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PULVERIZER HAVING ULTRASONIC DRIVE MEANS

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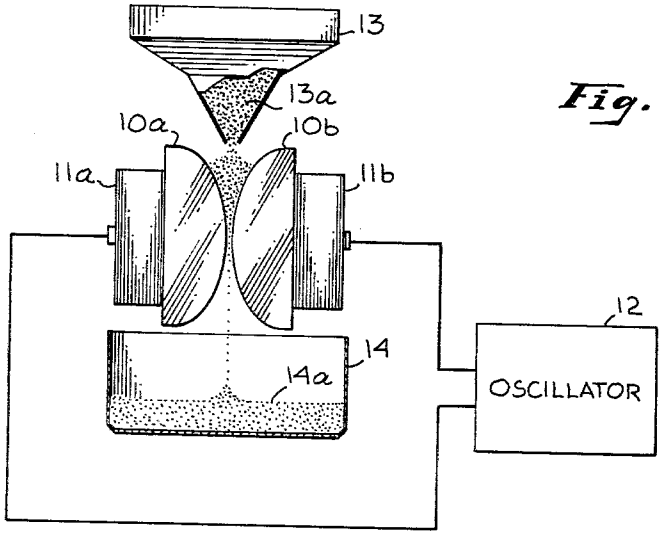


Fig. 1

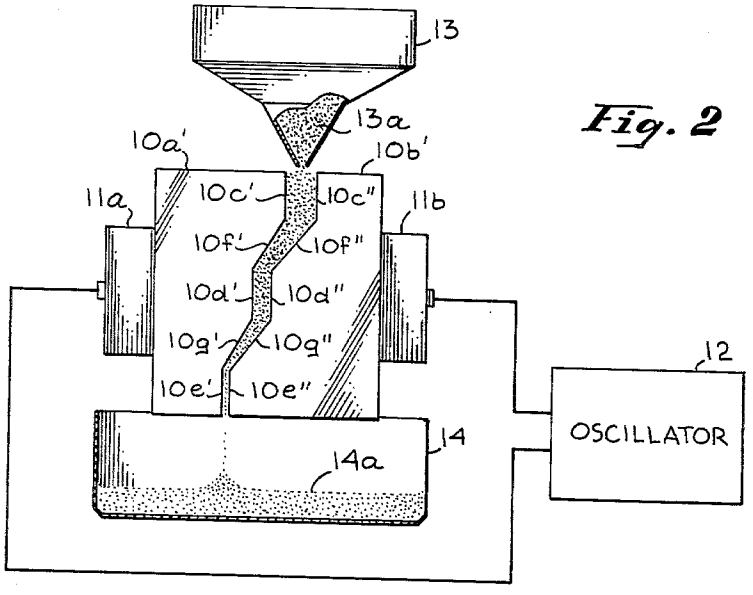


Fig. 2

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PULVERIZER HAVING ULTRASONIC DRIVE MEANS

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The present invention relates to pulverizing equipment in general and more particularly relates to ultrasonic pulverizing apparatus by means of which materials can be reduced to small particle size under accurately controlled conditions.

To pulverize is to reduce a material to a fine powder or dust, as by beating or grinding, and it goes without saying that the pulverization of materials plays a most important role in many industrial processes and in the preparation of many different kinds of commercial products, such as pigments, flour, powdered chemicals and medicines, and still others.

Probably the simplest kind of pulverizing apparatus, one with which we are all familiar, is the mortar and pestle. In another kind of pulverizer, usually found only in industry, large rotating spheres or cylinders are brought together, the material being crushed and ground between the contacting surfaces of the spheres or cylinders until they are reduced to the desired powdery state. However, although machines of the kind mentioned are perfectly satisfactory for many purposes, they are nevertheless limited in two important respects, namely, they are relatively slow-acting and the sizes of the particles produced by them cannot be controlled to the extent oftentimes desired.

It is, therefore, an object of the present invention to provide an ultrasonically-driven pulverizer and, therefore, one that is relatively fast-acting.

It is another object of the present invention to provide a pulverizer whose particle sizes can be accurately and easily controlled.

The present invention avoids the limitations of the pulverizing equipment encountered in the prior art, the basic concept of the invention residing in ultrasonically driving a pair of walls or plates, the initial spacing between the plates and their displacement due to their ultrasonic vibration determining the resulting particle sizes within accurately controlled limits. As will be seen below from the detailed description of the invention, by suitably shaping the walls, the materials to be pulverized may be gradually reduced in size and, in addition, may have shearing forces applied to them as well.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only and is not intended as a definition of the limits of the invention.

FIG. 1 schematically illustrates a preferred embodiment of a pulverizer according to the present invention; and

FIG. 2 schematically illustrates another embodiment of the invention in which shearing as well as pulverizing forces are developed.

Referring now to the drawing, the embodiment in FIG. 1 therein is shown to include a pair of convex-shaped walls or plates **10***a* and **10***b* with the convex surfaces of these walls facing each other. Respectively mounted on

or appropriately coupled to walls **10***a* and **10***b* are a pair of transducers **11***a* and **11***b*, both of which are electrically connected to an oscillator **12**.

