

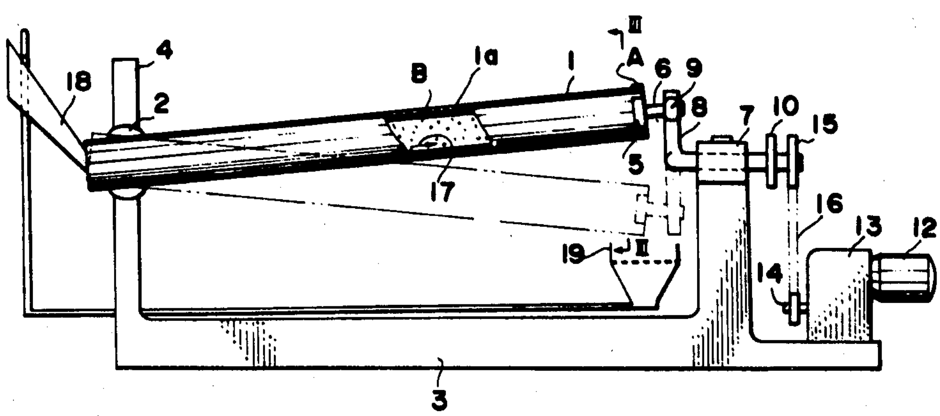


FIG. 1

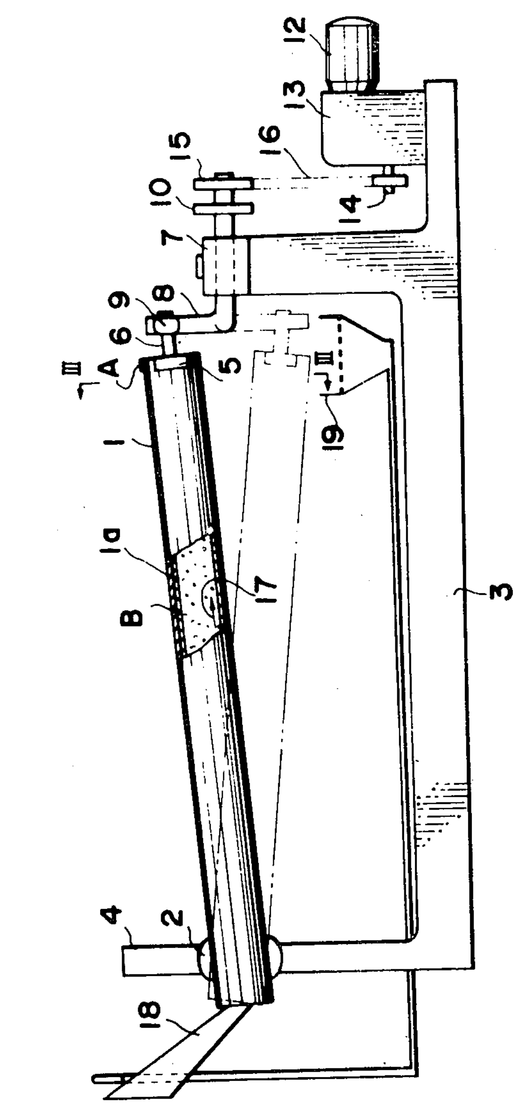


FIG.3

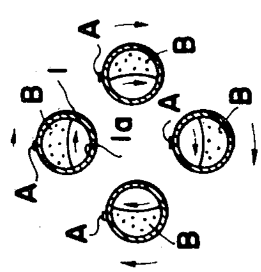
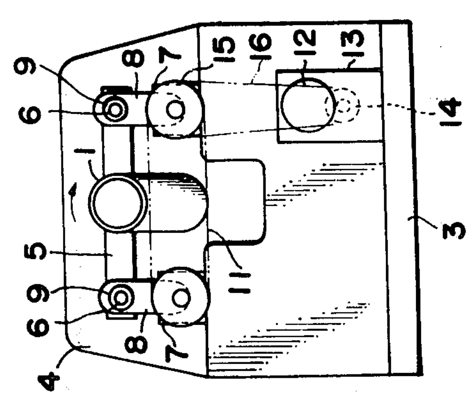



FIG.2



## GRINDING METHOD

This invention relates to a grinding method and apparatus wherein a cylindrical or polygonal tank of a proper length is rotatably held at one end and is made to make a circular motion at the other end. Alternatively the tank may be made to make any proper circular motions at both ends so that things to be ground put into the tank through one end will be made to flow while being ground by the centrifugal force for automatic discharge at the other end.

An object of the invention is to provide a centrifugal flow continuous grinding method.

Another object is to grind materials quickly, smoothly and positively within a short time.

FIG. **1** is a partly sectioned side view of apparatus performing the method according to the present invention.

FIG. **2** is an elevation of FIG. **1** from the right.

FIG. **3** is a sectioned view on line III—III in FIG. **1**, showing the flowing states of materials in the tank in respective positions in the circular motion of the tank.

In the drawings, the reference numeral **1** designates a cylindrical or polygonal grinding tank of a proper length pasted or lined on the inside surface *1a* with rubber, wood, paper, cloth, plastics, synthetic resin, leather, metal, brush or the like. The tank is held at one end in a frame **4** provided on a mount body **3** by a universal bearing **2.** The other end is attached to an arm frame **5** fitted at both ends with driving pin shafts **6.** A crank arm **8** is borne by each of two bearings **7** provided on the mount body **3.** Pin shaft **6** is pivoted at one end by a universal bearing **9** located in the end of a crank shaft **8** connecting operatively through bearing **7** with gear or pulley **10,15** driven through a chain or belt **11.**

A motor **12** fitted to the mount body **3** can have the number of revolutions freely varied by a speed change gear **13.** The chain or belt **16** is connected between a gear or pulley **14** fitted to the shaft of the motor **12** and a driving gear or pulley **15** fitted to the shaft of one of the crank arms **8.**

In such apparatus, when the motor **12** is driven, the crank arms **8** will rotate and the tank **1** will make a circular motion at one end. In this mode of operation, the tank will make a circular motion at the end but will not itself rotate as shown in FIG. **3.** That is to say, one point A at the end of the tank will be always directed upward. Therefore, the things to be ground and grinding agents B put into the tank will flow while describing a circle along the inner peripheral surface **1a** due the centrifugal force as indicated by the arrow (see FIG. **3)** and will be at the same time moved in the axial direction of the tank as indicated by the arrow **17** in FIG. **1.**

Therefore, if the things to be ground and grinding agents are put into the tank **1** through an inlet port **18** at the left end, they will flow while spirally moving on the inner peripheral surface **1a** due to the centrifugal force, while being automatically ground and will be taken out through the other end.

Needless to say, the outflowing time can be varied by varying the rotating velocity and radius of rotation. It is clear that it can be varied also by the length. Further, the ground things and grinding agents flowing out may be received with a receiver **19** and then sorted and only the grinding agents thereof fed back into the inlet port **18.**

Thus, in the present invention the tank is pivoted at one end and makes a circular motion at the other end so that the things to be ground will flow spirally therethrough. Accordingly, grinding efficiency is high, the grinding is fast, smooth and positive and furthermore the apparatus is simple.

I claim:

**1.** The grinding method comprising in combination the steps of:

a. confining a longitudinal hollow tank at one end in a fixed universal joint for limited rotational movement, said hollow tank having an internal surface lining,

b. feeding materials to be ground with a grinding agent in said first end of the tank,

c. grinding said materials by moving the opposite end of said tank in an arcuate path without rotating the tank, whereby the materials are ground by engaging the grinding agent and circling the inner peripheral lining of the tank as they flow from said one end to said opposite end of the tank, and

d. extracting materials and grinding agent from the said opposite end of the tank.

**2.** The grinding method of claim **1,** wherein the arcuate path consists of circular rotation.

* * * * *

# United States Patent [19]

**Rasmussen et al.**

[11] **4,369,926**

[45] **Jan. 25, 1983**


[54] **METHOD AND APPARATUS FOR GRINDING GRANULAR MATERIALS**


[75] Inventors: **Ole S. Rasmussen; Peter Lund,** both of Copenhagen, Denmark

[73] Assignee: **F. L. Smidth & Co.,** Cresskill, N.J.



[21] Appl. No.: **107,846**

[22] Filed: **Dec. 28, 1979**

[30] **Foreign Application Priority Data**

Dec. 29, 1978 [GB] United Kingdom ............... 50281/78

[51] **Int. Cl.**[3] ............................................ **B02C 17/06**

[52] **U.S. Cl.** ........................................ **241/18;** 241/24; 241/29; 241/30; 241/65; 241/72; 241/76; 241/153; 241/171; 241/181; 241/80; 241/97; 241/184

[58] **Field of Search** ....................... 241/23, 24, 29, 30, 241/65, 70, 71, 72, 76, 78, 79, 80, 79.1, 79.3, 81, 97, 153, 170, 176, 179, 180, 26, 184, 171, 181, 18


[56] **References Cited**

U.S. PATENT DOCUMENTS


| | | | |
|---|---|---|---|
| 1,217,351 | 2/1917 | Schwarz | 241/72 X |
| 1,748,920 | 2/1930 | Newhouse | 241/72 X |
| 2,160,169 | 5/1939 | Pontoppidan | 241/72 |
| 3,144,212 | 8/1964 | Klovers | 241/72 X |
| 3,529,781 | 9/1970 | Hastrup | 241/181 |
| 3,718,286 | 2/1973 | Fagerholt | 241/70 X |
| 3,877,650 | 4/1955 | Cornford | 241/72 X |
| 4,083,500 | 4/1978 | Kartman | 241/72 X |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| 427127 | 5/1945 | Canada . |
| 653193 | 11/1962 | Canada . |



*Primary Examiner*—Mark Rosenbaum

*Attorney, Agent, or Firm*—Pennie & Edmonds


[57] **ABSTRACT**


The invention relates to a method of and apparatus for dry grinding a granular material in a grinding tube mill (**1**) having a final grinding compartment (**2**) and one or more preceding grinding compartments (**3**) containing grinding bodies. The material, after having passed through the preceding compartment or compartments (**3**), is discharged through openings (**6**) in the mill (**1**) and is divided into a fine and a coarse fraction in a separator (**9**). The coarse fraction is returned to the preceding compartment or compartments (**3**), and the fine fraction is fed to the final compartment (**2**). The ground material is discharged by flowing over a dam ring (**12**) from the final compartment (**2**). Any grinding bodies carried with the overflow are separated by a sieving diaphragm (**13**) from the material and returned to the final compartment (**2**). The invention also relates to the granular material ground according to the method of the invention.


**29 Claims, 11 Drawing Figures**

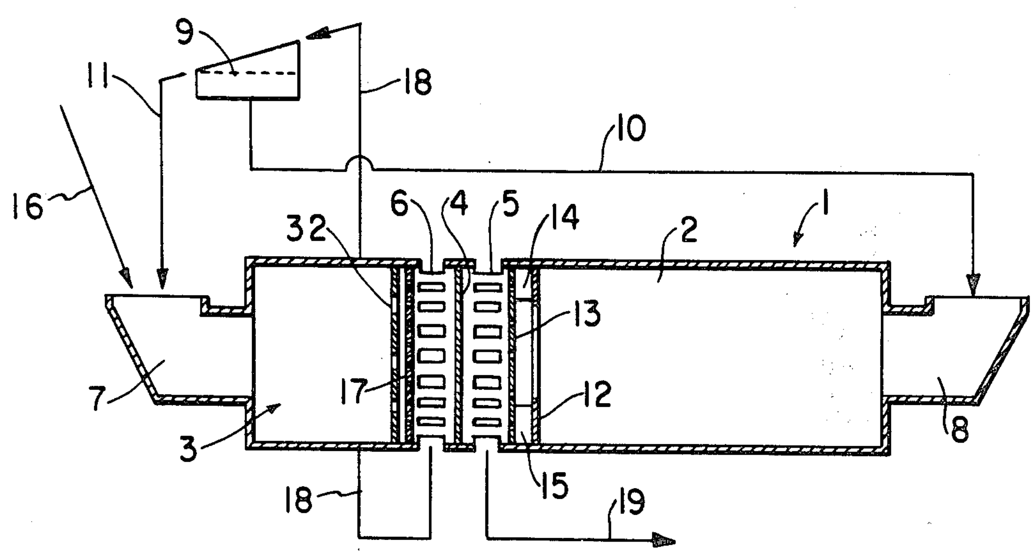


FIG. 1

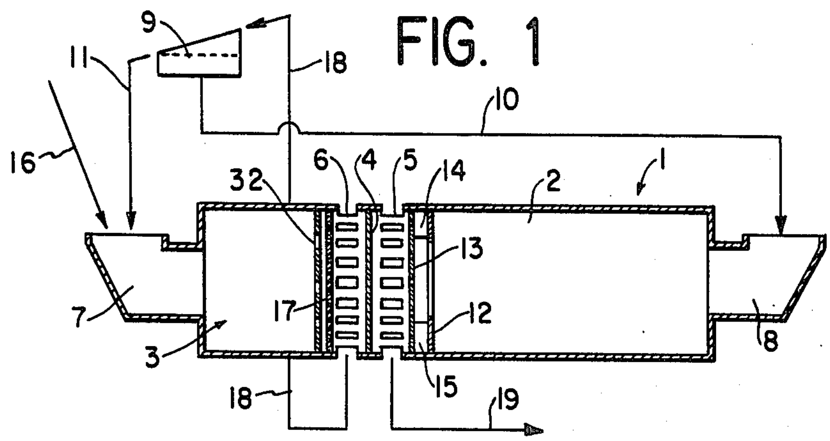



FIG. 2

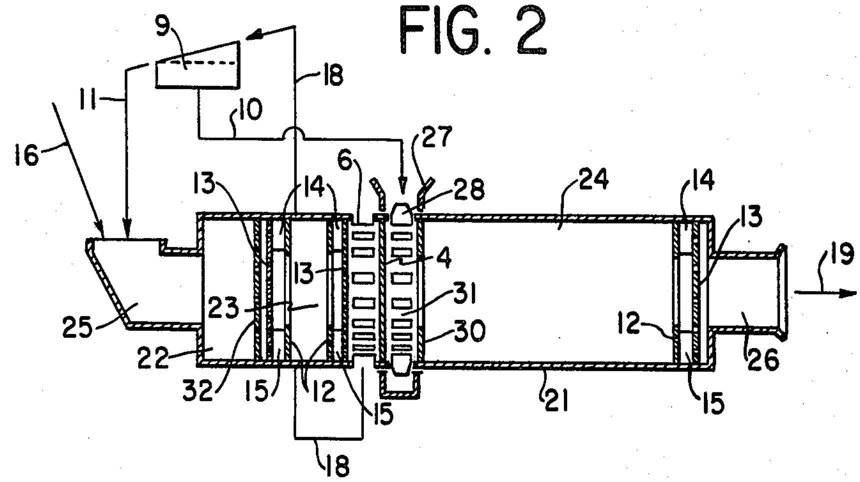



FIG. 3

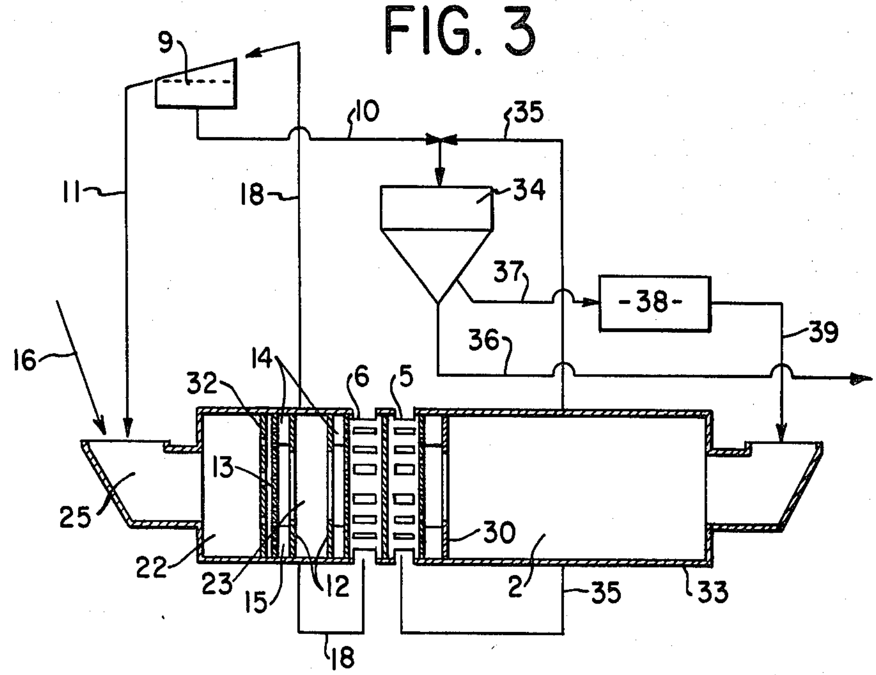


FIG. 4

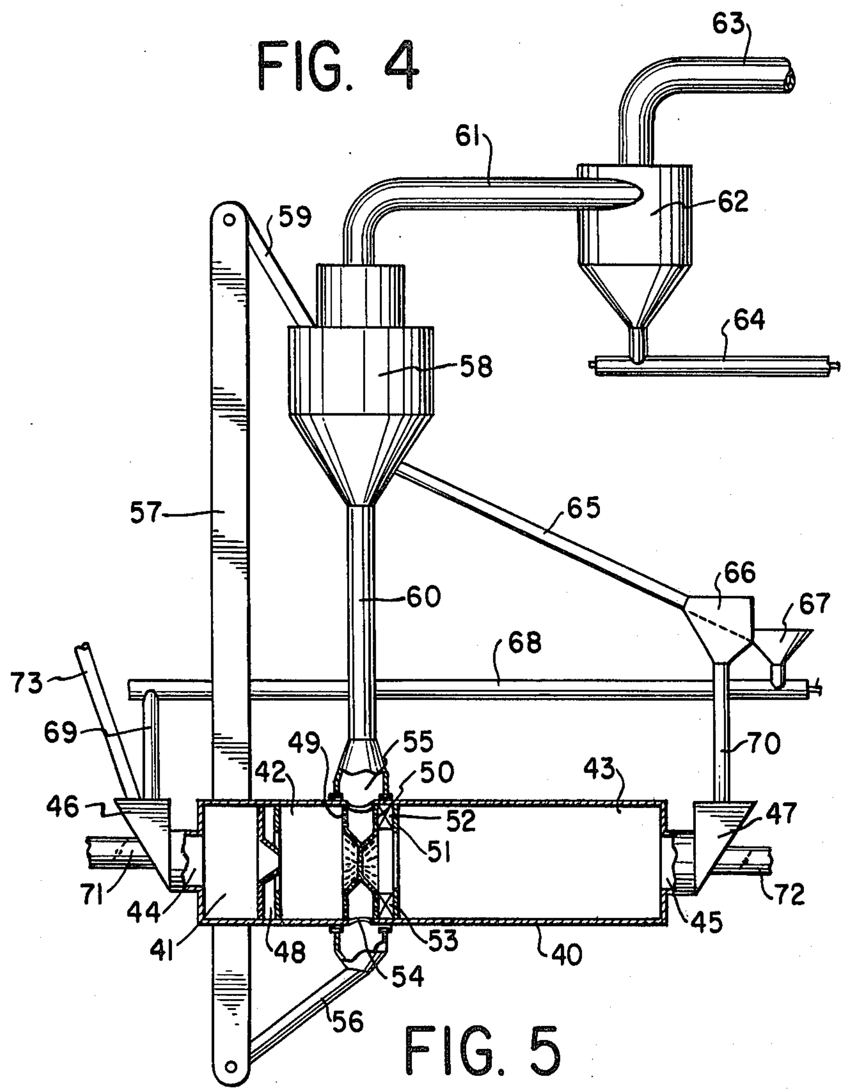

63
61
62
59
58
64
57
65
66
67
60
68
73
69
70
49
55
42
50
43
46
52
47
51
71
44
72
45
41
48
53
40
54
56

FIG. 5

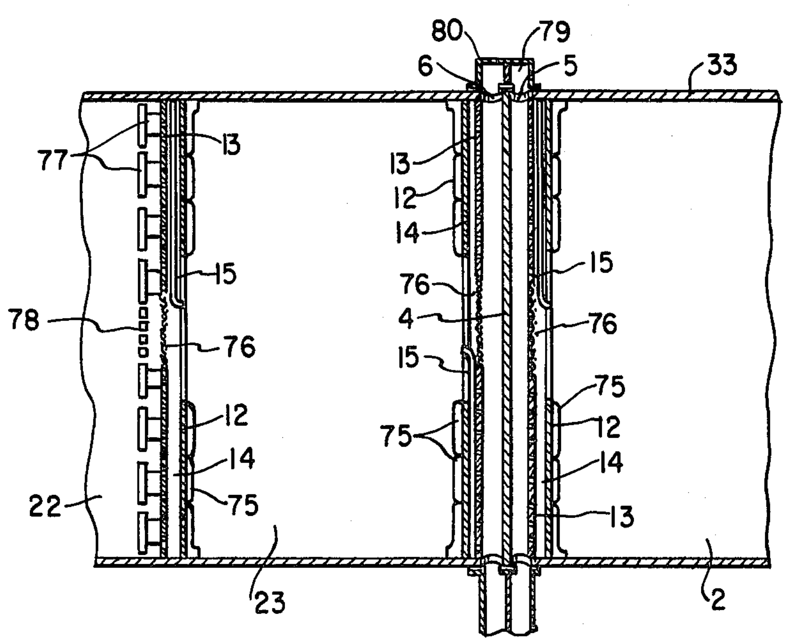

80
79
6
5
33
77
13
13
12
14
15
15
76
76
78
4
76
15
75
12
12
75
14
14
22
75
13
23
2

FIG. 6

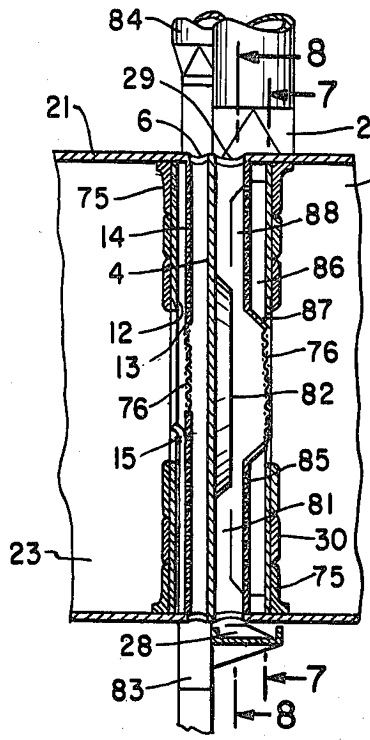



FIG. 7

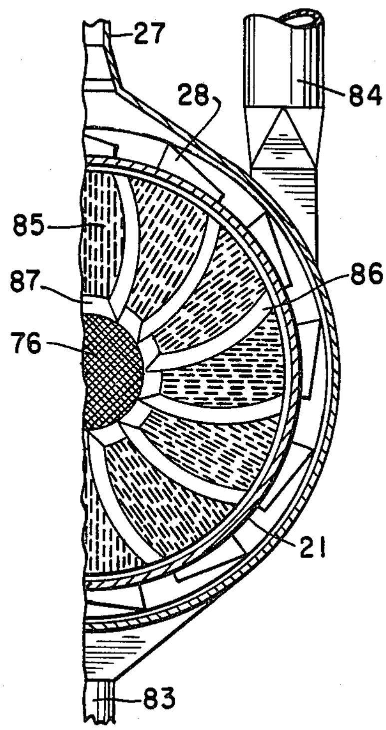



FIG. 8

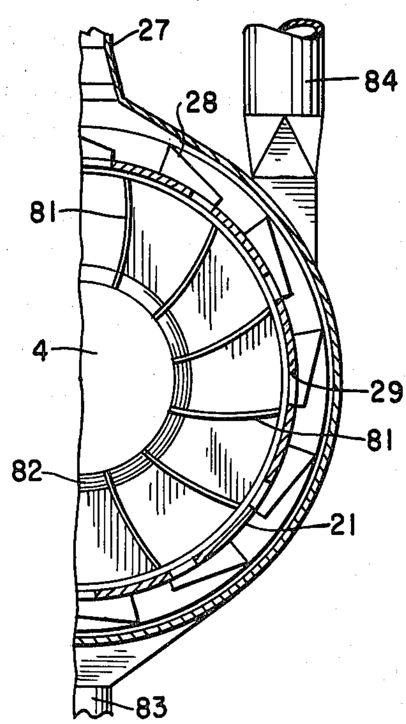


FIG. 9

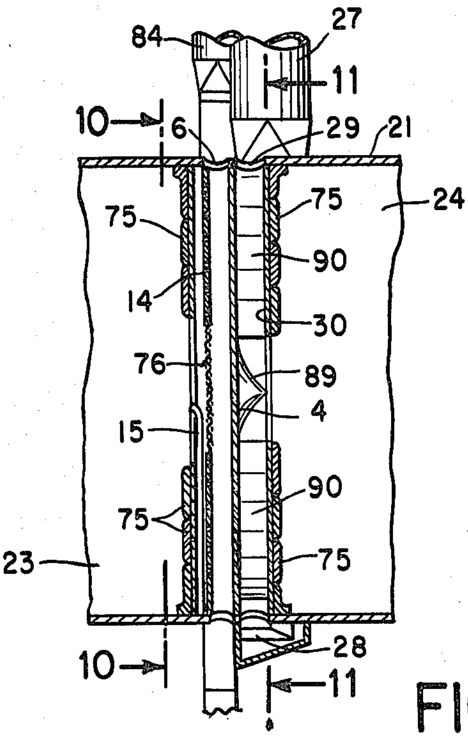



FIG. 10

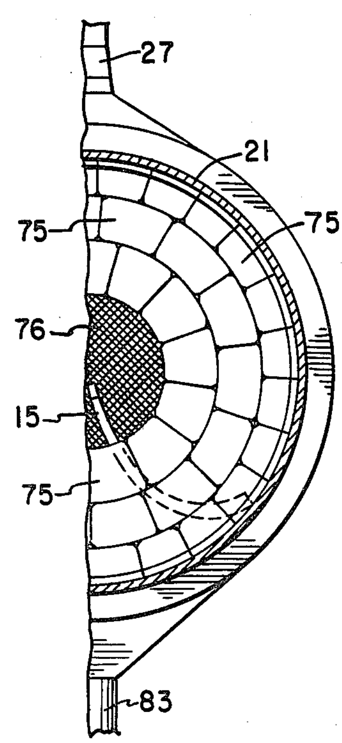
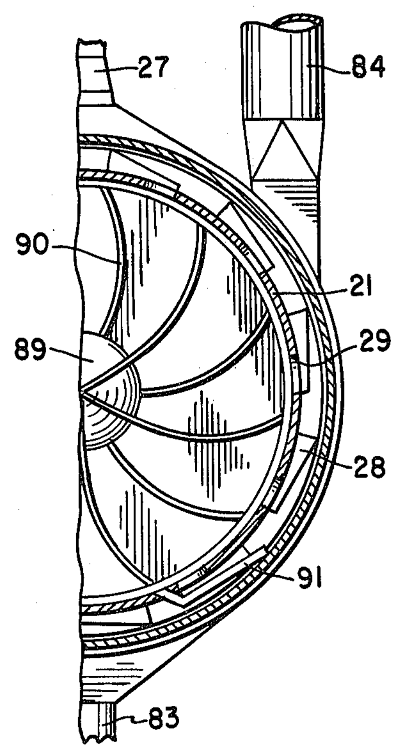



FIG. 11



# METHOD AND APPARATUS FOR GRINDING GRANULAR MATERIALS

## TECHNICAL FIELD

This invention relates to a method and an apparatus for dry grinding a granular material. The method is carried out in a tube mill having a final and one or more preceding grinding compartments containing grinding bodies in which the material, after having passed through the preceding compartment or compartments, is discharged through openings in the mill and is divided into a fine and a coarse fraction by a separation process from which the coarse fraction is returned to the preceding compartment or compartments, and the fine fraction is fed to the final compartment.

## BACKGROUND ART

In known processes of the type contemplated in the present invention, granular material is admitted into a tube mill and is ground and passed through different compartments. After passing through the tube mill the material is discharged from the mill. The grinding in the final compartment takes place with the assistance of grinding bodies having an average piece weight between 20 and 40 grams (g). The minimum size is typically about 20 millimeters (mm). As a result of the free flow area required together with the strength and manufacturing requirements, small grinding bodies are not used since the slots in conventional outlet diaphragms used in the final compartment cannot be constructed sufficiently narrow so as to allow the use of smaller grinding bodies and ensure effective screening of the ground material.

Although it has been widely recognized that in order to achieve optimum grinding economy, the size of grinding bodies used in the final grinding compartment of a mill should be far smaller than that presently in use, up until the present no method or apparatus has been devised in which such smaller grinding bodies may be used.

We have invented a grinding method and apparatus according to which optimum grinding economy is achieved in a tube mill having two or more compartments. According to a significant feature of our invention, the tube mill utilizes grinding bodies which are particularly dimensioned in accordance with the size of the particles of materials required in the final product.

## DISCLOSURE OF THE INVENTION

According to the present invention, a grinding method and apparatus are directed to achieving optimum grinding economy in a tube mill having two or more compartments by an arrangement which makes it possible to utilize grinding bodies of a size which is particularly related to the size of material required in the final product, preferably a very small size which produces a fine ground finished product.

The present invention relates to a method of dry grinding a granular material in a grinding tube mill having a final and one or more preceding grinding compartments containing grinding bodies. The material, after having passed through the preceding compartment or compartments, is discharged through openings in the mill and is divided into a fine and a coarse fraction by a separation process. The coarse fraction is returned to the preceding compartment or compartments, and the fine fraction being fed to the final compartment. The ground material is discharged from the final compartment and grinding bodies carried with the material are separated from the material and returned to the final compartment.

In particular, the present invention is directed to a method of dry grinding granular material to a finished ground material in a grinding tube mill. The tube mill has at least one opening, a final grinding compartment and at least one preceding grinding compartment containing grinding bodies. At least the preceding grinding compartment has an outlet sieving diaphragm. The method comprises the steps of passing the material through the preceding compartment or compartments, discharging the preground material through the openings in the tube mill, dividing the material into predetermined fine and coarse fractions, returning the coarse fraction to said at least one preceding compartment, feeding the fine fraction to the final compartment, discharging the ground material overflowing from the final compartment, separating the grinding bodies carried with the overflowing ground material and returning the grinding bodies to the final compartment.

Thus the material fed to the final grinding compartment does not contain particles of material larger than the small grinding bodies can grind, and also the grinding bodies are prevented from leaving the mill together with the ground material without the risk that they may clog the outlet from the compartment. This can be achieved even when grinding bodies having an average piece weight about 1 gram are used. The maximum size of the particles to be ground by these bodies are 1 millimeter.

Tests have shown that, in grinding cement, an economy of more than 14% can be achieved over long periods compared with conventional cement mill grinding to the same Blaine surface. The cement ground according to the present invention showed strengths superior to those of cement ground in conventional mills. These improved strengths are due to the steeper granulimetric analysis curves of the ground cement which can be attained and which, as experience shows, means improved strengths of cement ground to the same Blaine surface. This is an important advantage resulting from the use of small grinding bodies. Similar tests in which cement was ground to the same degree of strength development as conventionally ground cement showed improvements in grinding economy up to 27%.

Preferably, the separation of the material discharged from the preceding compartment or compartments is effected at such a particle size that the fine fraction from this separation fed to the final grinding compartment is finished ground in one passage through this compartment.

Preferably, the material is ground in a preceding and/or the final compartment by means of grinding bodies having an average piece weight below 10 grams, and preferably about 5 grams. The maximum size of the feed to the preceding and/or final compartment is equal to or below the width of the openings in the outlet sieve diaphragm of the respective compartment. In this case it is a question of using the optimum size of grinding bodies in a compartment for pregrinding the material. This measure contributes to the improvement of the grinding economy inasmuch as the initial coarse grinding is usually accomplished with grinding bodies having an average piece weight of about 1500 grams and which have an inferior grinding economy. Thus the grinding compartment used for this initial grinding can now be shortened in length.

In certain cases, e.g., when grinding cement, it is preferable that the fine fraction be cooled before being fed to the final grinding compartment.

In other cases, when grinding moist material, for example, cement raw materials, it is desirable that drying of the material take place simultaneously with the grinding and/or separation of the material by means of hot gases brought into contact with the material.

In one exemplary embodiment, the material discharged from the preceding compartment or compartments is deprived of any already finished ground material before being subjected to the separation.

Finally, it may also be useful to connect the final compartment to separator means including at least one or more cyclone separators, the separator being in a closed circuit arrangement therewith for precipating finished ground material. In this case part of the material may pass through the final compartment several times before it is finished ground.

The invention also relates to an apparatus for dry grinding granular material comprising a grinding tube mill divided into a final and one or more preceding grinding compartments containing grinding bodies. The mill is provided with openings through which material may be discharged from the preceding compartment or compartments. The mill also comprises means for separating the material discharged from the mill openings into coarse and fine fractions, means to convey material discharged from the mill openings to the separator means and to convey the coarse fraction from the separator means to the feed end of the preceding compartment or compartments and the fine fraction to the feed end of the final compartment. At least one dam ring and sieving diaphragm are positioned in the outlet end portion of the final compartment. The sieving diaphragm is spaced apart from the dam ring to form a chamber and defines openings smaller than the size of the grinding bodies in the final compartment. Lifting means are provided in the chamber to return to the final compartment the grinding bodies that in use, pass over the dam ring with the ground material.

In the apparatus according to the present invention, the sieving diaphragm is exposed to little wear. Therefore, it retains its original slit width and has no tendency to clog inasmuch as the dam ring relieves the pressure of the mill charge.

As a further consequence, the free passage area of the sieving diaphragm can be made considerably greater than that of a conventional diaphragm and therefore offers less resistance to the flow of material and/or air or gases.

The dam ring, which ensures the correct ratio of material and grinding bodies in the final compartment, is made of a special type of wear resistant steel to ensure long durability.

In a preferred examplary embodiment, a preceding compartment is provided at each of its inlet and outlet ends, with a dam ring and a sieving diaphragm spaced apart therefrom to form a chamber from which grinding bodies that pass over the dam ring are returned to the compartment by lifting means provided in the chamber. The diaphragms at the inlet and outlet ends have openings which are of substantially the same size. Also, these openings are smaller than the size of the grinding bodies in that compartment which have an average piece weight of less than 10 grams.

In the case of larger tube mills, for which central drives at the outlet end are preferred, it is useful to feed the material to the final compartment through openings in the mill and in such cases the final grinding compartment has a feed inlet chamber which communicates with the openings in the mill. The feed inlet chamber comprises a dam ring and lifting means for feeding the material into the compartment and for returning grinding bodies from the chamber to the compartment.

In a preferred embodiment, the inlet chamber of the final compartment comprises a dam ring and a sieving diaphragm.

In yet another examplary embodiment, the conveying means comprises means for conveying material from the outlets of both the final grinding compartment and a preceding grinding compartment to a preliminary separator for precipitating finished ground material. Further, the conveying means comprises means for conveying the non-precipitated material from the preliminary separator to a final separator which separates the material into the coarse and fine fractions.

The separator from which the fine fraction is fed to the final grinding compartment preferably is a vibratory screen. However, an air separator may also be used, for example, when simultaneously grinding and drying material. The fractioning may take place at a particle size of up to about 2 millimeters depending upon the grindability of the material to be ground.

In many cases, for example, when grinding cement, it is important to effectively cool the material being ground. This cooling may take place by means of air or atomized water brought into contact with the material during the grinding or separation of the material. An additional cooling of the material may be obtained by providing a separate cooler in the path of conveyance for the material being fed to the final grinding compartment.

In yet a further exemplary embodiment, the grinding bodies in the final grinding compartment are of an average weight of about 10 grams or less and more preferably of about 5 grams or less. The width of the openings of the diaphragm is preferably about between 2 and 5 millimeters.

In still yet another exemplary embodiment, means are provided for drying by hot gases, the material in at least one preceding grinding compartment simultaneously while being ground in that compartment.

## BRIEF DESCRIPTION OF DRAWINGS

Some examples of the method and apparatus according to the present invention will now be described in detail with reference to the accompanying drawings in which:

FIG. **1** is a schematic view of a preferred embodiment of the apparatus of the invention including a tube mill having one preceding and one final compartment;

FIG. **2** is a schematic view of an alternate embodiment of the apparatus of the invention including a tube mill having two preceding and one final compartments;

FIG. **3** is a schematic view of a third embodiment of the apparatus of the invention including a tube mill and a separator;

FIG. **4** is a schematic view of a fourth embodiment of the apparatus of the present invention;

FIG. **5** is a partial enlarged view of the tube mill of FIG. **3**;

FIG. **6** is an enlarged view of a portion of the tube mill of FIG. **2**;

material discharged from the final compartment **2** is fed to the same air separator **34** by means of a conveyor **35**. The fine fraction **36** from the air separator **34** is finished ground material. The coarse fraction **37** from the air separator **34** is led to a cooler **38**, of any known kind. In the cooler **38**, this fraction is cooled before being fed to the inlet of the final compartment **2** as indicated by **39**. The material, e.g., cement, can be cooled in all three compartments **2**, **22**, and **23** by means of air passed through the chambers and discharged through the openings in the mill shell. In this manner, fresh cooling air can be passed in through both ends of the mill **33** which is preferable to cooling by means of a single air stream passing through the whole length of the mill **33**. Additional cooling can be provided by atomizing water into the compartments. However, due to the intense development of heat in a mill in which small grinding bodies are used to a large extent it is often useful to cool the material before it is fed to the final compartment in which there is the greatest risk of clogging the material on the grinding bodies.

FIG. **4** shows an apparatus for simultaneously grinding and drying moist material, e.g., cement raw material. The apparatus comprises a tube mill **40** having a drying compartment **41**, a pregrinding compartment **42**, and a final grinding compartment **43**. The mill has trunnions **44** and **45** communicating with feed hoppers **46** and **47**. A diaphragm **48** having means for transportation of the predried material into the compartment **42** is provided between the compartments **41** and **42**. Compartment **42** has an outlet sieving diaphragm **49** constructed together with an outlet sieving diaphragm **50** for the final compartment **43**. A dam ring **51** is spaced apart from the diaphragm **50** to form a chamber **52** wherein lifting members **53** are mounted. The outlet formed by the parts **50** to **53** functions in the same way as described in connection with the parts **12** to **15** of FIG. **1**.

The material, having passed through the diaphragms **49** and **50**, leaves the mill through openings **54** in the mill shell. The mill shell is surrounded by a stationary casing **55** from the bottom of which a chute **56** leads to an inlet end of an elevator **57**. The outlet end of this elevator is connected to an air separator **58** by means of a chute **59**. The bottom of the air separator **58** is connected by a gas conduit **60** to the casing **55**. From the top of the air separator **58**, a conduit **61** leads to a cyclone **62**. In turn, another conduit **63** passes from the top of the cyclone **62** to a fan and is followed by an electrostatic precipitator (not shown). A worm conveyor **64** is provided at the bottom of the cyclone **62**.

The coarse fraction from the air separator **58** is passed through a pipe **65** to a vibratory screen **66** from which the coarse fraction via a hopper **67**, a worm conveyor **68**, and a chute **69** is fed to the inlet hopper **46** and into the drying chamber **41**. The fine fraction from the screen **66** is led through a chute **70** to the inlet hopper **47** and into the final compartment **43**. Inlet conduits **71** and **72** for hot air or gas are provided in the inlet hoppers **46** and **47**. Moist material passes through pipe **73**, hopper **46**, and trunnion **44** into the compartment **41** where it is predried by the hot gases admitted through conduit **71**. The predried material is transported through the diaphragm **48** into the grinding compartment **42** where it is preground and simultaneously further dried by the hot gas. The preground material leaves the compartment **42** through the sieving diaphragm **49**, passes through the openings **54**, chute **56**, elevator **57**, and chute **59** to the air separator **58**. The gas passes from the compartment **42** through the diaphragm **49**, the casing **55**, and conduit **60** to the air separator **58**. From conduit **72**, another stream of hot gas passes through the final compartment **43**, the sieving diaphragm **50**, casing **55**, and conduit **60** to the air separator **58**. The material discharged by overflow from the final compartment **43** in the manner previously described passes through the openings **54**, chute **56**, elevators **57**, and chute **59** to the air separator **58**, i.e., together with the preground material.

From the air separator **58** finished ground material is carried away with the gas through the conduit **61** and is precipitated in the cyclone **62** from which it is taken away by the conveyor **64**. The gas passes through the conduit **63** to the suction fan and electrostatic precipitator. The coarse fraction from the air separator **58** passes via the pipe **65** to the screen **66** from which the coarse fraction via the hopper **67**, conveyor **68** and chute **69** is returned to the drying compartment **41**. The fine fraction from the screen **66** passes through the pipe **70** and hopper **47** to the final compartment **43** and is ground in this compartment by means of grinding bodies having an average piece weight below 10 grams, preferably about 5 grams, depending on the grindability of the material and the particle size at which the fractioning takes place in the screen **66**. In order to avoid accumulation of oversize particles in the final compartment **43**, the openings in the screen **66** are made smaller than the openings in the sieving diaphragm **50**. The latter openings are preferably about 2 to 4 mm or even smaller.

The grinding bodies used in the compartment **42** may have an average piece weight of about 1500 grams. The mill shown in FIG. **4** may also be provided, if desired, with two preceding compartments.

According to FIG. **5**, the dam rings **12** in both the grinding compartments **2** and **23** are protected by heavy wear plates **75** which are normally made from a special steel alloy. The sieving diaphragms **13** in each compartment are thus protected against wear from the grinding charges in the chambers and are relieved of the pressure from the charges. Thus, small grinding bodies flowing with the material into the chambers **14** are not pressed into the openings of the respective diaphragm **13**, which otherwise would have a clogging effect.

Usually, one tube like lifting member **15** in each chamber **14** is sufficient to return small grinding bodies from the chambers to the grinding compartments **2**, **23**.

