

Feb. 11, 1958

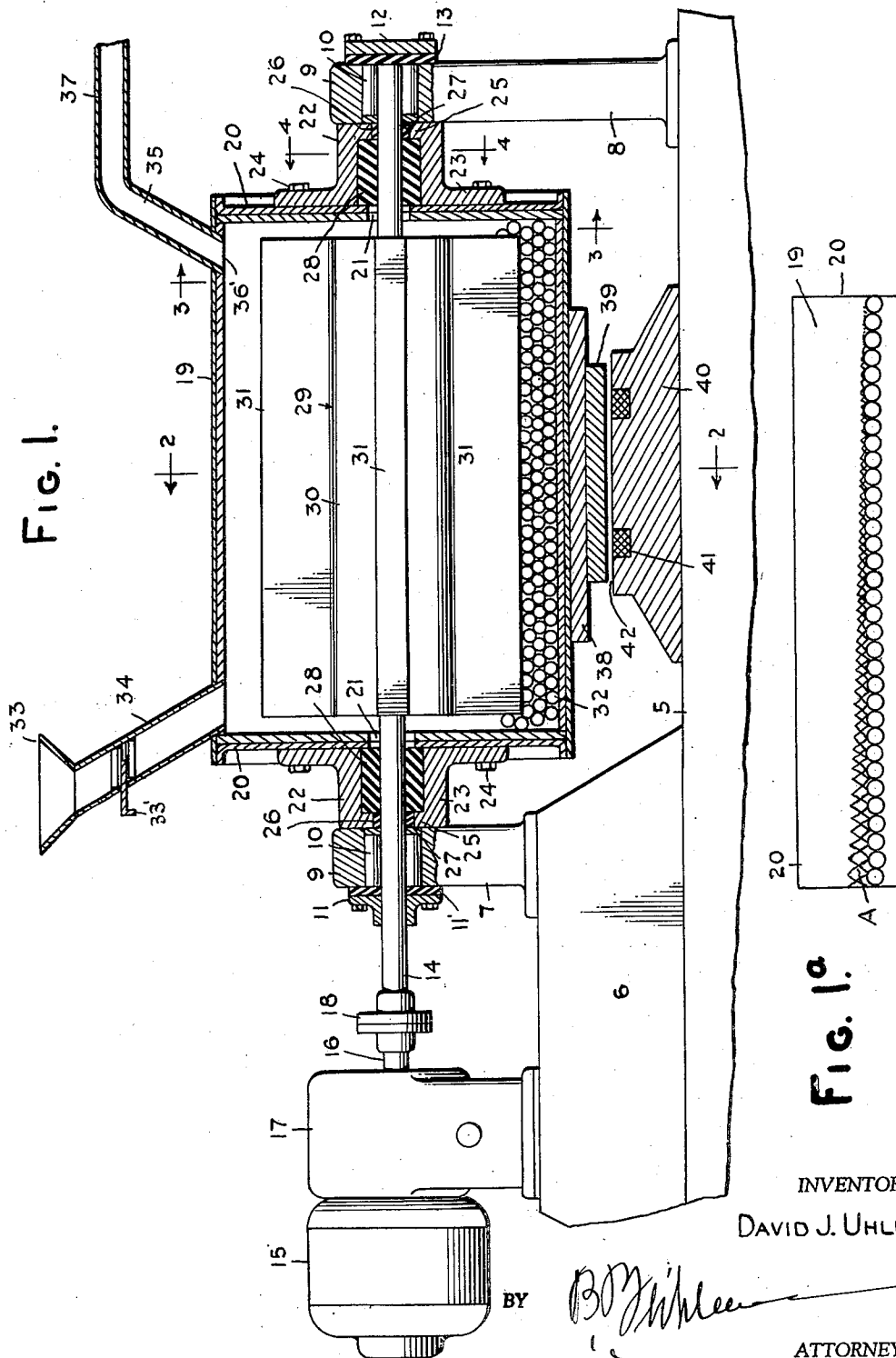
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2,822,987

APPARATUS FOR GRINDING SOLID MATERIAL

Filed June 28, 1955

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2.