Walls **10***a* and **10***b* may be made out of any material, the only requirement being that they be made of a material that is harder than the material they are to crush or pulverize. Transducers **11***a* and **11***b* may be of the magnetostrictive, piezoelectric or ferroelectric kind, all of which are well known, the only requirement here being that the design of the transducers be such that they are able to deliver the amount of power required by the walls. With respect to oscillator **12**, it should be able to generate signals at frequencies in the sonic and utlrasonic ranges and at a power level sufficient to meet the needs of the machine.

A complete system would also include a hopper **13** by means of which the material to be pulverized is fed to the pulverizer as well as a tank or receptacle **14** for collecting and holding the already pulverized material. The material before it is pulverized, that is, the material in hopper **13**, is designated **13***a* whereas the already pulverized material collected in tank **14** is designated **14***a*.

In considering the operation, it will be assumed that walls **10***a* and **10***b* are initially stationary and that the spacing between them at their closest points is "*d*." It will also be assumed that some of the material to be pulverized has been fed into the space between the upper parts of the walls, as is shown in the figure. If, now, oscillator **12** is turned on, transducers **11***a* and **11***b* will cause walls **10***a* and **10***b* to vibrate toward and away from each other at an ultrasonic rate, the walls crushing material **13***a* as they approach each other. The curvature of the walls, that is to say, their convex configuration, is important because it makes it possible to pulverize the material gradually as it moves downward toward and through the narrowest space between the walls. Thus, the larger pieces of material are broken up or divided at the wider regions of the space between the walls and, as these pieces settle, they are more finely divided up at the narrower regions. In other words, due to the configuration of the walls, material **13***a* is first coarsely divided and then finely divided, the final praticle size of the pulverized material being determined by the abovesaid separation "*d*" of the walls and the vibrational displacement of the walls. If the displacement of each of the walls is designated Δx, then the minimum separation between the walls and, therefore, the smallest particle size possible is $d-2\Delta x$. On the other hand, the maximum separation between the walls and, therefore, the largest particle size possible is $d+2\Delta x$. It is thus seen that particle size may vary only from $d-2\Delta x$ to $d+2\Delta x$ and that the ranges of particle size may be controlled by changing the actual values of "*d*" or Δx, or both.

Pulverizing walls **10***a* and **10***b* may be modified to provide shearing forces as well to material **13***a*, as is shown in FIG. 2 wherein the modified walls are respectively designated **10***a'* and **10***b'*. As shown, the opening or spacing between the walls is both staggered and tapered in a staircase type of arrangement, the upper region between them being wider than the lower region. In the FIG. 2 embodiment, the vertical sides of the wall surfaces facing each other are respectively designated **10***c'* and **10***c''*, **10***d'* and **10***d''*, and **10***e'* and **10***e''*. These other sides that apply solely pulverizing forces to the material. The sloping sides of the walls, on the other hand, are respectively designated **10***f'* and **10***f''* and **10***g'* and **10***g''*, and these are the sides that apply both pulverizing and shearing forces to the material.

In its operation, the larger pieces of material **13** are fed into the relatively wide space between sides **10***c'* and **10***c''*.

Upon turning on oscillator **12** and with the resulting vibration of walls **10***a'* and **10***b'*, these pieces are broken up into smaller pieces which ultimately move or settle in the narrow space between sides **10***f'* and **10***f''*. Here the material is simultaneously pulverized and sheared, the still smaller pieces resulting therefrom again settling still lower between sides **10***d'* and **10***d''*. This process continues until the particles are sufficiently reduced in size to fit between sides **10***e'* and **10***e''* where they are pulverized to their final fine particle size before becoming deposited in tank **14**. As before, the final particle size is determined by the initial spacing "*d*" between sides **10***e'* and **10***e''* and the vibrational displacement Δx of the walls, either or both of which may be varied.

Although a couple of arrangements of the invention have been illustrated above by way of example, it is not intended that the invention be limited thereto. More specifically, it should be recognized that walls **10** may be given any one of a number of different shapes and sizes and that the spacings between them may also be varied. Again, by way of example, one wall may be kept stationary and the other wall moved against it. Accordingly, the invention should be considered to include any and all modifications, alterations or equivalent arrangements falling within the scope of the annexed claim.

Having thus described the invention, what is claimed is:

Pulverizer apparatus comprising: a pair of walls movably positioned in face-to-face relationship, each oppositely associated face being alternately vertical and inwardly and downwardly inclined at substantially the same angle on the same side relative to a vertical plane in order to provide both pulverizing and shearing forces to material fed between said walls; a pair of ultrasonic transducer elements respectively mounted on said pair of walls for vibrating said walls toward and away from each other in response to a single applied thereto at an ultrasonic frequency; and an oscillator for applying a signal at an ultrasonic frequency to said pair of transducers.

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