The sieving diaphragm **13** may be made of perforated steel plates supported in a light frame fastened to the mill shell. The central parts **76** of the diaphragms **13** may be made of wire mesh.

The diaphragm between the compartments **22** and **23** preferably consists of a wear resistant central grate **78** surrounded by heavy wear plates **77** spaced apart to form a coarse screen which retains the grinding bodies in the compartment **22**. Lifters (not shown) are normally provided in the space between this coarse screen and the sieving diaphragm **13** for returning any coarse particles to the compartment **22**.

FIG. **5** shows stationary outlet casings **79** and **80** for the material discharged through the openings **5** and **6** in the mill shell.

FIGS. **6** to **8** show scoops **28** mounted on the mill shell and communicating with the openings **29** in the mill shell. At the inlet end of the final compartment **24**, and connected to the soild wall **4** and a cone **82** on same, scoops **81** are provided which open into a chamber **88**, the downstream wall of which is formed by a sieving

FIG. 7 is a cross-sectional view taken along line 7—7 of FIG. 6;

FIG. 8 is a cross-sectional view taken along line 8—8 of FIG. 6;

FIG. 9 is an enlarged view of modification of the tube mill shown in FIGS. 6 to 8;

FIG. 10 is a cross-sectional view taken along line 10—10 of FIG. 9; and

FIG. 11 is a cross-sectional view taken along line 11—11 of FIG. 9.

## BEST MODE FOR CARRYING OUT THE INVENTION

FIG. 1 shows a tube mill **1** having a final grinding compartment **2** and a preceding pregrinding compartment **3**. These two compartments are separated by a solid wall **4**. The final compartment **2** has outlet openings **5** in the mill shell and the compartment **3** has outlet openings **6** in the mill shell. The mill has trunnions **7** and **8**. A vibratory sieve **9** is provided outside the mill **1**. A conveyor **10** leads from a vibratory sieve **9** to a trunnion **8** and another conveyor **11** leads to the trunnion **7**. The final compartment **2** is provided at its outlet end with a dam ring **12** and a sieving diaphragm **13** spaced apart to form a chamber **14** in which there are provided lifting members **15** leading to the final compartment **2**.

The material to be ground is fed to the compartment **3** through the trunnion **7** as indicated by arrow **16**. This material is preground in the compartment **3** by means of grinding bodies preferably having an average piece weight of about 1,500 grams. Sufficiently preground material passes from the compartment **3** through slots in the sieving diaphragm **17** to the outlets **6**. The slots in the sieving diaphragm preferably have a width of between about 6 to 8 millimeters.

An elevator **18** lifts the preground material from the outlets **6** to the sieve **9**. The size of the openings in the sieving plate of the sieve **9** are chosen so that the fine fraction passing through the sieve **9** and fed, by the conveyor **10**, to the final compartment **2** can be finished ground in one passage through this compartment by means of grinding bodies preferably having an average piece weight of, for example, about 5 grams. The openings of the sieve **9** can have maximum dimensions of 1 to 2 millimeters, depending on the grindability of the material.

The coarse fraction from the sieve **9** is fed to the preceding compartment **3** by means of the conveyor **11** and is then subjected to a renewed grinding in the compartment **3**.

In the final compartment **2**, the dam ring **12** ensures the correct ratio of grinding bodies and material to be ground. The finished ground material is discharged from the compartment by flowing over the dam ring **12**. However, it is impossible to prevent a certain amount of the small grinding bodies from flowing over the dam ring **12** with the material. These grinding bodies would clog the openings in a sieving diaphragm **12** exposed directly to the pressure of the charge in the compartment. As is evident from FIG. **1**, these grinding bodies are instead led to the sieving diaphragm **13** which is relieved from direct pressure by the dam ring **12**. It is thereby possible to separate the bodies from the finished ground material without any clogging of the diaphragm **13** and to return the bodies to the compartment **2** by means of the lifting members **15** which will be described in more detail below. The openings in the relieved diaphragm **13** may be as small as 1 to 2 millimeters. The finished ground material leaving the openings **5** is carried away by a conveyor indicated by **19**.

The apparatus shown in FIG. **2** comprises a tube mill **21** having two preceding compartments **22** and **23** and a final compartment **24**. The mill **21** has trunnions **25** and **26**. The conveyor **11** from the sieve **9** leads to the trunnion **25** and the conveyor **10** leads to a stationary housing **27** surrounding the mill **21**. Dam rings **12** and sieving diaphragms **13** are provided at each end of the compartment **23** so as to form chambers **14** in which lifting members **15** are provided. Similarly, at the outlet end of the final compartment **24**, a dam ring **12**, a sieving diaphragm **13**, and lifting members **15** are provided in the chamber **14**.

The final compartment **24** is provided with scoops **28** communicating with openings **29** in the mill shell. A dam ring **30** together with the solid wall **4** forms an inlet chamber **31** to the final compartment **24**.

The material to be ground is fed to the compartment **22** through the trunnion **25** as indicated by the arrow **16**. In the compartment **22** this material is preground by means of grinding bodies having an average piece weight of, e.g., of 1,500 grams. Sufficiently preground material passes from the compartment **22** first through a heavy grate diaphragm **32**, and then through a sieving diaphragm **13** having openings of about 5 to 6 mm. Further, the material passes through the chamber **14** having lifting members **15** and over the dam ring **12** into the compartment **23** where it is further preground by means of grinding bodies having an average piece weight, e.g., of 5 grams. The preground material passes out of the compartment **23** over the dam ring **12** via the chamber **14** having lifting members **15** and through the sieving diaphragm **13** at the outlet end of the compartment **23**. The outlet sieving diaphragm **13** has openings of the same size as that of the inlet sieving diaphragm **13** of the compartment **23** so that an accumulation of oversize unground particles will not take place in the compartment. Such particles will be returned to the compartment **22** via the sieve **9** as explained in connection with FIG. **1**.

The fine fraction from the sieve **9** is passed to the inlet housing **27** by means of the conveyor **10** and is fed into the final compartment **24** by the scoops **28**. Due to the adjustment of the openings in the sieve **9** this fine fraction can be finished ground in one passage through the final compartment **24** by means of grinding bodies having an average piece weight, e.g., of 5 grams or even as small as 1 gram depending on the particle size fractioning of the sieve **9**. The finished ground material is discharged by overflow through the trunnion **26** via dam ring **12**, chamber **14** having lifting members **15**, and the sieving diaphragm **13** which has openings of the order of 2 to 4 mm.

In the apparatus shown in FIG. **2**, the aim is to move as much of the grinding work as possible from the compartment **22** to the compartments **23** and **24**. Thus, the length of the compartment **22** which has the lowest grinding economy is shortened.

The apparatus shown in FIG. **3** comprises a tube mill **33** having two pregrinding compartments **22** and **23** similar to those shown in FIG. **2**, and a final grinding compartment **2** similar to that shown in FIG. **1**. The material discharged from the compartment **23** is taken to the sieve **9** by the conveyor **18**. The coarse fraction from the sieve **9** is fed to the compartment **22** by the conveyor **11**, whereas the fine fraction from the sieve **9** is taken by the conveyor **10** to an air separator **34**. The diaphragm **85** and a cone **87**. A dam ring **30** with wear plates **75** is spaced apart from the diaphragm **85** to form another chamber in which a second set of scoops **86** is mounted. These scoops **86** open into the final compartment **24**.

A stationary casing **83** surrounding the mill shell receives the material discharged from the compartment **23**. At the top of this casing **83** an outlet conduit **84** is provided for the discharge of any air or gas led through the preceding chambers **22** (FIG. **2**) and **23**.

The material from the conveyor **10**, illustrated in FIG. **2**, is delivered into the casing **27** and is shovelled into the chamber **88** by the scoops **81**. From the chamber **88** the material passes through the diaphragm **85** to the next chamber provided with the scoops **86** which deliver the material into the final compartment **24**. The scoops **86** also return small grinding bodies which have passed over the dam ring **12** into the chamber containing the scoops **86**. The openings in the diaphragm **85** are small enough to prevent the passage of the small grinding bodies but large enough to allow the material to be fed to the final compartment to pass through. Therefore, the particle size fractioning limit of the sieve **9** (FIG. **2**) and the size of the small grinding bodies are adjusted in accordance with this requirement.

In the tube mill shown in FIGS. **9** to **11**, a dam ring **30** having wear plates **75** is positioned apart from the solid wall **4** so as to form an inlet chamber in which are mounted scoops **90**, the outer ends of which follow a cone **89**. Besides the scoops **28** an additional scoop **91** is mounted on the mill shell. This scoop **91** projects close to the wall of the stationary casing **27** as can be seen in FIG. **11**.

FIG. **10** shows that the lifting member **15** for returning small grinding bodies to the compartment **23** is formed as a spiral. The material is fed tangentially into the casing **27** through a pipe **92** and against the direction of rotation of the mill and is caught by the scoops **28** which lead the material to the scoops **90**. These scoops deliver the material into the final compartment **24**. Any small grinding bodies which pass over the dam ring **30** into the casing **27** accumulate at the bottom of the casing beyond the path of the scoops **28** and are returned to the final compartment **24** by means of the scoop **91**.

We claim:

1. A method of dry grinding granular material in a grinding tube mill having a final and at least one preceding grinding compartment containing grinding bodies, comprising directing the material to the tube mill, grinding the material in the preceding compartment, discharging the preground material from the preceding compartment through openings in the mill, dividing the preground material into fine and coarse fractions by a separation process, returning the coarse fraction to the preceding compartment, directing the fine fraction to the final compartment for grinding therein, discharging the ground material from the final compartment together with any grinding bodies carried therewith, separating the grinding bodies from the material discharged from the final compartment in the tube mill proper, and returning the grinding bodies to the final compartment.

2. The method according to claim **1**, wherein the material is ground in the preceding grinding compartment with grinding bodies having an average piece weight of less than about 10 grams.

3. The method according to claim **2** wherein the maximum size of particles fed to the preceding compartment is equal to or below the width of the openings in an outlet sieve diaphragm of the compartment.

4. The method according to claim **3** including the step of cooling the fine fraction before being fed to the final grinding compartment.

5. The method according to claim **4** including drying the material to be ground simultaneously with the grinding or separation of the material by means of hot gases brought in to contact with the material.

6. The method according to claim **4** including drying the material to be ground simultaneously with the grinding and separation of the material by means of hot gases brought into contact with the material.

7. The method according to any of claims **6** or **5** including removing finished ground material from the material discharged from the preceding compartment before being subjected to the separation process.

8. The method according to claim **7** wherein the final grinding compartment is coupled to particle separator means for precipitating finished ground material.

9. The method according to claim **8** wherein dividing the material includes separating the coarse and fine fractions at such a particle size so as to permit feeding the fine fraction to the final grinding compartment and obtaining finished ground material in one passage through the final compartment.

10. The method according to claim **9** including grinding the material in the final compartment with grinding bodies having an average piece weight less than about 10 grams.

11. The method according to claim **10** wherein the material is ground in the final compartment with grinding bodies having an average piece weight of about 5 grams.

12. The method according to claim **11** wherein the final grinding compartment is operated in closed circuit with separator means including at least one cyclone separator for precipitating finished ground material.

13. A method of dry grinding granular material to a finished ground material in a grinding tube mill, the tube mill having at least one opening, a final grinding compartment and at least one preceding grinding compartment containing grinding bodies, at least one preceding grinding compartment having an outlet sieving diaphragm, comprising the steps of passing the material through the preceding compartment, discharging the preground material through the openings in the tube mill, dividing the preground material into predetermined fine and coarse fractions, returning the coarse fraction to the preceding compartment, feeding the fine fraction to the final compartment for grinding therein, discharging the ground material by overflow from the final compartment, separating the grinding bodies carried with the overflowing ground material in the tube mill proper and returning the grinding bodies to the final compartment.

14. An apparatus for dry grinding granular material comprising a grinding tube mill divided into a final and at least one preceding grinding compartment containing grinding bodies, the mill being provided with openings through which material may be discharged from the preceding compartment, means for separating the material discharged from the mill openings into coarse and fine fractions, means to convey material discharged from the mill openings to said separator means and to convey the coarse fraction from the separator means to the feed end of the preceding compartment and the fine fraction to the feed end of the final compartment, at

least one dam ring and sieving diaphragm positioned in the outlet end portion of the final compartment, the dam ring relieving the pressure of the mill charge, the sieving diaphragm being spaced apart from the dam ring to form a chamber and defining openings smaller than the size of the grinding bodies in the final compartment, lifting means provided in said chamber to return to the final compartment the grinding bodies that in use, pass over the dam ring with the ground material.

**15.** An apparatus for dry grinding a granular material comprising a grinding tube mill having a final grinding compartment and at least one preceding grinding compartment, having grinding bodies disposed therein and inlet and outlet end, the tube mill having at least one opening for the discharge of material from the preceding compartment, means for separating the material into coarse and fine fractions, first means for conveying material discharged from the mill opening to the separating means, second means for conveying the coarse fraction from the separating means to the inlet end of the preceding compartment, and third means for conveying the fine fraction to the feed end of the final compartment, the outlet end portion of the final compartment having a dam ring and a sieving diaphragm having openings dimensioned less than the size of the grinding bodies therein and spaced apart from the dam ring to define a chamber therebetween, the dam ring relieving the pressure of the mill charge, lifting means disposed in said chamber for lifting and returning grinding bodies passing into the chamber with the ground material to the final grinding compartment.

**16.** The apparatus according to claim **15** wherein at least one preceding compartment includes grinding bodies having an average piece weight of approximately 10 grams or less and a dam ring and a sieving diaphragm are disposed at each of its inlet and outlet ends, the sieving diaphragm being spaced apart from the dam ring to define a chamber therebetween, the chamber having means for returning grinding bodies passing over the dam ring, and the diaphragms at the inlet and outlet ends defining openings of substantially the same size, said openings being smaller than the size of the grinding bodies in said compartment.

**17.** The apparatus according to claim **15** or **16** wherein the final grinding compartment includes a feed inlet chamber which communicates with the openings in the mill and which comprises a dam ring and lifting means for feeding the material into the compartment and for returning grinding bodies from the chamber to the compartment.

**18.** The apparatus according to claim **17** further comprising a sieving diaphragm disposed adjacent the inlet end of the final compartment.

**19.** The apparatus according to claim **18** further comprising a preliminary separator for precipitating finished ground material, a final separator for separating the material into coarse and fine fractions, fourth conveying means for conveying material from the outlet ends of the final grinding compartment and the preceding grinding compartment to the preliminary separator, and fifth conveying means for conveying the non-precipitated material from the preliminary separator to the final separator.

**20.** The apparatus according to claim **19** wherein the separator from which the fine fraction is fed to the final grinding compartment comprises a vibratory screen.

**21.** The apparatus according to claim **20** further comprising means for cooling the material fed to the final grinding compartment.

**22.** The apparatus according to claim **21** wherein the grinding bodies in the final grinding compartment are of an average piece weight of not greater than 10 grams.

**23.** The apparatus according to claim **22** wherein the grinding bodies in the final grinding compartment are of an average piece weight of about 5 grams or less.

**24.** The apparatus according to claim **23** wherein the width of the openings in the diaphragm is about between 2 and 5 millimeters.

**25.** An apparatus for dry grinding a granular material, comprising a grinding tube mill having a final grinding compartment and at least one preceding grinding compartment having an inlet and an outlet end, and grinding bodies disposed therein, the tube mill having at least one opening for the discharge of material from said at least one preceding compartment, a separator for separating the material into coarse and fine fractions, means for conveying material discharged from the mill opening to the separator and for conveying the coarse fraction from the separator to the inlet of said at least one preceding compartment and for conveying the fine fraction to the feed inlet end of said final compartment, the outlet end portion of said final compartment having a dam ring and a sieving diaphragm spaced apart therefrom and having a plurality of openings, the dam ring relieving the pressure of the mill charge, the dam ring and sieving diaphragm defining a chamber therebetween having means disposed in said chamber for lifting the grinding bodies passing into said chamber with the ground material and returning the grinding bodies to said final grinding compartment for final grinding, the grinding bodies in said at least one preceding grinding compartment having an average piece weight being not greater than 10 grams and the openings of the diaphragm in said at least one preceding grinding compartment being dimensioned less than the corresponding grinding bodies, the grinding bodies in said final grinding compartment having an average piece weight less than the average piece weight of the grinding bodies in said at least one preceding compartment and the openings of the diaphragm in said final grinding compartment being dimensioned less than the corresponding grinding bodies.

**26.** The apparatus according to claim **25** further comprising means for drying by hot gases, the material in said at least one preceding grinding compartment simultaneously while being ground in said compartment.

**27.** The apparatus according to claim **26** wherein at least one preceding grinding compartment at its inlet and outlet ends is provided with a dam ring and a sieving diaphragm spaced apart to form a chamber from which grinding bodies that pass over the dam ring are returned to said compartment by lifting means provided in the said chamber, the diaphragms at the said inlet and outlet ends having openings of the same size, said openings being dimensioned from approximately 2 to 5 mm and being smaller than the size of the said grinding bodies therein.

**28.** The apparatus according to claim **27** wherein a cooler is provided in the path of conveyance for the material being fed to the final grinding compartment.

**29.** An apparatus for dry grinding granular material comprising a grinding tube mill divided into a final and at least one preceding grinding compartment containing grinding bodies, the mill being provided with openings through which material may be discharged from the preceding compartment, means for separating the material discharged from the mill openings into coarse and fine fractions, means to convey material discharged from the mill openings to said separator means and to convey the coarse fraction from the separator means to the feed end of the preceding compartment nd the fine fraction to the feed end of the final compartment, at least one dam ring and sieving diaphragm positioned in the outlet end portion of the final compartment, the dam ring relieving the pressure of the mill charge, the sieving diaphragm being spaced apart from the dam ring to form a chamber and defining openings smaller than the size of the grinding bodies in the final compartment, lifting means provided in said chamber to return to the final compartment the grinding bodies that in use, pass over the dam ring with the ground material, the grinding bodies in said at least one preceding grinding compartment having an average piece weight of approximately equal to or less than 10 grams and the openings of the diaphragm in said at least one preceding grinding compartment being dimensioned less than the corresponding grinding bodies, the grinding bodies in said final grinding compartment having an average piece weight less than the average piece weight of the grinding bodies in said at least one preceding compartment and the openings of the diaphragm in said final grinding compartment being dimensioned less than the corresponding grinding bodies.

* * * * *

# United States Patent [19]

**Moore et al.**

[11] **4,397,425**

[45] **Aug. 9, 1983**


[54] **GRINDING APPARATUS**


[75] Inventors: **Jerry W. Moore; James Allen,** both of Shreveport, La.

[73] Assignee: **Pennzoil Company,** Houston, Tex.



[21] Appl. No.: **150,711**

[22] Filed: **May 19, 1980**

[51] **Int. Cl.**[3] .............................................. **B02C 19/08**

[52] **U.S. Cl.** .............................. **241/169.1;** 241/169.2; 241/199.12; 241/205

[58] **Field of Search** .................. 241/169.2, 169.1, 261, 241/199.11, 199.12, 205


[56] **References Cited**


U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 1,028,663 | 6/1912 | Bauermeister | 241/169.1 |
| 2,602,596 | 7/1952 | Jones et al. | 241/DIG. 27 |
| 2,631,786 | 3/1953 | Morgans et al. | 241/DIG. 27 |
| 3,773,468 | 11/1973 | Hubbard et al. | 241/169.2 |
| 3,897,017 | 7/1975 | Rogers | 241/257 R |
| 4,003,523 | 1/1977 | Doolittle | 241/DIG. 27 |
| 4,209,136 | 6/1980 | Lindén et al. | 241/169.2 |
| 4,303,610 | 12/1981 | Sardisco et al. | 422/61 |

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 12058 | of 1848 | United Kingdom . | |
| 2706 | of 1887 | United Kingdom | 241/199 |
| 20024 | of 1890 | United Kingdom . | |

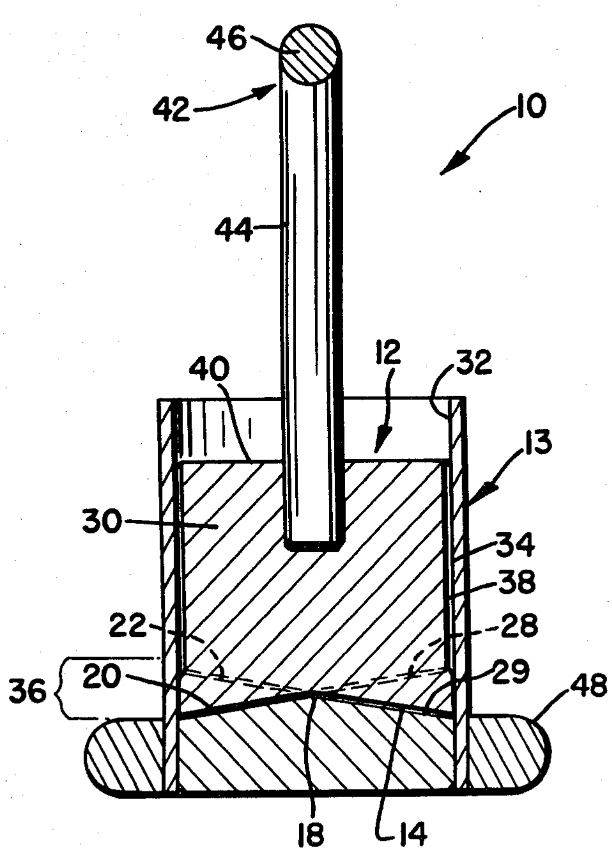


*Primary Examiner*—Mark Rosenbaum
*Assistant Examiner*—Timothy V. Eley
*Attorney, Agent, or Firm*—Lowe, King, Price & Becker


[57] **ABSTRACT**


A grinding apparatus for thoroughly crushing, particulating and/or fragmenting materials that are firm or soft. The apparatus is particularly suitable for grinding plant leaf tissue. The grinding apparatus includes a rotatable reamer and a cup for receiving the reamer. The reamer has teeth that form a grinding surface, these teeth extending radially outward from a center point of the grinding surface. A second set of teeth form the inner bottom surface of the cup and provide another grinding surface. The cup teeth correspond to the reamer teeth so as to mesh therewith and produce a camming action during rotation of the reamer.


**4 Claims, 4 Drawing Figures**



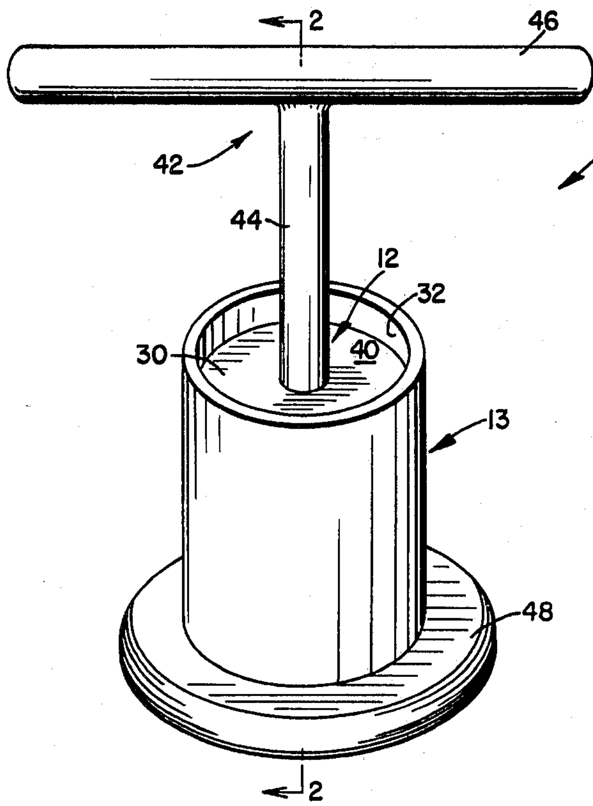



Fig.1

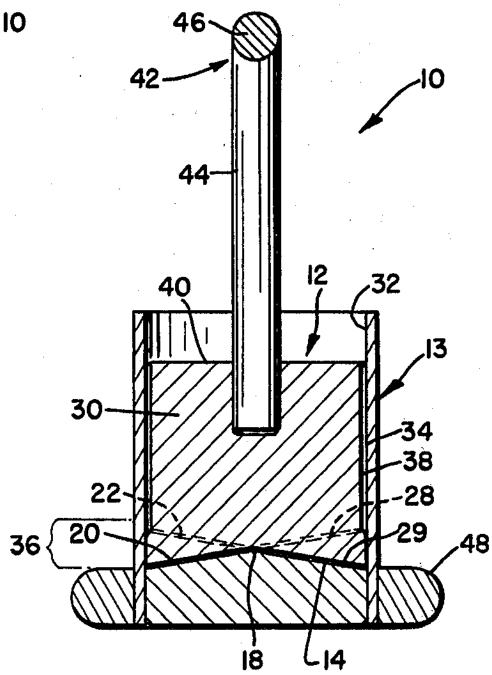



Fig.2

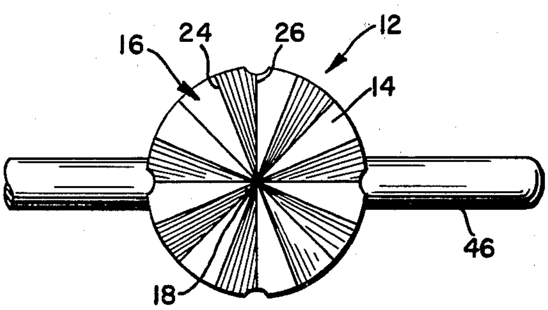



Fig.3

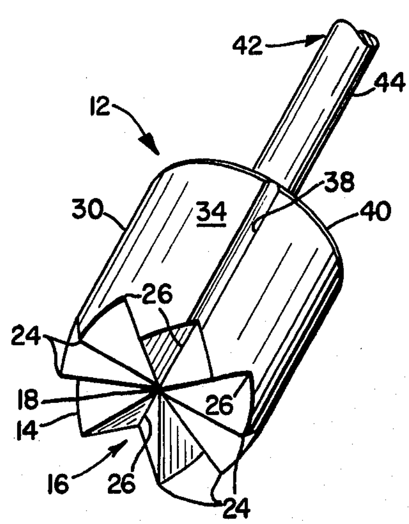



Fig.4

## GRINDING APPARATUS

### BACKGROUND OF THE INVENTION

This invention relates generally to a grinding apparatus and more particularly to a grinding apparatus that is particularly useful for thoroughly grinding, particulating and fragmenting a soft material such as plant leaf tissue.

A material such as plant leaf tissue is soft, and therefore is difficult to grind using a conventional grinder. Prior art grinders of which we are aware do not provide the cutting, dividing, shearing and piercing action in the grinding elements necessary to thoroughly grind, particulate and fragment these materials. Additionally, these grinders do not have a piston-like action which accentuates the cutting, dividing, piercing and shearing action of the grinding elements. Rather, these grinders require the exertion of substantial force by the user to accentuate various of these actions. Illustrative of these grinders is that of British Pat. No. 12,058 (1848) to Herbert, which shows, in FIG. 2, a pestle having V-shaped teeth and a mortar having V-shaped indentations for receiving these teeth. However, the grinding elements of the Herbert patent do not provide a shearing action and fail to provide a piston-like action that accentuates the cutting and other actions thereof. Similar to the grinder of Herbert is that of British Pat. No. 2,706 (1887) to Norcombe. Also exemplary of these grinders is that of British Pat. No. 20,024 (1890) to Newey which shows a crushing surface having V-shaped projections that extend radially outward from a focal point. However, the crushing surface is for a sugar and salt crusher and there is not shown any particular surface for the crushing surface to contact against.

### SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a new and improved apparatus for thoroughly grinding, particulating and fragmenting soft materials such as plant leaf tissue.

It is a further object of the present invention to provide a new and improved grinding apparatus that provides a cutting, piercing, dividing and shearing action.

It is a still further object of the present invention to provide a new and improved grinding apparatus that accentuates the cutting, dividing, piercing and shearing action and does not require application of a substantial force by the user to accentuate these actions.

It is an even further object of the present invention to provide a grinding apparatus that is easily grasped by the hand for rotating the reamer.

Other objects and advantages of the present invention will become apparent as the description thereof proceeds.

In satisfaction of the foregoing objects and objectives, a grinding apparatus, in accordance with the invention comprises a rotatable reamer having teeth that form a first grinding surface, and a cup for receiving the reamer. The teeth forming the first grinding surface extend radially outward from a center point of the grinding surface. The inner bottom surface of the cup is formed with teeth that correspond to the reamer teeth so as to mesh with those teeth and to give the grinding apparatus a camming action during rotation of the reamer. The cup teeth provide a second grinding surface.

In the description of the drawing and in the detailed discussion of the invention which follows, there is shown and essentially described only the preferred embodiment of the invention, simply by way of illustration of the best mode contemplated of carrying out the invention. As will be realized, the invention is capable of other and different embodiments, and its several details are capable of modification in various respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

### BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of the grinding apparatus of the present invention with the rotatable reamer in place within the cup;

FIG. 2 is a cross-sectional view of the grinding apparatus shown in FIG. 1, taken along the line 2—2 in FIG. 1;

FIG. 3 is an end view of the rotatable reamer of FIG. 1; and

FIG. 4 is a perspective view of the reamer of FIG. 1.

### BEST MODE FOR CARRYING OUT THE INVENTION

Referring to the Figures, a grinding apparatus **10** in accordance with the present invention, comprises a rotatable reamer **12** and a cup **13**. Grinding apparatus **10** is useful for thoroughly crushing, particulating and fragmenting both hard and soft materials. The apparatus is particularly useful for particulating and fragmenting soft materials such as plant leaf tissue. Grinding apparatus **10** and this use are disclosed in copending patent application Ser. No. 150,710 of John B. Sardisco and C. O. Phillips, filed May 19, 1980, and entitled "Test Kit for Field Analysis of Plant Tissue Magnesium and Calcium" (now issued as U.S. Pat. No. 4,303,610, Dec. 1, 1981). Reamer **12** has teeth **14** that form a first grinding surface **16**. Teeth **14** extend radially outward from a center point **18** of grinding surface **16**.

Referring particularly to FIG. **2**, the inner bottom surface **20** of cup **13** is formed with teeth **22** that correspond to reamer teeth **14** so as to mesh with those teeth and to give grinding apparatus **10** a camming action when reamer **12** is rotated in cup **13**. Cup teeth **22** provide a second grinding surface. It is preferred that cup teeth **22** are identical in shape to reamer teeth **14**, and that teeth **22** and teeth **14** have an identical V-shaped configuration. However, teeth **22** and teeth **14** could differ in shape from one another. For example, teeth **22** could be U-shaped and teeth **14** could be V-shaped. Also, teeth **22** and teeth **14** could have an identical U-shaped configuration. Other configurations could be used. However, the cutting and piercing action of grinding apparatus **10** would be substantially reduced by any of these modifications.

V-shaped teeth **14** have peaks **24** and valleys **26**, and V-shaped teeth **22** have peaks **28** and valleys **29**. The camming action is produced, during rotation of reamer **12**, as peaks **24** of reamer teeth **14** move from valleys **29** of cup teeth **22** to peaks **28** of teeth **22** and then return to valleys **29**. FIG. **2** shows peaks **24** of teeth **14** in valleys **29** of teeth **22**.

Still referring particularly to FIG. **2**, it is preferred that body **30** of reamer **12** is cylindrically shaped, and that wall **32** of cup **13** conform to peripheral wall surface **34** of reamer body **30**. Thus, reamer **12** and cup **13** are both cylindrically shaped. However, there are less advantageous possibilities. For example, body **30** could be frustoconically shaped and cup **13** cylindrically shaped. Wall surface **34** of reamer body **30** preferably fits snugly against the cup wall **32**.

Referring to FIGS. **2**, **3** and **4**, in order to permit the exit of air from and the entry of air into the bottom portion **36** of cup **13** during insertion of reamer **12** into and removal of reamer **12** from cup **13**, as well as during rotation of reamer **12** due to the camming action, it is necessary to provide grooves **38** along wall surface **34**, when there is the snug fit. Grooves **38** preferably divide wall surface **34** into four equal parts to permit even air exchange. Three grooves could be used with about equal advantage. Each of grooves **38** extends from top surface **40** of reamer **12** to grinding surface **16**. More grooves could be used, but no appreciable advantage results, and fewer than three or four grooves results in less even air exchange, although one groove is adequate.

Referring to FIG. **4**, grinding apparatus **10** preferably further includes a T-shaped handle **42** for rotating reamer **12**. Handle **42** extends upwardly from top surface **40** of reamer **12** and is preferably perpendicular to top surface **40**. Handle **42** is easy to grasp with the hand, for rotating reamer **12**. Handle **42** is comprised of an elongated arm element **44** and a cross piece element **46**. Other handle configurations could be used. For example, reamer **12** could be rotated by means of an elongated arm such as elongated arm element **44**, i.e., no crosspiece is present. This arm could be grasped with the hand for rotating he reamer, could be gear driven, or could be frictionally rotated by a belt driven by a motor. In the latter two instances, grinding apparatus **10** could have a large size and be used commercially. When grinding apparatus **10** does not have a handle such as handle **42**, rotation is accomplished, for example, by grasping reamer body **30** with the hand. Handle **42** or any other suitable handle could be removable from reamer body **30** and provided as a separate piece. In this case, the top portion of reamer body **30** would have an aperture that is illustratively square-shaped, into which the lower end of the handle is inserted. The lower end of the handle would match the shape of the aperture. Cup **13** preferably has extended base element **48** to prevent tipping.

In use, the material to be ground is placed inside cup **13** and reamer **12** is then inserted into the cup. Cup **13** is held by one hand of the user, and T-shaped handle **42** is grasped by the user's other hand. Reamer **12** is then rotated and the material is ground. The ground material is removed from the cup by turning the cup upside down and tapping the cup against a surface. A brush may be used to assist removal. Alternatively, a vacuum line is inserted into the cup and the material collected in a bag on the other end of the vacuum line, or a fluid is added to the cup and the ground material washed from the cup. The latter alternative is useful when it is desired to extract the material with the wash fluid or a combination of the wash fluid and an extracting fluid.

In this disclosure there is shown and essentially described only the preferred embodiment of the invention, but as mentioned above, it is to be understood that the invention is capable of changes or modifications within the scope of the inventive concept expressed herein. Several changes or modifications have been briefly mentioned for purposes of illustration.

We claim:

**1**. A grinding apparatus for thoroughly crushing, particulating and fragmenting soft materials such as plant leaf tissue, comprising:

(a) a rotatable reamer having a substantially cylindrical peripheral wall surface and teeth forming a first grinding surface, said teeth extending radially outward from a center point of said grinding surface;

(b) a cup for receiving said reamer, said cup having an inner bottom surface and substantially straight cylindrical side wall means conforming to the peripheral wall surface of the reamer along a major portion of the reamer during rotation of the reamer within the cup, said peripheral wall surface and cup side wall means each being substantially smooth to provide a snug fitting relationship whereby preventing material from passing between the peripheral wall surface of the reamer and the side wall means, said inner bottom surface formed with teeth defining a second grinding surface and being substantially identical to the teeth of said first grinding surface so as to mesh therewith and provide a camming action during rotation of said reamer relative to the cup, whereby grinding of material placed between the first and second grinding surfaces is effected during rotation of said reamer within the cup;

(c) a groove extending from the top surface of said reamer to said first grinding surface, said groove acting to permit substantially all of the air in the bottom portion of said cup to escape during rotation of said reamer, said air escaping being necessitated by the camming action of said grinding apparatus; and

(d) a handle attached to the reamer and projecting longitudinally upwardly therefrom for rotating the reamer within the cup.

**2**. The grinding apparatus of claim **1**, wherein the teeth of said first grinding surface are V-shaped.

**3**. The grinding apparatus of claim **1**, wherein said handle is T-shaped, for ease of grasping by the hand and of rotating said reamer.

**4**. The grinding apparatus of claim **1**, wherein said cup has an extended base element.

* * * * *

# United States Patent [19]

**Urich et al.**

[11] **Patent Number: 4,773,601**

[45] **Date of Patent: Sep. 27, 1988**


[54] **COMBINATION SMALL-SCALE TUB GRINDER AND WOOD CHIPPER**


[75] Inventors: **Oren D. Urich**, Windsor; **Ralph T. O'Donnell**, Loveland; **Roy D. Cash**, Greeley, all of Colo.

[73] Assignee: **S.B.O., Inc.**, Greeley, Colo.



[21] Appl. No.: **912,257**

[22] Filed: **Sep. 29, 1986**

[51] **Int. Cl.**[4] .......... **B02C 13/282**

[52] **U.S. Cl.** .......... **241/101.7**; 241/186.4; 241/189 R

[58] **Field of Search** .......... 241/101.7, 73, 189 R, 241/186.4, 186 R, 194, 195, 190, 98, 79, 79.1



[56] **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2,650,745 | 9/1953 | Oberwortman . | |
| 2,810,529 | 10/1957 | Jensen . | |
| 3,615,059 | 10/1971 | Moeller . | |
| 3,743,191 | 7/1973 | Anderson . | |
| 3,912,175 | 10/1975 | Anderson . | |
| 3,966,128 | 6/1976 | Anderson et al. . | |
| 4,003,502 | 1/1977 | Barcell . | |
| 4,087,051 | 5/1978 | Moeller | 241/190 X |
| 4,106,706 | 8/1978 | Burrows . | |
| 4,232,719 | 11/1980 | Payton | 241/101.7 X |
| 4,266,899 | 5/1981 | Skeem | 241/101.7 X |
| 4,449,672 | 5/1984 | Morlock et al. | 241/101.7 |

OTHER PUBLICATIONS

W. W. Grinder, Inc.
C. Q. Concho, Lindig Manufacturing Corp.
Promark Model 310 Brush Chipper.
Alko International.



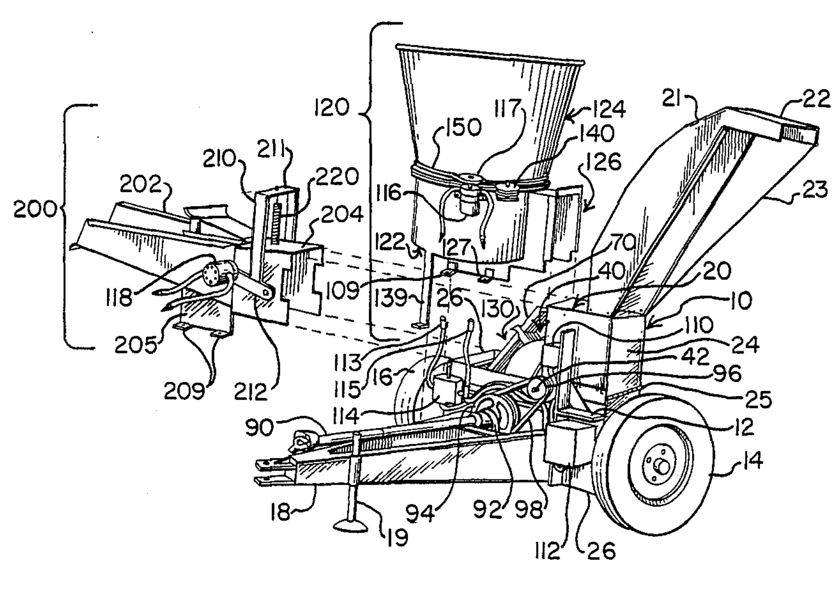
*Primary Examiner*—Mark Rosenbaum
*Attorney, Agent, or Firm*—James R. Young



[57] **ABSTRACT**

A mini-sized hammer mill apparatus is adaptable for both rotatable tub feeding of hay, fodder, feed grains, and the like, as well as for chute feeding of wood and debris for comminution. A number of features optimize the mini size for effective, reliable, and smooth operation by small horsepower tractors, including: side feed tangentially out of a cylindrical hopper under a rotatable tub into the periphery of a large diameter, narrow rotor, or through a chute with tensioned roller feeder; radially adjustable grinding and metering finger/grate bar combination, secondary grinding fingers and breaker bar, self-sharpening hook-like pointed hammers, rotatable tub mounting structure, and enhanced energy dissipating, down-sized cyclone with reverse-louvered pressure dissipators.