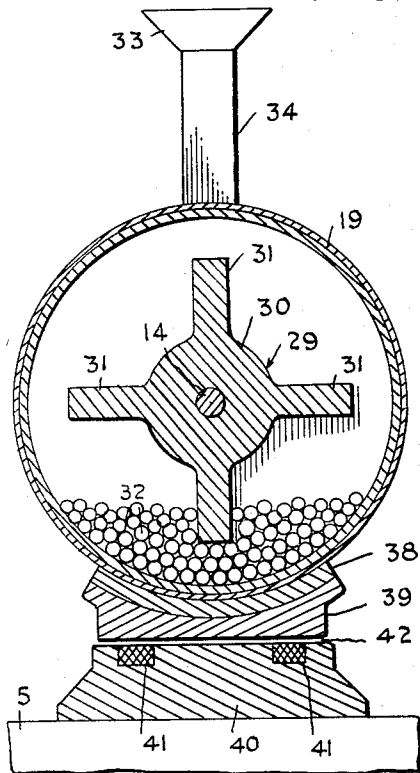


FIG. 3.

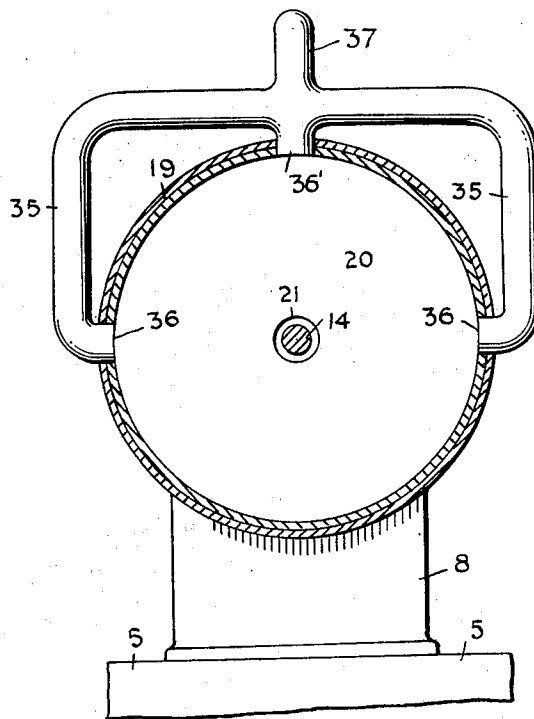


FIG. 4.

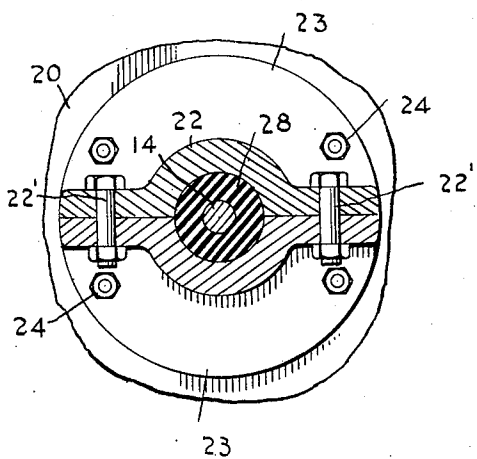
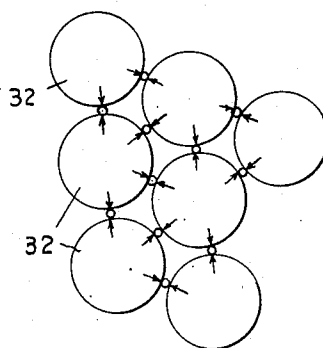


FIG. 5.



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APPARATUS FOR GRINDING SOLID MATERIAL

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6 Claims. (Cl. 241-172)

My invention relates to apparatus for finely dividing solid material.

An important object of the invention is to provide an apparatus which is economical in use and will produce a large output.

A further object of the invention is to provide an apparatus which may be successfully used for finely grinding various types of solid material.

A further object of the invention is to provide an apparatus which will so finely grind the solid material that it first takes on substantially the characteristics of a liquid during handling and later somewhat the characteristics of a gas.