**51 Claims, 9 Drawing Sheets**



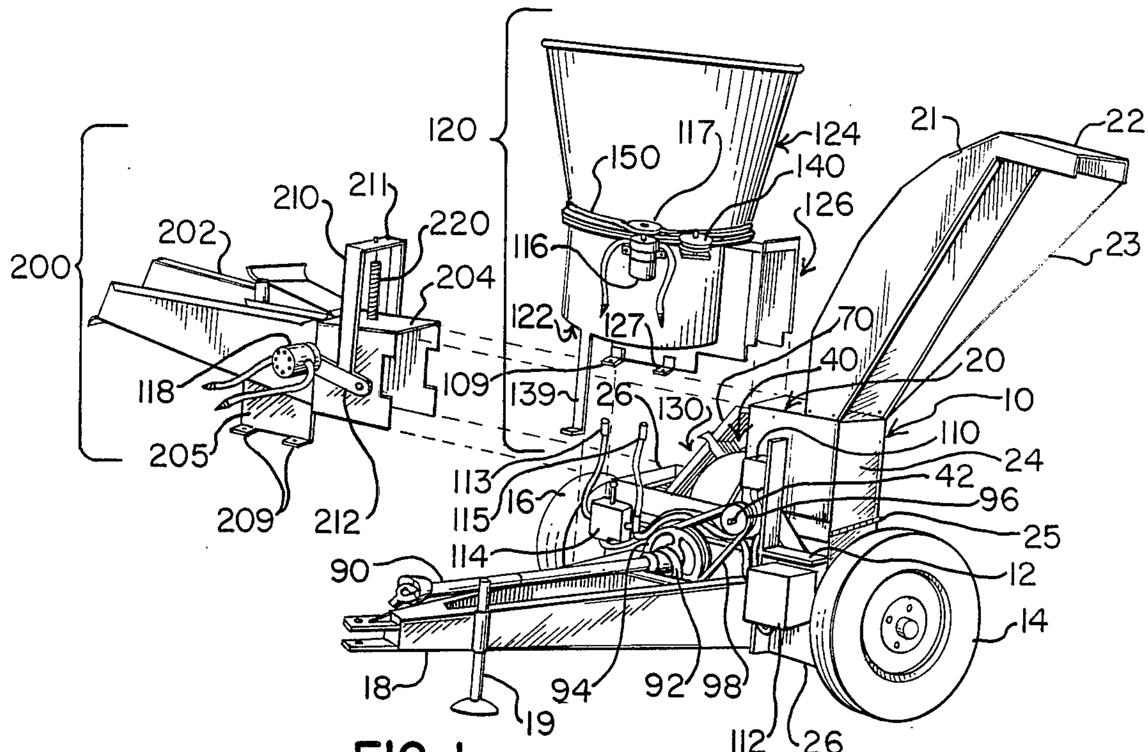

200
202
210
211
220
204
118
205
209
212
120
150
117
124
140
126
116
122
127
109
139
26
130
70
40
20
10
110
24
42
96
25
12
14
113
115
16
114
90
18
19
94
92
98
112
26
21
22
23

FIG. 1

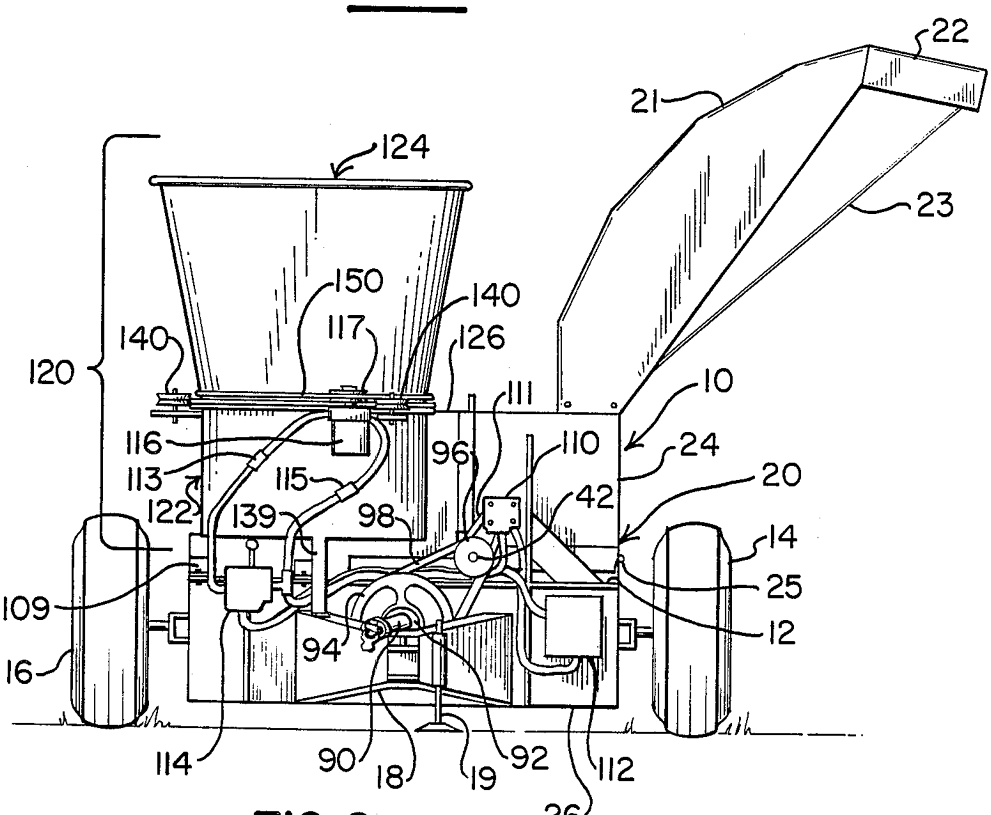

22
21
23
124
150
140
117
126
120
140
10
116
113
115
96
111
110
24
20
122
139
98
42
14
25
109
12
16
94
114
90
18
19
92
112
26

FIG. 2

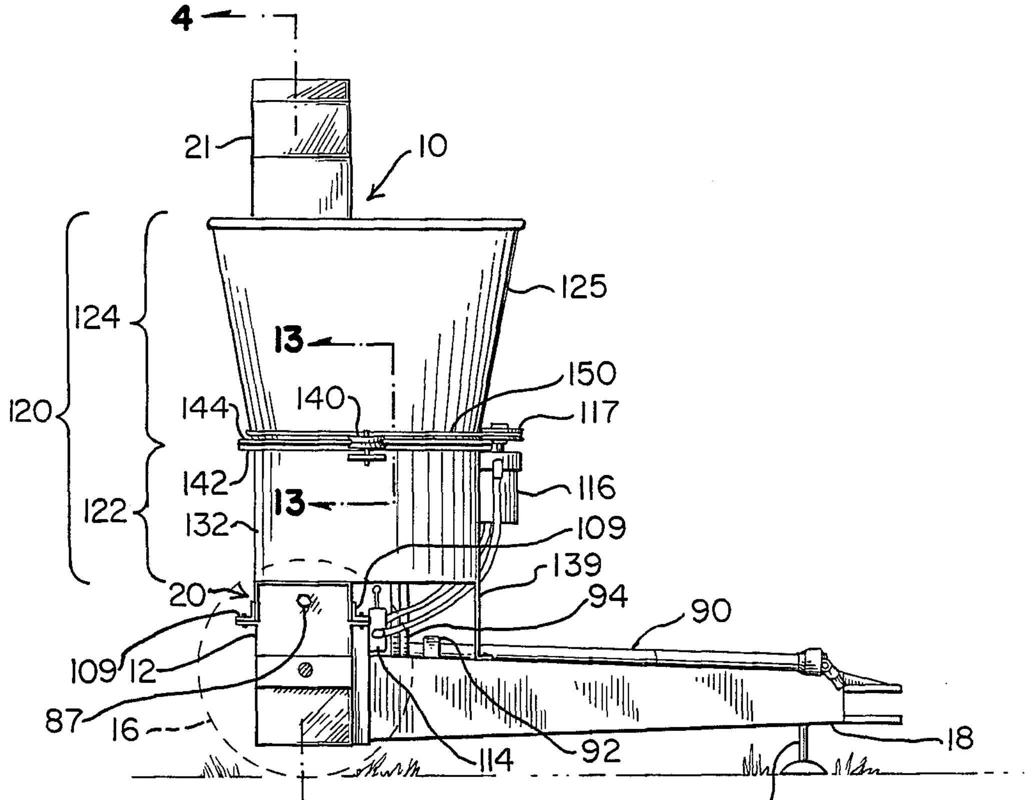

4
21
10
124
120
125
13
144
140
150
117
142
122
116
132
109
139
20
94
90
109
12
87
16
114
92
18
19
4

FIG. 3

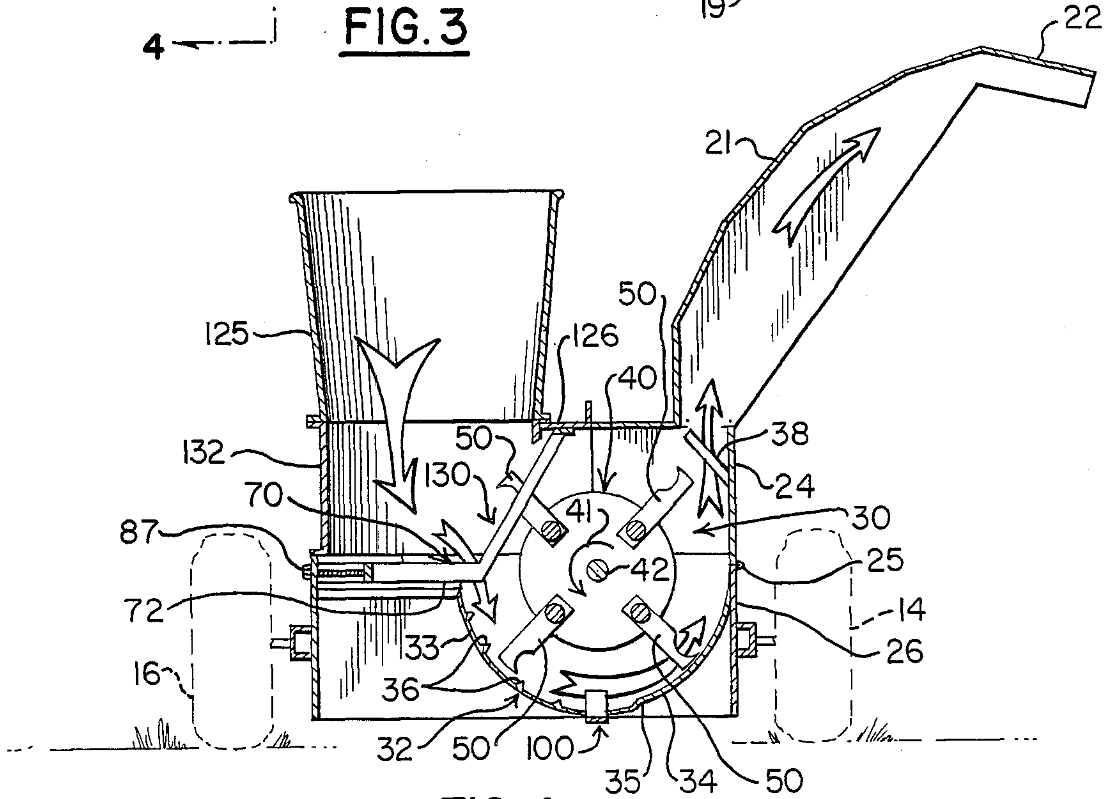

22
21
50
125
126
40
38
50
132
130
24
70
41
30
87
42
25
72
14
33
26
16
36
32
50
100
35
34
50

FIG. 4

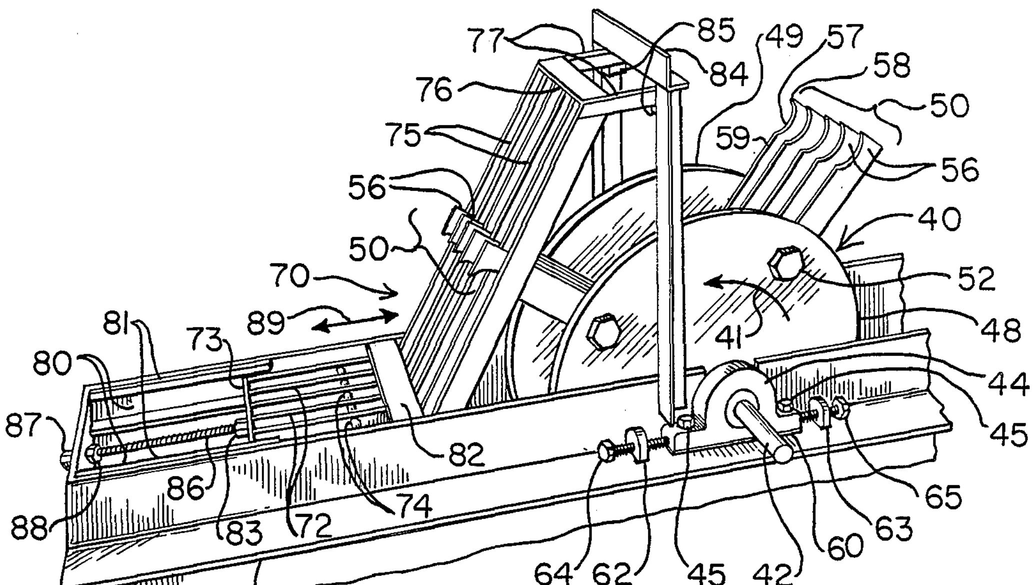



FIG. 5

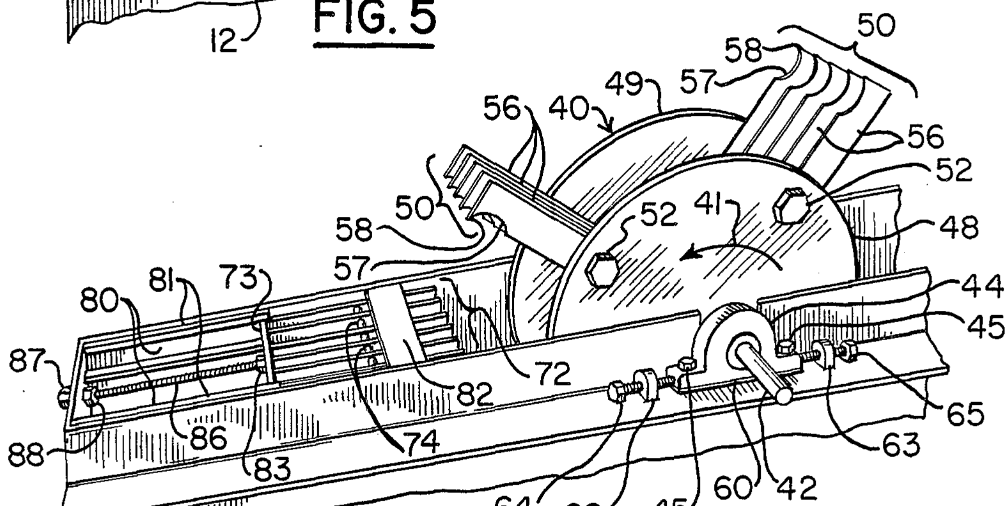



FIG. 7

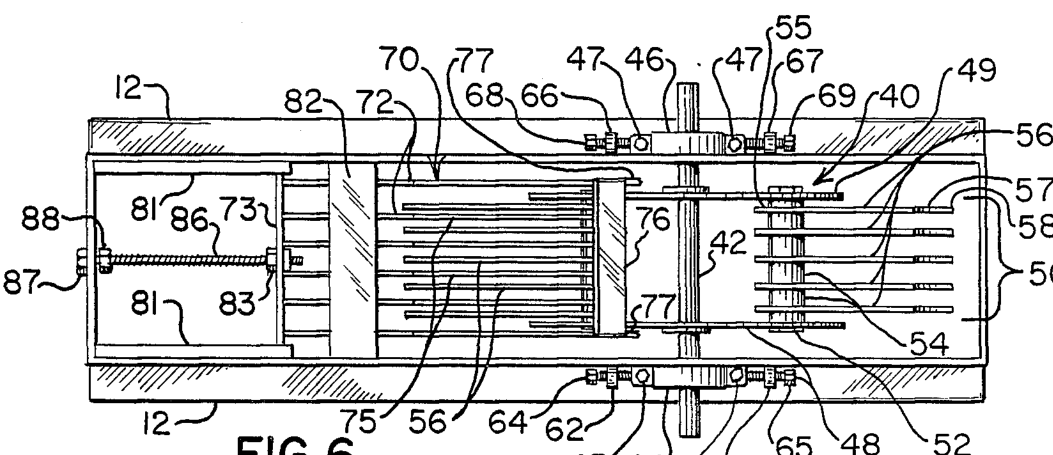



FIG. 6

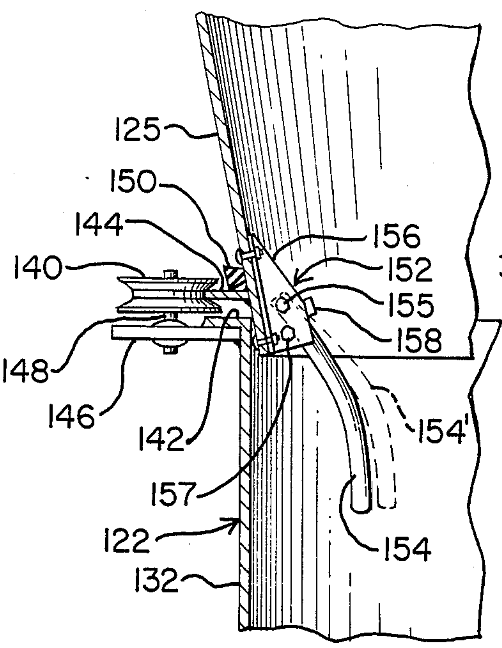



FIG. 12

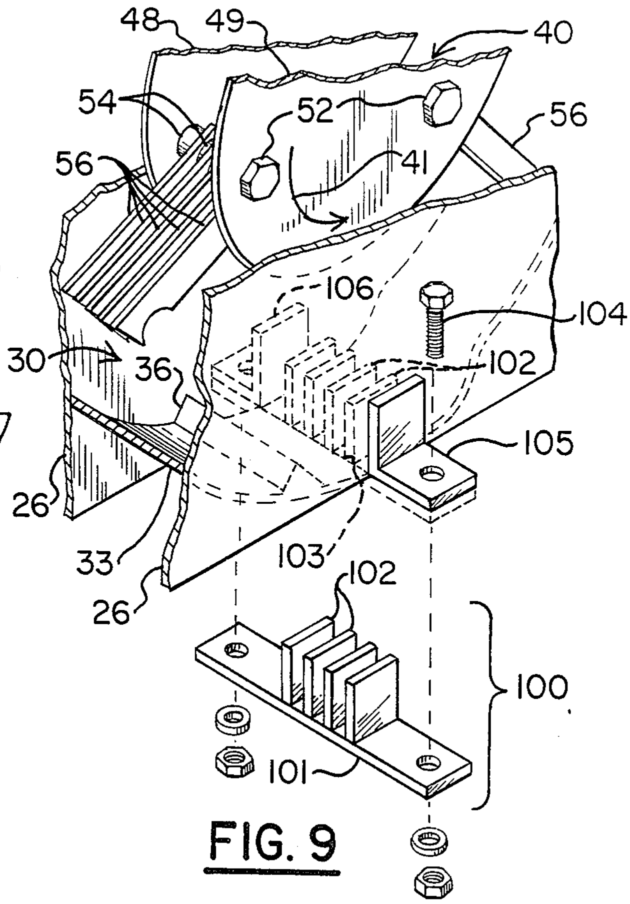



FIG. 9

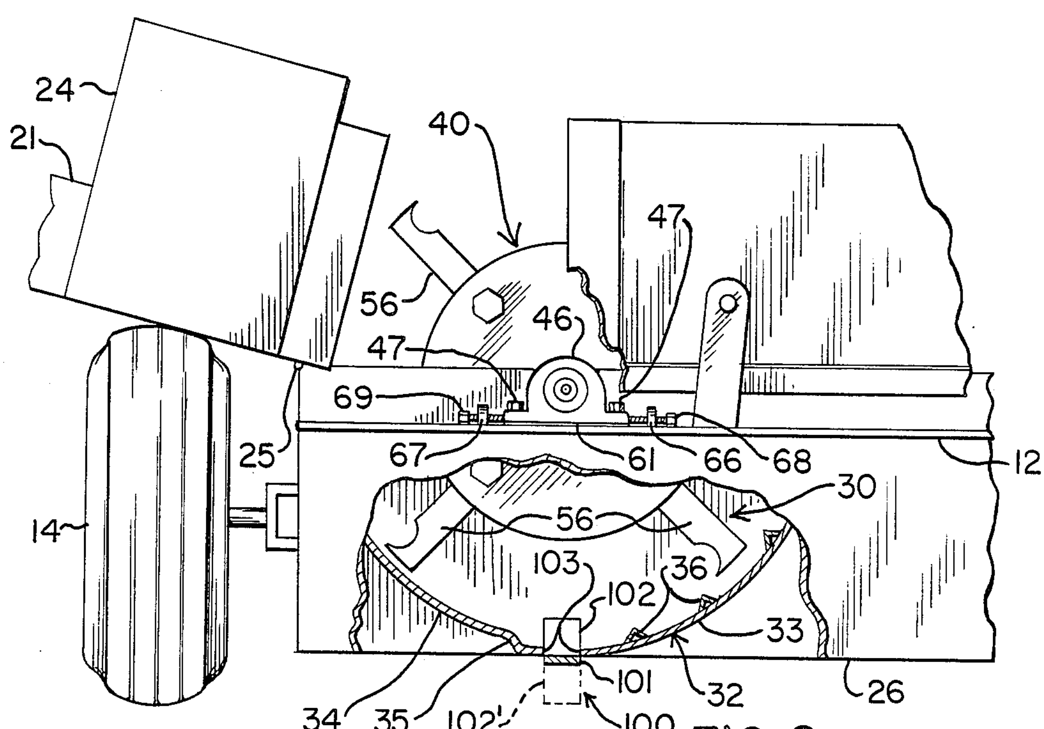



FIG. 8

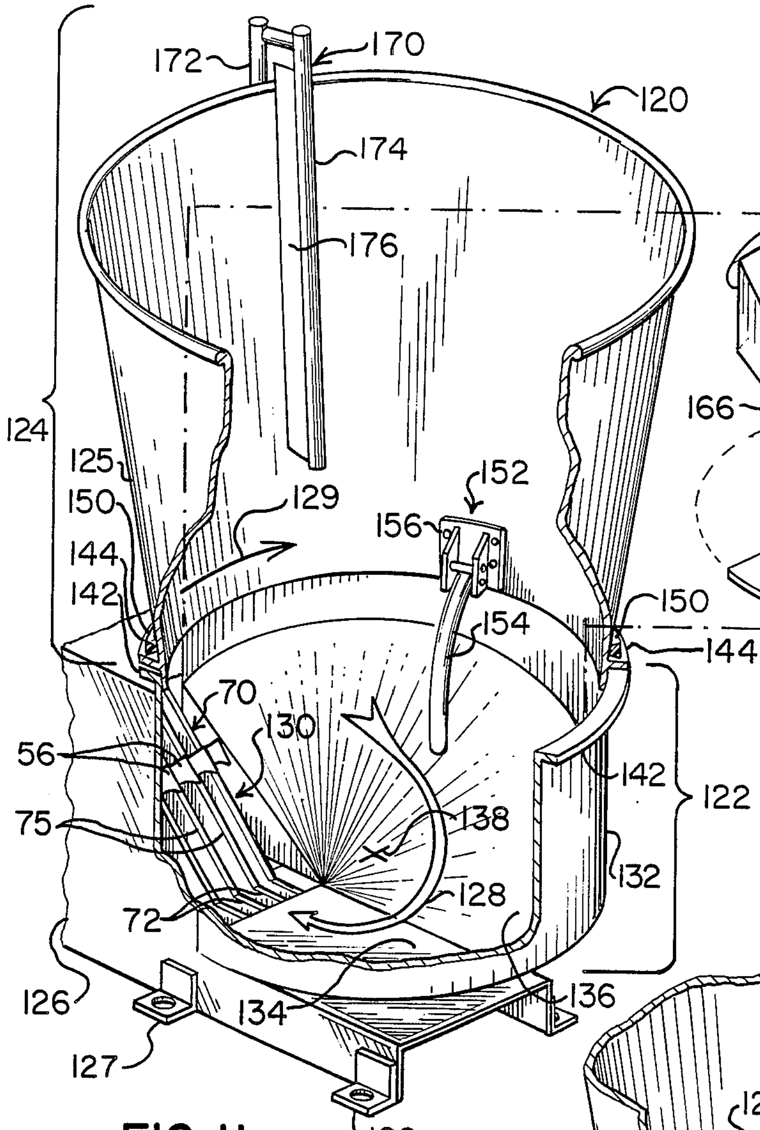



FIG. 11

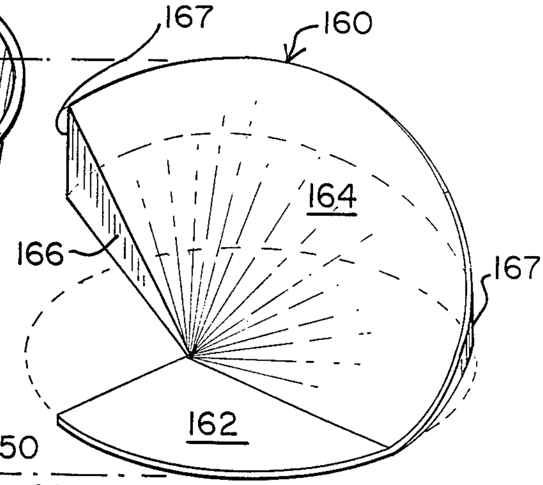



FIG. 13

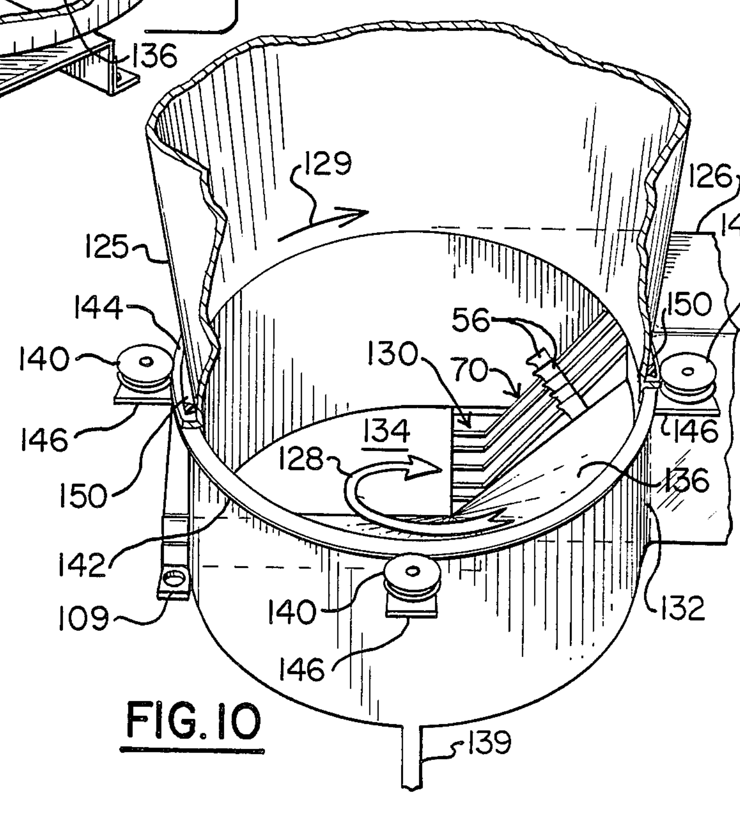



FIG. 10

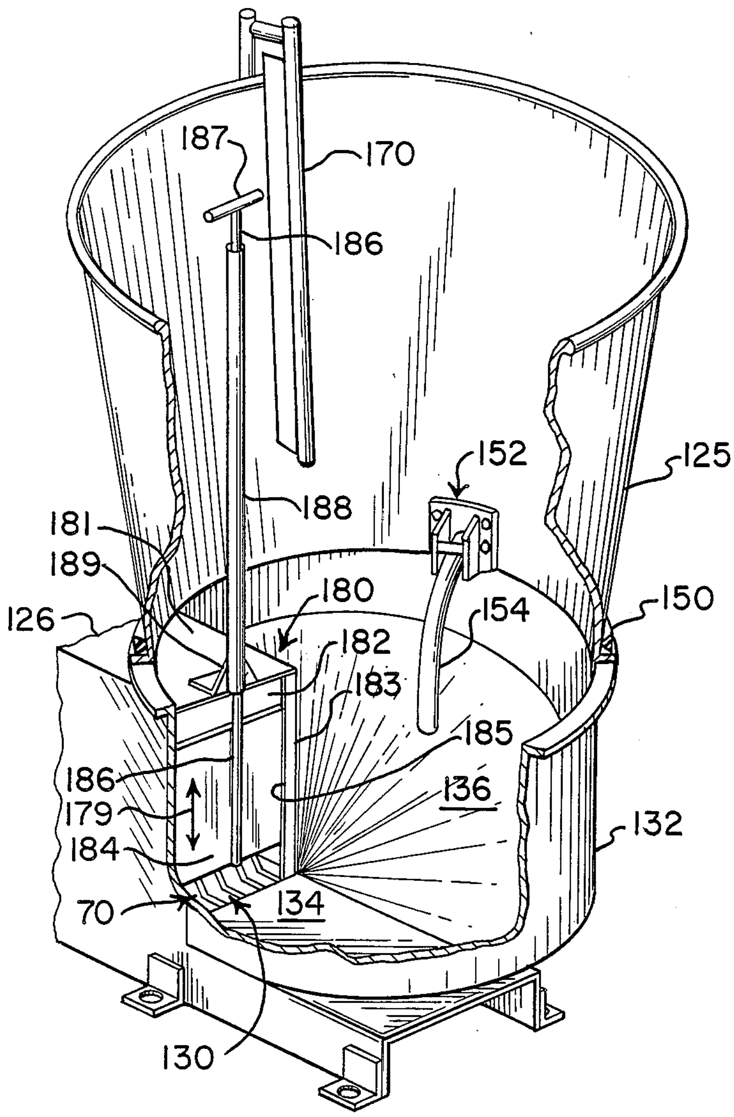

187
170
186
152
125
188
181
189
180
154
150
126
182
183
185
136
186
179
184
132
70
134
130

FIG. 14

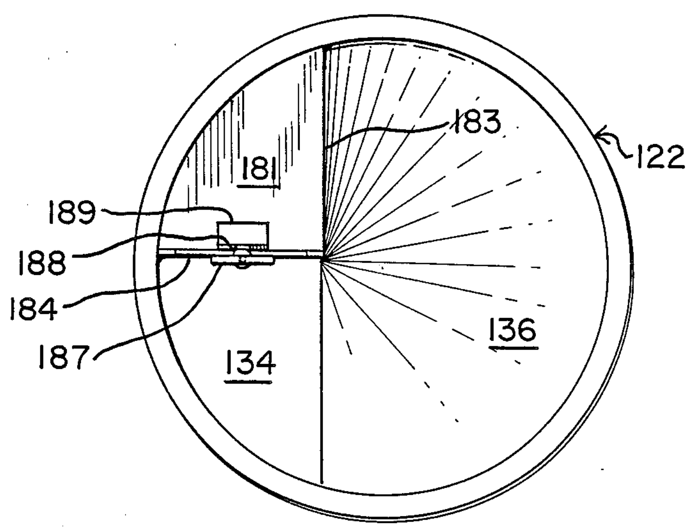

183
122
181
189
188
184
136
187
134

FIG. 15

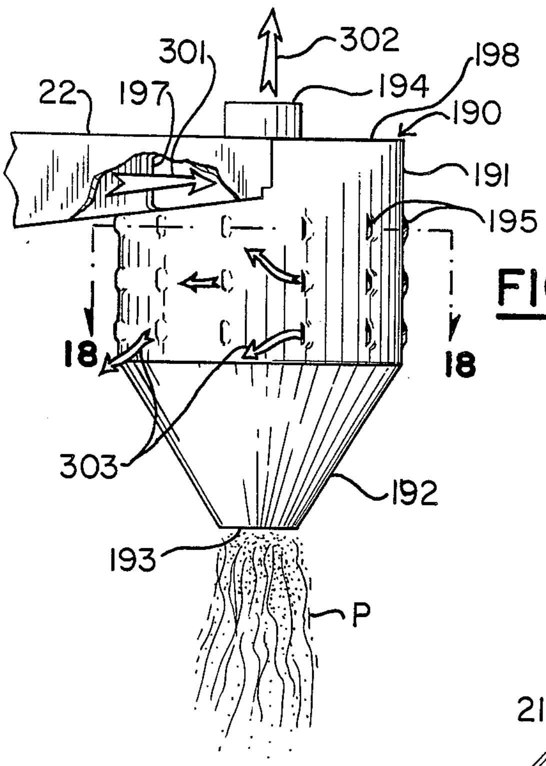
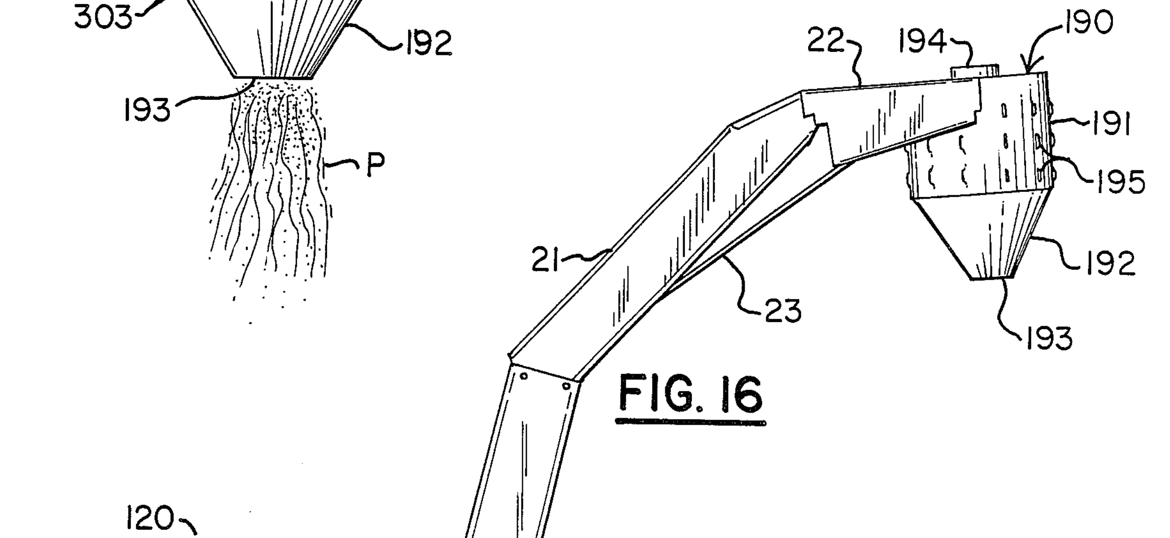



FIG. 17



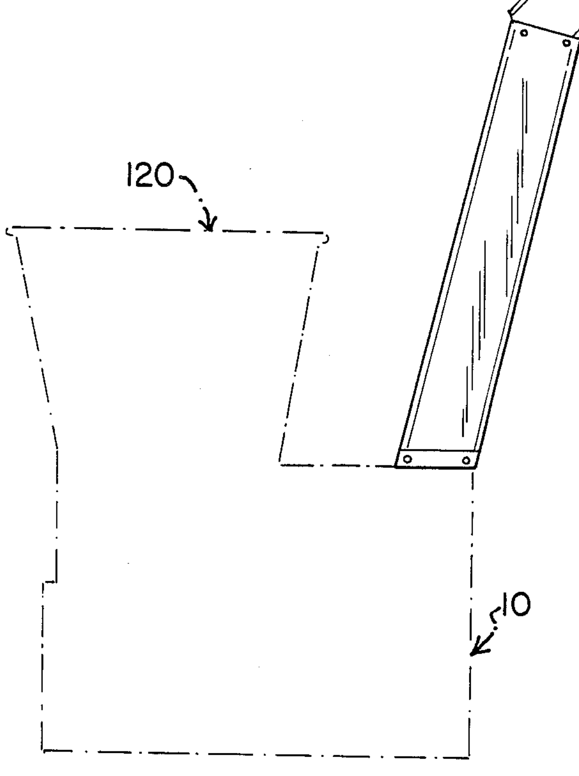




FIG. 16

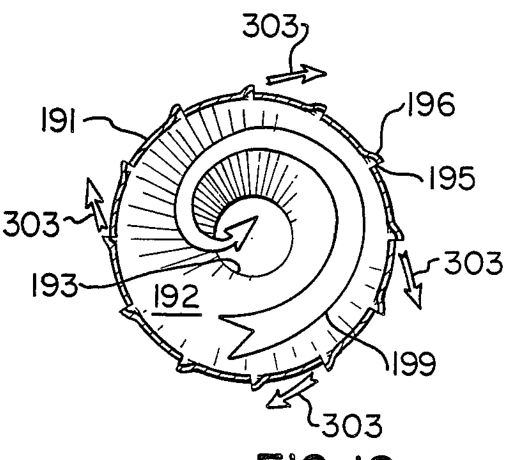



FIG. 18

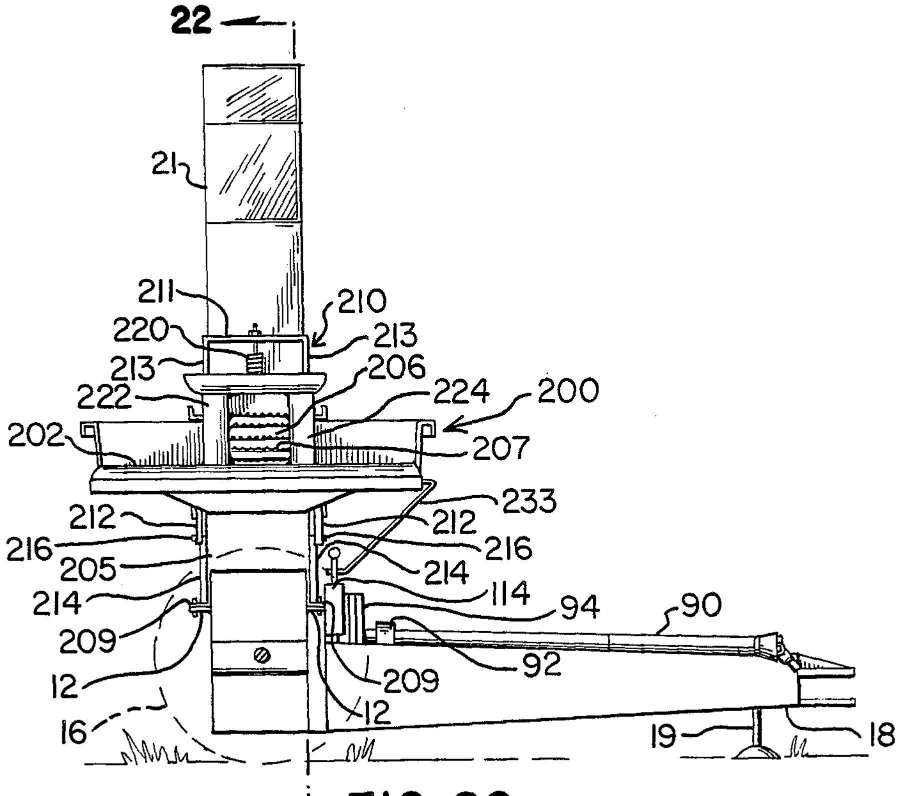

22
21
211
220
213
210
213
206
222
224
200
202
207
233
212
212
216
205
216
214
214
114
94
90
209
92
12
209
12
16
19
18
22

FIG. 20

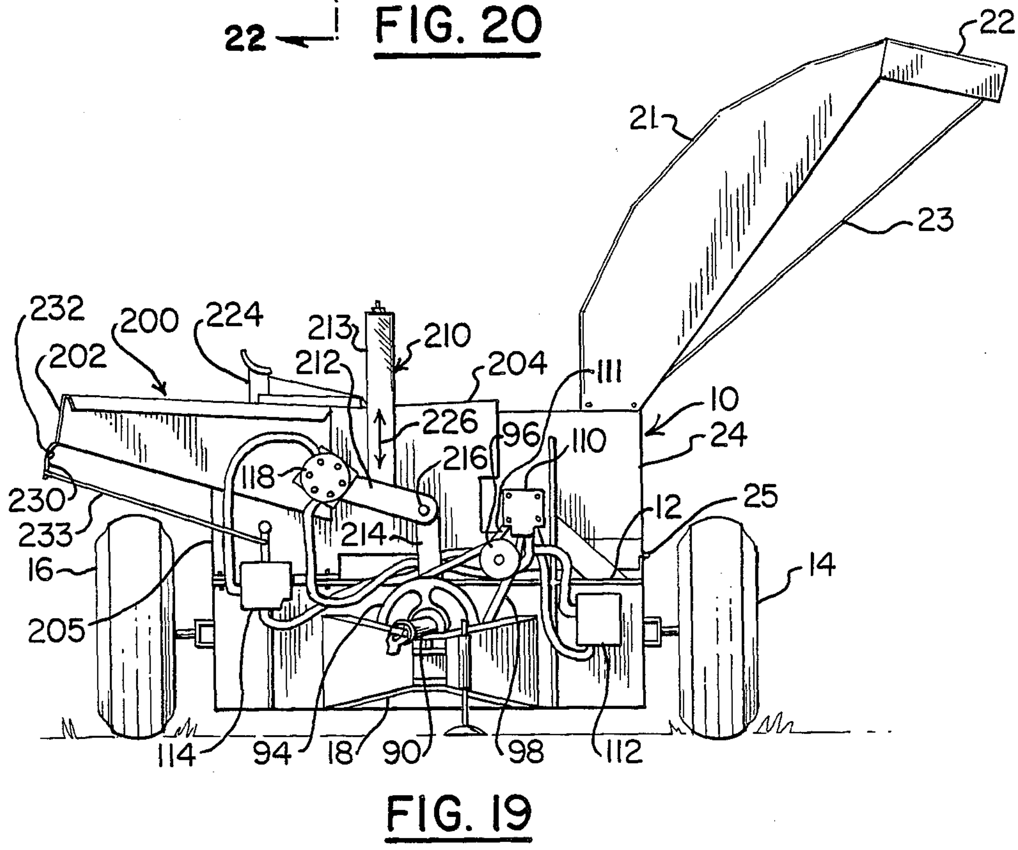

22
21
23
232
200
224
213
210
202
212
204
111
226
10
96
110
24
118
216
230
214
12
25
233
16
14
205
114
94
18
90
98
112

FIG. 19

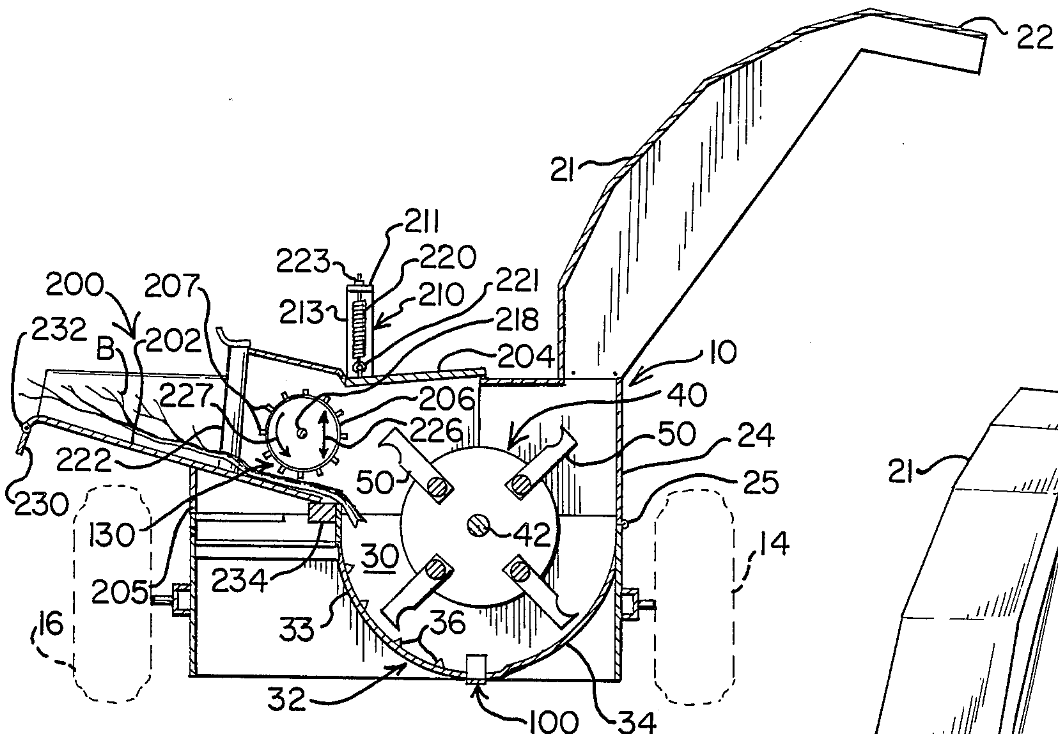

22
21
211
223
220
221
210
213
218
204
10
200
207
232
202
B
227
206
40
226
50
24
222
50
25
230
42
130
14
234
30
205
33
36
16
32
100
34

FIG. 22

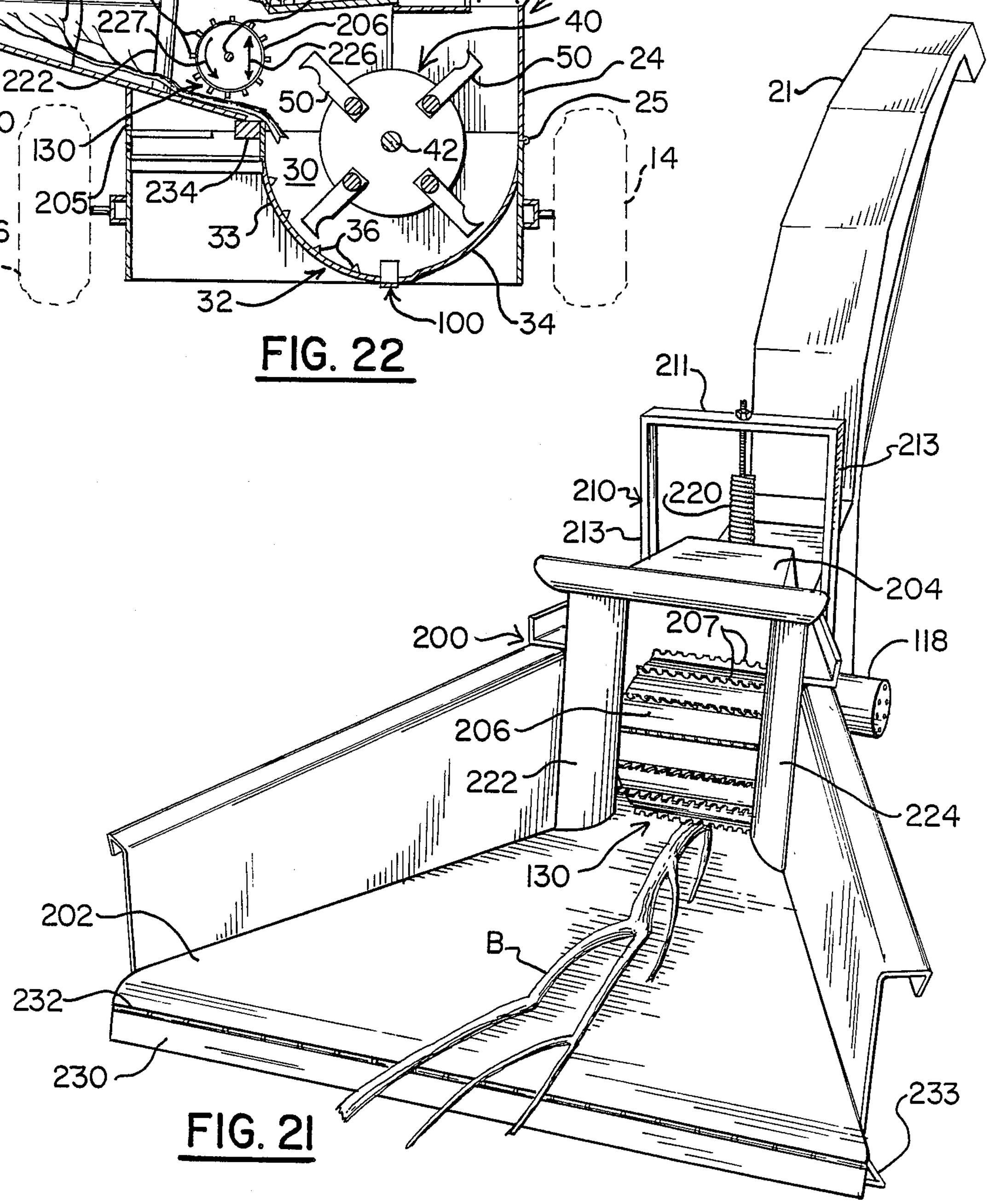

21
211
213
210
220
213
204
200
207
118
206
222
224
130
202
B
232
230
233

FIG. 21

# COMBINATION SMALL-SCALE TUB GRINDER AND WOOD CHIPPER

## BACKGROUND

1. Field of Invention

The present invention is generally related to comminuting (grinder) apparatus, and more specifically to a combination small-scale tub grinder and wood chipper and specific features that improve such apparatus.

2. Description of the Prior Art

Grinding grains, corn, hay, forage, and roughage products for more effective and digestible livestock feed is an old and well-known process. There are many kinds of machines for grinding or comminuting such products, including, for example stone mills, burr mills, hammer mills, roller mills, and others. Because of the fibrous and stalky, nature of hay, straw, and other roughages, hammer mill type grinders are generally considered to be the most effective for comminuting these forage or roughage materials; however, handling and feeding hay into a hammer mill in a uniform manner without much tedious manual labor has presented problems.

In the last two or three decades, machines generically known as tub grinders have become popular for comminuting hay, straw, and other roughages, because they are designed to feed very large bales of hay into hammer mill apparatus without excessive manual labor. In such tub grinders, the bales of hay or other roughage material are gradually fed into a hammer mill by a large rotating tub. The hammer mill is positioned on the floor or bottom of the tub, and the rotating tub rotates the bottom of the bale over the hammer mill. The hammers on the hammer mill rotating at a high angular velocity chew off the hay on the bottom of the bale as the bales rotates over the hammer mill in the floor of the tub. Typical examples of such tub grinders are shown in the following patents: U.S. Pat. No. 2,659,745, issued to W. Wortman; U.S. Pat. No. 3,615,059, issued to E. Moeller; U.S. Pat. No. 3,743,191, issued to R. Anderson; U.S. Pat. No. 3,912,175, issued to R. Anderson; U.S. Pat. No. 3,966,128, issued to J. Anderson, et. al.; U.S. Pat. No. 4,003,502, issued to E. Barcell; U.S. Pat. No. 4,087,051, issued to C. Moeller; and U.S. Pat. No. 4,106,706, issued to H. Burrows.

Such tub grinders are effective, but they are very large and relatively expensive machines that require high-powered tractors or stationary engines for sufficient power to operate them. This situation leaves smaller scale livestock feeding operators and hobby livestock feeders, who typically have only low horsepower tractors and limited funds, without any effective hay comminuting capability other than perhaps hand-feeding hay into smaller hammer mills.

While the solution to this problem at first glance appeared to be merely reducing the conventional large tub grinders in scale, it was really not so simple. Many components of large tub grinders that function well with large bales and powerful tractors do not function so well with small bales and limited horsepower. For example, a hammer mill rotor cannot be scaled down so small that it has insufficient weight and inertia, even if the tub is scaled down to handle conventional, man-sized square or round bales. Yet, a smaller tub cannot accommodate a larger hammer mill in the same manner as a larger tub can. Further, even though hay bales can be smaller in size, the hay is the same and is just as tough as hay in large bales to grind. Therefore, in a directly scaled down tub grinder and/or using smaller horsepower tractors, uneven feeding and jamming, as well as slugging the hammer mill and overloading the tractor engine result in nonuniform product and a generally frustrating experience for the operator.



Also, most small-scale operators and hobbiests really cannot afford to have separate grinding machinery for comminuting hay and for milling corn and other feed grains. It is much preferred to have a single machine that can handle roughage, such as hay and straw, as well as all kinds of grains and corn. However, the conventional tub grinders for hay cannot handle grains effectively, while the conventional hammer mills for grains cannot handle hay effectively without laborious and time consuming hand-feeding.

Still further, many small-scale operators also have need for wood chipper machinery for comminuting brush cleared from wooded areas or branches pruned from orchards and trees. Disposal of such brush and branches is easier when they are reduced to chips. There are also a number of beneficial uses for wood chips, such as bedding for livestock, mulch in gardens and around ornamental shrubbery, decorative ground coverings, and the like. Again, however, most small-scale operators cannot afford, or cannot justify economically, owning a separate wood chipper machine, even though they need one on a regular basis.

Prior to this invention, therefore, there was a significant need for a smaller-scale hammer mill machine that could be driven by a small horsepower tractor and that still had the capability and versatility of effectively handling and comminuting both hay and all kinds of corn and feed grains, as well as having the ability to comminute brush and branches into wood chips.

## SUMMARY OF THE INVENTION

Accordingly, it is a general object of this invention to provide a small-scale hammer mill that is capable of handling and comminuting hay, corn, and other feed grains, as well as comminuting brush and branches into wood chips.

A more specific object of this invention is to provide a comminuting apparatus with a feeder system that can effectively and uniformly feed hay, as well as corn and other feed grains, into a hammer mill without jamming and slugging so that a small horsepower tractor can be used to drive the apparatus, and good, uniform and acceptable comminuted feed product can be produced.

Another specific object of this invention is to provide a hammer mill that can be used effectively as a wood chipper.

Another specific object of this invention is to provide a hammer mill that can be easily converted from a feed grinding mill to a wood chipper.

Another specific object of this invention is to provide a hammer mill having sufficient feed and milling controls and adjustments to accommodatea variety of comminuting requirements from hay, corn, and grain for livestock feed to brush and branches for wood chips.

Additional objects, advantages, and novel features of this invention are set forth in part in the description that follows, and in part will become apparent to those skilled in the art upon examination of the following specification or may be learned by the practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and in combinations particularly pointed out in the appended claims.

To achieve the foregoing and other objects and in accordance with the purposes of the present invention, as embodied and broadly described herein, the apparatus of this invention may comprise a rotary hammer mill rotatably mounted in a housing that encloses a milling chamber and apparatus capable of feeding a variety of materials to be comminuted radially into the rotary hammer mill. There are two alternative feeder apparatus that can be conveniently mounted on the hammer mill. One of the feeder assemblies is a tub feeder for handling livestock feed, such as hay, corn, and grains, and the other is a drum feeder for handling brush and branches for wood chipping. A slidably adjustable grinding finger and grate in the feeder area adjacent the rotary hammer mill, along with self-sharpening hooked hammers extending radially from the rotary hammer mill cooperate to provide an even feed of materials into the milling chamber. A set of removeable secondary grinding fingers on the bottom of the milling chamber, along with concaves in close radial spacing of the hammers increase grinding action. The tub feeder has a rotary receptacle over a hopper with spiral sloped floor that moves the material to be comminuted in a downward spiral to an opening into the milling chamber where the material exits the tub tangentially to be directed radially into the rotary hammer mill. An agitator bar, sloped insert for the hopper floor, and grain door enclosure enhance the handling of various kinds of feed materials. The drum feeder has a rotary feed drum with teeth on its peripheral surface positioned in a chute radially adjacent the hammer mill rotor, which drum feeder is biased toward the chute to enhance clamping control and metering of brush and branches radially into the hammer mill rotor. A control bar on the chute is connected to the drum drive for conveniently stopping the drum rotation. A cyclone energy dissipator for the outlet spout has a plurality of louvered openings for releasing air in a direction opposite the flow of comminuted material for enhanced deceleration of the comminuted product that is propelled by the hammer mill rotor out of the milling chamber.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in, and form a part of, the specifications illustrate the preferred embodiments of the invention, and together with the description serve to explain the principles of the invention. In the drawings:

FIG. **1** is a perspective view of the combination tub grinder and wood chipper hammer mill invention according to the present invention, illustrating the interchangeable tub feeder and wood feeder components removed from, but in proximity to, the base hammer mill apparatus;

FIG. **2** is a front elevation view of the hammer mill apparatus according to the present invention with the tub feeder assembly mounted thereon;

FIG. **3** is a right side elevation view of the hammer mill apparatus according to the present invention with the tub feeder assembly mounted thereon;

FIG. **4** is a cross-sectional view of the hammer mill apparatus according to this invention taken along lines **4—4** of FIG. **3**;

FIG. **5** is an enlarged perspective view of the hammer mill rotor assembly and the preferred embodiment grinding finger and grate assembly according to the present invention, but not showing the exterior housing portions of the hammer mill for clarity of illustration;

FIG. **6** is a top plan view of the hammer mill rotor assembly and the grinding finger and grate assembly shown in FIG. **5**;

FIG. **7** is a perspective view of the hammer mill rotor assembly and a modified version of the grinding finger assembly according to the present invention;

FIG. **8** is a partial enlarged rear elevation view of the hammer mill of the present invention with the upper housing portion pivoted to the open position and with several portions of the housing cut away to reveal the components inside;

FIG. **9** is an enlarged fragmentary view in perspective of the lower part of the hammer mill housing illustrating a set of removeable secondary grinding fingers;

FIG. **10** is an enlarged perspective view looking down from above and the front of the tub feeder assembly of the present invention with a portion of the tub cut away to reveal the lower interior portion of the tub feeder assembly;

FIG. **11** is another perspective view of the tub feeder assembly of the present invention looking into the tub from the right rear of the apparatus and with portions of the tub and hopper assemblies cut away to reveal the components inside;

FIG. **12** is a partial sectional view of the rotatable mounting assembly of the tub feeder taken substantially along lines **13—13** of FIG. **3**;

FIG. **13** is a perspective view of an auxiliary hopper bottom insert for the tub feeder assembly;

FIG. **14** is a perspective view similar to FIG. **13**, but with an auxiliary grain door according to the present invention positioned over the opening to the hammer mill housing;

FIG. **15** is a plan view of the bottom of the hopper of FIG. **14** with the auxiliary grain door in position therein;

FIG. **16** is a front elevation view of the spout portion of the hammer mill with an improved cyclone pressure dissipator according to this invention mounted thereon;

FIG. **17** is an enlarged front elevation view of the cyclone shown in FIG. **16**, with a portion of the spout end section cut away to reveal the inlet to the cyclone pressure dissipator;

FIG. **18** is a sectional view of the cyclone pressure dissipator of the present invention taken substantially along lines **18—18** of FIG. **17**;

FIG. **19** is a front elevation view of the hammer mill according to the present invention similar to the front elevation view in FIG. **2**, except with the wood feeder assembly mounted on the hammer mill instead of the tub feeder assembly;

FIG. **20** is a right side elevation view of the hammer mill according to the present invention with the wood feeder assembly mounted thereon;

FIG. **21** is an enlarged perspective view of the wood feeder assembly of the present invention; and

FIG. **22** is a cross sectional view of the hammer mill according to the present invention with the wood chipper assembly mounted thereon, taken substantially along lines **22—22** of FIG. **20**.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The improved small-scale, all-purpose hammer mill according to the present invention is illustrated in FIG. **1** with the base hammer mill assembly **10** mounted on a pair of wheels **14**, **16** with a drawbar **18** and a power takeoff shaft **19** adapted for detachable connection to a conventional farm tractor. This hammer mill apparatus **10** is particularly designed and adapted for use with small-horsepower farm tractors and for use in grinding or comminuting a wide variety of livestock feed products, including hay, corn, and grain, as well as for chipping brush and branches for livestock bedding and other purposes.

To accommodate this variety of uses for one relatively small-scale hammer mill apparatus, there is provided as shown in FIG. **1** a tub feeder assembly **120** for mounting on and feeding livestock food products into the hammer mill rotor assembly **40**. Also, as shown in FIG. **1**, there is provided an alternate wood feeder assembly **200** that is adapted for mounting on the hammer mill assembly **10** as an alternative or substitute for the tub feeder **120**. This wood feeder assembly **200** is specially adapted for feeding brush and branches into the hammer mill **10** for producing wood chips.

The hammer mill assembly **10** according to the present invention is illustrated in FIGS. **2** through **4** with the tub feeder assembly **120** mounted thereon. A detailed description of the basic components of the hammer mill assembly **10** is best made by reference initially to these FIGS. **2** through **4** along with FIG. **1**.

As briefly mentioned above, the hammer mill assembly **10** has a main frame **12** and housing **20** mounted on a pair of wheels **14**, **16** with a drawbar **18** extending forwardly thereof for attachment to a farm tractor (not shown). A drawbar stand **19** is illustrated to support the front end of the drawbar **18** when it is not attached to a tractor. A spout **21** with an adjustable end section and adjusting rod **23** are attached to the top portion **24** of the housing **20** for directing the finished ground feed or wood chip products to an appropriate receptacle or storage area (not shown).

The top portion **24** of the housing **20** is pivotally connected to the bottom portion **26** by a hinge **25** and combines with the bottom portion of the housing **26** to partially enclose a milling chamber **30**. As best shown in FIG. **4**, the bottom of the milling chamber **30** is enclosed by a curved bottom wall **32** that is slightly larger in radius than the maximum radius of the components of the hammer mill rotor assembly **40**. As also best shown in FIG. **4**, the hammer mill rotor assembly **40** is mounted for rotation in the direction indicated by arrow **41** about its main shaft **42**.

Referring now again to FIGS. **1** and **2**, the hammer mill rotor assembly **40** is driven by a multiple V-belt connected to a main pulley **96**, which is mounted on the main rotor shaft **42** exterior of the housing. The drive belt **98** is driven by a drive pulley **94** connected to the power takeoff shaft **90** which, as briefly mentioned above, is adapted for releasable attachment to the power takeoff of a tractor. A bearing block **92** supports the rear end of the power takeoff shaft and journals the front end of the counter shaft on which the drive pulley **94** is mounted in a conventional manner.

Also shown in FIGS. **1** and **2** are hydraulic drive components for the tub feeder assembly **120** and for the wood feeder assembly **200**. For example, a hydraulic pump **110** is mounted adjacent the main pulley **96** and is driven via belt **111** by a secondary drive pulley (not shown) mounted on the main shaft **42** behind the main pulley **96**. A hydraulic fluid reservoir **112** is shown mounted on the lower left portion of the bottom housing section **26**, and a control valve assembly **114** is shown mounted on the lower right portion of the housing **26**. Appropriate hydraulic lines and fittings are provided to connect these hydraulic components as would be known to persons having ordinary skill in this art. Releaseable connectors **113**, **115** are provided for detachably connecting the hydraulic lines to either the hydraulic motor **116** on the tub feeder assembly **120** or the hydraulic motor **118** on the wood feeder assembly **200**, to accommodate whichever of these assemblies is being utilized at any particular time on the hammer mill assembly **10**.

While this illustration is made and described with hydraulic drive components for the tub feeder assembly **120** and the wood feeder assembly **200**, mechanical drives, such as appropriate gear boxes and belt drives can also be provided to drive the tub feeder assembly **120** and the wood feeder assembly **200**. However, such alternative mechanical drives are considered to be within the abilities of persons having ordinary skill in the art. Therefore, while these inventors have also provided the hammer mill apparatus of this invention with such mechanical drives, it is not considered necessary to illustrate or describe them in detail for purposes of describing the unique features of this invention.

Referring again primarily to FIG. **4**, the unground or raw feed product is introduced into the grinding chamber **30** through opening **130**. The hammer assemblies **50** of the rotor assembly **40** engage the incoming product at the opening **130** and tear or force it through a grinding finger and grate assembly **70**, thereby pulling the product into the lower curved portion of the grinding chamber **30**. In the lower curved portion, the product is ground across a series of concaves **36** protruding inwardly from the primary stage **33** of the curved bottom wall **32**, thereby creating additional physical grinding and turbulence in the flow of the product through the grinding chamber **30**.

An optional secondary set of grinding fingers **100** are positioned to protrude into the bottom portion of the grinding chamber **30** for additional final breaking and tearing of the product to substantially complete the comminuting process. In order to maximize acceleration of the ground material down stream from the secondary fingers **100** for discharge from the milling chamber **30**, the curved bottom wall **32** is bent or transformed upwardly at **35** into a slightly smaller radius closer to the distal ends of the hammer assemblies **50**. The comminuted material is then discharged from the grinding chamber **30** into the spout **21**. An optional screen **38** can be provided in the discharge area of the grinding chamber **30** so that only particles less than a pre-selected maximum size can be discharged into the spout **21**. Any larger particles would be blocked and knocked back into the grinding chamber **30** to be caught again by the hammer assemblies **50** for further grinding.

The hammer mill rotor assembly **40** and the grinding finger and grate assembly **70** are best described by reference to FIGS. **5** and **6**. The rotor assembly **40** is comprised of a plurality of hammer assemblies **50** mounted between 2 large circular rotor plates **48**, **49**. These rotor plates **48**, **49** are in turn mounted on a main rotor shaft **42**, which is journaled at each end in respective front and rear bearing blocks **44**, **46**. The bearing blocks **44**, **46**, are mounted on the respective horizontal front and rear frame members **12** of the hammer mill apparatus **10**. The main pulley **96**, shown in FIGS. **1** and **2**, but not in FIGS. **5** and **6**, is mounted on this main shaft **42** for

US005361996A

# United States Patent [19]

Svensson et al.

[11] Patent Number: 5,361,996

[45] Date of Patent: Nov. 8, 1994

[54] METHOD AND ARRANGEMENT FOR FINELY-GRINDING MINERALS

[75] Inventors: U. Krister Svensson; Conny L. Rehnvall, both of Sala, Sweden

[73] Assignee: Sala International AB, Sala, Sweden

[21] Appl. No.: 992,071

[22] Filed: Dec. 17, 1992

[30] Foreign Application Priority Data

Dec. 20, 1991 [SE] Sweden ............................ 9103781-2

[51] Int. Cl.[5] ............................................ B02C 17/16

[52] U.S. Cl. ........................................ 241/30; 241/34; 241/171; 241/172

[58] Field of Search ...................... 241/30, 34, 58, 60, 241/171, 172

[56] References Cited

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 1,990,178 | 2/1935 | Frisch | 83/9 |
| 2,111,663 | 3/1938 | Graemiger | 83/44 |
| 2,136,907 | 11/1938 | Roder | 83/44 |
| 2,491,466 | 12/1949 | Adams | 241/34 |
| 2,498,089 | 2/1950 | Lippman | 23/278 |
| 2,602,594 | 7/1952 | Hesse | 241/19 |
| 3,149,789 | 9/1964 | Szegvari | 241/27 |
| 3,179,345 | 4/1965 | Kivert et al. | 241/30 |
| 3,739,911 | 6/1973 | Wehren et al. | 241/45 |
| 3,779,469 | 12/1973 | Putman | 241/30 |
| 3,860,804 | 1/1975 | Rutman | 235/151.1 |
| 3,957,210 | 5/1976 | Dürr | 241/46.02 |
| 4,244,531 | 1/1981 | Szegvari | 241/172 |
| 4,303,205 | 12/1981 | Geiger et al. | 241/17 |
| 4,382,557 | 5/1983 | Duerr | 241/1 |
| 4,660,776 | 4/1987 | Ikehuri et al. | 241/38 X |
| 4,673,134 | 6/1987 | Barthelmess | 241/57 |
| 4,850,541 | 7/1989 | Hagy | 241/171 |
| 4,979,686 | 12/1990 | Szegvari et al. | 241/172 |
| 4,998,678 | 3/1991 | Dürr | 241/171 |
| 5,133,506 | 7/1992 | Bogen | 241/46.17 |
| 5,242,122 | 9/1993 | Bogen | 241/34 X |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| 19834 | 12/1980 | European Pat. Off. . |
| 267170 | 5/1988 | European Pat. Off. . |
| 369149 | 5/1990 | European Pat. Off. . |
| 1607476 | 9/1969 | Germany . |
| 1607480 | 10/1969 | Germany . |
| 1957953 | 6/1971 | Germany . |
| 369679 | 9/1974 | Sweden . |
| 7312165 | 5/1978 | Sweden . |
| 1197582 | 7/1970 | United Kingdom . |

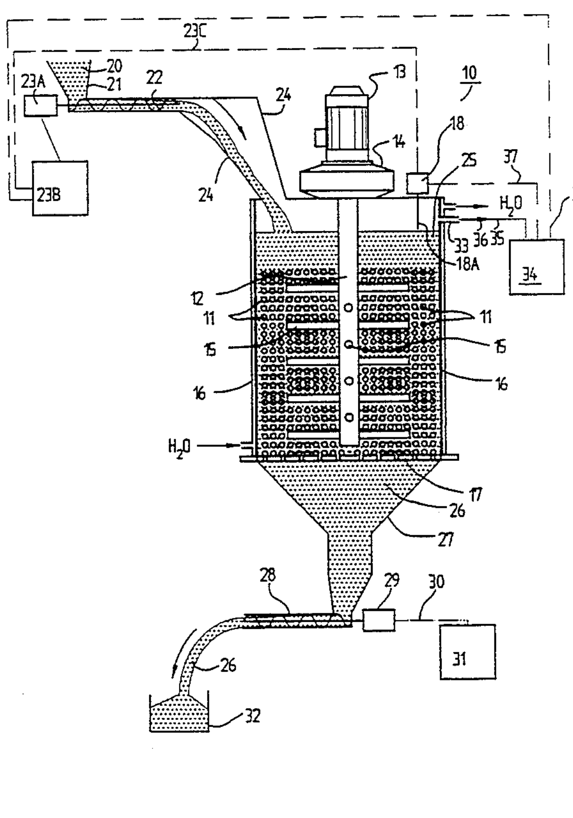
*Primary Examiner*—Douglas D. Watts
*Attorney, Agent, or Firm*—Nils H. Ljungman & Associates

[57] ABSTRACT

The invention relates to a method for finely grinding minerals and similar materials in an essentially dry state to particle sizes at which the ground material can be used as a filler. The method is characterized by effecting at least the final grinding phase in a closed grinding cavity that has been placed under a sub-pressure. The pressure in the grinding space shall preferably be lower than the prevailing ambient pressure by up to about 10 kPa.

The invention also relates to a mill having a grinding cavity that can be placed under a sub-pressure.

20 Claims, 1 Drawing Sheet



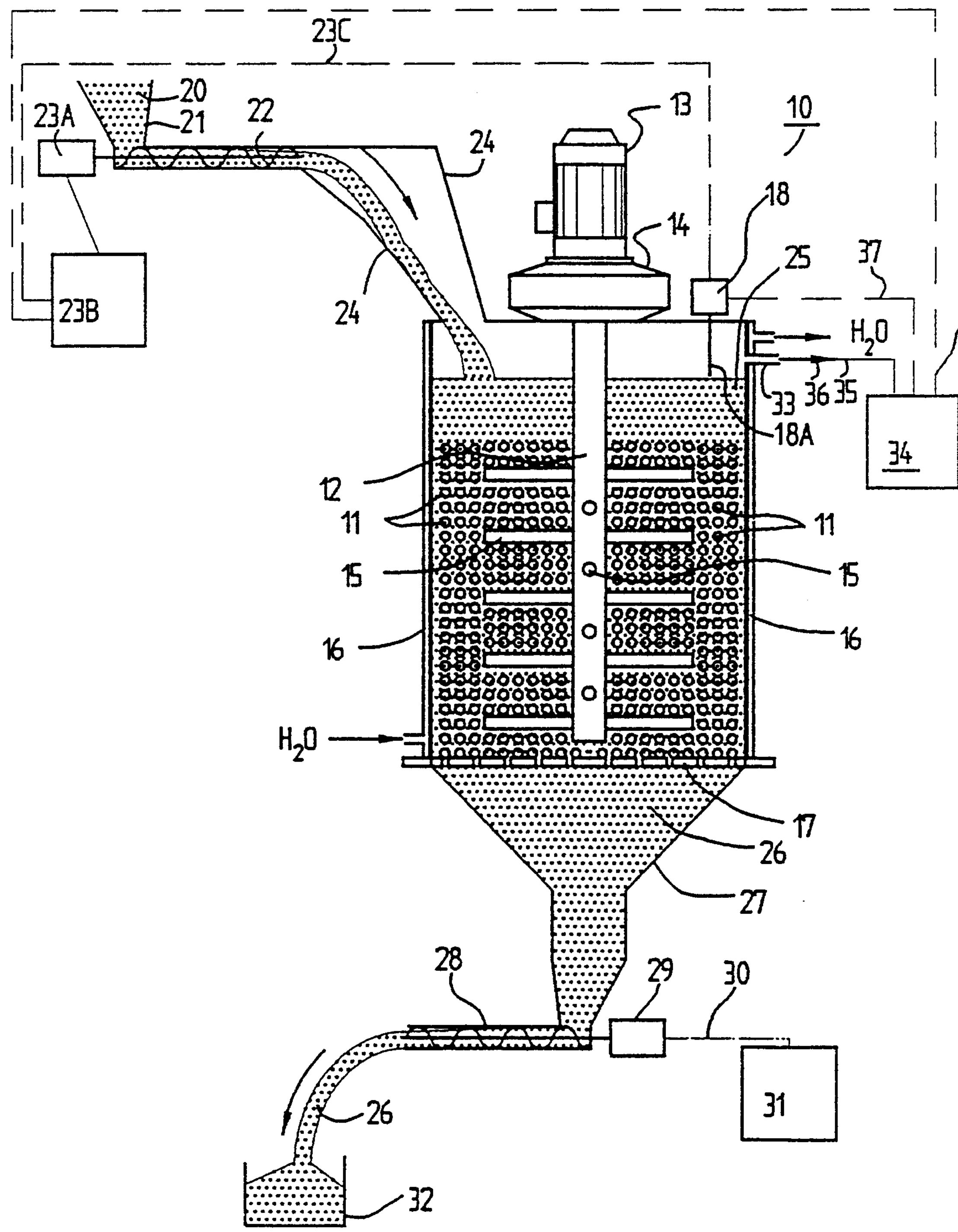

23C
20
21
22
23A
24
13
10
18
14
25
37
38
24
23B
$H_2O$
33
36
35
18A
34
12
11
11
15
15
16
16
$H_2O$
17
26
27
28
29
30
26
31
32

Fig.

## METHOD AND ARRANGEMENT FOR FINELY-GRINDING MINERALS

### BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method pertaining to the fine-grinding of minerals and similar materials down to a particle size in which the finely ground material can be used suitably as a filler. The present invention also relates to a mill arrangement for use when carrying out the method.

2. Background Information

Minerals and similar materials intended for use as a filler in the production of different products, for example, in the manufacture of paper, plastics, paints, coatings, adhesive products and sealing materials, must have an average particle size which lies at least beneath 45 μm (97%). Furthermore, it is necessary that the material has a specific surface area corresponding to a Blaine-number greater than 400 $m^2/kg$. In the majority of cases, an average particle size smaller than 10 μm is required, for instance, when the material is used as a filler in paper and paints, while certain other applications require a still finer particle size, so-called ultra fine particles having an average particle size or grain size of <2 μm, for example, when the material is used as a filler in paper sizing coatings.

In certain cases, the filler material used for these purposes may comprise a precipitate which already has the desired particle size, or a particle size which lies close to the desired particle size, although filler materials are normally produced by a grinding process that includes a fine-grinding stage in which minerals or similar natural materials are ground to a desired particle fineness. Standard materials from which fillers are produced include different carbonate materials, such as lime stone or dolomite, different sulphate materials, such as gypsum, and silicon-based material, for example, clays such as kaolin. Fine-ground products of this kind cannot be produced readily by wet grinding processes, such processes being those normally applied for grinding materials down to desired fineness, since a wet-ground product needs to be subsequently dried. The fine material tends to lump together during this drying process and the resultant agglomerates need to be broken down in a further grinding process. The capital investment required herefor renders the wet-grinding alternative prohibitive in the majority of cases. In consequence, it is necessary to use a dry grinding process which, in the majority of cases, implies the use of a mill which operates with an agitated grinding medium, although it should be possible to use other grinding methods, at least in conjunction with smaller quantities of material, for instance batch wise grinding methods using steel or ceramic grinding bodies. The inventive method, however, is discussed below primarily with reference to an agitated grinding medium.

The technique of grinding down material with the aid of an agitated medium (Stirred Ball Milling) has been known to the art for almost 60 years. The technique had its industrial breakthrough in 1948, in conjunction with pigment grinding in the paint and lacquer industry. The technique has been developed progressively during recent years and has obtained increased application. As a result, many different types of grinding mills that use an agitated medium have been proposed, as is evident, for instance, from an article published in International Journal of Mineral Processing, 22 (1988), pages 431–444. One of these mills is equipped with pin agitator rotors, by means of which the requisite grinding energy is introduced by forced displacement of the grinding medium. Because the mill is able to grind material rapidly down to extremely fine-grain sizes, normally within the range of 1–10 μm, the technique of grinding with the aid of an agitated medium has been applied to an increasing extent for various types of material. For example, fine grinding of this nature is applied in the production of fine-grain products within the fields of paint and lacquer technology, pharmacology, electronics, agrochemistry, food-stuffs, biotechnology, rubber, coal and energy. Examples of this latter case include coal-oil-mixtures and coal-water-suspensions. The technique of grinding with an agitated medium is now also being applied within the mineral processing field. Examples of such application include the grinding of limestone, kaolin, gypsum, aluminium hydroxide and the manufacture of paper fillers and paper coating materials, as beforementioned.

The results of experiments and tests carried out in recent years have shown that when grinding with an agitated grinding medium, the fineness of the ground material is dependent solely on the specific energy input, which can be expressed in kWh/tonne of material ground. Furthermore, it is found that the advantages afforded by this grinding technique over the alternative techniques are greatly enhanced with increasing fineness of the ground material, in other words grinding with the aid of an agitated grinding medium becomes more attractive with the desired fineness of the end product. Thus, a finer end product requires a higher specific energy input, i.e. a higher specific power input and/or longer grinding time. Obviously, it is preferred primarily to try with a higher power input, so as not to influence the productivity of the mills concerned negatively. Grinding times of 6–8 hours, which have been suggested, for instance, in conjunction with the grinding of pyrites in South Africa, are naturally not so attractive, although in many cases necessary, since a higher power input would place even greater demands on the ability of the mill to withstand a harsh environment, particularly when grinding harder materials.

A suitable mill for grinding material down to extremely fine-grain products with high power inputs is described in our earlier publication EP-A-0 451 121, while a suitable continuous grinding method for application in such mills is described in SE-A-9100884-7 (EP-A-0506638).

One serious problem experienced when finely grinding materials in a dry state resides in the occurrence of a cladding or blocking phenomenon, the actual cause of which cannot be established precisely, but which is accentuated with the fineness of the grain sizes to be produced. This phenomenon is probably caused by newly formed fine grains baking together, as a result of a combination of different physical forces, for instance surface phenomena, van der Waals forces and the formation of condensate.

One method of attempting to counteract the aforesaid problem involves the addition of a liquid dispersant to the material being ground. The primary drawbacks associated with the use of a dispersant are, of course, the costs of the chemicals used and the unavoidable contamination of the finished product. The demands placed commercially on the quality of certain fine grain products are so strict as to render a product which is contaminated with a dispersant or reaction products of such dispersant totally unacceptable. Consequently, these products must be finely ground with the utmost of care, therewith inhibiting productivity, partly with the intention of attempting to minimize cladding and partly because of the actual cladding phenomenon itself.

## OBJECT OF THE INVENTION

Consequently, there is a great need for an improved dry fine-grinding method, above all when manufacturing fillers, that is capable of eliminating the blocking and cladding problems which occur when the grain sizes of the grinding bodies approach the grain sizes of the end product. Such a method would be attractive both technically and economically and enable filler material to be produced for all conceivable applications.

## SUMMARY OF THE INVENTION

It has now surprisingly been found possible to avoid the blocking and cladding problems that occur when dry fine-grinding minerals and similar materials, mentioned in the introduction, without requiring the addition of chemical substances.

The inventive method and arrangement are characterized by the steps and features set forth in the following method and apparatus claims.

Accordingly, at least the final phase of the inventive method is carried out in a closed grinding cavity which operates at sub-pressures. The sub-pressure in the grinding cavity is conveniently chosen so as to lie beneath the prevailing ambient pressure by up to about 10 kPa. The pressure in the grinding cavity can be chosen during the grinding process with regard to appropriate, directly measurable grinding parameters, for example the instantaneous throughflow of grinding medium or the current grinding energy. The sub-pressure is preferably created and maintained in the grinding cavity with the aid of a vacuum pump connected to said cavity. In many cases, the vacuum pump may have the form of a simple water-syphon, although larger mills may require the use of more powerful motor-driven pumps.

The inventive method can be carried out advantageously in a mill which uses agitated grinding medium and which may be provided with means for controlling and adjusting the residence time of the material in the mill, the through-flow capacity of the mill and the extent to which the mill is filled, as described in our earlier publication SE-A-9100884-7.

Although the reasons for the problems solved by the present invention and the solution of these problems cannot yet be explained theoretically, it has been found possible to make the fine grinding process much more effective when practising the invention, both with regard to improved throughflow of material in the continuous grinding mill and the improved use of the volumetric capacity of the grinding cavity.

In summary, the invention can be further characterized by the following paragraphs:

Paragraph A

One aspect of the invention resides in a method for finely grinding minerals and similar materials in an essentially dry state to particle sizes appropriate for use as a filler, characterized by carrying out at least the final phase of the fine grinding process in a closed grinding cavity that has been placed under sub-pressure.

Paragraph B

Another aspect of the invention resides in a method according to paragraph A, characterized by establishing in the grinding cavity a pressure which is lower than the prevailing ambient pressure by up to about 10 kPa.

Paragraph C

Yet another aspect of the invention resides in a method according to paragraphs 1 and 2, characterized by selecting the grinding cavity pressure during the grinding process with regard to the grinding process, for instance with regard to the relevant through-flow of ground material or grinding energy.

Paragraph D

A further aspect of the invention resides in a method according to paragraphs A–C, characterized by generating and maintaining the grinding cavity sub-pressure with the aid of a vacuum pump connected to the grinding cavity.

Paragraph E

A still further aspect of the invention resides in a method according to paragraphs A–D, characterized by effecting the grinding process in a mill that operates with agitated grinding media.

Paragraph F

An additional feature of the invention resides in a grinding mill for carrying out the fine-grinding method according to paragraphs A–E, characterized in that the mill includes a grinding cavity which can be placed under a sub-pressure.

## BRIEF DESCRIPTION OF THE DRAWINGS

The inventive fine-grinding method will now be described in more detail with reference to the associated drawing, the single FIGURE of which illustrates the inventive method as carried out with the aid of a mill operating with an agitated grinding medium.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The illustrated apparatus includes a mill **10** which operates with agitated grinding medium **11** and which includes a rotor **12** driven by a motor **13** through the intermediary of a planet gear **14**. The rotor **12** is provided with pins **15** which extend in four different directions substantially perpendicular to the rotor axis. The mill **10** is cooled by a water-filled jacket **16**, to and from which water is continuously introduced and removed through respective inlets and outlets, as marked by the arrows designated $H_2O$. Fitted to the bottom part of the mill **10** is a metal bottom plate **17** having downwardly-conical circular openings which are adapted to hold the grinding media but which allow the ground material to pass through. Mounted on the upper part of the mill **10** is a level monitor **18**, which may be provided with a forked sensor **18A**.

Material **20** to be finely ground in the mill is fed, via a hopper **21**, through a pressure-tight screw feeder **22**, which is controlled to deliver a predetermined quantity of material to the mill with each unit of time, this control being effected by a drive means **23** comprised of a motor **23A** and a speed-regulating device **23B**. Signals can be transmitted from the level monitor **18** through a cable **23C**, so as to interrupt the supply of material subsequent to the lapse of a given period of time after the level monitor **18** has indicated that the material **20** present in the mill **10** has reached its highest permitted level. The level monitor **18** may appropriately be provided with a clock which automatically produces a signal to commence feeding of material into the mill subsequent to the lapse of a predetermined time period. The material **20** is introduced into the mill **10** through a filling funnel **24** which is connected to the screw feeder **22** in an air tight fashion. It is ensured that only material **20** fed to the mill is present in the upper mill part **25**, whereas the remainder of the mill **10** is also intended to include grinding medium **11**. The ground material, referenced **26**, is sieved from grinding medium on the bottom plate **17** and is transported in the form of a coherent flow of material through a funnel **27** and to a motor-driven pressure-tight discharge device **28**, which in the illustrated case has the form of a screw feeder whose speed can be continuously adjusted. The screw feeder **28** is driven by a motor **29** whose speed is controlled by means of a control device **31**, via a line **30**. The control device **31** may have the form of a variator or a frequency converter.

Passing through the wall of the mill **10** is a connector pipe **33** which is intended for connection to a vacuum pump **34**, as indicated by lines **35**, wherein the arrow **36** indicates the outflow of gas (air) from the grinding cavity of the mill **10** as the pump **34** operates. The vacuum pump **34** can be started and stopped manually, and the subpressure is set manually to the level desired. However, it is also possible with the illustrated, preferred embodiment of the invention to automatize fully the actions of the vacuum pump, both with regard to starting and stopping of the pump and also with regard to setting of the desired pressure level. As illustrated by the broken lines **37**, **38** the vacuum pump **34**, or a pump operation control means (not shown), can be connected electrically to the level monitor **18** or to the speed control device **23B** which functions to control the drive means, or to both the monitor and said means, so that impulses can be obtained from said monitor and said means in a predetermined manner.