In accordance with the invention, the solid material to be finely ground may be first divided into particles of about one-half inch to one inch in diameter, and this divided material is introduced into a shell which is subjected to a high degree of vibration, preferably in a substantially vertical direction. The shell contains grinding elements or balls, and the volume of the grinding balls is much less than the volume of the shell chamber. The vibration of the shell causes the grinding balls to vibrate and shift in all directions, and the vibration of the balls grinds the solid divided material arranged between them. While the balls and the material to be ground are being vibrated, the rotor is turned relatively slowly, and serves to shift the balls to distribute the wear upon the same. The grinding balls shift in various directions, and the grinding action is effected by the falling action of the balls by gravity during the vibration of the balls and not to any considerable extent to the tumbling action of the balls caused by the rotor. The divided solid material to be ground is preferably introduced into the casing or shell near one end of the shell, and upon being finely ground is removed from the shell preferably near its opposite end. The above description sets forth generally the principal features of the invention, but it is not intended that the scope of the claims be in any way restricted by such description.

In the accompanying drawings forming a part of this application and in which like numerals are employed to designate like parts throughout same,

Figure 1 is a central vertical longitudinal section through apparatus embodying my invention,

Figure 2 is a transverse section taken on line 2-2 of Figure 1,

Figure 3 is a transverse section taken on line 3-3 of Figure 1,

Figure 4 is a transverse section taken on line 4-4 of Figure 1,

Figure 5 is an enlarged diagrammatic view illustrating the grinding action, and,

Figure 1a is a diagrammatic view showing the travel of the material through the shell.

In the drawings, the numeral 5 designates a concrete foundation upon which is rigidly mounted a stationary base 6. Rigidly mounted upon the base 6 is a vertical support or post 7 and a vertical support or post 8 is

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rigidly mounted upon the foundation 5. The vertical support 7 is provided with a radial bearing 9, holding bearing rollers 10. The numeral 11 designates a seal cap and 11' a compressible seal. The vertical post 8 is provided with a similar bearing 9, as shown in connection with the support 7, having the same bearing rollers 10. The numeral 12 designates a seal cap secured to the support 8 and 13 is a compressible seal.

The bearings 9 receive a horizontal shaft 14, for rotatably supporting the same. The numeral 15 designates an electric motor, driving a shaft 16 through a speed reducer gearing unit 17. The shaft 16 is connected with a shaft 14 by a coupling 18. By adjusting the speed reducer gearing unit, the motor 15 may drive the shaft 14 at a speed of from one to one hundred R. P. M.

The numeral 19 designates a preferably cylindrical horizontal shell or casing including ends 20. This shell is arranged between the vertical supports 7 and 8 and the ends 20 have large openings 21 formed therein, of larger diameter than the shaft 14 so that the shaft will not contact with the walls of the openings 21. The shaft 14 extends centrally through the shell 19 and openings 21.

Disposed outwardly of the ends 20 are split sleeves 22 having split flanges 23, which are rigidly secured to the ends 20 by bolts 24, although these parts may be welded together. The sleeve sections may be secured together by bolts 22'. The sleeves 22 have outer ends 25, having openings 26, larger in diameter than the shaft 14 so that the walls of these openings will not contact with the shaft 14. Compressible packing 27 may be held within the openings 26. Arranged within the sleeves 22 are tubular resilient dampening glands 28, which may be formed of rubber or the like, having the desired degree of stiffness. These glands, being resilient, will permit of suitable vertical or radial vibrations of the shell 19 but serve to hold the shell in place.

Arranged within the shell 19 is a rotor 29 including a hub 30 rigidly mounted upon the shaft 14, and blades 31 secured to the hub and extending throughout the major portion of the length of the shell 19 and terminating near and spaced from the ends 20. These blades also have a smaller diameter than the interior of the shell and are accordingly spaced from the periphery of the shell.

Mounted within the lower portion of the shell is a mass of grinding elements or balls 32, preferably formed of steel, and are free to shift and roll within the shell. These grinding balls preferably have diameters of one-fourth inch to three inches. The volume of the grinding balls is preferably one-fifteenth percent to forty percent of the volume of the chamber of the shell. The diameter of the balls varies with respect to the material to be ground, for regulating the weight of the balls, and the harder the material to be ground, the larger will be the diameter of the balls.