In operation, outflow of finely-ground material **26** is first adjusted with the aid of the outfeed device **28**, the motor **29** and the control device **31**. The flow of ingoing material **20** is then adjusted, by adjusting the speed of the screw feeder **22** with the aid of the drive means **23A,B**, so as to ensure that the level of the material in the upper part **25** of the mill **10** will increase in accordance with the selected infeed of material. When the infeed and outfeed flows of material have been set and finely adjusted in the aforedescribed manner, and the upper level of the material **20** reaches the sensor **18A** of the level monitor **18**, a signal-is sent from the level monitor **18** to the speed-regulating device **23B**, through the cable **23C**, causing the infeed of material **20** to be interrupted. After a given length of time has elapsed, the device **23B** receives a further signal, in response to which the infeed of material is recommenced. Ground material **26** is discharged through the screw feeder **28** in an essentially constant, predetermined flow during the whole of the grinding process, this discharged, ground material **26** subsequently being collected in a storage container **32**.

The vacuum pump **34** can be programmed to start and stop in response to signals from either the level monitor **18** or the drive device control means **23B**, or from both said monitor and said means. It is also possible with the aid of the signals to set the grinding cavity to a desired sub-pressure with the aid of the vacuum pump, through the connecting pipe **33**, so that the grinding process will be carried out constantly at an optimum sub-pressure. By optimum sub-pressure is meant the lowest sub-pressure required for acceptable throughput and/or grinding energy.

We claim:

**1**. A method for finely grinding minerals and similar materials in an essentially dry state to particle sizes appropriate for use as a filler, said method comprising:
- providing a mill, the mill comprising a cavity for grinding materials therein;
- closing the grinding cavity from air surrounding the mill by providing walls enclosing the cavity, said walls being configured to prevent flow of surrounding air through the grinding cavity;
- providing means for providing a vacuum and reducing pressure within the closed grinding cavity;
- carrying out at least a portion of the fine grinding process in the closed grinding cavity of the mill;
- preventing flow of surrounding air through the grinding cavity during said at least a portion of the fine grinding process;
- providing a vacuum and reducing a pressure within the closed grinding cavity of the mill to a pressure less than a prevailing ambient pressure during at least said portion of the fine grinding process to reduce clumping of materials during at least said portion of the fine grinding process; and
- reducing clumping of materials during at least said portion of the fine grinding process by said reducing of pressure within the closed grinding cavity.

**2**. A grinding mill for grinding minerals and similar materials in an essentially dry state, the mill comprising:
- a grinding cavity, said grinding cavity comprising walls enclosing said grinding cavity, said walls comprising means for preventing air surrounding the mill from flowing through the grinding cavity;
- means for introducing materials to be ground into the grinding cavity, said means for introducing materials comprising pressure-tight feeder means for feeding materials to be ground into the cavity;
- means for grinding the materials in the grinding cavity to produce a ground material;
- means for removing ground materials from the grinding cavity, said means for removing ground materials comprising pressure-tight feeder means for feeding ground materials out of the grinding cavity; and
- means for providing a vacuum and reducing a pressure in the grinding cavity to a pressure less than a prevailing ambient pressure during at least a portion of the grinding process.

**3**. The method according to claim **1**, wherein:
- said mill comprises a vertical mill, the vertical mill comprising a top, a bottom, first pressure-tight feeder means for feeding materials to be ground into the cavity, and second pressure-tight feeder means for feeding ground materials out of the grinding cavity; and
- said method further comprises the steps of:
  - feeding the raw material into the grinding cavity of the mill through the top of the mill with said first pressure-tight feeding means; and
  - grinding the materials as the materials pass through the grinding cavity from the top of the mill to the bottom of the mill; and
  - feeding the ground material out of the grinding cavity of the mill from the bottom of the mill with said second pressure-tight feeding means.

**4**. The method according to claim **3**, wherein:

said at least a portion of the fine grinding process comprises at least a final grinding of the materials;

said reducing of the pressure within the grinding cavity comprises generating and maintaining the grinding cavity pressure less than the prevailing ambient pressure during said final grinding of the materials with the aid of a vacuum pump connected to the grinding cavity; and

said grinding comprises grinding with an agitated grinding medium as the material to be ground moves from the top of the mill to the bottom of the mill.

**5**. The method according to claim **4**, further including:

selecting the grinding cavity pressure during said at least a portion of the fine grinding process as a function of a parameter of the grinding process, said parameter comprising at least one of:

a level of material in the closed grinding cavity;

relevant through-flow of ground material through the closed grinding cavity; and

grinding energy;

wherein said selecting comprises maintaining at least one of:

a predetermined through-flow of material through the grinding cavity, and

a predetermined grinding energy,

by adjusting said pressure in the cavity.

**6**. The method according to claim **5**, wherein:

said feeding the raw material into the top of the mill comprises feeding the raw material into the top of the mill with a motor-driven, pressure-tight screw feeder;

said discharging of the ground material from the bottom of the mill comprises discharging the ground material from the bottom of the mill with a motor-driven, pressure-tight screw feeder;

said reducing of the pressure comprises reducing the pressure in the grinding cavity by as much as about 10 kilopascals lower than the prevailing ambient pressure during said final grinding of the materials; and

said grinding comprises grinding the products to a particle size of less than about 2 micrometers.

**7**. The method according to claim **6**, further including:

predetermining a stay time of the material in the cavity of the mill;

grinding the material in the cavity of the mill for the predetermined stay time at said pressure less than the prevailing ambient pressure; and

maintaining the predetermined stay time:

partly by discharging ground material from the cavity of the mill at a predetermined, essentially constant rate; and

partly by adjusting the infeed of material to the cavity of the mill in relation to the quantity of material discharged from the mill such that the amount of material present in the cavity of the mill will increase during the infeed of material thereto, and decreasing the infeed of material to the cavity of the mill when the level of the material in the cavity is over a predetermined highest level in the cavity of the mill.

**8**. The method according to claim **7**, wherein:

said adjusting of the infeed of material comprises starting the infeed of material to the cavity of the mill upon a level of the material in the cavity reaching a predetermined first level; and

said decreasing comprises stopping the infeed of material into the cavity of the mill upon the level of the material in the cavity reaching the predetermined highest level.

**9**. The method according to claim **1**, wherein the material to be ground has air present therewithin, and the mill comprises no air inlets for admitting surrounding air into the grinding cavity, said method further comprises the steps of:

admitting air present in the material into the grinding cavity during feeding of material into the grinding cavity during said at least a portion of the grinding process; and

admitting no additional surrounding air into the grinding cavity during said at least a portion of the grinding process.

**10**. The method according to claim **9**, wherein:

said at least a portion of the fine grinding process comprises at least a final grinding of the materials;

said mill comprises a vertical mill, the vertical mill comprising a top, a bottom, first pressure-tight feeder means for feeding materials to be ground into the cavity; and second pressure-tight feeder means for feeding ground materials out of the grinding cavity; and

said method further comprises the steps of:

feeding the raw material into the grinding cavity of the mill through the top of the mill with said first pressure-tight feeding means; and

feeding the ground material out of the grinding cavity of the mill from the bottom of the mill with said second pressure-tight feeding means;

said reducing of the pressure within the grinding cavity comprises reducing the pressure in the grinding cavity by as much as about 10 kilopascals lower than the prevailing ambient pressure and maintaining the reduced grinding cavity pressure less than the prevailing ambient pressure with the aid of a vacuum pump connected to the grinding cavity;

said grinding comprises grinding the materials in the cavity of the mill with an agitated grinding medium as the material to be ground moves from the top of the mill to the bottom of the mill; and

said grinding comprises grinding the material to particle sizes of less than about 2 micrometers.

**11**. The method according to claim **10**, wherein:

said walls enclosing the grinding cavity comprise:

a vertical wall disposed about the sides of the grinding cavity;

a horizontal wall disposed across the top of the grinding cavity, said horizontal wall comprising an opening, said opening being connected to said first feeding means; and

a conical wall disposed at the bottom of the grinding cavity, the conical wall comprising a first portion disposed adjacent the vertical wall and a second portion disposed away from the vertical wall, both of the first and second portions having a diameter, and the diameter of the second portion being less than the diameter of the first portion, said second portion comprising the bottom of the grinding cavity, and said second portion defining an opening through which said ground material is discharged from the cavity.

12. The grinding mill according to claim 2, wherein the material to be ground has air present therewithin, and said mill comprises:

a vertical mill, the vertical mill having a top and a bottom, and said vertical mill being configured for grinding the materials as the materials pass from the top of the mill to the bottom of the mill through the grinding cavity;

first pressure-tight feeder means for feeding materials to be ground into the grinding cavity through the top of the mill, the first pressure tight feeder means admitting air present in the material, along with the material, into the grinding cavity;

second pressure-tight feeder means for feeding ground materials out of the grinding cavity through the bottom of the mill; and

no additional air inlets for admitting air, other than air present in the material, into the grinding cavity.

13. The grinding mill according to claim 12, wherein:

said grinding means comprises:

a grinding medium in the grinding cavity; and

means for agitating the grinding medium;

said mill further comprises:

means for monitoring at least one of:

a level of material in the grinding cavity;

through-flow of material through the mill; and

grinding energy; and

means for automatically controlling said means for reducing the pressure within the cavity as function of said monitored at least one of:

a level of material in the grinding cavity;

through-flow of material through the mill; and

grinding energy.

14. The grinding mill according to claim 13, wherein:

said first pressure-tight feeder means for feeding materials to be ground into the grinding cavity comprises a first motor-driven device;

said second pressure-tight feeder means for feeding ground materials out of the grinding cavity comprises a second motor driven device;

said mill further comprises:

means for adjusting a speed of said first motor-driven device;

means for adjusting a speed of said second motor-driven device; and

a level monitor mounted in the cavity in the mill, said level monitor being connected to said means for adjusting a speed of said first motor-driven device to control the first motor-driven device as a function of the amount of material present in the mill.

15. The grinding mill according to claim 14, wherein:

said means for providing a vacuum and reducing pressure in the grinding cavity comprises means for reducing pressure in the grinding cavity to about 10 kilopascals less than prevailing ambient pressure;

said mill comprises means for maintaining the pressure of up to about 10 kilopascals below the prevailing ambient pressure within the grinding cavity of the mill;

said means for agitating the grinding medium comprises a motor-driven pin rotor, said pin rotor having a plurality of pins extending therefrom;

said first motor driven device and said second motor driven device comprise pressure-tight screw feeders;

said mill further comprises a perforated disc for isolating the grinding medium from the ground material leaving the mill; and

said means for automatically controlling said means for reducing the pressure comprises:

means for electrically connecting said means for automatically controlling to at least one of:

said level monitor, and

said means for for adjusting a speed of said first motor-driven device,

to receive signals from said at least one of:

said level monitor, and

said means for for adjusting a speed of said first motor-driven device,

to control said means for reducing pressure.

16. The grinding mill according to claim 15, wherein:

said first and second motor driven devices comprises first and second screw feeders;

said means for controlling comprises means for starting and stopping the means for reducing pressure to control said means for reducing pressure;

said means for providing a vacuum and reducing pressure comprises one of:

a water-syphon vacuum pump; and

a motor-driven vacuum pump;

said means for maintaining pressure of up to about 10 kilopascals below said prevailing ambient pressure within the mill comprises:

said walls enclosing said grinding cavity;

said pressure-tight screw feeders;

a filling funnel connected air-tight between said first pressure-tight screw feeder and said cavity to conduct material from said first motor-driven device to said cavity; and

connecting means for connecting said cavity to said means for reducing pressure; said walls comprising:

a vertical wall disposed about the sides of the grinding cavity;

a horizontal wall disposed across the top of the grinding cavity, said horizontal wall comprising an opening, said opening being connected to said filling funnel; and

a conical wall disposed at the bottom of the grinding cavity, the conical wall comprising a first portion disposed adjacent the vertical wall and a second portion disposed away from the vertical wall, both of the first and second portions having a diameter, and the diameter of the second portion being less than the diameter of the first portion, said second portion comprising the bottom of the grinding cavity, and said second portion defining an opening through which said ground material is discharged from the cavity;

said mill further comprises cooling means disposed adjacent said cavity for cooling said cavity during said grinding; and

said cooling means comprising a water-filled jacket disposed about said grinding cavity, said water-filled jacket comprising means for flowing water through said jacket.

17. A method for finely grinding minerals and similar materials in an essentially dry state to particle sizes appropriate for use as a filler, said method comprising:

providing a mill, the mill comprising a cavity for grinding materials therewithin;

providing first pressure-tight feed means for feeding material to be ground into the cavity, said first pressure-tight feed means comprising a pressure-tight connection to the cavity to prevent surrounding air from entering the cavity;

providing second pressure-tight feed means for feeding ground material out of the cavity, said second pressure-tight feed means comprising a pressure-tight connection to the cavity to prevent surrounding air from entering the cavity;

providing vacuum producing means for reducing pressure within the grinding cavity, said vacuum producing means comprising a connection to the cavity, and said vacuum producing means comprising a connection to a vacuum source;

connecting each of said first pressure-tight feed means, said second pressure tight feed means and said vacuum source, to the grinding cavity;

substantially closing the grinding cavity, except for said connections for said first pressure-tight feed means, said second pressure-tight feed means and said vacuum producing means, from air surrounding the mill to substantially prevent surrounding air from entering into the grinding cavity and to substantially prevent flow of surrounding air through the grinding cavity;

reducing pressure within the grinding cavity of the mill to a pressure less than a prevailing ambient pressure during at least a portion of the fine grinding process by connecting the vacuum source to said connection of the cavity;

finely grinding the materials in the grinding cavity under reduced pressure;

substantially preventing flow of surrounding air into the grinding cavity during said fine grinding under reduced pressure; and

reducing clumping of materials during said fine grinding by said reducing of a pressure within the grinding cavity.

**18**. The method according to claim **17**, wherein:

said mill comprises a vertical mill, the vertical mill comprising a top, a bottom; and



said method further comprises the steps of:

feeding the raw material into the grinding cavity of the mill through the top of the mill with said first pressure-tight feeding means; and

grinding the materials as the materials pass through the grinding cavity from the top of the mill to the bottom of the mill; and

feeding the ground material out of the grinding cavity of the mill from the bottom of the mill with said second pressure-tight feeding means.

**19**. The method according to claim **18**, wherein:

said at least a portion of the fine grinding process comprises at least a final grinding of the materials;

said reducing of the pressure within the grinding cavity comprises generating and maintaining the grinding cavity pressure less than the prevailing ambient pressure during said final grinding of the materials with the aid of a vacuum pump connected to the grinding cavity; and

said grinding comprises grinding with an agitated grinding medium as the material to be ground moves from the top of the mill to the bottom of the mill.

**20**. The method according to claim **19**, wherein:

said feeding the raw material into the top of the mill comprises feeding the raw material into the top of the mill with a motor-driven, pressure-tight screw feeder;

said discharging of the ground material from the bottom of the mill comprises discharging the ground material from the bottom of the mill with a motor-driven, pressure-tight screw feeder;

said reducing of the pressure comprises reducing the pressure in the grinding cavity by as much as about 10 kilopascals lower than the prevailing ambient pressure during said final grinding of the materials; and

said grinding comprises grinding the products to a particle size of less than about 2 micrometers.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 5,361,996

DATED : November 8, 1994

INVENTOR(S) : Ulf Krister SVENSSON and Conny Lars REHNVALL

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

In column 5, line 50, after 'a' delete "signal-is" and insert --signal is--.

Signed and Sealed this

Seventeenth Day of September, 1996

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

US006196481B1

(12) **United States Patent**
**Barbagli**

(10) **Patent No.: US 6,196,481 B1**
(45) **Date of Patent: Mar. 6, 2001**

(54) **GRINDING DEVICE FOR DRIED SPICES AND HERBS**

(75) Inventor: **Costantino Barbagli**, Florence (IT)

(73) Assignee: **Drogheria E Alimentari S.r.l.**, Prato (IT)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/396,192**

(22) Filed: **Sep. 14, 1999**

(30) **Foreign Application Priority Data**

Sep. 14, 1998 (IT) .......................................... MI9800604 U

(51) **Int. Cl.**[7] ........................................ **A47J 42/04**
(52) **U.S. Cl.** ........................................ **241/30**; 241/169.1
(58) **Field of Search** ................................ 241/169.1, 168, 241/30

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,184,719 * 12/1939 Mantelet ........................ 241/169.1
3,136,491 * 6/1964 Posmanter ........................ 241/169.1
4,771,955 * 9/1988 Paulson ........................ 241/169.1
4,960,246 * 10/1990 Fohrman ........................ 241/169.1
5,088,652 * 2/1992 Chen ........................ 241/169.1

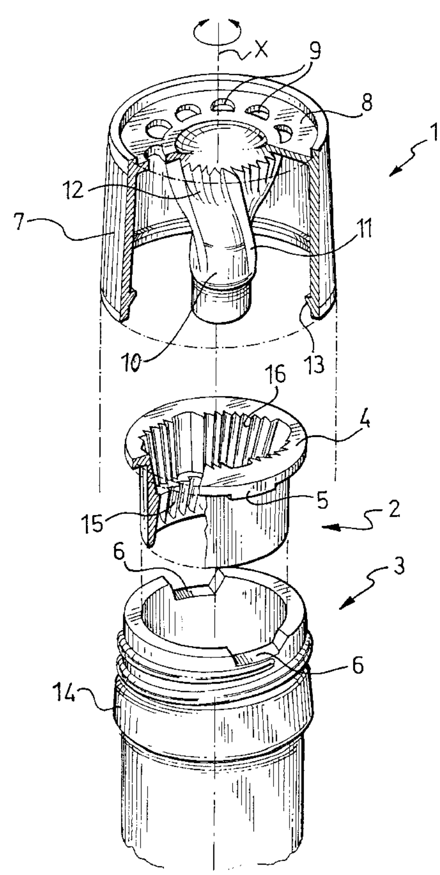
* cited by examiner

*Primary Examiner*—Mark Rosenbaum
(74) *Attorney, Agent, or Firm*—Sheridan Ross P.C.

(57) **ABSTRACT**

A grinding device for grinding dried spices and herb, as well as other materials, is disclosed. In particular, the grinding device has a movable member which rotates about an axis and a fixed member. The movable member has a closure surface having a plurality of apertures and a grinding surface having a first series and a second series of ribs. The ribs of the second series have a pitch and a height which are less than those of the ribs of the first series. The fixed member has a complementary grinding surface. The complementary grinding surface has a first series of complementary ribs at the level of the first series of ribs of the movable member, and a second series of complementary ribs at the level of the second series of ribs of the movable member. The ribs of the second series of complementary ribs have a pitch and a height which are less than those of the ribs of the first series of complementary ribs. The complementary grinding surface has ribbed zones alternating with smooth zones.

**13 Claims, 2 Drawing Sheets**



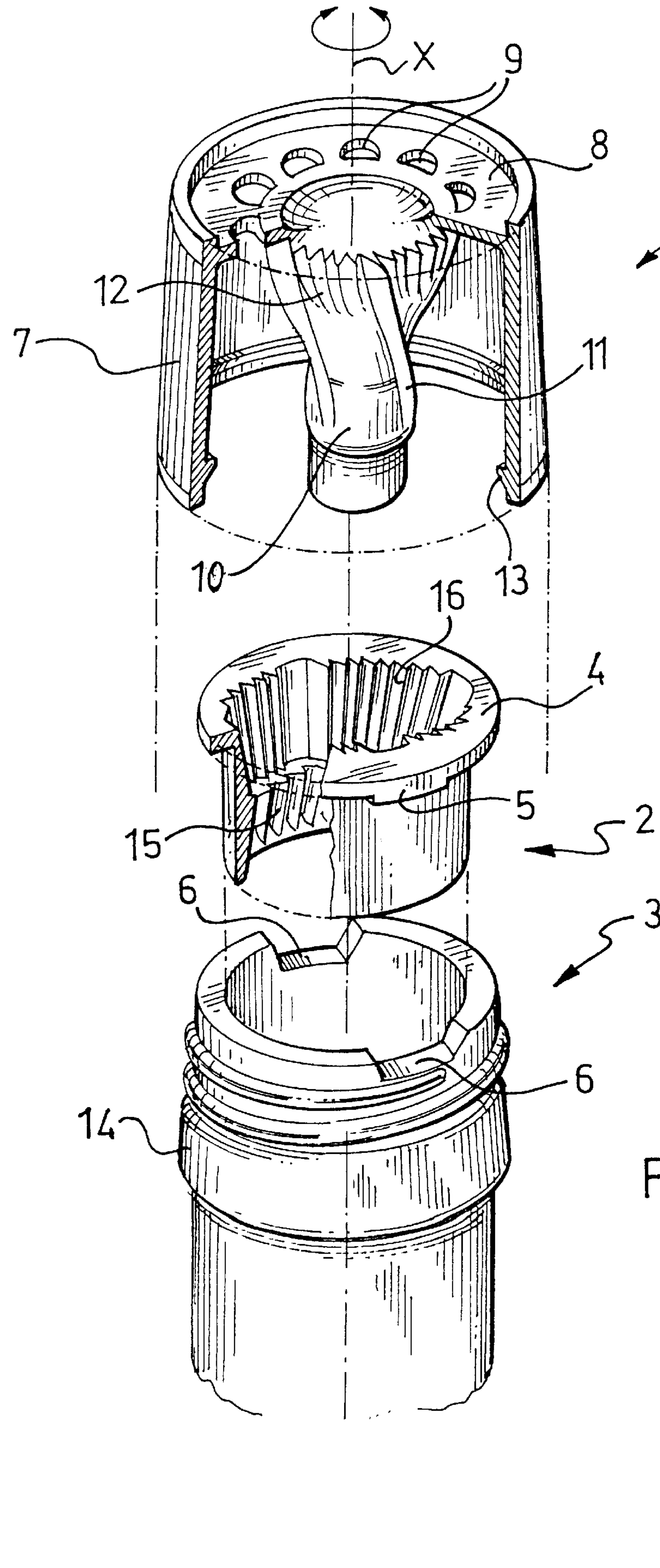



FIG.1

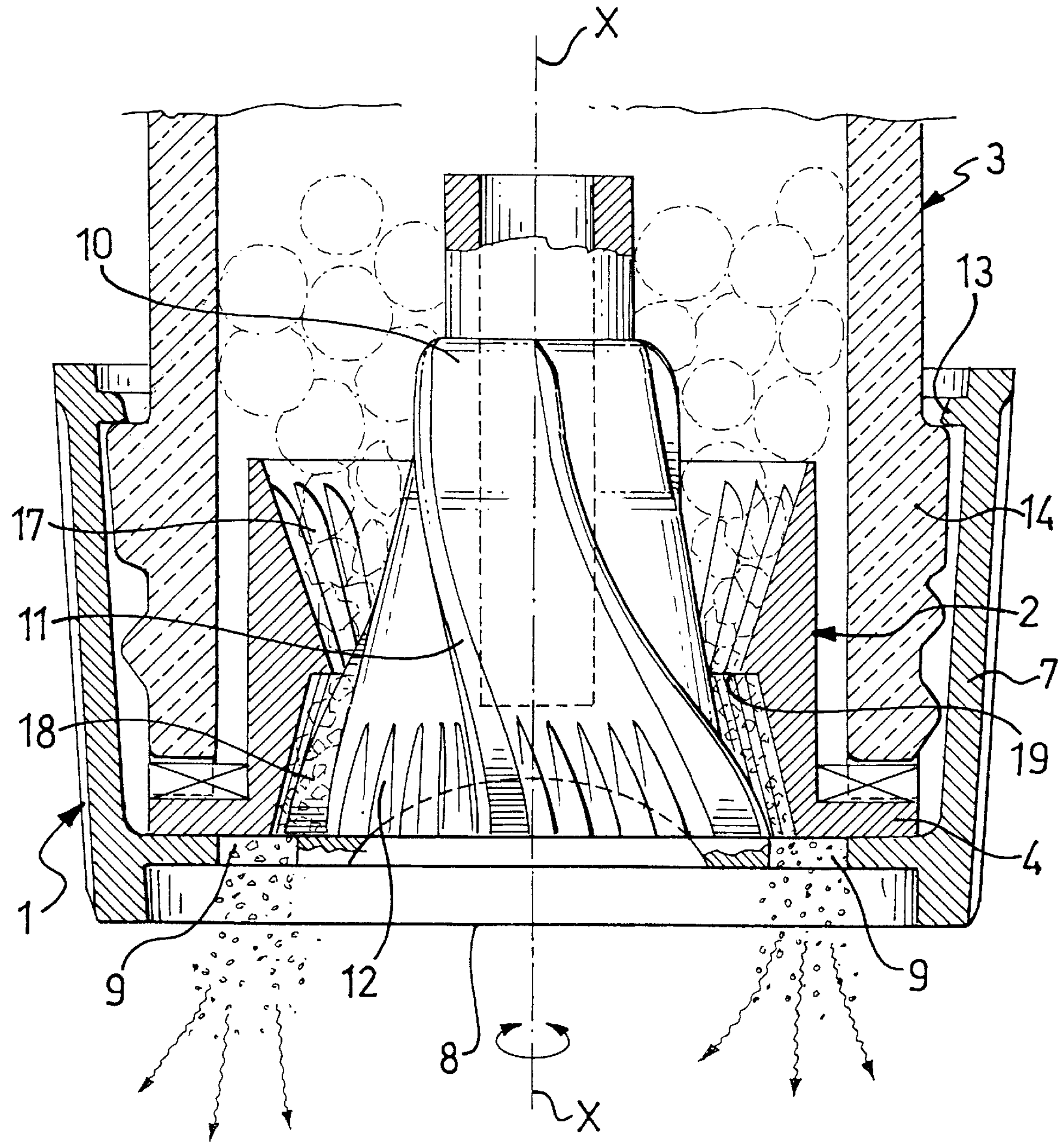



FIG.2

# GRINDING DEVICE FOR DRIED SPICES AND HERBS

## DESCRIPTION

1. Field of the Invention

The present invention relates to a grinding device for dried spices and herbs.

2. Background art

Various types of mills are known for pepper and other spices. In these devices, grinding is effected by friction between a fixed part and a movable part. The two parts have, on the respective contact surfaces, teeth or sharp-edged corrugations which are intended to grind the pepper grains by friction. In reality, said surfaces are not in contact, but are spaced so as to create between them an air gap which determines the final grain size of the ground material. Grinding is effected by rotating the movable part with respect to the fixed part, so that the pepper grains are "seized" between the teeth of the mill and are finely ground by the latter to the desired dimension.

This type of mill, however, requires the grains to be ground to be already of sufficiently small size and furthermore to be sufficiently hard so as not to form a compact mass which is difficult to grind. It is not therefore possible to use this type of mill to grind, for example, dried mushrooms, which are characterized by pieces which are frequently of considerable and non-uniform size and which furthermore often have a softness such as to form in the known mills a paste which is difficult to grind.

## SUMMARY OF THE INVENTION

The present invention overcomes the problems of the prior art by providing a universal grinding device, suitable for grinding both pepper and other spices and dried food products such as, for example, dried mushrooms.

This result has been achieved by means of a grinding device comprising:

a movable member, rotating about an axis, which comprises a closure surface having a plurality of apertures and a grinding surface having a first and second series of ribs, the ribs of said second series having a pitch and a height which are less than those of the ribs of the said first series;

a fixed member, which comprises a complementary grinding surface having a first series of complementary ribs, at the level of the said first series of ribs, and a second series of complementary ribs, at the level of the said second series of ribs, the ribs of said second series of complementary ribs having a pitch and a height which are less than those of the ribs of said first series of complementary ribs.

## BRIEF DESCRIPTION OF THE DRAWINGS

The characteristics and advantages of the grinding device of the present invention will become clear from the description of some preferred embodiments thereof, provided hereinafter by way of non-limiting example, with reference to the appended drawings:

FIG. **1** shows a perspective exploded view in partial section of the grinding device of the present invention;

FIG. **2** shows a sectional view of the device in FIG. **1**, turned upside down.

## DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1** and **2**, the grinding device of the present invention comprises a movable member **1** and a



fixed member **2**, intended to engage with the neck **3** of a spice container (shown only partially).

The movable member **1** comprises a support having a substantially cylindrical surface **7** bounded at one end by a closure surface **8**. Starting from said closure surface **8**, there extends in the direction of extension of said cylindrical surface **7** a body **10** of frustoconical shape which forms a cavity between said cylindrical surface **7** and the frustoconical body **10** itself.

The surface of the frustoconical body **10**, termed grinding surface, comprises a first series **11** and a second series **12** of ribs, in which the ribs of said second series **12** have a pitch and a height which are less than those of the ribs of the said first series **11**. Moreover, preferably, the ribs of said second series **12** cover over only that part of the grinding surface which is close to the closure surface **8**. More preferably, the ribs of said second series **12** cover from ⅕th to ¼ of the entire grinding surface.

In the preferred embodiment of the present invention, shown in FIGS. **1** and **2**, at least one of said series of ribs has ribs with a substantially helical profile.

The closure surface **8** furthermore has a plurality of apertures **9** arranged in a ring round the base of said frustoconical body **10**.

Said apertures **9** preferably have a crescent shape, with the convex side turned towards the centre of the closure surface **8** at the base of the frustoconical body **10**. This particular shape has the advantage of making it more difficult for the larger grains being ground to escape, increasing their dwell time inside the mill. Said characteristic makes it possible to obtain more homogeneous grinding of the grains.

The cylindrical surface **7** has inside it an annular relief **13**, arranged in proximity to the open end of said surface **7**, and capable of snapping onto a corresponding annular relief **14** provided on the neck **3** of the spice container. In this way, the movable part **1** is rotatably supported on said neck **3**.

The fixed member **2** has an outer cylindrical surface terminating at one end in a flange **4**. The lower surface of said flange **4** has one or more raised portions **5**, capable of engaging with corresponding notches **6** provided on the edge of said neck **3** of the spice container, so as to prevent rotation of the fixed member **2** about the longitudinal axis X.

The presence of the annular relief **13** on the movable member **1**, together with the presence of said raised portions **5** on the fixed member **2**, makes it possible to simplify considerably the assembly of the device on an industrial scale, increasing accuracy of execution and productivity (smaller number of operations required).

The inner surface of said fixed member **2** defines a complementary grinding surface on which are provided a first series **15** and a second series **16** of complementary ribs, placed respectively at the level of said first series **11** and second series **12** of ribs on said frustoconical body **10**. The ribs of said second series **16** of complementary ribs have a pitch and a height which are less than those of the ribs of said series **15**.

Preferably, said ribs and complementary ribs have a sawtooth profile, with an inclined flank and a vertical flank, which form a sharp edge at the apex.

In the preferred embodiment of the present invention, shown in FIGS. **1** and **2**, said complementary grinding surface of the fixed member **2** has two sections of frustoconical shape, converging towards the centre so as to form a surface having substantially the shape of an hour-glass, the first of said sections comprising said first series **15** of complementary ribs and the second of said sections comprising said second series **16** of complementary ribs.

In each case, the inside diameter of said fixed member **2** is always such as to form an air gap between said complementary grinding surface and the grinding surface of the frustoconical body **10**, so as to allow the particles of the spices and dried herbs being ground to be seized between the teeth and, once ground, to fall towards the apertures **9**.

It is also preferable for said complementary grinding surface to have ribbed zones alternating with smooth zones, so as to create actual grinding zones and zones without ribs in which the release of the ground material is facilitated.

With reference to FIG. **2**, the grinding device of the present invention is assembled in the following manner. The fixed member **2** is inserted into the neck **3** of the spice container, fitting the raised portions **5** together with the corresponding notches **6** so as to prevent its rotation about the axis X. The movable member **1** is then inserted coaxially with said fixed member **2**, until the annular relief **13** snaps into the corresponding relief **14** of the neck **3**, leaving the said movable member **1** free, however, to rotate about the axis X. Between the grinding surface of said frustoconical body **10** and the complementary grinding surface of said fixed member **2**, two grinding zones **17**, **18** are created, communicating by way of an annular air gap **19** formed at the point where the two frustoconical sections of said complementary grinding surface meet.

The lower grinding zone **18**, moreover, communicates with the outside by means of the apertures **9**.

Still with reference to FIG. **2**, the operation of the grinding device of the present invention is as follows. When the spice container is turned upside down, as shown in FIG. **2**, the grains, for example, peppercorns, are conveyed inside the upper grinding zone **17**, which for this purpose has a flared funnel shape. In said zone **17** a first, coarse grinding takes place, which is obtained by rotating the movable member **1** about the longitudinal axis X. In this way, the grains are seized between the ribs **11**, **12** and the complementary ribs **15**, **16** of the body **10** and of the fixed member **2**, respectively, and are then ground by friction. The grain size of the ground material in this zone **17** depends on the width of the annular air gap **19**, through which the grains, partially ground, pass by gravity into the second zone **18**, in which fine grinding takes place.

The zone **18** is in fact characterized by a smaller distance between the grinding surface and the complementary grinding surface, so that the grains are finely ground and then fall by gravity towards the outside through the apertures **9**.

The rotational movement of said movable member **1** about the axis X is typically an alternating movement in a clockwise/anticlockwise direction. While movement in one direction brings about the grinding of the grains, movement in the other direction frees them from engagement between the ribs, allowing them to fall by gravity into the next zone or towards the outside.

The grinding device according to the present invention therefore makes it possible also to grind dried food products such as dried mushrooms, inasmuch as the first grinding zone **17** is capable of reducing the larger pieces, making them sufficiently small to be able to be transferred to the second grinding zone **18**, where the actual grinding takes place.

It is clear that what has been described is only a particular embodiment of the grinding device of the present invention, to which a person skilled in the art will be capable of making all modifications necessary for its adaptation to particular applications, without thereby departing from the scope of protection of the present invention.

What we claim is:

**1**. A grinding device comprising:

a movable member, rotating about an axis (X), which comprises a closure surface having a plurality of apertures and a grinding surface having a first series and a second series of ribs, the ribs of said second series having a pitch and a height which are less than those of the ribs of said first series;

a fixed member, which comprises a complementary grinding surface having a first series of complementary ribs, at the level of said first series of ribs, and a second series of complementary ribs, at the level of said second series of ribs, the ribs of said second series of complementary ribs having a pitch and a height which are less than those of the ribs of said first series of complementary ribs wherein said complementary grinding surface has ribbed zones alternating with smooth zones.

**2**. A grinding device according to claim **1**, wherein at least one of the said series of ribs has ribs with a substantially helical profile.

**3**. A grinding device according to claim **1** or **2**, wherein said movable member comprises a frustoconical body on which is defined a grinding surface which comprises said ribs.

**4**. A device according to claim **3**, wherein said apertures have a crescent shape with a convex side turned towards the center of said closure surface at the base of said frustoconical body.

**5**. A grinding device according to claim **1** or **2**, wherein said complementary grinding surface of said fixed member has two sections of frustoconical shape, converging towards the centre so as to form a surface having substantially the shape of an hour-glass, the first of said sections comprising said first series of complementary ribs and the second of said sections comprising said second series of complementary ribs.

**6**. A grinding device according to claim **1** or **2**, wherein said ribs and complementary ribs have a sawtooth profile, with an inclined flank and a vertical flank, which form a sharp edge at the apex.

**7**. A device according to claim **1** or **2**, wherein said movable member comprises a cylindrical surface which has inside it an annular relief, arranged in proximity to the open end of said cylindrical surface, capable of snapping into a corresponding annular relief on a neck of a spice container.

**8**. A device according to claim **1** or **2**, wherein said fixed member comprises a flange the lower surface of which has one or more raised portions, capable of engaging with corresponding notches provided on an edge of a neck of a spice container.

**9**. A device according to claim **1** or **2**, wherein said second series of ribs covers only the part of the grinding surface which is close to the closure surface.

**10**. A device according to claim **9**, wherein said second series of ribs covers over from ⅕th to ¼ of the entire grinding surface.

**11**. A method for grinding dried spices and herb, comprising:

engaging a movable member and a fixed member in a coaxial relationship such that a grinding surface of the movable member and a complimentary grinding surface of the fixed member are in close proximity and form an upper grinding zone between a first series of ribs located on said grinding surface and a first series of complimentary ribs located on said complementary grinding surface, and a lower grinding zone between a second series of ribs located on said grinding surface and a second series of complimentary ribs located on said complimentary grinding surface, wherein said complimentary grinding surface has ribbed zones alternating with smooth zones;

introducing grinding material at said upper grinding zone;

grinding said grinding material to a first grain size by rotating said movable member about said fixed member in a first direction;

releasing said grinding material through to said lower grinding zone by rotating said movable member about said fixed member in a second direction;

grinding said grinding material to a final grain size in said lower grinding zone by rotating said movable member about said fixed member in said first direction; and,

releasing said grinding material through a lower end of said movable member by rotating said movable member about said fixed member in said second direction.

**12**. A method according to claim **11**, wherein said first direction and said second direction are opposite.

**13**. A method according to claim **11**, wherein said first direction is clockwise and said second direction is counterclockwise.

* * * * *

US006637684B1

(12) **United States Patent**
**Ross et al.**

(10) **Patent No.: US 6,637,684 B1**
(45) **Date of Patent: Oct. 28, 2003**

(54) **HAND OPERATED FOOD GRINDING APPARATUS**

(75) Inventors: **Gary Ross**, Oxnard, CA (US); **Dave C. Whitmer**, Oxnard, CA (US)

(73) Assignee: **Highwave Incorporated**, Oxnard, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/124,983**

(22) Filed: **Apr. 17, 2002**

(51) **Int. Cl.**$^{7}$ ................................................ **B02C 19/08**
(52) **U.S. Cl.** .................................. **241/169.1**; 241/169.2
(58) **Field of Search** ........................... 241/169.1, 169.2, 241/DIG. 27

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 4,121,775 A | * | 10/1978 | Roseberg et al. | 241/30 |
| 4,397,425 A | * | 8/1983 | Moore et al. | 241/169.1 |
| 4,582,265 A | * | 4/1986 | Petronelli | 241/95 |
| 4,765,549 A | * | 8/1988 | Sherman | 241/169 |
| 5,322,227 A | * | 6/1994 | Fiocchi | 241/100 |
| 5,618,004 A | * | 4/1997 | Klearman et al. | 241/21 |
| 5,730,372 A | * | 3/1998 | Bradley | 241/29 |
| 6,209,439 B1 | * | 4/2001 | Repac et al. | 83/858 |

* cited by examiner

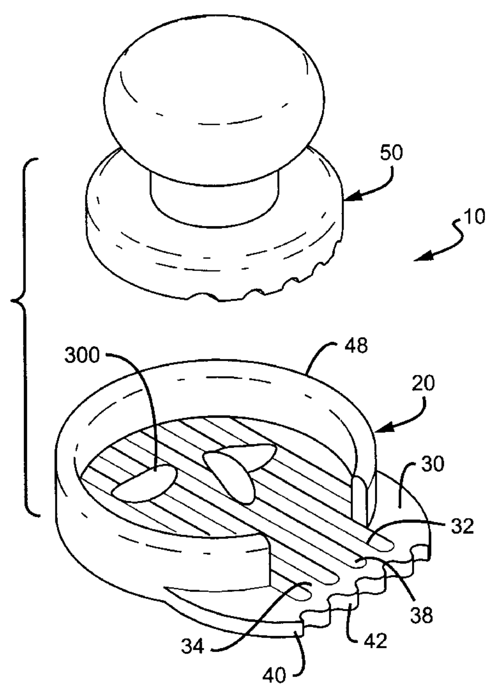
*Primary Examiner*—Mark Rosenbaum

(74) *Attorney, Agent, or Firm*—Thomas I. Rozsa; Tony D. Chen

(57) **ABSTRACT**

The present invention is hand operated food grinding apparatus into which is designed a series of opposing parallel ridges to enable the food item such as garlic, peppercorn, spices, coffee etc. to be ground into coarsely ground portions or finely ground portions depending on the arrangement and design of the opposing parallel ridges. The hand grinding apparatus has a base having an upper surface made of a series of parallel ridges separated by parallel groves wherein each of the parallel ridges has a flat upper surface, and also comprises a top member having a lower surface made of an opposing series of parallel ridges separated by parallel grooves wherein each of the parallel ridges has a surface, and wherein a respective ridge of the base member is aligned with a respective ridge of a top member or a respective ridge of a base member is offset from a respective ridge or a top member. In an alternative embodiment of the present invention, a hand grinding apparatus has a first base member having an upper surface made of a series of parallel ridges which are rounded in a concave fashion to be rounded into the base and are separated by a series of parallel concave grooves, wherein each of the parallel concave ridges has a rounded or flat surface, and also has a second top member having a lower surface made of a series of parallel convex ridges separated by parallel convex grooves, wherein each of the parallel convex ridges has a rounded or flat surface, and wherein each of the convex parallel ridges of the top member is aligned with each of the concave parallel grooves of the base member or offset therefrom.