The divided solid material is introduced into a hopper 33, and is fed by gravity through the inclined tube 34, which is connected with the shell at its top and near one end thereof. The inclined tube 34 may be provided with a slide valve 33', by which the tube 34 may be partly or wholly closed. This slide valve can be adjusted to regulate the rate of supply of the divided solid material and may be adjusted to regulate the degree of suction to be created within the shell 19, for withdrawing the divided material after treatment. By regulating the degree of suction, the treated material having a selected degree of fineness may be removed while the larger divided material will remain within the shell. Instead of feeding the divided material into the shell 19 by gravity, it may be fed therein by positively operating mechanical means such as a screw conveyor, a chain link conveyor, or a pusher conveyor. It is desired that this material be initially introduced into the shell 19 at its top adjacent to

one end thereof. The finely ground material is removed from the shell by suction through pipes 35, Figure 3, which lead into the shell near its opposite end, at its horizontal diameter, at 36, and at its top, as shown at 36'. The pipe 35 is connected with a common suction pipe 37 which leads to and is connected with a stationary casing including suction-operated means. The pipe 37 is stationary, to a considerable extent, to prevent rotation of the shell 19, but would have a flexible connection with the stationary suction casing, to permit of vibration of the shell 19 with respect to the suction casing. The finely ground material is removed through the suction pipe 37 and this suction should be strong enough to overcome the packing of the finely ground material. This finely ground material has a tendency to conglomerate on the bottom of the shell 19. This packing or conglomerating is also overcome, to a certain extent, by shifting or changing the position of the grinding balls 32 by means of the blades 31 of the rotor. Instead of removing the finely ground material by suction, the suction means may be dispensed with, and such material may be removed by gravity through an opening formed in the bottom of the shell 19, near the end 20, and this opening would be controlled by a valve.

Means are provided to vertically vibrate the shell 19 in a radial direction, at a high speed. This vibration may vary from between one hundred and fifty vibrations per second to thirty thousand vibrations per second, or even higher. In the present embodiment of the invention, I have shown electromagnetic means to vibrate the shell vertically and radially. This vibrating means includes a plate 38 which may be of metal and which is rigidly secured to the shell 19 by welding or the like. This plate may be cylindrically curved. Rigidly secured to the plate 38 by any suitable means is an armature 39, formed of magnetic material, and having a flat face arranged near and spaced from an electromagnet 40 having an operating coil 41. The electromagnet 40 is rigidly mounted upon the foundation 5. There is an air gap 42 between the armature and the electromagnet so that the parts will not contact. When the electromagnetic coil 41 is energized by alternating current of a suitable frequency, the armature 39, plate 38 and shell 19 are set into vibration, in unison with the frequency of the alternating current, and the vibration of the shell 19 is in a direction generally vertically and radially of the shell. The frequency of vibration may be varied by varying the frequency of the alternating current by any of the well known means. While I have shown electromagnetic means to vibrate the shell, it is to be understood that the invention is not restricted to this type of vibrator, as I may use mechanical, steam, air or hydraulic vibrators which are well known in the art.

The grinding elements or balls 32 occupy a volume of fifteen to forty percent of the volume of the cylindrical shell 19, and these grinding balls level off and their level is some distance above the outer ends of the radial blades 31 when these blades move to the lower vertical position. The divided material to be ground is fed into one end of the shell 19 from the hopper 33, and when the vibration of the shell 19 is started, this divided material levels off and the feeding of the divided material is continued until the divided material entirely covers the grinding balls. The feeding of the divided material is regulated so that a layer of the same covers the grinding balls, and the level of the grinding material is adjacent to the level of the balls. The solid material to be ground may be silica, or any other hard material, and this solid material has been previously divided into particles of about one sixteenth of an inch, or finer, to one inch in diameter. The shell 19 is rapidly radially and vertically vibrated by the operation of the electromagnetic vibrator, vibrating at a frequency of about one hundred and fifty to thirty thousand vibrations or cycles per second. The solid divided material is subjected to a grinding action of the