**20 Claims, 3 Drawing Sheets**



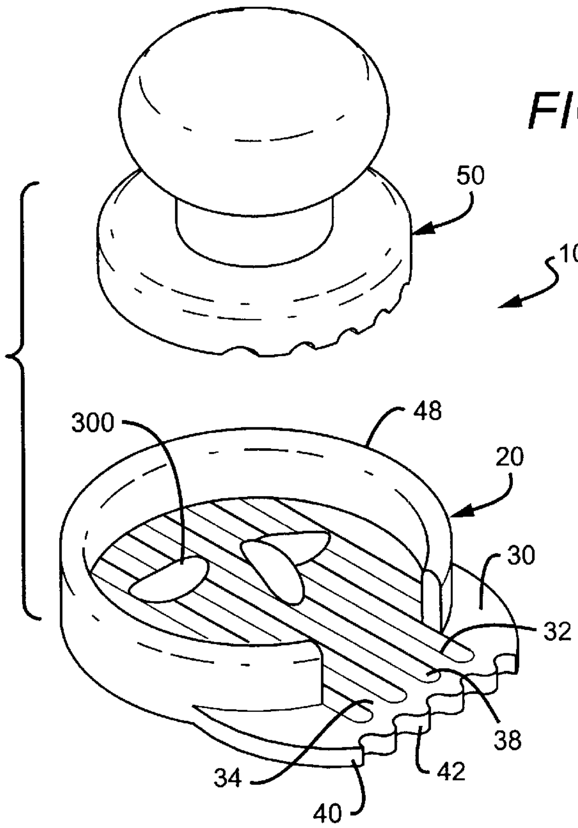



FIG. 1

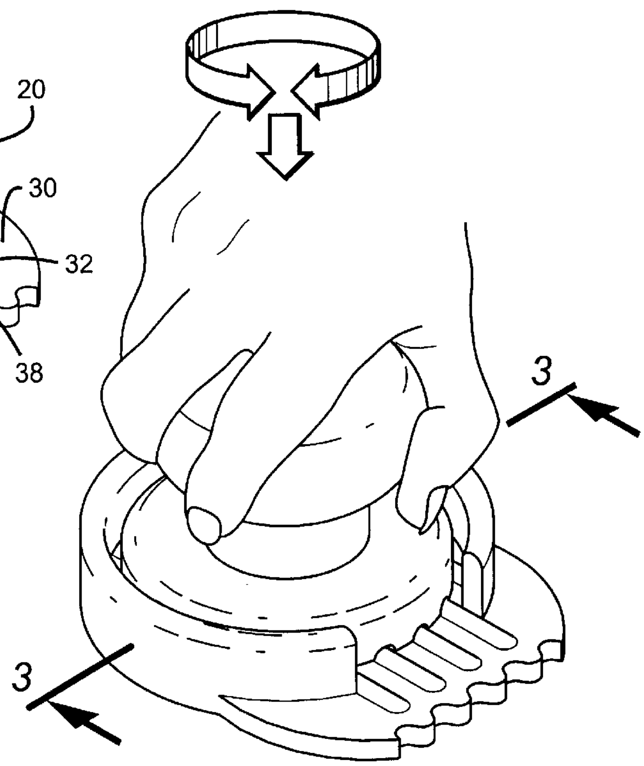



FIG. 2

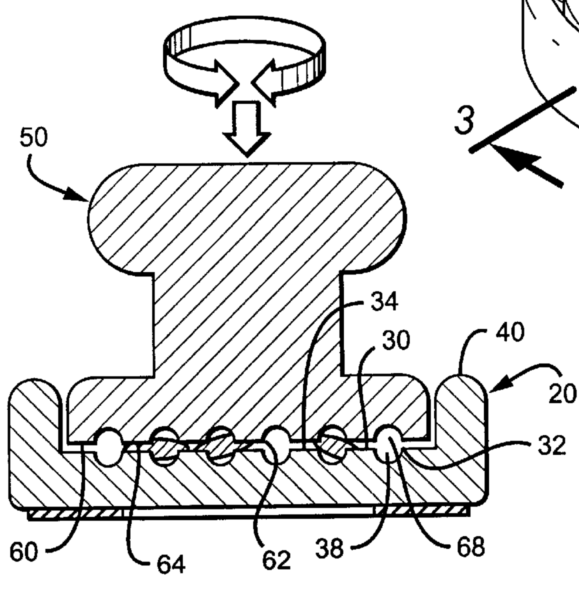



FIG. 3

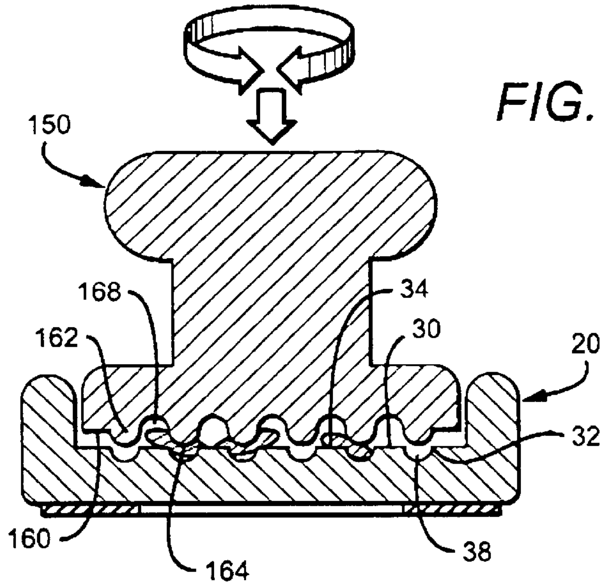



FIG. 3A

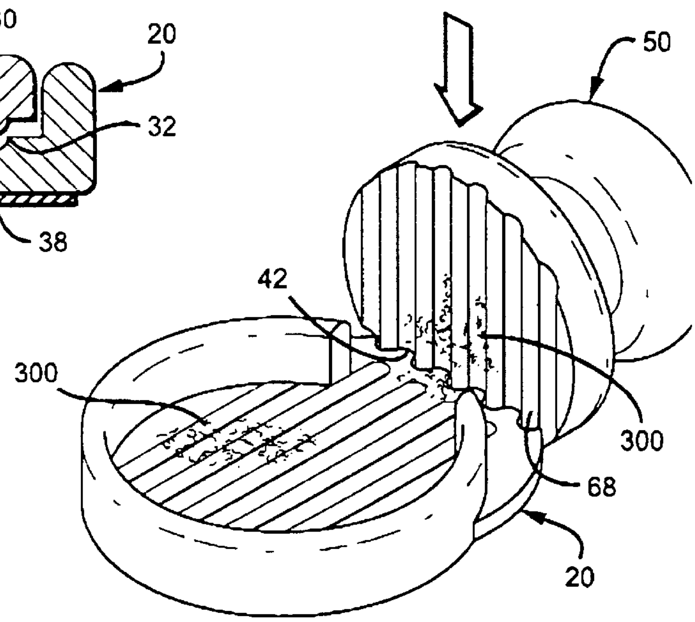



FIG. 4

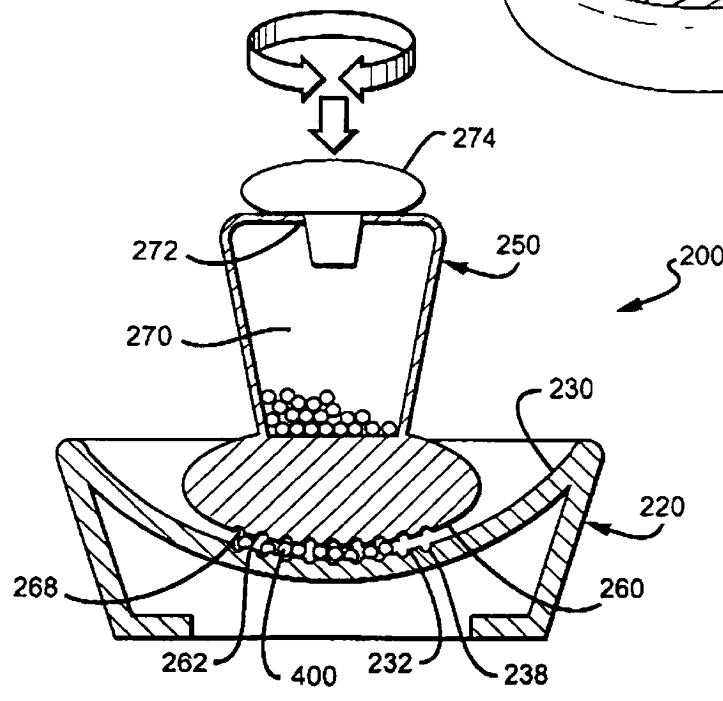



FIG. 7

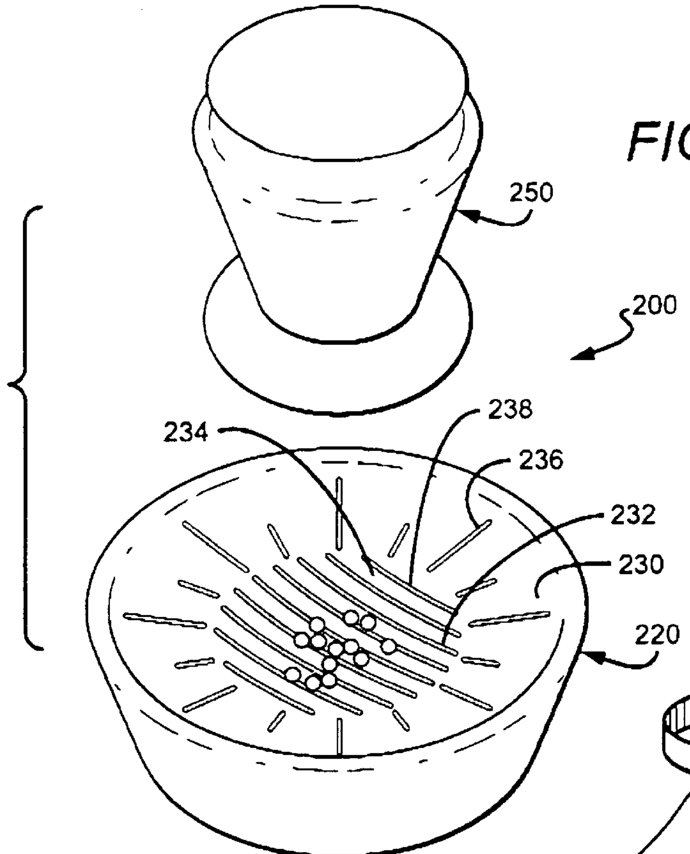



FIG. 5

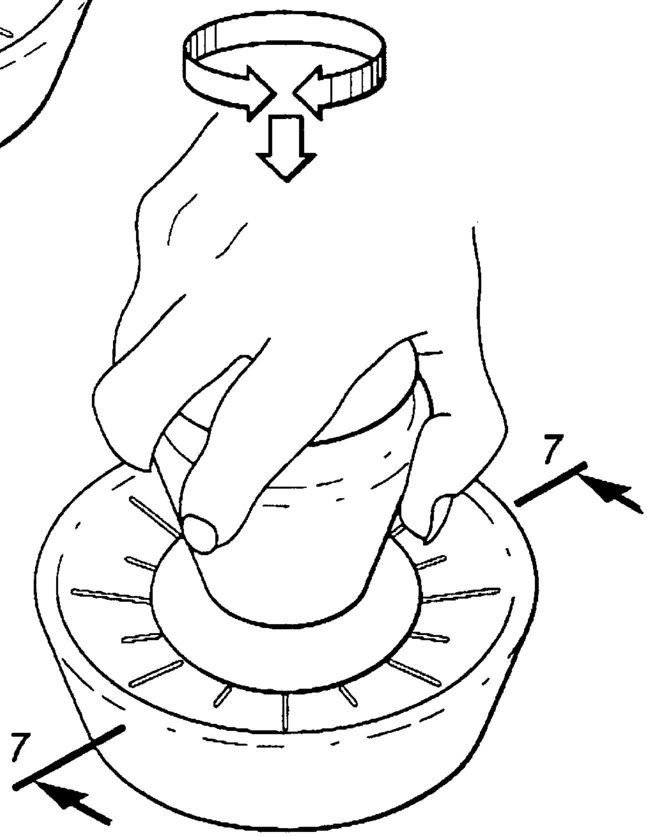



FIG. 6

# HAND OPERATED FOOD GRINDING APPARATUS

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the general field of food preparation items. In particular, the field of the present invention relates to food grinding apparatus operated by hand, as opposed to electric or other motorized apparatus.

2. Description of the Prior Art

In general, prior art food grinding apparatus which is used to grind foods such as garlic or peppercorns are generally smooth surface devices wherein pressure is applied between the surfaces to grind the foods. A common food grinding apparatus known in the prior art is a mortar and pestle which preparers of Latin foods use to prepare sauces and salsas.

It has been discovered that the operation of two smooth surfaces grinding against each other such as a mortar and pestle do not provide a finely ground or chopped or minced food item. There is a significant need to provide a hand operated food grinding apparatus which can enable the user to finely grind and mince food items.

## SUMMARY OF THE INVENTION

The present invention is hand operated food grinding apparatus into which is designed a series of opposing parallel ridges to enable the food item such as garlic, peppercorn, spices, coffee etc. to be ground into coarsely ground portions or finely ground portions depending on the arrangement and design of the opposing parallel ridges.

It has been discovered, according to the present invention, that if the hand grinding apparatus comprises a base having an upper surface made of a series of parallel ridges separated by parallel groves wherein each of the parallel ridges has a flat upper surface, and also comprises a top member having a lower surface made of an opposing series of parallel ridges separated by parallel grooves wherein each of the parallel ridges has a flat surface, and wherein a respective ridge of the base member is aligned with a respective ridge of a top member, then the hand held member can be used to coarsely grind garlic because some of the garlic falls into the grooves of the base and top members and can be removed therefrom.

It has also been discovered, according to the present invention, that if the hand grinding apparatus comprises a base having an upper surface made of a series of parallel ridges separated by parallel groves wherein each of the parallel ridges has a flat upper surface, and also comprises a top member having a lower surface made of an opposing series of parallel ridges separated by parallel grooves wherein each of the parallel ridges has a flat lower surface, wherein a respective ridge of the base member is offset from a respective ridge of a top member such that the ridges of the top member are aligned with the grooves of the base member, then the handheld member can be used to finely grind garlic because the ridges of the top member will be aligned with the grooves of the base member so that garlic will be ground even if it falls into the grooves of the base and top members.

It has additionally been discovered, according to the present invention, that if a hand grinding apparatus comprises abase having an upper surface made of a series of parallel ridges separated by parallel grooves wherein each of the parallel ridges has a flat upper surface, and also comprises a top member having a lower surface made of a series of parallel ridges separated by parallel grooves, wherein each of the parallel ridges has a rounded semicircular surface wherein a respective ridge of the base member is aligned with a respective ridge of a top member, then the handheld member can be used to finely grind garlic because some of the garlic falls into the grooves of the top and the grooves of the lower member and can be removed therefrom.



It has additionally been discovered, according to the present invention, that if a hand grinding apparatus comprises a base having an upper surface made of a series of parallel ridges separated by parallel grooves wherein each of the parallel ridges has a flat upper surface, and also comprises a top member having a lower surface made of a series of parallel ridges separated by parallel grooves, wherein each of the parallel ridges has a rounded semicircular surface wherein a respective ridge of the base member is offset from a respective ridge of a top member, such that a rounded ridge of a top member is aligned with a groove of the base member, then the handheld member can be used to finely grind garlic because some of the garlic falls into the grooves of the base and top members and the offset rounded ridges of the top member can be used to grind the garlic even when it falls into the grooves of the base member to create a more finely ground garlic.

It has also been discovered, according to an alternative embodiment of the present inventions that if a hand grinding apparatus comprises a first base member having an upper surface made of a series of parallel ridges which are rounded in a concave fashion to be rounded into the base and are separated by a series of parallel concave grooves, wherein each of the parallel concave ridges has a rounded or flat surface, and also comprises a second top member having a lower surface made of a series of parallel convex ridges separated by parallel convex grooves, wherein each of the parallel convex ridges has a rounded or flat surface, and wherein each of the convex parallel ridges of the top member is aligned with each of the concave parallel grooves of the base member, then the handheld member can be used to coarsely grind peppercorns, coffee, seeds and other food items which are smaller and more delicate than garlic.

It has also been discovered, according to an alternative embodiment of the present invention, that if a hand grinding apparatus comprises a first base member having an upper surface made of a series of parallel ridges which are rounded in a concave fashion to be rounded into the base and are separated by a series of parallel concave grooves, wherein each of the parallel concave ridges has a rounded or flat surface, and also comprises a second top member having a lower surface made of a series of parallel convex ridges separated by parallel convex grooves, wherein each of the parallel convex ridges has a rounded or flat surface, and wherein each of the convex parallel ridges of the top member is offset from each of the concave parallel ridges of the base member, so that a respective convex parallel ridge of the top member is aligned with a concave groove of the base member, then the handheld member can be used to finely grind peppercorns, coffee, seeds and other food items which are smaller and more delicate than garlic.

It is therefore an object of the present invention to provide a hand grinding apparatus which enables food items such as garlic to be coarsely ground by having a base member having a series of parallel ridges separated by parallel grooves wherein each of the surfaces of the parallel ridges is flat and having a top member having an opposing lower surface having a series of parallel ridges separated by parallel grooves wherein each of the parallel ridges has a flat surface.

US006638757B1

(12) United States Patent
Teran et al.

(10) Patent No.: US 6,638,757 B1
(45) Date of Patent: Oct. 28, 2003

(54) **BIOLOGICAL DIGESTION OF ANIMAL CARCASSES**

(75) Inventors: **Alfredo J. Teran**, Cape Canaveral, FL (US); **W. Todd Willoughby**, Cape Canaveral, FL (US); **Richard G. Wood**, Cape Canaveral, FL (US)

(73) Assignee: **Agrimond, L.L.C.**, Cape Canaveral, FL (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/055,605**

(22) Filed: **Jan. 23, 2002**

**Related U.S. Application Data**

(62) Division of application No. 09/471,955, filed on Dec. 22, 1999, now Pat. No. 6,350,608.

(51) **Int. Cl.**$^7$ .............................. **C12S 3/00**; C05F 1/00
(52) **U.S. Cl.** ................................ **435/267**; 71/9; 71/15; 210/620; 241/1; 241/30
(58) **Field of Search** ................................ 435/262, 245, 435/267; 210/608–613, 620; 241/1, 5, 30; 71/9, 15

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 3,429,806 A | | 2/1969 | Carter et al. | 210/3 |
| 3,462,275 A | * | 8/1969 | Bellamy | |
| 3,778,233 A | | 12/1973 | Blough et al. | 23/259.1 |
| 3,961,078 A | * | 6/1976 | Stitt | |
| 3,997,437 A | | 12/1976 | Prince et al. | 210/4 |
| 4,009,100 A | | 2/1977 | Hess et al. | 210/14 |
| 4,053,394 A | | 10/1977 | Fisk | 210/8 |
| 4,225,381 A | | 9/1980 | Ishikawa et al. | 162/51 |
| 4,259,361 A | | 3/1981 | Procter | 426/285 |
| 4,391,887 A | * | 7/1983 | Baumgarten et al. | |
| 5,076,504 A | * | 12/1991 | Young | |
| 5,162,016 A | * | 11/1992 | Malloy | 452/149 |
| 5,206,169 A | | 4/1993 | Bland | 435/284 |
| 5,323,969 A | * | 6/1994 | Mendenhall et al. | 241/1 |
| 5,405,554 A | * | 4/1995 | Neff et al. | 516/21 |
| 5,423,988 A | | 6/1995 | Yamasaki et al. | 210/611 |
| 5,545,325 A | | 8/1996 | Hsu et al. | 210/605 |
| 5,651,891 A | | 7/1997 | Molof et al. | 210/605 |
| 5,853,588 A | | 12/1998 | Molof et al. | 210/605 |
| 5,954,964 A | * | 9/1999 | Nielsen et al. | 210/609 |
| 6,039,874 A | | 3/2000 | Teran et al. | 210/605 |
| 6,193,889 B1 | | 2/2001 | Teran et al. | 210/609 |

FOREIGN PATENT DOCUMENTS

| | | | | | |
|---|---|---|---|---|---|
| CA | 2195473 | | | 1/1997 | |
| CA | 2195473 | A1 | * | 7/1998 | |
| CH | 690957 | A5 | | 12/1978 | |
| CH | 690957 | A | * | 3/2001 | |
| DE | 2922828 | A1 | * | 12/1980 | C02F/3/12 |
| DE | 3714677 | A1 | * | 11/1988 | A22B/5/00 |
| DE | 3841928 | A1 | * | 6/1990 | A23K/1/10 |
| DE | 19623163 | A1 | * | 12/1996 | C12P/5/02 |
| GB | 1 489 592 | A | * | 10/1977 | |
| JP | 58-99190 | A | * | 6/1983 | |

OTHER PUBLICATIONS

Neumann et al. CAPLUS Abstract No. 1967:40576 of 'Activated sludge for purification of waste waters of an animal processing plant', GWF, Gas–Wasserfach (1966), vol. 107 (40–41), pp. 1151–1155.*

OA1 Rick Brooks, "North Carolina Hurricane Damages Rise", *The Wall Street Journal*, p. A2, Sep. 21, 1999.

OA2 Florida Statute 1997, Chapter 823—Public Nusainces, p. 1708; §823.041—"Disposal of Bodies of Dead Animals; Penalty".

* cited by examiner

*Primary Examiner*—William H. Beisner
(74) *Attorney, Agent, or Firm*—Brian S. Steinberger; Law Offices of Brian S. Steinberger, P.A.

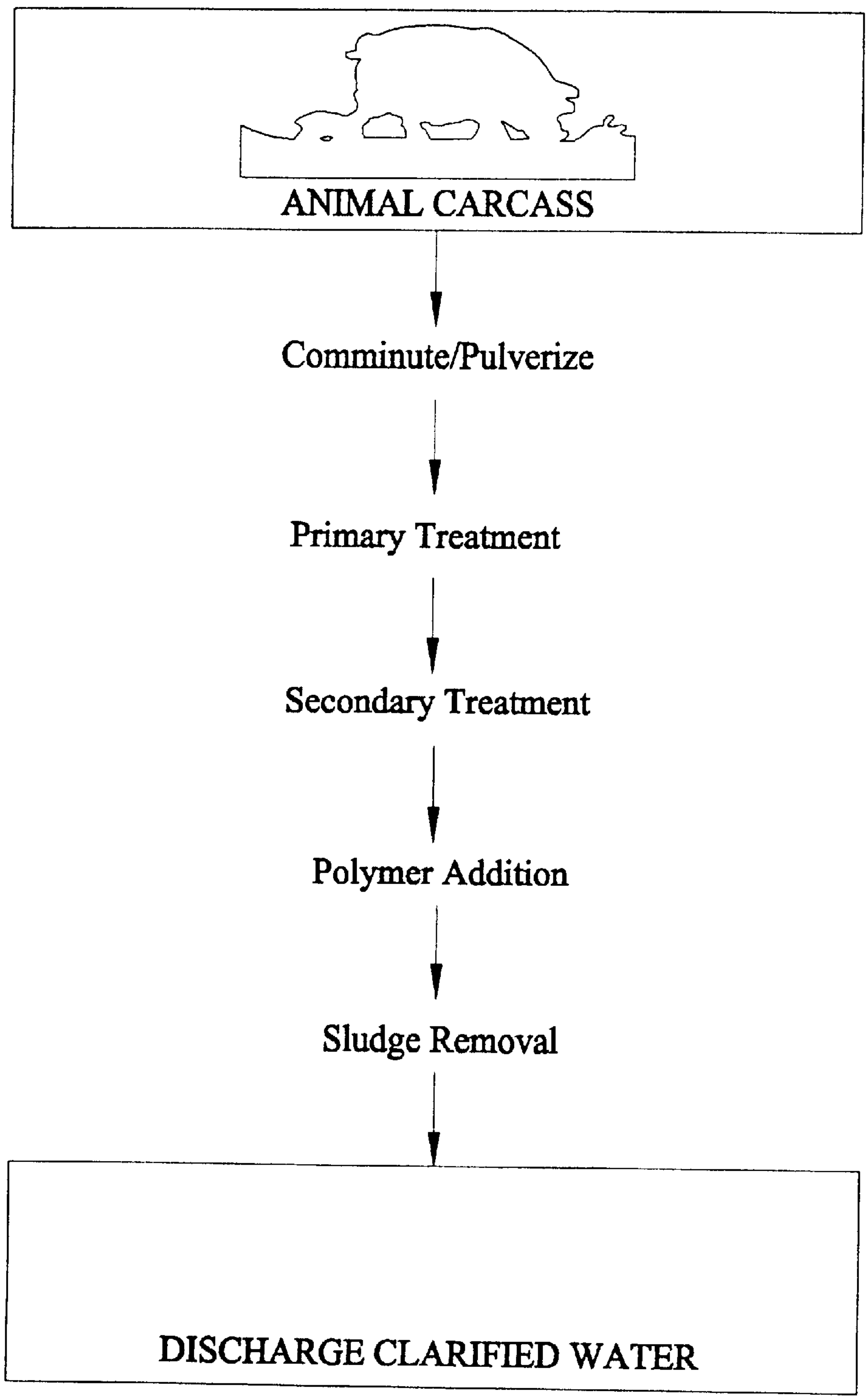
(57) **ABSTRACT**

A process is provided for the biological digestion of animal carcasses. First, the carcass is cut into smaller pieces with equipment that masticates, grinds or comminutes in the presence of water to create a solid-liquid mixture. The next steps include treating the solid-liquid mixture with a special blend or combination of bacteria that have been specifically cultured to digest the carcass; the mixture is subsequently aerated to form a stabilized biomass. The stabilized biomass is aerated in an open basin to further digest and liquefy the carcass, water, bacteria mixture. From the open basin, the primarily liquid waste stream is passed to a clarifying tank where the suspended solids are precipitated as sludge, thus clarifying the liquid. Sludge is removed from the clarifying chamber and the clarified liquid is either discharged or recirculated for further use in this novel process. In the preferred embodiment of the invention, technology known as hydrolaze is used to masticate, comminute or pulverize the carcass.

**12 Claims, 3 Drawing Sheets**

Fig. 1

BIOLOGICAL DIGESTION OF ANIMAL CARCASSES
(FLOW DIAGRAM OF PROCESS)



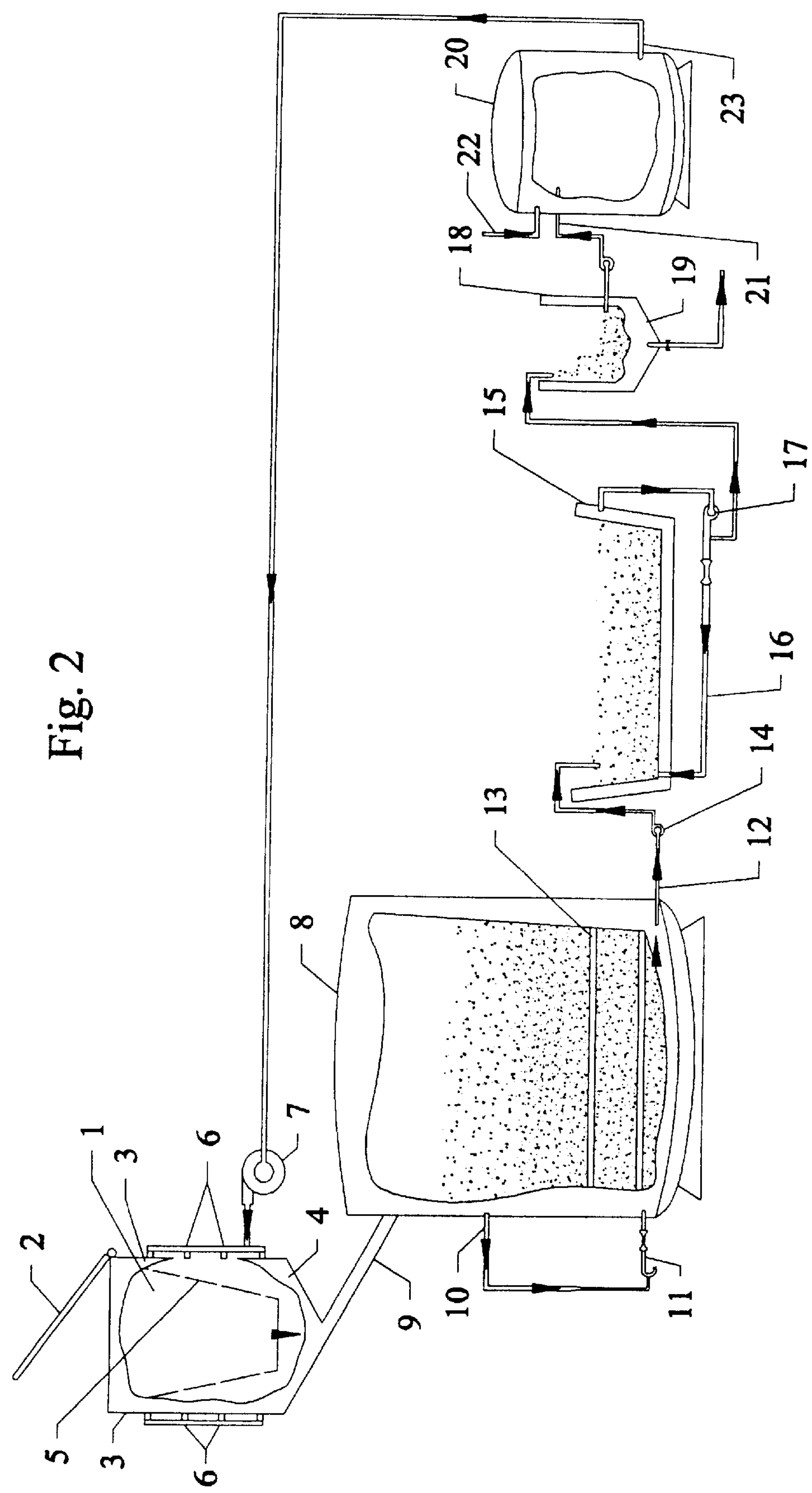



Fig. 2

COD reduction after settling without polymer, with polymer, and filtration.

1- Raw Waste
2- Supernatant (no polymer)
3- Supernatant (with polymer)
4- Supernatant after filtration

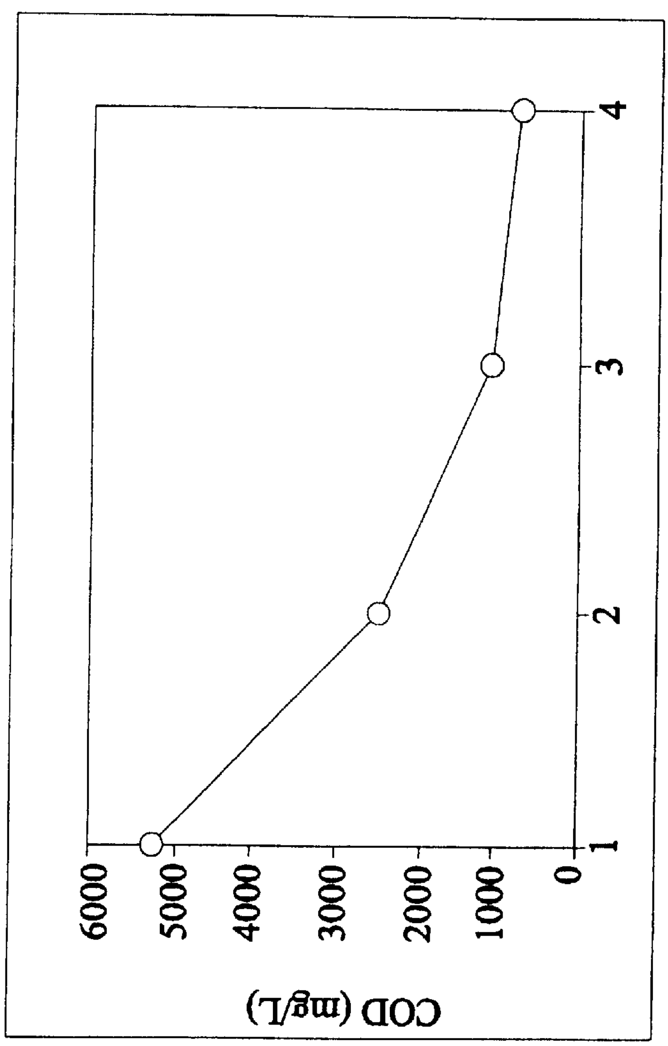



Fig. 3

# BIOLOGICAL DIGESTION OF ANIMAL CARCASSES

This is a Divisional of application Ser. No. 09/471,955 filed Dec. 22, 1999, now U.S. Pat No. 6,350,608.

## BACKGROUND AND PRIOR ART

As the human habitat expands and as more and more animals become domesticated or intertwined in the human environment, people take on the responsibility of disposing of animals that die. Animal deaths may be due to predators desire for foodstuff, disease, natural causes, or natural disasters, such as the recent Hurricane Floyd in North Carolina where state officials estimated that more than 100,000 hogs drowned in the deluge, which also killed one million chickens and turkeys (*The Wall Street Journal*, Tuesday, Sep. 21, 1999, page A2). Collecting, handling, transporting and disposing of dead animals are difficult and costly, since the carcasses soon become offensive and putrescible if left to decay by natural processes. Our world needs an inexpensive, ecologically safe process for disposing of dead animal carcasses.

Various means of disposing of animal carcasses are currently used. In North Carolina, *The Wall Street Journal*, supra, reports that incinerators will be brought in to dispose of the carcasses of dead farm animals, contributing to a "smelly, stinky mess." Florida statute 823.041, mandates that the bodies of dead animals be disposed of by burning or burying at least 2 feet below the surface of the ground; or disposed of by rendering companies licensed to do business in the state.

Furthermore, it is taught in U.S. Pat. No. 3,429,806 that meatpacking waste, including blood, is disposed of through a series of three stabilization ponds and one aeration pond producing a discharge stream suitable for use as a soil conditioner. This elaborate system requires treatment for 10 days in each stabilization pond and 5 days in the aeration pond. Thus the process is not only costly but time consuming. Aerobic liquid composting of animal waste is disclosed in U.S. Pat. No. 3,778,233; a rotating shaft and propeller induces air into liquefied animal waste. U.S. Pat. No. 5,206,169 teaches a composting system with increased ventilation and solar panels to provide heat of decomposition and evaporation of moisture that converts animal carcasses to carbon dioxide gas, water vapor and stabilized compost consisting of nitrogen, phosphorus, potassium and calcium. U.S. Pat. No. 3,997,437 uses an aerator which shears the solid particles while simultaneously adding oxygen to sludge being treated and recirculated for an extended period of time. Aeration is used primarily to digest sludge. U.S. Pat. No. 4,009,100 oxygenates a mixture of waste water and activated sludge which is agitated to avoid settling using a water jet either at surface or just below the surface. U.S. Pat. No. 4,053,394 teaches the odorless recycling of raw sewage liquor treated with aerobic bacteria, air, oxygen, ozone, or a blend thereof to provide pure water. U.S. Pat. No. 5,423,988 discloses a waste treatment process with microorganisms from household waste to eliminate the need for an activated charcoal absorption tower.

More recently, U.S. Pat. Nos. 5,545,325; 5,651,891 and 5,853,588 disclose wastewater treatment processes which combine aerobic, anoxic and anaerobic treatment zones followed by a final clarification or settling step using a mechanical means or chemical means, such as a polymeric material to clarify the final effluent. Such multiple stage treatment processes are costly to build and operate, although



purportedly less time is required for production of purified wastewater, e.g., days instead of months. Nonetheless, the cost of such customized construction would be a deterrent in reaching the desired goal of removing animal carcasses in an effort to cleanup the environment.

The waste disposal industry is still seeking an inexpensive, ecologically safe method for disposing of animal carcasses. The variety of disposal methods offered is, to some extent, evidence that none is without disadvantage. A more optimum, inexpensive solution for animal carcass disposal without noxious odors.

## SUMMARY OF THE INVENTION

The first objective of the present invention is to provide a novel, inexpensive, on-site disposal process for animal carcasses.

The second objective of this invention is to provide a system for the disposal of animal carcasses in which space age technology, known as HYDROLAZE, is utilized in the disintegration/comminuting of a carcass.

The third objective of this invention is to provide a system for the disposal of dead animals that utilizes a primary aeration tank and a secondary aeration tank for the complete digestion and liquefication of carcasses.

The fourth objective of this invention is to provide a system for the disposal of animal carcasses such that in the primary aeration tank a unique blend of bacteria is employed to efficiently digest the animal carcass.

The fifth objective of this invention is to provide a system for the disposal of animal carcasses that produces a clarified liquid that is reusable in the system as the liquid supply for the comminuting and pulverizing animal carcasses.

The sixth objective of this invention is to provide a system for the disposal of animal carcasses that produces a clarified liquid that is suitable for further treatment and subsequent safe return to the environment.

The seventh objective of the present invention is to provide a system for the disposal of animal carcasses that eliminates noxious processing odors.

A preferred embodiment of the invention consists of the features of construction which are illustrated in FIGS. **1–3**, wherein animal carcasses are processed through five units, including: **1**. Comminuting/pulverizing chamber, **2**. primary aeration tank; **3**. secondary aeration tank; **4**. clarifying tank and **5**. a final disposal/reuse tank. The operating procedures and devices are hereinafter described in detail and the scope of which will be indicated in the appended claims.

Further objects and advantages of this invention will be apparent from the following detailed description of a presently preferred embodiment which is illustrated schematically in the accompanying drawings.

## BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a flow chart of the process for disposing of animal carcasses.

FIG. **2** is an illustrative cross-sectional view of a processing facility for the present invention.

FIG. **3** is a graph showing the reduction of organic matter as measured by chemical oxygen demand (COD)during the final clarification of effluent.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Before explaining the disclosed embodiment of the present invention in detail it is to be understood that the invention is not limited in its application to the details of the particular arrangement shown since the invention is capable of other embodiments. Also, the terminology used herein is for the purpose of description and not of limitation.

The present invention is particularly described with respect to disposal of the carcasses of dead hogs, but it should be apparent to those skilled in the art that the teachings herein have other applications; for instance to the disposal of animal carcasses including, but not limited to, equine, bovine or marine animals, goat, sheep, swine, dog, cat, poultry or other beast or bird.

The present invention can also be used to dispose of animals whose deaths are due to disease or infection; however, added precautions, including sterilization or disinfection can be included since the aerobically digested water and solids may contain pathogenic organisms. The end products of this process, namely sludge and clarified water, may be treated with disinfecting agents such as ozone, heat, phenols, alcohols, strong acids or alkalies, and halogens which cause coagulation and denaturing of cell protein. Direct sunlight, ultraviolet rays, or ionizing radiation destroys pathogens. Chlorination, which has the undesirable by product of trihalomethane in certain applications, is the most frequently used disinfectant. With greater attention to control and dichlorination, it is relatively inexpensive, readily applied and controlled, and can be monitored by a simple and quick test. Thus, by employing a sterilization or disinfection step before the digested carcass end products are discharged, diseased animal carcasses are advantageously disposed of by this system.

Referring to FIGS. **1** and **2**, each operating procedure and device used is listed below for further details.

Unit **1**. Hydrolaze chamber. The dead hogs are placed in an enclosed chamber **(1)** wherein the top side consists of a hinged lid **(2)**, with two vertical sides **(3)** and a bottom wall **(4)**housing a wide mesh basket **(5)**; positioned along the vertical sides are rotatable spray nozzles**(6)** that are integrally connected to a high pressure pump **(7)** through which fluid is pumped. Thus, when fluid flow and pump are activated, the animal carcass can be cut into approximately 10.25 cm to approximately 15.4 cm (4 to 6 inch) pieces in a matter of seconds and converted to a mixture of liquid-solid organic material, suitable for further processing in the aerobic treatment tanks. The action by the pressurized fluid and nozzle configuration is designated herein as hydrolaze.

The effective range of fluid pressure exiting the nozzles can be in a range between 9,000 pounds per square inch to approximately 15,000 pounds per square inch. This action by the pressurized fluid and nozzle configuration is designated herein as hydrolaze.

The term "hydrolaze" as described above and shown in FIG. **2**, shall mean water or any water-containing fluid fed through a high pressure nozzle such that the water performs like a laser cutting tool; an example is described later. The hydrolaze consists of one or more high pressure pumps and nozzles which can deliver water at pressures ranging from approximately 9,000 pounds per square inch (psi) to approximately 15,000 pounds per square inch (psi). The water is delivered from the pumps through high-pressure hoses to the nozzles which then direct the water towards the carcass. The nozzles are designed to provide a water stream less than five millimeters in diameter. The combination of high pressure and the "pinpoint" stream of water results in a concentrated force in a very small area which will easily cut through the skin and bone of the animal carcass. The nozzles are both fixed and oscillating to ensure complete coverage of the interior of the pulverizing chamber (Unit **1**) and complete mastication of the animal carcass. The water used can be recycled water carrying the cultured bacteria from the previous treatment cycle and thus the bacteria can begin the digestion process in the pulverizing chamber. The effective range of fluid pressure exiting the nozzles can be in a range between approximately 9,000 psi and 15,000 psi.

The interior of the chamber contains a steel mesh with openings from approximately 10.25 centimeters (4 inches) to approximately 15.4 centimeters (6 inches) square. This creates a basket which holds the carcass and prevents further processing of pieces larger than the mesh openings. The result is a more homogenous mix of animal carcass, water and bacteria which will speed up the digestion process. Thus, the hydrolaze pulverized carcass is treated to form a solid-liquid mixture suitable for processing in the primary aeration tank (Unit **2**).

Unit **2**. The Primary Aeration Tank is a fully enclosed chamber**(8)** having three inlets; one for receiving the mixture from Unit **1** **(9)**, another for introduction of the bacterial culture**(10)** and a third inlet for air **(11)** One outlet **(12)** is positioned at the bottom of the tank to permit removal of the aerated mixture from Unit **2**. The interior of the chamber contains a small mesh grating **(13)** which retains the large solids in the solid-liquid mixture from Unit **1** in a position for prolonged contact with the bacterial culture that is introduced. Bacteria and a combination of bacteria referred to as a special blend of bacteria are introduced above the mesh grating. The special blend of bacteria comprises a culture of the most effective bacteria for digesting the type of animal waste being processed. Cultured bacteria are fed into the aerobic digestion chamber in large supply, during the initial start up of the process. The ratio of bacteria to waste water in the system can be from approximately 1 part bacteria to approximately 10,000 parts waste water. For example, during the start up of the system, typically one gallof of concentrated and cultured bacteria are used for each 10,000 gallons of waste water. The optimum amount of bacteria is dependent on the purity of the culture and the concentration of the bacteria in the slurry. Subsequently, after a stable biomass is created, maintenance doses are used. Maintenance doses can be approximately one fourth of the initial start up amount; e.g., ¼ part bacteria to approximately 10,000 parts waste water in the system. The stabilized iomass will continue to generate and become self-sustaining if a constant food source is supplied. Thus, an additional benefit of the present invention is a system that will function with minimal maintenance relying mainly on the natural digestion of animal carcasses with non-pathogenic bacteria.

When processing occurs at atmospheric pressure and an outside temperature between 15° C. and 26° C. (59° F. and 78.8° F.) there is no need to control the temperature. Heat is also generated during the aerobic digestion of the animal carcass. It should be noted that a temperature below 15° C. causes the reaction to take place much slower. A temperature above 26° C. is not desirable because helpful bacteria may be killed resulting in slower digestion. The bacteria themselves can alter the temperature. In cold climates, the temperature in an active basin can be as much as 10° C. above the outside air temperature. Also, while higher temperatures normally found in the summer months will slow down the bacterial activity, the system does not have any significant bacteria loss until the water temperature exceeds 32° C. (89.6° F.). Feeding more makeup water and removing more treated water during the process can reduce water temperature during the warm months.

Air is introduced below the mesh grating to augment the aerobic digestion of the carcass by a special blend of bacteria introduced above the mesh grating. Air increases the speed of digestion thereby creating a stable, primarily liquid, biomass. When a stabilized biomass was created, sludge began to build up in the form of suspended solids. Dissolved oxygen levels in the tank began to rise, indicating the biomass had stabilized. The liquid in Unit **2** was them pumped to Unit **3**. The pump **(14)** used in this step is an industrial pump having a minimum flow rate of 500 gallons per minute. A suitable pump is manufactured and distributed by Goulds Pumps, Inc. 240 Fall Street, Seneca Falls, N.Y. The size and type of pump can be selected according to the flow rate desired.

Unit **3**. The Secondary Aeration Tank is an open basin **(1)** which receives the liquid from Unit **2** containing bacteria which tend to stay with the liquid. Here the liquid is treated with air that is introduced at the bottom of the basin **(16)**. Although other sources of oxygen may be used to directly aerate the bacteria it is most economical to use air which is 21% oxygen. Further digestion of the waste stream occurs producing a mixture which varies in color depending on the type of animal being consumed, typically the color was a yellowish tan. A frothy mixture producing a head of foam of 10.25 centimeters (4 inches) to approximately 15.4 centimeters (6 inches) indicated an active group of bacteria. There were areas in the mixture void of foam where the water was moving too rapidly for the foam to buildup. There was no odor detectable even when within a foot of the mixture. No clumps or solids were visible although there may have been some near the bottom of the basin. Any solids remaining in the mix were eventually consumed. The aerated material in Unit **3** is now pumped via mechanical means **(17)** to a conical settling tank (Unit **4**).

Unit **4**. In the Conical Settling tank **(18)** about 50 parts per million (ppm) of a commercially available polymer, such as Agrimond Poly-Clear **100**, which is chemically named [poly (diallyldimethylammonium chloride)] was added to clarify the waste stream. It is understood that the amount and type of polymer may vary depending on the type of mixture and the amount of solids in the mix. The polymer encourages particles to clump together and precipitate as sludge **(19)**. The sludge resembles a thick soupy mixture and is drained away to drying beds where natural evaporation of moisture occurs. The clarified liquid portion of the waste stream is pumped to an in-system supply tank **(20)** which is used to supply fluid to the high pressure pump and nozzles used in Unit **1** (Hydrolaze chamber). Alternatively, water can be returned safely to the environment if treated to meet environmental standards. By using the water in a closed loop for this system, two advantages are gained. First, the hassle of obtaining a permit for returning the water to the environment is omitted. Second, some of the effective bacteria which has been cultured for the advantageous aeration of this particular organic material is returned to the system for further use in disposing of animal carcasses.

Unit **5**. Hydrolaze Supply tank **(20)** is an enclosed chamber having two inlets; one inlet **(21)** receives the clarified liquid from Unit **4** and another inlet **(22)** receives make-up water, such as well water, to make up for losses from evaporation, drift, removal of solids and discharge to the aerobic treatment basin **(15)** The make-up water can be supplied from any source of potable water. The outlet flow **(22)** is under low pressure (e.g., about 30 psi to about 40 psi) and if recirculated in this disposal system, is fed to the high pressure pump and nozzles to comminute or pulverize the animal carcasses.



Alternatively, as discussed earlier, the water from Unit **5** can be returned safely to the environment; additional processing can be done to obtain the necessary permits and to meet local environmental standards.

## DESCRIPTION OF ANOTHER EMBODIMENT

The process of the present invention as shown in 'FIG. **1** could be accomplished as described above in the preferred embodiment if a standard commercial meat-mincing machine is used instead of the Hydrolaze unit to comminute or pulverize the animal carcass. For esample, a commercially available grinder such as one manufactured by JWL Environmental, model "Muffin Monster" could pulverize the complete animal carcass prior to digestion. Whole animals or animal parts or viscera or organs or bones, or combinations of these materials could be passed through hog breaker or prebreaker. These are heavy-duty machines capable of breaking up animal bone and other tissues and are common to the rendering industry. During the pulverization of the carcass, water can be added to create a solid-liquid mixture suitable for processing in the primary aeration tank (Unit **2**). Subsequent processing of the animal carcass continues in Units **2** through as disclosed above in the preferred embodiment.

## EXAMPLE

Testing of the process was conducted at facilities in Cape Canaveral, Fla. between March 1999 and July 1999.

To simulate the process, five pounds of ground pork were added to 50 gallons of tap water in a small open basin. 500 ml of Type P bacteria were added to the mix. The simulated wastewater was mixed in an 80 gallon open top plastic reservoir. Wastewater was taken from the bottom of the reservoir, pumped through the venturi to provide sufficient aeration, and returned to the reservoir at an angle for better mixing and circular motion. It was determined that each pound of meat has an equivalent of an average of 750 mg/L of Chemical Oxygen Demand once it gets dissolved in 50 gallons of water.

COD is a measurement of the total amount of organic matter in a waste stream. The COD measurement in this example indicates the meat from pork has a high COD primarily resulting from the protein and fat content. The 750 mg/l COD/lb. of meat in the initial concentration translates to a COD of 3,750 mg/l using 5 lbs. of meat, the bacteria accounted for the remaining COD balance. After processing, the final COD for 5 lbs. of meat was approximately 750 mg/l representing a 5:1 or 80% reduction in the initial COD concentration. Each step in the process contributes to the reduction of the COD concentration.

After the initial phase, the special culture of bacteria was introduced and after about one week, a sufficient biomass is established. Thereafter, ground meat was added on a regular basis (1.5 pounds every three days). At the second phase of the experiment the additional hog parts such as neck bones and feet were added. It took two days for the parts to be digested by the bacteria. Also, within the first two days, the bacteria started digesting/pitting the bones.

For the clarification step as outlined above in Unit **4**, no polymers, several different polymers at various dosages in combination with a filtration step were used to determine clarification effectiveness FIG. **3** shows chemical oxygen demand (COD) reduction after settling without polymer, with polymer, and with polymer followed by filtration.

The ultimate benefits of the proposed system were the ability to handle dead hogs on-site in an economical and environmentally friendly process. All processing is contemplated for above ground tanks and could conceivably operate as a gravity fed system except for the return of the clarified liquid to the first treatment chamber. Thus, the installation of pumping equipment is viewed as an optional means of moving the aerobically treated animal carcass from one tank or chamber to another.

A surprising and unexpected benefit in this process is the speed with which an animal carcass can be completely disposed of in the combinations of steps outlined. The key finding is the identification of the bacteria that are most effective in digesting or consuming the carcass, culturing these bacteria, and introducing them to the aeration tank with the comminuted carcass. In a matter of approximately two to approximately seven days, the carcass can be completely digested and reduced to a sludge suitable for soil conditioning when dried and a clarified liquid for further use in processing or safe return to the environment. In other words, animals that once roamed the earth are reduced to dust and water in a matter of days.

Although the preferred embodiment is applying the invention to animal carcasses, particularly, dead hogs, it is reiterated that the invention can be applied to other carcasses such as, but not limited to, mammals, marine animals, and the like.

While the invention has been described, disclosed, illustrated and shown in various terms of certain embodiments or modifications which it has presumed in practice, the scope of the invention is not intended to be, nor should it be deemed to be, limited thereby and such other modifications or embodiments as may be suggested by the teachings herein are particularly reserved especially as they fall within the breadth and scope of the claims here appended.

We claim:

**1**. A process for disposing of animal carcasses comprising the steps of:

(a) depositing an animal carcass in a receptacle for mastication in the presence of a water stream to create a solid-liquid mixture;

(bi) passing said solid-liquid mixture of step (a) to an enclosed aeration tank;

(bii) introducing a bacteria culture and air into the tank to initiate formation of a biomass;

(c) mixing all of the components of step (b) until the solid-liquid mixture forms a stabilized biomass with a frothy liquid consistency;

(d) passing said liquid from step (c) into an open aeration basin for further digestion of the liquid, stabilized biomass;

(e) passing the aerated liquid of step (d) to a clarifying tank where suspended solids precipitate as sludge; and

(f) removing sludge from the clarifying tank of step (e) to form clarified water.

**2**. The process of claim **1** wherein the depositing step (a) includes the step of: comminuting the carcass with a combination of a high pressure and pin point water stream directed at the carcass.

**3**. The process of claim **2** wherein the water stream has a pressure of approximately 9,000 psi to approximately 15,000 psi and a diameter of less than approximately 5 millimeters.

**4**. The process of claim **1** wherein the clarifying tank of step (e) employs polymeric material consisting of poly (diallyldimethylammonium chloride) to cause particles to clump together enhancing formation of the sludge.

**5**. The process of claim **1** wherein the aerobic digestion of an animal carcass occurs over a period of approximately 2 to approximately 7 days.

**6**. The process of claim **1**, wherein step (bii) includes the step of:

introducing the bacteria at a ratio of approximately ¼ to approximately 1 part of the bacteria to approximately 10,000 parts waste stream.

**7**. The process of claim **1**, further comprising the step of:

generating an aerobic digestion in the process outdoors during an outside temperature range of approximately 15C to approximately 26C.

**8**. The process of claim **1** wherein the mixing step (c) includes the step of:

producing a frothy mixture head between approximately 10.25 cm to approximately 15.4 cm to indicate an active group of the bacteria culture.

**9**. A process for disposing of animal carcasses, comprising the steps of:

depositing an animal carcass in a receptacle; and

comminuting the carcass with a water stream having a pressure of approximately 9,000 psi to approximately 15,000 psi combined with a diameter of the water stream being less than approximately 5 millimeters directed at the carcass until the carcass becomes a solid-liquid mixture.

**10**. The process of claim **9**, further comprising the step of:

introducing a bacteria culture at a ratio of approximately ¼ to approximately 1 part of the bacteria to approximately 10,000 parts waste stream along with air into the solid-liquid mixture to initiate formation of a biomass mixture.

**11**. The process of claim **9**, further comprising the step of:

generating an aerobic-digestion in the process outdoors during an outside temperature range of approximately 15C to approximately 26C.

**12**. The process of claim **9**, further comprising the step of:

producing a frothy mixture head in the mixture between approximately 10.25 cm to approximately 15.4 cm to indicate an active group of the bacteria culture.

* * * * *

US006871808B2

(12) **United States Patent**
**Holcomb et al.**

(10) **Patent No.: US 6,871,808 B2**
(45) **Date of Patent: Mar. 29, 2005**

# (54) APPARATUS FOR GRINDING MATERIAL, SUCH AS SPICE OR GRAIN

(75) Inventors: **David A. Holcomb**, Seattle, WA (US); **Peter A. Ryding**, Seattle, WA (US); **Jason O. Germany**, Seattle, WA (US)

(73) Assignee: **Chef'N Corporation**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/124,569**

(22) Filed: **Apr. 16, 2002**

(65) **Prior Publication Data**

US 2003/0192971 A1 Oct. 16, 2003

(51) **Int. Cl.**[7] .................................................. **A47J 43/04**
(52) **U.S. Cl.** .................................................. **241/169.1**
(58) **Field of Search** .............................. 241/169.1, 262, 241/168, DIG. 17, 285.3

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 1,020,380 A | 3/1912 | Williams | |
| 1,481,632 A | 1/1924 | Tatum | |
| 1,947,253 A | 2/1934 | Ellis | 60/52 |
| 3,237,873 A | 3/1966 | Raski | 241/27 |
| 4,226,370 A | 10/1980 | Watson | 241/30 |
| 4,374,574 A | 2/1983 | David | 241/169.1 |
| 4,573,244 A | 3/1986 | Holcomb et al. | 241/169 |
| 4,610,397 A | 9/1986 | Fischer et al. | 241/86 |
| 4,697,749 A | 10/1987 | Holcomb et al. | 241/169 |
| 4,830,291 A | 5/1989 | Williams | 241/73 |
| 5,082,190 A | 1/1992 | Chen | 241/169.1 |
| 5,660,341 A | 8/1997 | Perkins et al. | 241/93 |
| 5,685,501 A * | 11/1997 | Wagner | 241/169.1 |
| 5,730,374 A | 3/1998 | Wu | 241/169 |
| 5,988,543 A | 11/1999 | Wu | 241/168 |
| 6,616,076 B2 * | 9/2003 | Wong | 241/168 |

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| DE | 643 997 C | 4/1937 | |
| EP | 282259 A2 * | 9/1988 | A47J/42/10 |
| FR | 777375 A | 2/1935 | |
| FR | 821940 A | 12/1937 | |

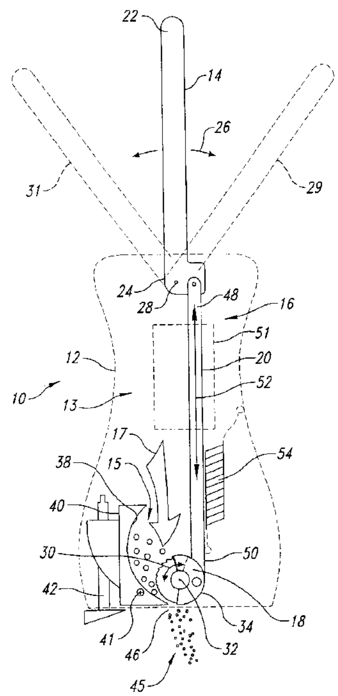
* cited by examiner

*Primary Examiner*—Allen Ostrager
*Assistant Examiner*—Jimmy T Nguyen
(74) *Attorney, Agent, or Firm*—Seed IP Law Group PLLC

(57) **ABSTRACT**

A mill for grinding a spice or grain material has a grinding mechanism including: a lever mounted for pivotal movement about a lever axis, a grinder bit mounted for rotational movement about a grinder bit rotational axis, the grinder bit rotational axis being at least approximately parallel to the lever axis, and a linkage coupled to the grinder bit and coupled to the lever to transfer pivotal movement from the lever to the grinding bit. The grinder bit may be cylindrical and include a gradated set of teeth. A cam pivots an engagement surface to adjust a spacing between the engagement surface and the grinding bit to select a size of resulting particles.

**35 Claims, 5 Drawing Sheets**



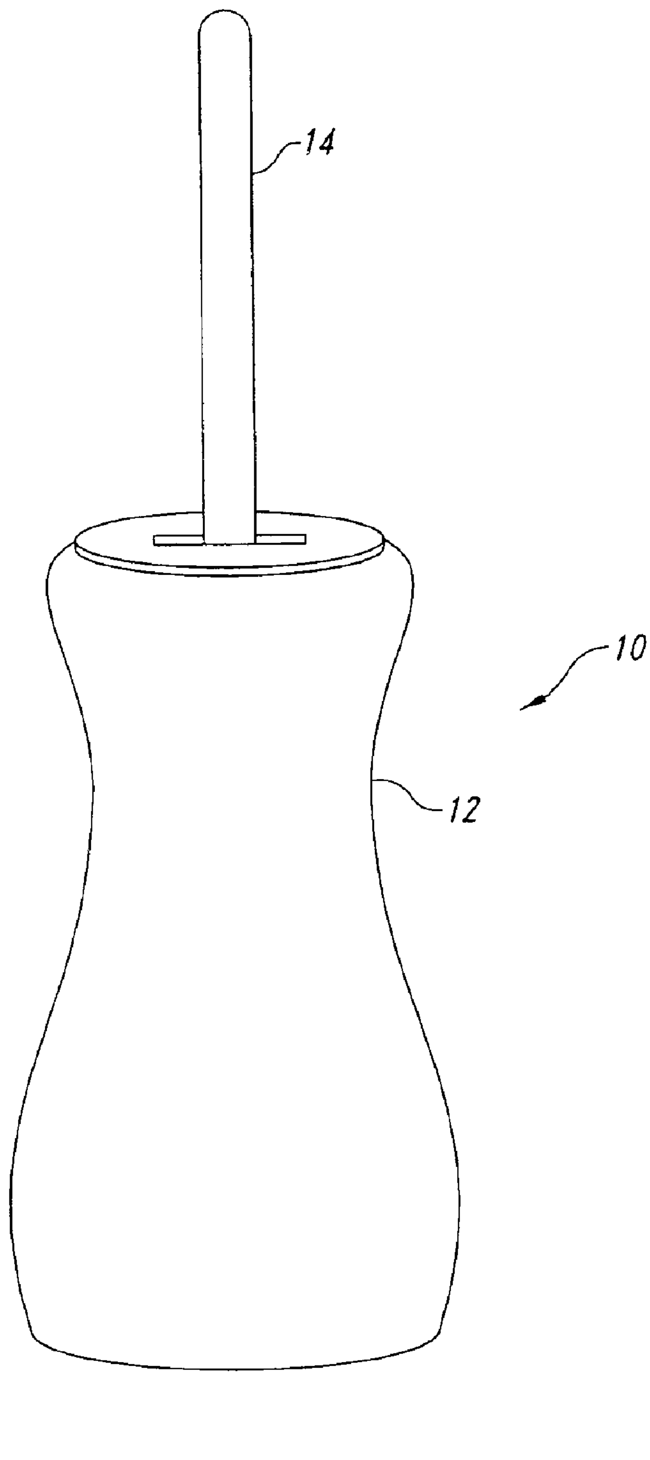



*Fig. 1*

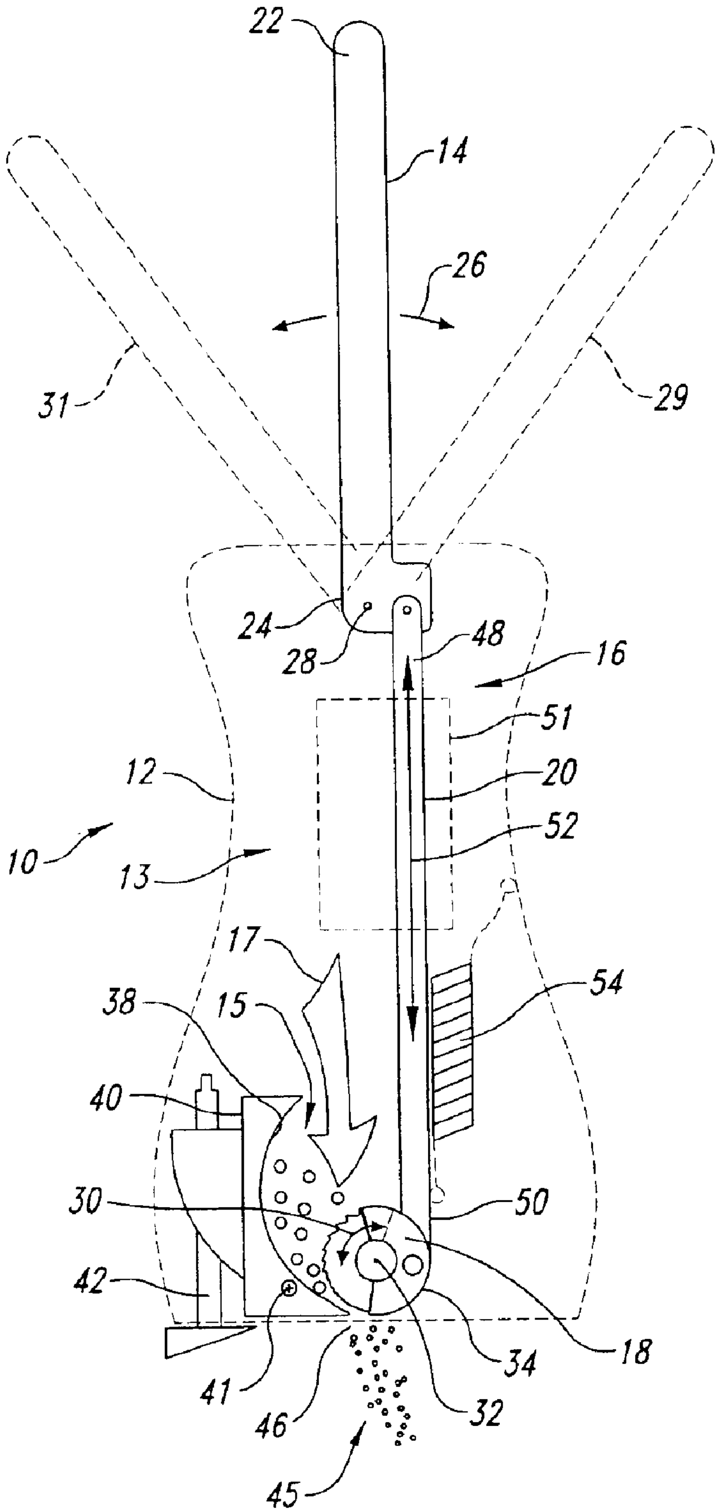

22
14
26
31
29
24
28
48
16
51
12
20
10
52
13
17
54
38
15
40
30
50
42
18
41
34
46
32
45

Fig. 2

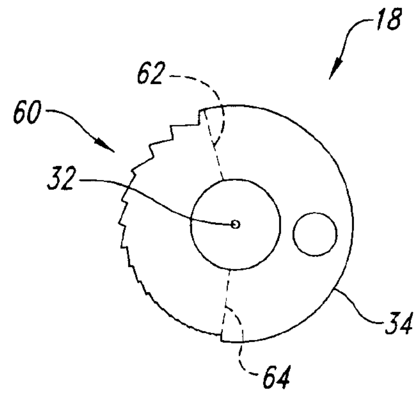



Fig. 3

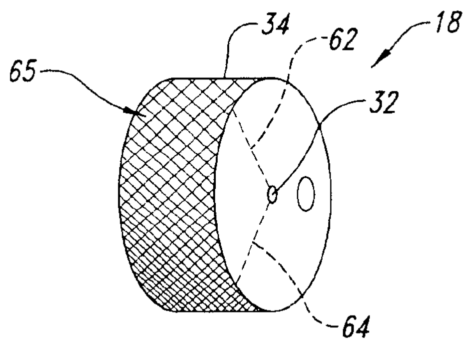



Fig. 4

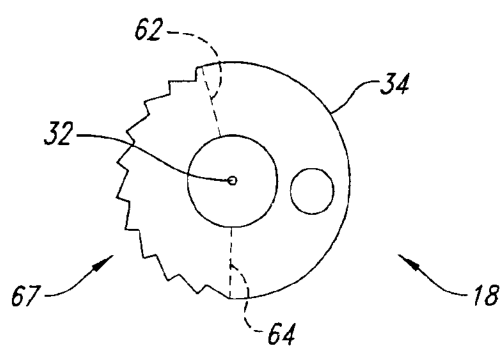



Fig. 5

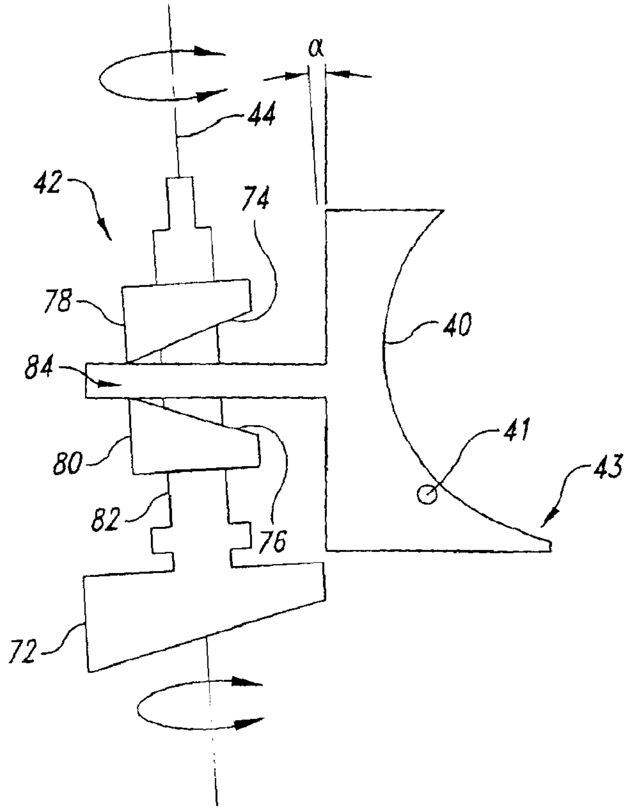

α
44
42
74
78
40
84
41
80
43
82
76
72

Fig. 6

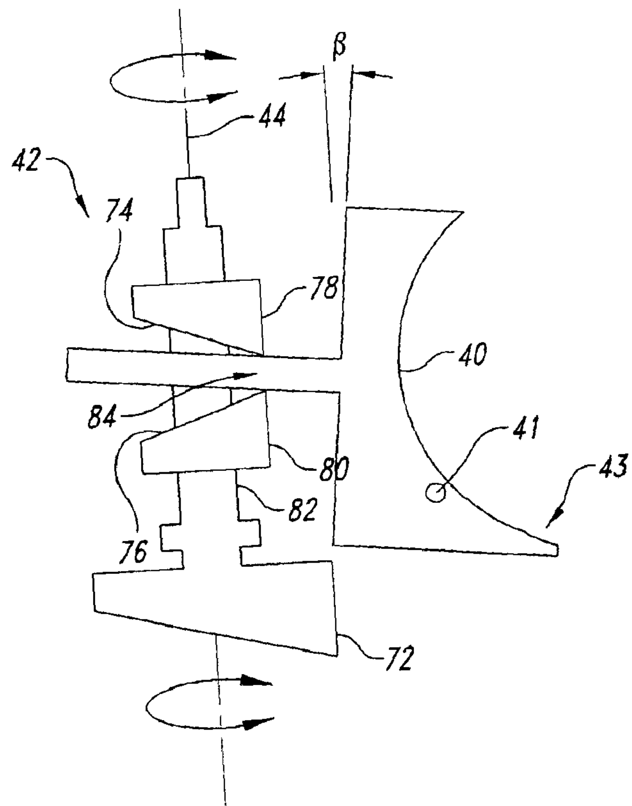

β
44
42
74
78
40
84
41
80
43
82
76
72

Fig. 7

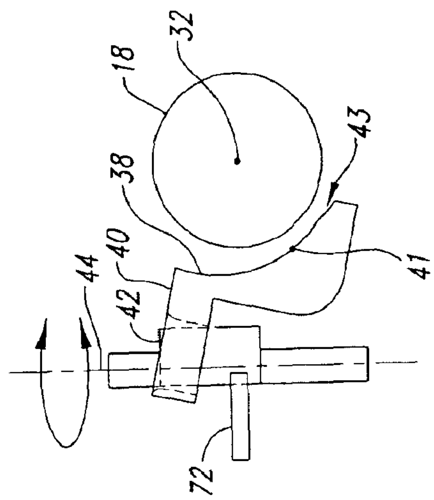



Fig. 12

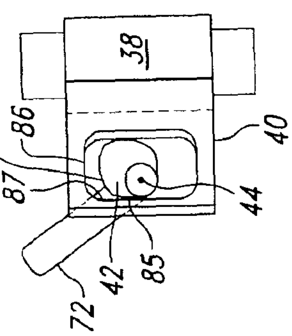



Fig. 13

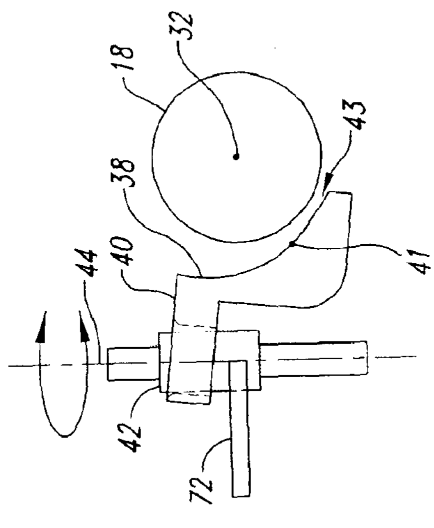



Fig. 10

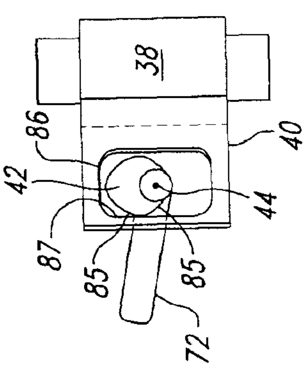



Fig. 11

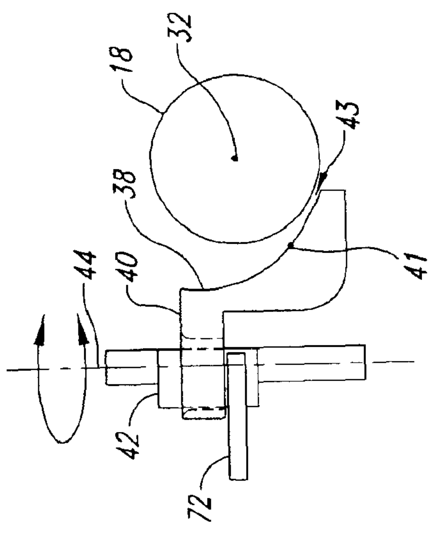



Fig. 8

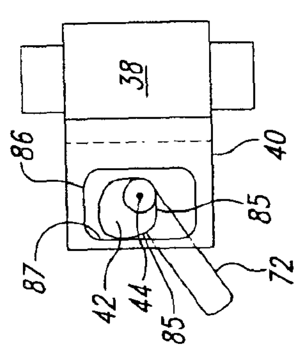



Fig. 9

# APPARATUS FOR GRINDING MATERIAL, SUCH AS SPICE OR GRAIN

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is generally related to grinding mechanisms, and more particularly to grinders or mills for grinding materials, such as spices and grain.

2. Description of the Related Art

Mills for grinding materials such as spices and grains are common household items. For example, pepper mills are ubiquitous in households and restaurants. Such mills generally include a housing or body which presents an attractive outward appearance, and which forms a chamber or reservoir for holding a material (e.g., peppercorns) to be ground. The body also typically encloses a grinding mechanism in fluid communication with the chamber, the grinding mechanism grinding the material and dispensing the ground material through an opening or exit in the bottom of the body. The grinding mechanism typically includes an actuator (e.g., crank arm, operating lever), a grinding bit, an engagement surface for cooperating with the grinding bit to grind the material therebetween, and a transmission drivingly coupling the actuator to the grinding bit. Often the body will form a second chamber, separate from the first chamber, for holding a material that does not requiring grinding (e.g., salt).

Most mills are hand operated and may be used by chefs or cooks in the preparation of food, or by servers and/or diners at dining tables. Many mills have a crank arm which is turned continuously and unidirectionally (e.g., clockwise or counterclockwise) with one hand of the user, while the other hand holds the mill in a generally vertical direction such that the ground material drops out of the bottom. Other mills have an operating lever which is reciprocatingly operated (i.e., bi-directionally) with the fingers or thumb of the hand holding the mill.

Typically, the grinding mechanisms fall into two categories, rotary mechanisms and linear mechanisms. Many rotary mechanisms are driven by turning a crank arm directly connected to a drive shaft of the grinding mechanism, which in turn is directly connected to the grinding bit. The crank arm, drive shaft and grinding bit each rotate about respective axes or rotation, the axes being parallel to each other, or even collinear. A number of rotary mechanisms are driven by reciprocating movement of an operating lever. Such rotary mechanisms include a grinding bit axially mounted on a drive shaft, and transmission means in the form of gears for translating the reciprocating motion of the operating lever into rotation of the drive shaft for driving the grinding bit. Again, the axes of rotation of the drive shaft and grinding bits are parallel or even collinear. Linear grinding mechanisms rely on linear movement of the grinding bit to grind the material. Typically, linear mechanisms employ the axial translation of a transmission element, such as a rack, to produce the linear translation of the grinding bit.

Most grinders also include mechanisms for adjusting the space between the grinding bit and the engagement surface to allow the user to select a desired grain size. In rotary mechanisms, the grinding bits are typically conical and having a uniform set of teeth around the periphery of the cone or truncated cone. The space between the engagement surface and the grinding bit may be adjusted by translating the conical grinding bit along its longitudinal axis with respect to the engagement surface. In linear mechanisms, the grinding bit typically takes the form of a straight or beveled surface having a set of uniform teeth. The space between the engagement surface and the grinding bit is adjusted by translating the grinding bit either toward or away from the engagement surface.

It is desirable to reduce the cost and complexity of mills. It is also desirable to produce mills that are sturdy and easy to operate. Further, it is desirable to provide a mill that efficiently and uniformly grinds material to any selected size.



## BRIEF SUMMARY OF THE INVENTION

In one aspect, a mill for grinding a spice or grain material includes a body, a grinder bit at least partially received in the body and mounted for pivotal movement about a grinder bit rotational axis, a linkage at least partially received in the body and mounted for translation in a linkage plane, the linkage plane being non-parallel to the grinder bit rotational axis, the linkage coupled to the grinder bit at a point on the grinder bit spaced from the grinder bit rotational axis, and an engagement surface opposed to the grinder bit and spaced therefrom to cooperatingly receive the material to be ground therebetween.

In another aspect, a grinding mechanism for a grinder includes a lever mounted for pivotal movement about a lever axis, a grinder bit having a grinding surface, the grinder bit mounted for rotational movement about a grinder bit rotational axis, the grinder bit rotational axis being at least approximately parallel to the lever axis, and a linkage coupled to the grinder bit and coupled to the lever to transfer pivotal movement from the lever to the grinding bit.

In a yet another aspect, a grinding mechanism includes a grinding bit mounted for rotation, an engagement member having an engagement surface opposed to the grinding bit, the engagement member mounted for pivotal movement about an adjustment axis with respect to the grinding bit to selectively adjust a space between the grinding bit and the engagement surface of the engagement member to receive material to be ground therebetween, and a cam mounted for rotation, the cam having a first cam surface engaging a portion of the engagement member.

In a further aspect, a grinding bit for a spice grinder includes a cylindrical body having a peripheral edge, and a number of grinding protuberances extending along the peripheral edge between a first angular position and a second angular position, the grinding protuberances being of at least two different sizes, the grinding protuberances gradating in size between the first and the second angular positions. The grinding protuberances may, for example, take the form of teeth or knurls.

In yet a further aspect, a spice mill includes a lever mounted for pivotal movement about a lever axis, rotatable means for grinding mounted for rotation about a grinder rotation axis, the grinder axis parallel to the lever axis, and axial linkage means for coupling pivotal movement of the lever to the rotatable grinding means.

In an even further aspect, a method of operating a grinding mechanism includes pivoting a lever about a lever axis and rotating a grinder bit about a grinder bit rotational axis at least approximately parallel to the lever axis in response to the pivoting of the lever about the lever axis.

In yet an even further aspect, a method of operating a grinding mechanism includes pivoting a cam about a cam axis, and pivoting an engagement surface about an adjustment axis with respect to a grinder bit where the adjustment

US006877684B2

(12) **United States Patent**
**Wu**

(10) **Patent No.: US 6,877,684 B2**
(45) **Date of Patent: Apr. 12, 2005**

(54) **GRINDING TOOL**

(75) Inventor: **Hua-Te Wu**, Tainan (TW)

(73) Assignee: **Yienn Lih Enterprise Co., Ltd.**, Tainan (TW)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 82 days.

(21) Appl. No.: **10/628,333**

(22) Filed: **Jul. 29, 2003**

(65) **Prior Publication Data**

US 2005/0023389 A1 Feb. 3, 2005

(51) **Int. Cl.**[7] .......................... **A02D 34/90**; A47J 42/00; A47J 43/00

(52) **U.S. Cl.** ..................... **241/169.1**; 241/168; 241/169

(58) **Field of Search** ................................ 241/168, 169, 241/169.1

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,343,437 A * 8/1982 Czelen .................... 241/169.1
4,374,574 A * 2/1983 David ..................... 241/169.1
5,082,190 A * 1/1992 Chen ....................... 241/169.1
6,533,199 B2 * 3/2003 Wu ......................... 241/169.1
6,616,076 B2 * 9/2003 Wong ......................... 241/168
2004/0069881 A1 * 4/2004 Arduini .................. 241/169.1

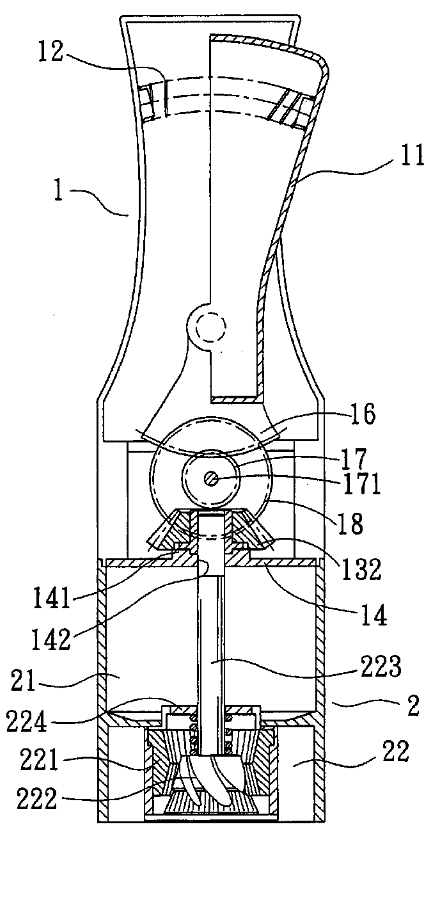
* cited by examiner

*Primary Examiner*—Allen Ostrager
*Assistant Examiner*—Jason Y Pahng
(74) *Attorney, Agent, or Firm*—Rosenberg, Klein & Lee

(57) **ABSTRACT**

A grinding tool operable with single hand includes a housing capable of standing upright, a lever, a one-way mechanism, and a grinding mechanism; the lever has an inner end formed with gear teeth, and is pivoted to the housing, and biased outwardly of the housing by a spring to be capable of being pushed and released repeatedly; the one-way mechanism has an actuating gear engaging the inner end of the lever, and a one-way bearing; the actuating gear is engaged with the bearing for causing angular displacement of the bearing together with it only when it is turned in a first direction by means of pushing the lever inwardly of the housing; the grinding mechanism includes an inner wheel turnable together with the bearing, and a stationary outer wheel around the inner wheel so that the contents can be ground between the wheels when the lever is pushed and released repeatedly.