balls, and this grinding action is caused by the rapid vibration of the grinding balls. The shell 19 vibrates vertically and this vibration is transmitted to the balls which vibrate in all directions including radial or vertical directions with respect to the shell. The grinding balls during their vibration are in a state of suspension, and the rotor 29 shifts or repositions the balls to distribute the wear upon the balls. The material to be ground passes between the spaces between the balls, as the vibration continues. The weight of the balls lifted by the vibrations and the balls falling back next to each other, with the material between the balls, produces a grinding or crushing action. Since the balls also turn, during their vibrations, this imparts to the material a rubbing or attrition action. The combined grinding or crushing action and the rubbing or attrition action produces a large quantity of extremely fine ground material. The ground particles may be finer than seven and one-half micron in size. The silica or other materials is introduced, in a divided state, into one end of the shell 19, and when the grinding action starts, the divided material will have its particle size getting smaller and smaller and such material, while being thus ground, shifts toward the opposite end of the shell 19 because the heavier and larger particles will push or thrust the lighter smaller particles toward the discharge end of the shell 19. In this manner, the grinding balls are covered with a layer of the material to be ground, and such material has its particle sizes decreasing toward the discharge end of the shell 19. As the particle sizes of the material get smaller from the grinding action of the balls 32, the material increases in volume, and when the particle size is sufficiently small, these small particle sizes float in the air within the shell 19 and these floating particle sizes are picked up and removed through the pipe 37 and associated elements by the action of the suction. As diagrammatically shown in Figure 1a, the divided solid material is indicated by xxx, as shown at A. The divided material is introduced into the left end of the shell 19 and tends to accumulate at the left end and when the vibration starts, the divided material will cover the balls 32 and will shift horizontally toward the right or discharge end of the shell 19. The xxx decrease in size to the right indicating that the material particles decrease in size to the right. When the particle size is sufficiently small, the ground material is removed by the suction, as stated. The material will be so finely ground that it becomes first similar to liquid in handling, and then somewhat like a gas finally in handling.

When soft solid material is to be ground, such as coal, the coal is first divided into particles one sixteenth of an inch to one inch in diameter and are then introduced into the inlet end of the vibrating shell 19. The vibrating device is now operated to vibrate the shell about one hundred and fifty vibrations per second. The divided coal is thereby finely ground and converted into a dust, having particle sizes finer than seven and one-half micron in size. The powdered coal is removed from the pipe 37 by suction. In grinding carbon material, such as coal, the oxygen must be kept below sixteen parts of oxygen to one part of carbon to prevent the formation of an explosive mixture. When harder material is being ground, the number of vibrations per second are increased and may be increased to thirty thousand vibrations per second, depending upon the hardness of the material.

As stated, the shell 19 is rapidly vibrated and may be vibrated from one hundred and fifty to thirty thousand vibrations per second. The frequency of vibration may be varied within limits and may extend beyond the upper limit, as stated. The frequency of vibration will depend largely upon the character and hardness of the material to be ground.

High frequency vibrators of the electromagnetic type are well known and are shown in Patents 2,147,677; 2,462,554 and 2,360,893. High frequency vibrators are

manufactured by Syntron, located at Homer City, Pennsylvania. Syntron manufactures electromagnetic vibrators of various types. Syntron also manufactures steam or hydraulic vibrators. The invention is not restricted to any particular type of vibrator used.

As clearly shown in Figure 1, the shell 19 is relatively long, and relatively few balls 32 contact with the ends 20 of the shell, and these balls are freely movable with relation to and from these ends 20. This materially reduces wear upon the balls, since the wear is constantly distributed by the shifting of the balls, as explained.

It is to be understood that the form of my invention herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention, what I claim is:

1. Apparatus for finely grinding divided solid material, comprising fixed spaced apart bearings, a substantially horizontal shaft journaled within the bearings extending therebetween and adapted to rotate, a substantially cylindrical shell of relatively large diameter positioned between said bearings with its longitudinal axis arranged substantially horizontally and surrounding said shaft and having ends spaced from the bearings, sleeve devices secured to said ends of the shell and surrounding said shaft and spaced therefrom and positioned between the fixed bearings and said ends of the shell, resilient elements mounted within the sleeve devices and between the sleeve devices and said shaft for insulating the shaft and fixed bearings from vibrations, a rotor including radial vanes secured to said shaft within the shell and being materially smaller in diameter than said shell and adapted to turn slowly with said shaft inside of the shell, and electromagnetic means connected with the side wall of the shell to impart high frequency vibration to it bodily substantially vertically, the shell having inlet and outlet opening means for the material being treated and adapted to contain a multiplicity of grinding balls.