**6 Claims, 10 Drawing Sheets**



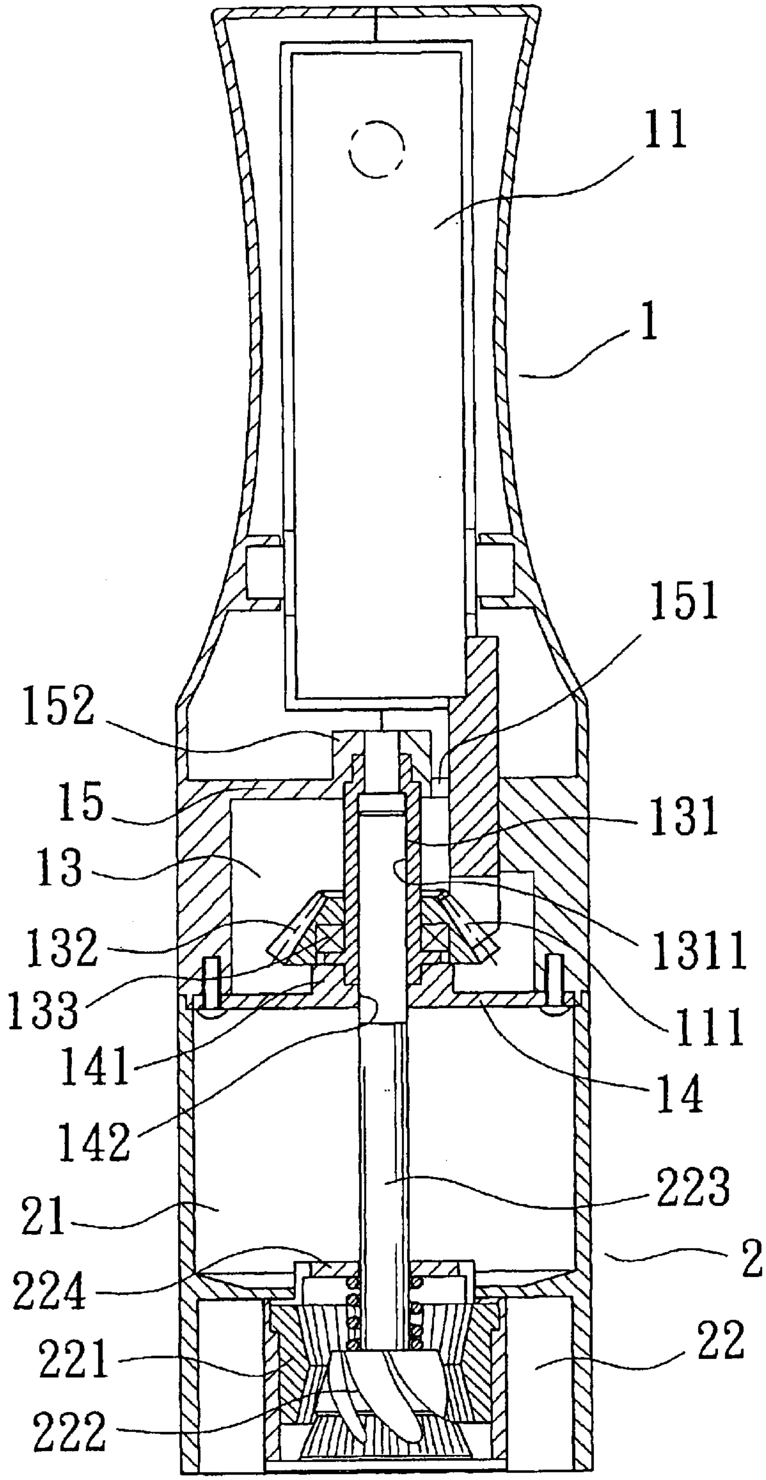

11
1
151
152
15
131
13
1311
132
111
133
141
14
142
223
21
2
224
221
22
222

FIG. 1

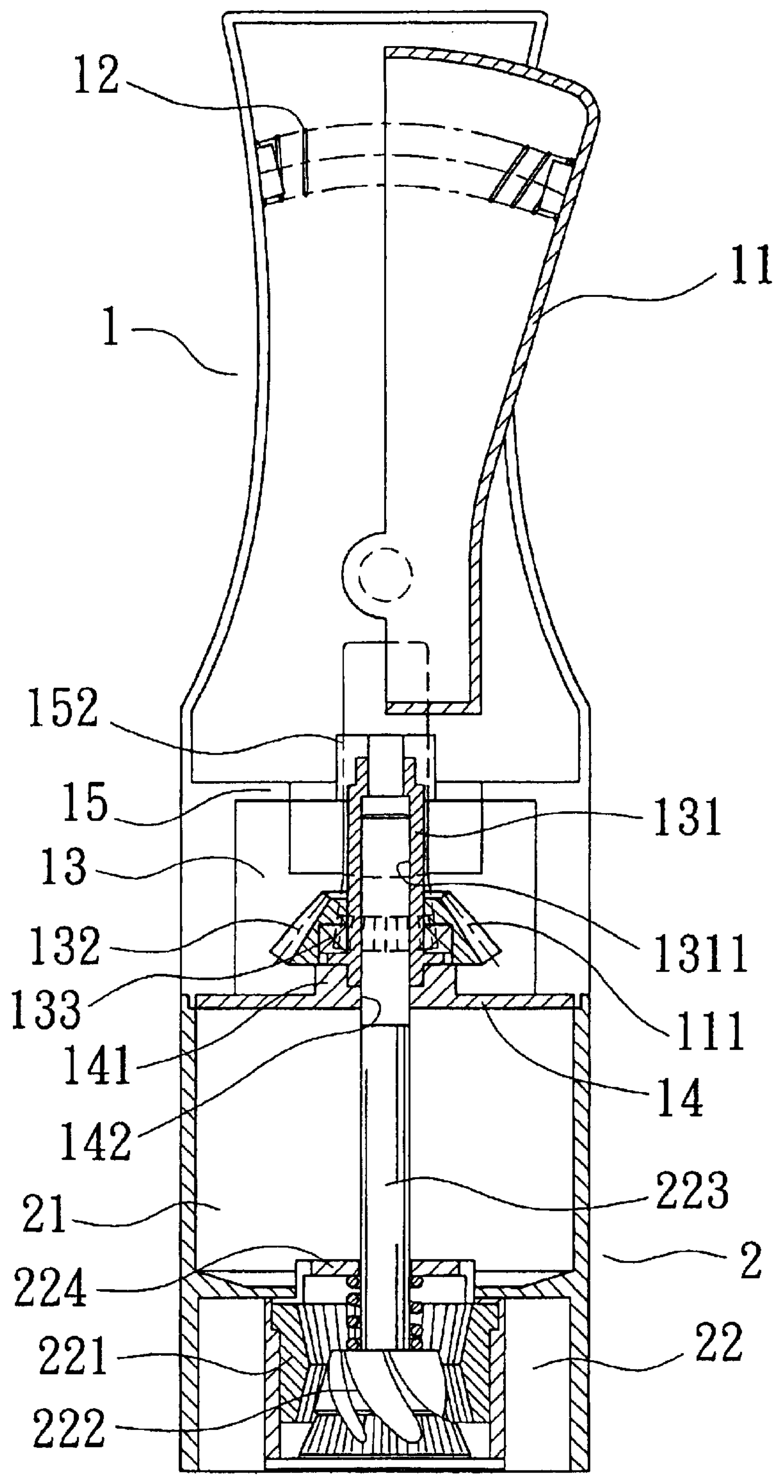

12
11
1
152
15
131
13
1311
132
133
111
141
14
142
223
21
2
224
221
22
222

FIG. 2

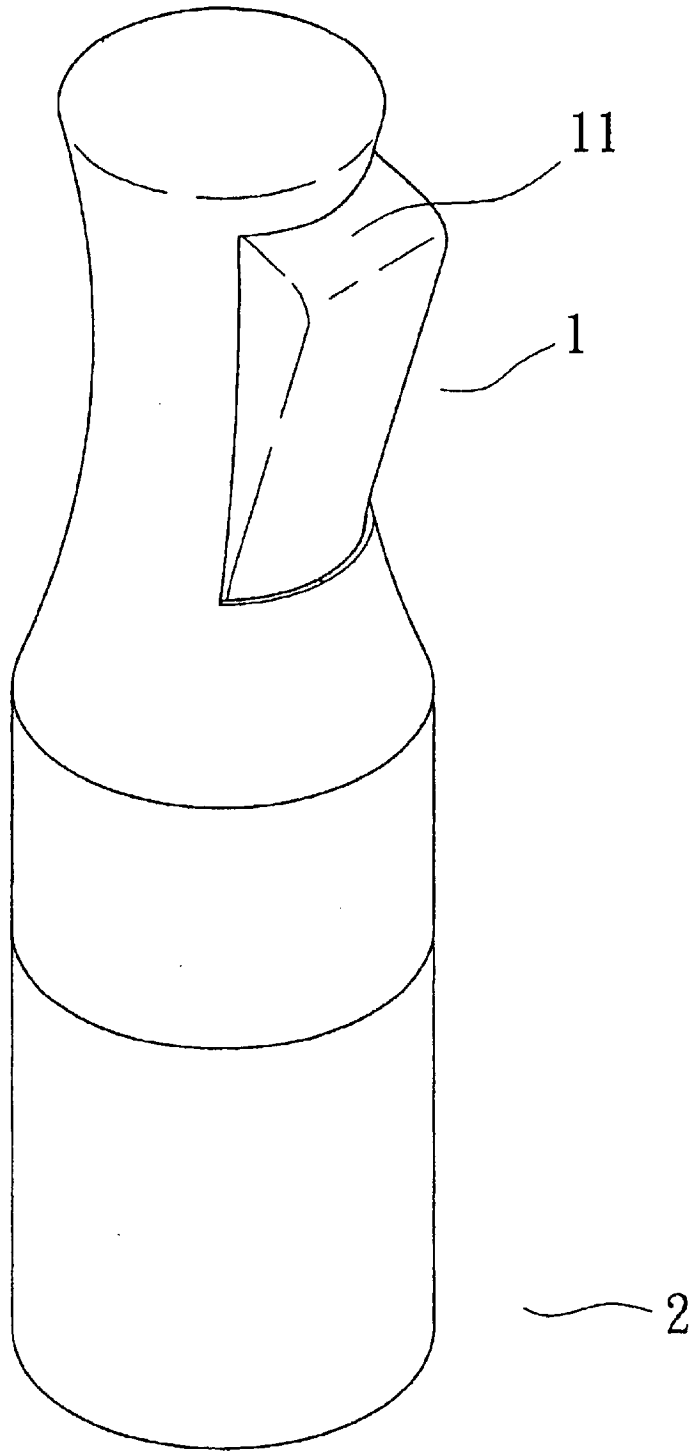



FIG. 3

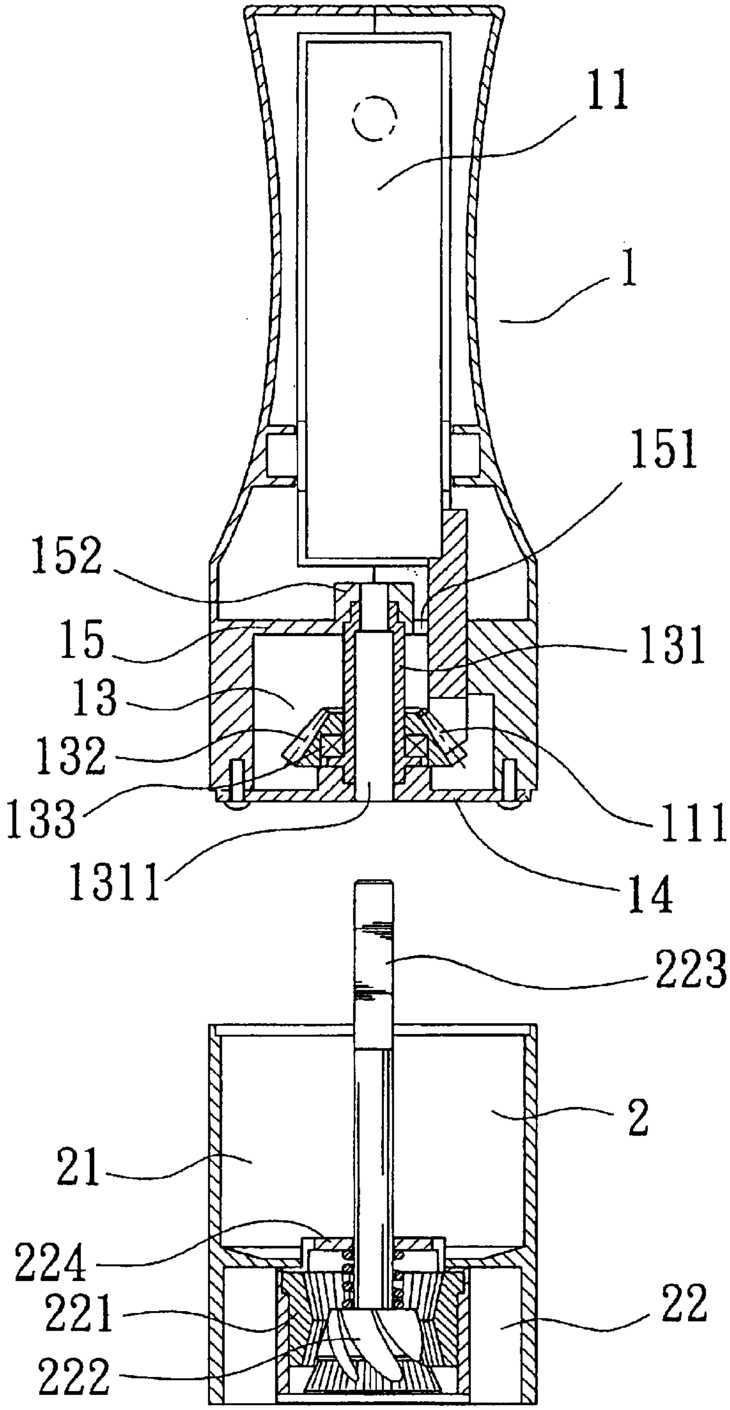



FIG. 4

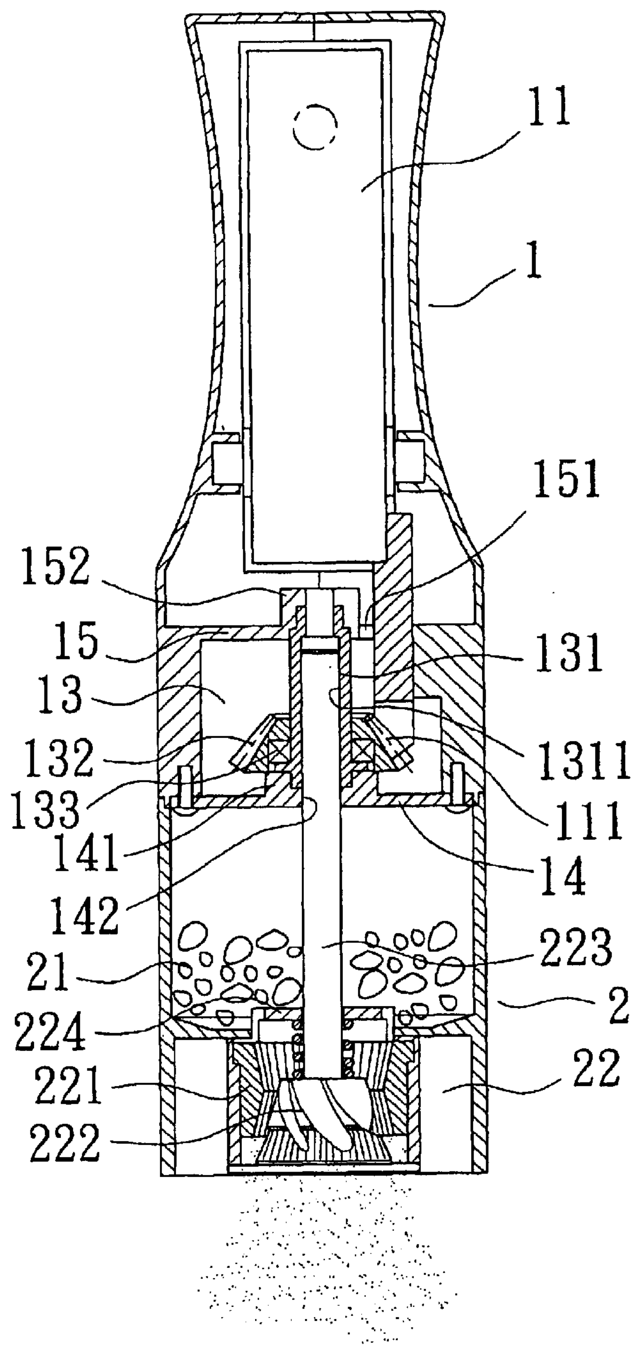

11
1
151
152
15
131
13
1311
132
133
111
141
14
142
223
21
2
224
22
221
222

FIG. 5

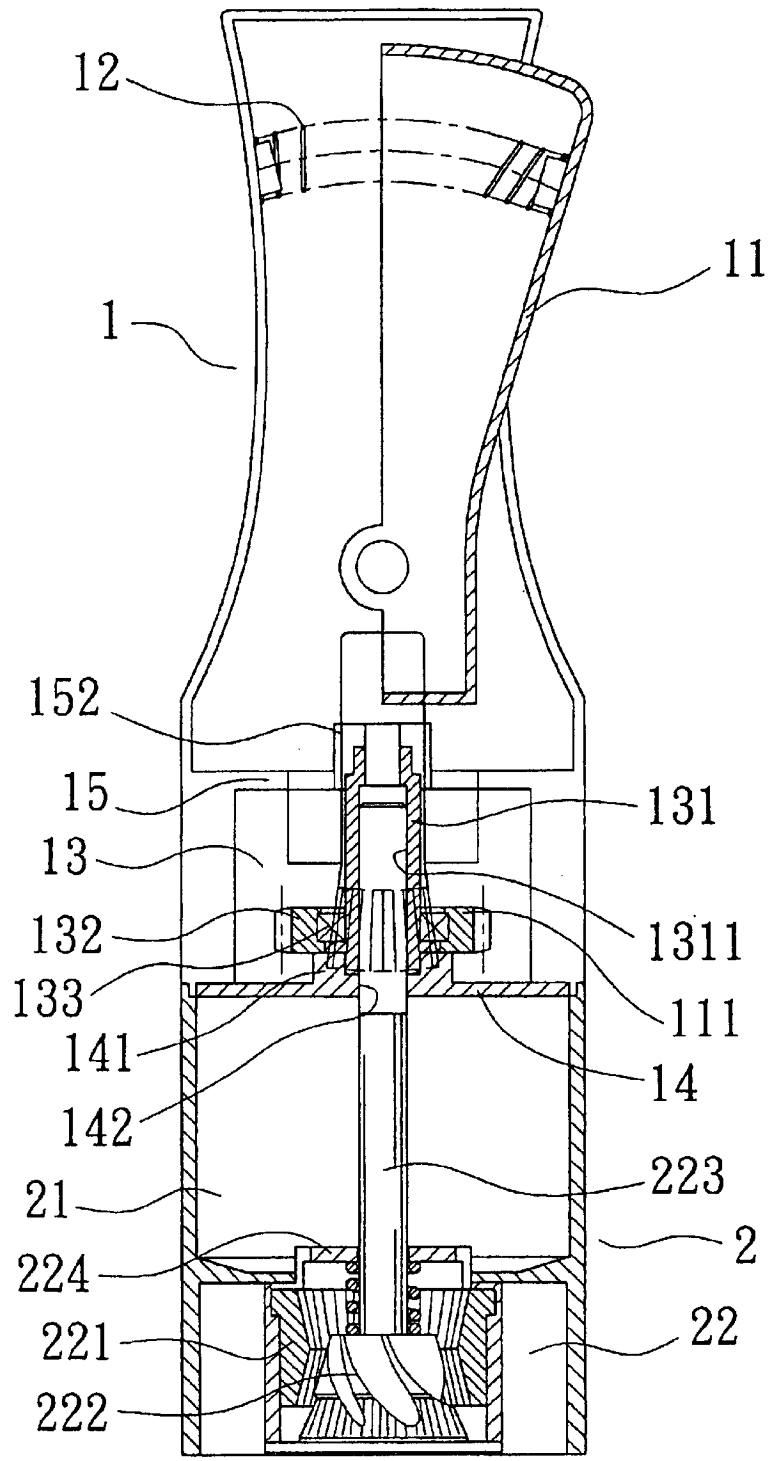

12
11
1
152
15
131
13
1311
132
133
111
141
14
142
223
21
2
224
22
221
222

FIG. 6

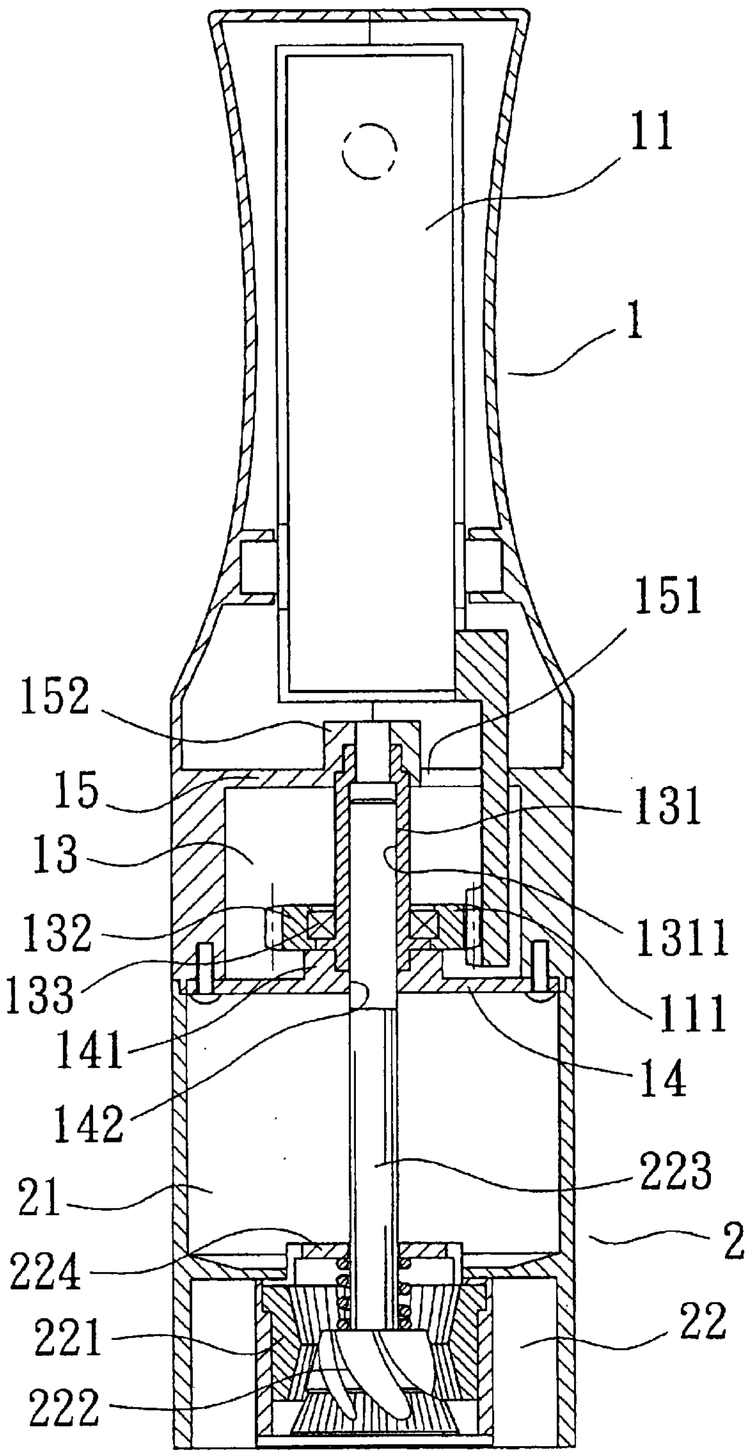

11
1
151
152
15
131
13
1311
132
111
133
141
14
142
223
21
2
224
22
221
222

FIG. 7

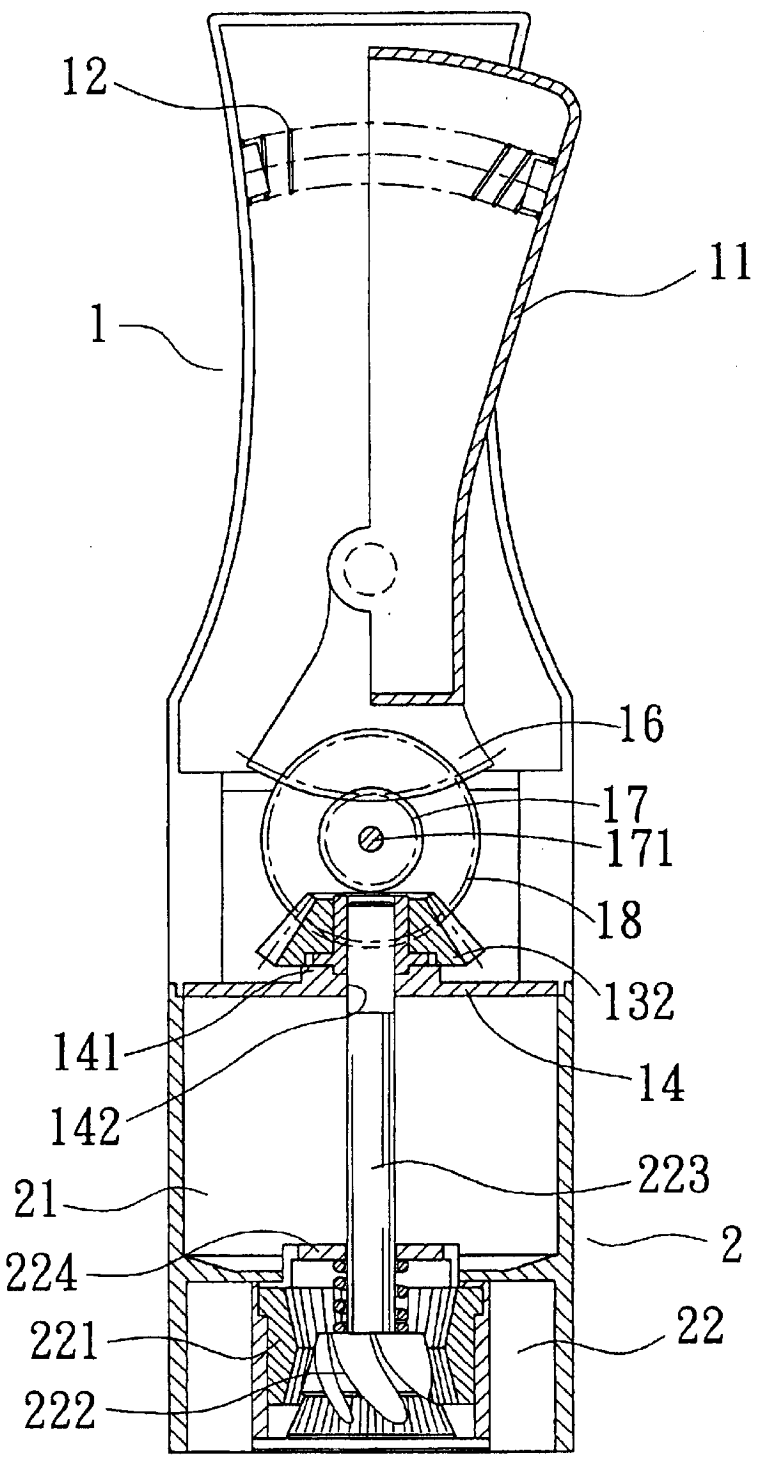



FIG. 8

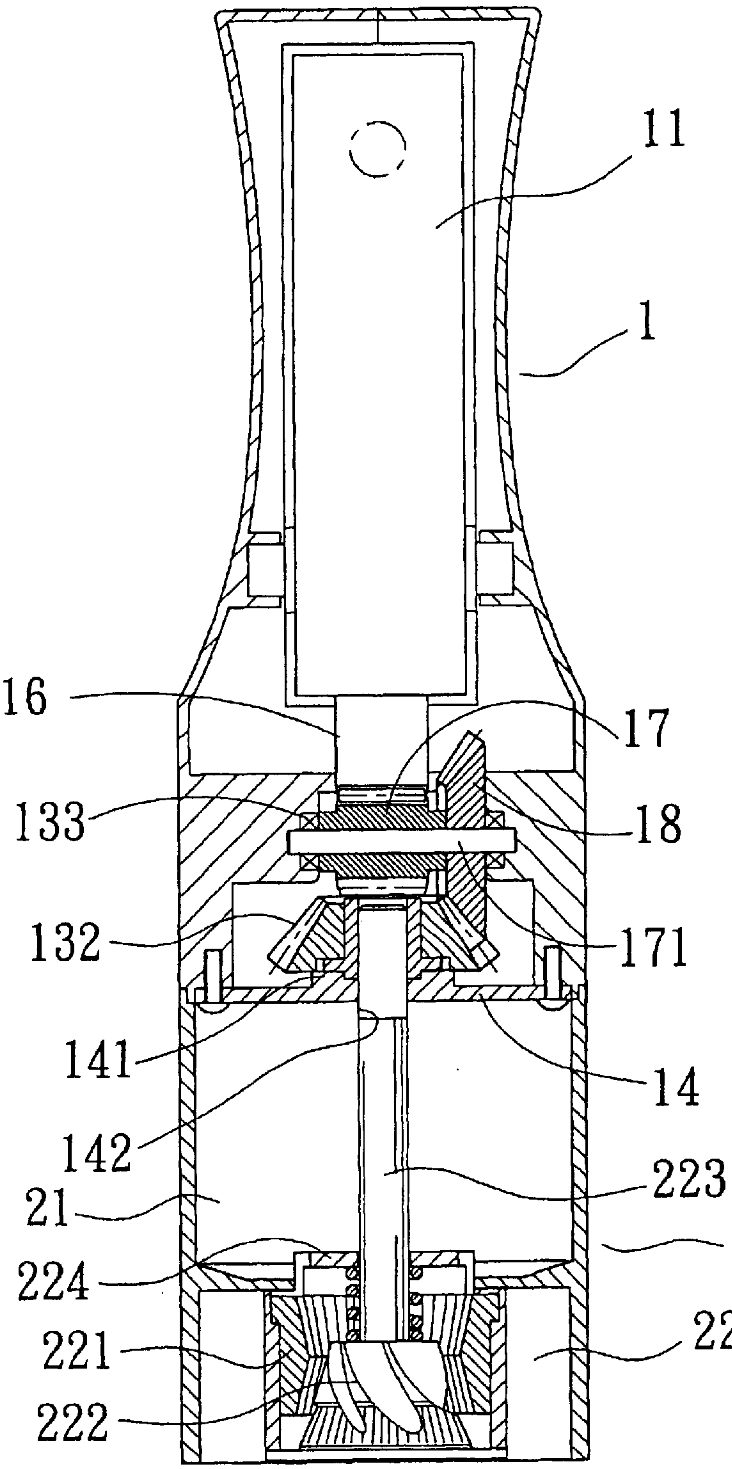



FIG. 9

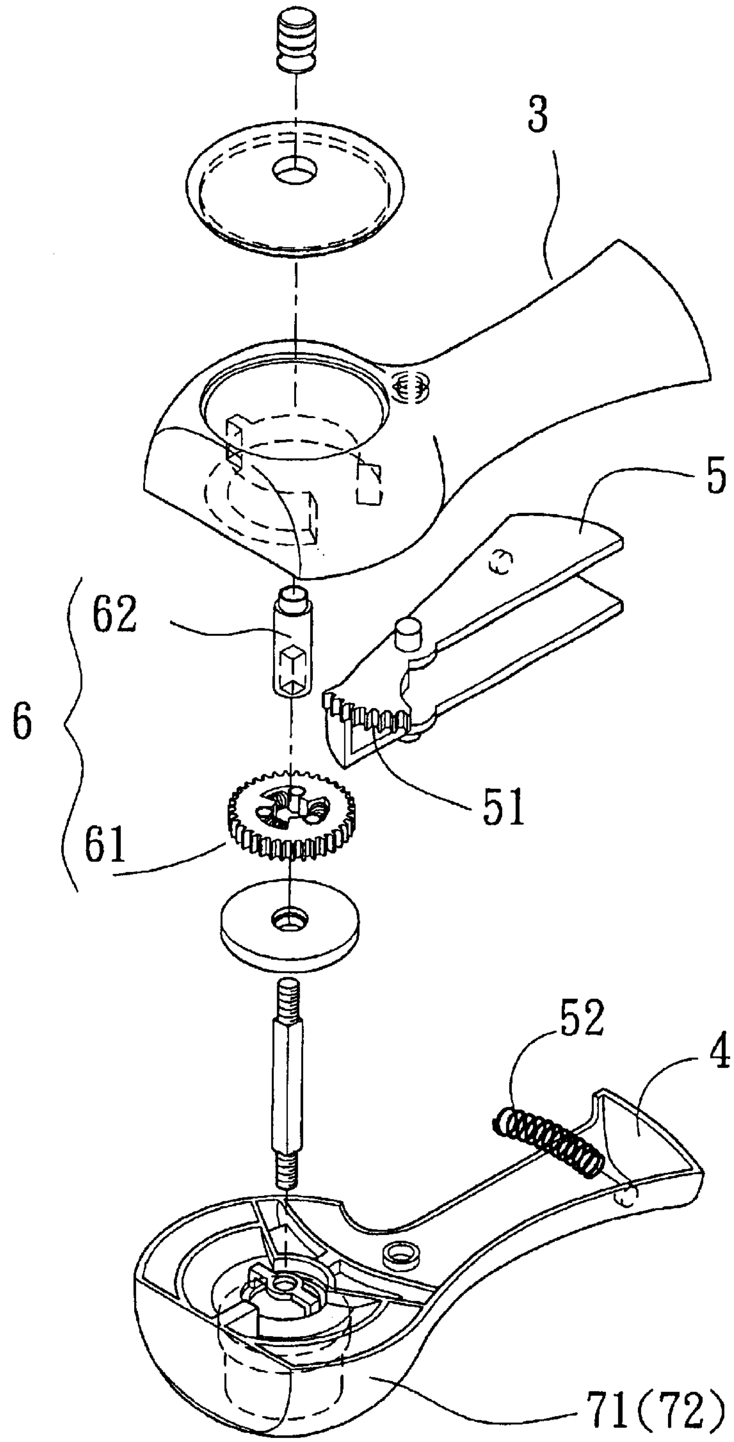



FIG. 10(PRIOR ART)

# GRINDING TOOL

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a grinding tool, more particularly one, which is made for use in an upright position according to ergonomics principles so as to be relatively easy to take hold of, convenient and easy to use, and capable of grinding the contents thereof more smoothly.

2. Brief Description of the Prior Art

Referring to FIG. **10**, a prior grinding tool was disclosed on a patent application, "PEPPER GRINDING TOOL WITH A SIDEWAYS LEVER OPERATED WITH ONE HAND" with application Ser. No. 09/948,911, with U.S. Patent and Trademark Office by the inventor of the present invention.

The grinding tool includes a housing, a lever, a one-way member, and a grinding assembly.

The housing includes an upper housing part **3** and a lower housing part **4** joined to the upper housing part **3**; the upper and the lower housing parts **3** and **4** each has a first portion, and a second elongated portion projecting sideways from the first portion; the second elongated portions of the housing parts form a lateral opening between them.

The lever **5** has teeth **51** on a front end, and is pivoted to the housing at an intermediate portion thereof with the teeth **51** facing the first portions of the upper and the lower housing parts **3** and **4**, and with a rear portion thereof being biased outwardly of the lateral opening of the housing by a first spring **52** connected to both the lever **5** and one of the second portions of the housing parts **3** and **4**.

The one-way member **6** is received in angularly displaceable manner in the first portions of the housing. The one-way member **6** has a round main body **61** having teeth on an outer side abutting the teeth **51** of the lever **5**. The main body **61** is connected in selectively engaged manner to a tube **62**; the main body **61** will be engaged with the tube **62** for angular displacement therewith in a first direction responsive to the lever **5** being pushed inwardly of the second portions of the housing parts **3** and **4**; the main body **61** will be disengaged from the tube **62** for angular displacement relative thereto in a second direction opposing the first direction responsive to the lever **5** being reversibly displaced from the pushed position by means of the spring **52**.

The grinding assembly includes an outer grinding element **71** secured in the first portion of the lower housing part **4**, and an inner grinding element **72** received in angularly displaceable manner in the outer grinding element **71**. The inner grinding element **72** is connected to a lower end of the tube **62** so as to turn relative to the outer grinding element **71** when the elongated portion of the housing is held in a laid down horizontal position with one hand, and the lever **5** is pushed inwardly of the second portion of the housing and released repeatedly.

The grinding tool is found to have disadvantages as followings:

1. Because the grinding tool can only be put away in a laid down position, the outer end of the elongated portion of the housing is prone to be undesirably made to touch the table when the grinding tool is put on the table. Consequently, it is not convenient for the user to take hold of the grinding tool from the laid down position.
2. The user is likely to have a sore wrist after having been operating the grinding tool for extended period of time because he has to operate the tool while holding it in a laid down position.
3. Pepper corns contained in the housing have to pass through the one-way member before they pass into the grinding assembly, and in turns, working of the one-way member will be made less smooth by the pepper corns.



## SUMMARY OF THE INVENTION

It is a main object of the present invention to provide a single-hand operated grinding tool to overcome the above disadvantages.

The grinding tool includes a housing capable of standing upright on the table, a lever, a one-way mechanism, and a grinding mechanism. The one-way mechanism has a actuating gear engaged with a toothed end of the lever, and a one-way bearing; the actuating gear is engaged with the one-way bearing for angular displacement of the bearing together with it only when it is turned in a first direction by means of pushing the lever inwardly of the housing. The grinding mechanism includes an inner wheel turnable together with the bearing, and a stationary outer wheel around the inner wheel so that the contents can be ground between the wheels when the housing is held in substantially upright position, and when the lever is pushed and released repeatedly.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood by referring to the accompanying drawings, wherein:

FIG. **1** is a vertical section of the grinding tool according to the present invention,

FIG. **2** is another vertical section of the grinding tool according to the present invention,

FIG. **3** is a perspective view of the grinding tool according to the present invention,

FIG. **4** is a vertical cross-sectional view of the upper and the lower bodies of the present grinding tool, separated from each other,

FIG. **5** is a view showing the operation of the grinding tool according to the present invention,

FIG. **6** is a vertical section of the grinding tool in the second embodiment,

FIG. **7** is another vertical section of the grinding tool in the second embodiment,

FIG. **8** is a vertical section of the grinding tool in the third embodiment,

FIG. **9** is another vertical section of the grinding tool in the third embodiment, and

FIG. **10** an exploded perspective of the prior grinding tool as described in the Background.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a preferred embodiment of a grinding tool in the present invention includes a housing, a lever **12**, a one-way mechanism **13**, and a grinding mechanism **22**.

The housing includes an upper body **1**, and a lower body **2** releaseably joined to a lower end of the upper body **1**. The upper body **1** has an elongated upper portion, and a transverse separating board **15** fixedly disposed in a lower portion. The board **15** has an annular holding projection **141** formed on the middle, and an elongated hole **151** formed thereon. The upper body **1** has a transverse locating board **14** fixedly disposed under the transverse separating board **15**.

The board **14** has an annular holding projection **141** formed on the middle thereof. The lower body **2** has a transverse locating portion **224** fixedly disposed therein, a holding room **21** above the transverse locating portion **224**, and a lower room under the locating portion **224** for receiving the grinding mechanism **22** therein. The locating portion **224** is formed in such a manner that pepper corns in the holding room **21** can fall into the grinding mechanism **22**. To load the grinding tool with pepper corns, the upper body **1** is separated from the lower body **2**, and pepper corns are put into the holding room **21** of the lower body **2**.

The lever **11** is pivoted to the upper body **1** at an intermediate portion thereof. An elastic element **12** is connected to both an upper end of the lever **11** and an upper end of the upper body **1** to bias the lever upper end away from the upper end of the upper body **1**. The lever **11** is passed through the elongated hole **151** of the separating board **15** at a lower end. The lower end of the lever **11** has a sector-shaped lower end **111**, which is formed with gear teeth.

The one-way mechanism **13** includes a tube **131**, an actuating gear **132** in the form of a bevel gear, and a one-way bearing **133**, and is received in between the boards **14** and **15** of the upper body **1**; the one-way bearing **133** is connected in selectively engaged manner to an annular inner side of the actuating gear **132**. In other words, the bearing **133** will turn together with the actuating gear **132** when the actuating gear **132** is turned in a first direction by means of pushing the lever **11** close to the upper end of the upper body **1** and then releasing the lever **11** repeatedly, but the bearing **133** won't turn together with the gear **132** when the actuating gear **132** is turned in a second direction opposite to the first direction by means of releasing the lever **11** from the pushed position. The tube **131** is securely connected to an annular inner side of the one-way bearing **133**, and is passed into the annular holding projections **152** and **141** at two ends so as to be rotary between the boards **15** and **14**. The tube **131** further has an axial hole **1311**, which is formed with a polygonal cross-section.

The grinding mechanism **22** is received in the lower room of the lower body **2**, and includes an outer grinding wheel **221** secured in position, an inner grinding wheel **222** received in angularly displaceable manner in the outer grinding wheel **221**, and a spring disposed between the locating portion **224** and the inner wheel **222**. A transmission shaft **223** is connected to the inner grinding wheel **222**. The shaft **223** is formed with a square cross-section at an upper end, and is passed into the axial hole **1311** of the tube **131**. Thus, rotation of the tube **131** can be passed on to the inner grinding wheel **222** via the shaft **223**, and the inner grinding wheel **222** will turn relative to the outer grinding wheel **221** in single direction to grind the contents of the lower body **2** between it and the outer wheel **221** when the upper body **1** of the housing is held upright with one hand, and the lever **11** is pushed close to the upper end of the upper body **1** and released repeatedly.

Referring to FIGS. **5**, and **6**, actuating gear **132** can be a face gear instead of a bevel gear according to the second embodiment.

Referring to FIGS. **8**, and **9**, the lever **11** is formed with a curved lower end **16** instead, which has spur gear teeth thereon, while a spur gear **17** is arranged in the upper body **1** of the housing, and engages the spur gear teeth of the curved lower end **16**. And, the spur gear **17** has a central shaft **171**, which is fitted into one-way bearings **133** at two ends thereof, and which is passed through, and fixed to a bevel gear **18**. The bevel gear **18** engages the actuating gear **132** so that rotation thereof can be passed on to the actuating gear **132**. Thus, the grinding tool of the third embodiment can work in the same way as the above embodiments.

From the above description, it can be easily understood that the grinding tool of the present invention has advantages as followings:

1. Because the grinding tool can be put away on the table in an upright position when it is not used, it is relatively easy and convenient for a user to take hold of the grinding tool again.
2. The user operates the grinding tool when holding the tool in the upright position therefore he is less likely to have a sort wrist after having been operating the tool for extended period of time.
3. Pepper corns are contained in the lower body therefore they won't pass into the one-way mechanism **13** to hinder smooth working of the one-way mechanism.

What is claimed is:

**1**. An improvement on a grinding tool, comprising

a housing includes an upper body and a lower body releaseably joined to a lower end of the upper body;

a lever having a sector-shaped lower end formed with gear teeth; the lever being pivoted to the upper body at an intermediate portion thereof; an upper end of the lever being biased away from an upper end of the upper body by a first elastic element connected to both the lever and the upper body;

a one-way mechanism received in angularly displaceable manner in the upper body of the housing; the one-way member having an actuating gear abutting the gear teeth of the lever; the one-way mechanism having a one-way bearing connected to an annular inner side of the actuating gear; the one-way mechanism having a tube securely connected to an annular inner side of the one-way bearing; the actuating gear being engaged with the one-way bearing for angular displacement therewith in a first direction responsive to the lever being pushed close to the upper end of the upper body; the actuating gear being disengaged from the one-way bearing for angular displacement relative thereto in a second direction opposing the first direction responsive to the lever being reversibly displaced from the pushed position by means of the first elastic element; and

a grinding mechanism including an outer grinding wheel secured in a lower end of the lower body of the housing, and an inner grinding wheel received in angularly displaceable manner in the outer grinding wheel; the inner grinding wheel being connected to a lower end of the tube so as to turn relative to the outer grinding wheel to grind contents of the lower body therebetween when the housing is held substantially upright with one hand, and the lever is pushed close to the upper end of the upper body and released repeatedly.

**2**. The grinding tool as claimed in claim **1**, wherein the upper body of the housing has a transverse separating board in a lower end portion, and a transverse locating board under the transverse separating board; the boards having annular holding projections formed on middles thereof; the tube of the one-way mechanism being passed into the annular holding projections at two ends thereof.

**3**. The grinding tool as claimed in claim **1**, wherein the tube of the one-way mechanism has an axial hole formed with a polygonal cross-section while a transmission shaft is connected to the inner grinding wheel, and the tube at lower and upper ends thereof respectively; the upper end of the transmission shaft being formed with a square cross-section, and passed into the axial hole of the tube.

**4**. The grinding tool as claimed in claim **1**, wherein the actuating gear is a bevel gear.

**5**. The grinding tool as claimed in claim **1**, wherein the actuating gear is a face gear.

**6**. The grinding tool as claimed in claim **1**, wherein the lever is formed with a curved lower end instead, which has spur gear teeth thereon, while a spur gear is arranged in the upper body of the housing, and engages the spur gear teeth of the curved lower end of the lever; the spur gear having a central shaft fitted into one-way bearings at two ends thereof; the central shaft being passed through, and fixed to a bevel gear; the actuating gear being engaged with the bevel gear instead.

* * * * *