2. Apparatus for finely grinding divided solid material, comprising a pair of fixed spaced apart bearings, a substantially horizontal shaft journaled within said bearings for rotation and extending therebetween, means to rotate the shaft at a relatively low rate of speed, a substantially cylindrical shell of relatively large diameter positioned between the bearings with its longitudinal axis arranged substantially horizontally and having end walls provided with clearance openings receiving said shaft, the shaft extending axially through said shell, the end walls being spaced from said bearings, sleeve devices secured to the end walls of the shell between the bearings and end walls and free from connection with the bearings and having bores receiving said shaft and being spaced from the shaft, annular resilient cushioning elements held within the bores of the sleeve devices and surrounding the shaft and contacting it to insulate the shaft and bearings from vibrations and bodily supporting the shell upon the rotary shaft, a rotor carried by the shaft within said shell and having circumferentially spaced radial vanes which terminate a substantial distance inwardly of the side wall of the shell, a multitude of grinding balls contained within the shell and adapted during vibration of the shell to be engaged by the vanes of the rotor and thereby repositioned within the shell so that they will wear evenly, high frequency vibration means connected with the side wall

of the shell for causing it to vibrate bodily relative to said shaft and bearings substantially vertically, and means connected with the shell near its top for introducing the material to be ground therein and for removing the finely ground material therefrom by suction or the like.

3. Apparatus for finely grinding divided solid material according to claim 2, and wherein each of said sleeve devices comprises a pair of opposed substantially semi-cylindrical separable sleeve sections, and bolt means detachably securing said sleeve sections together in clamping engagement with said annular resilient element.

4. Apparatus for finely grinding divided solid material, comprising a pair of fixed spaced apart bearings, a substantially horizontal shaft extending between said bearings and journaled upon the same for rotation, means to turn said shaft, a shell surrounding said shaft between said bearings and having ends spaced from the bearings and substantially central openings receiving the shaft, the side walls of said openings being spaced from the shaft, resilient cushioning devices secured directly to the ends of the shell and between such ends and said bearings and engaging the shaft and suspendingly supporting the shell bodily from the shaft and serving to insulate the shaft from shock and vibration, means for imparting substantially vertical high frequency vibratory movement to the entire shell, said shell adapted to contain a multiplicity of small material grinding bodies, and a rotor structure smaller in diameter than said shell mounted upon said shaft within the shell and adapted to contact and move said grinding bodies when the shell is vibrating and the shaft is turning.

5. Apparatus for finely grinding divided solid material according to claim 4, and means for introducing the divided material into the shell and for withdrawing the material from the shell after grinding, said means located near the top of the shell.

6. Apparatus for finely grinding divided solid material comprising a pair of spaced bearing supports, a substantially horizontal rotary shaft journaled upon the bearing supports and extending therebetween, a substantially cylindrical shell adapted to hold grinding balls disposed between the bearing supports and having a substantially horizontal longitudinal axis and axial opening means receiving said shaft through said shell with clearance between the shaft and shell, resilient supporting units secured directly to the ends of said shell and engaging said shaft for resiliently supporting the shell bodily upon the shaft, a grinding ball agitating rotor carried by said rotary shaft inside of said shell and engageable with the balls upon rotation of the shaft when the shell is vibrated, a stationary electromagnet arranged below said shell, the top face of the electromagnet being substantially flat, and a magnetizable armature secured directly to the lower side wall of said cylindrical shell and having its upper side curved to fit said shell and having a substantially flat bottom arranged in opposed closely spaced relation to the flat top face of the electromagnet, the electromagnet and armature coacting to impart substantially vertical high frequency vibratory motion to said shell.

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