United States Patent

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[54] **MATERIAL TREATMENT APPARATUS WITH ROTARY STIRRER IN VIBRATORY CONTAINER**
21 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **241/172,** 51/7, 241/175, 259/72
[51] **Int. Cl.** **B02c 17/14,** B24b 31/06
[50] **Field of Search** ..... 241/46.11, 46.17, 137, 138, 172, 175, 176, 253; 51/163, 313—316; 259/102

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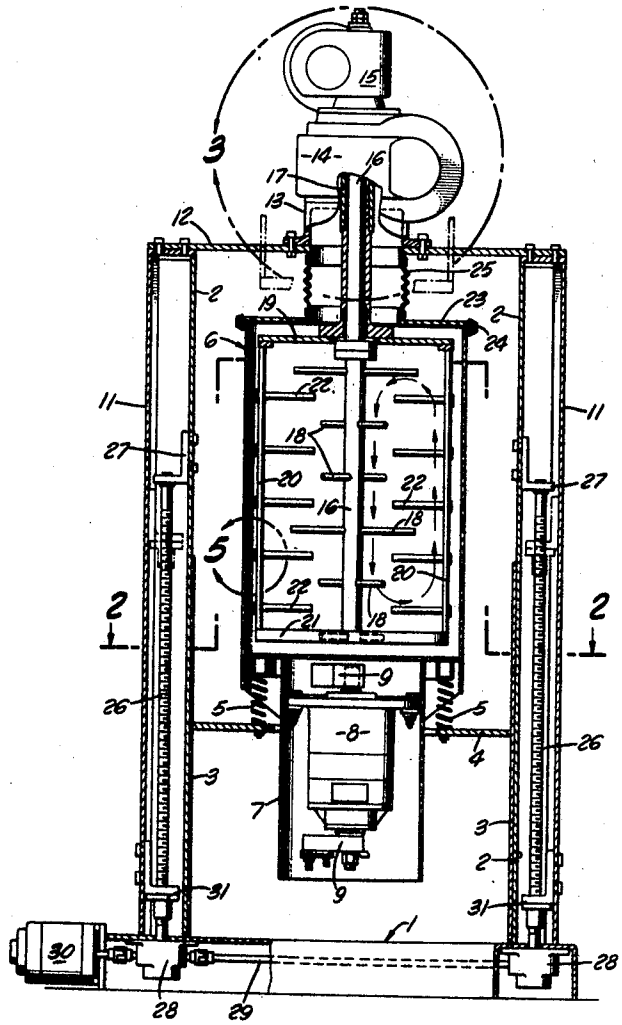
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ABSTRACT: An apparatus for treating material including a chamber for receiving treating media and material to be treated. High frequency vibrating means are used for vibrating the container to effect high frequency impact between the media and material and to fluidize the media and material. The apparatus includes rotating impellers movable through the media and material. Counter-rotating impellers may be employed, and the impeller system may be raised from and lowered into the container during operation of the apparatus.



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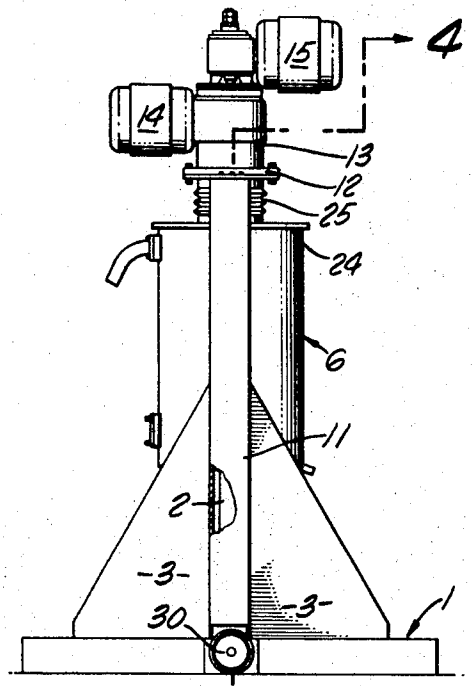


FIG. 1.

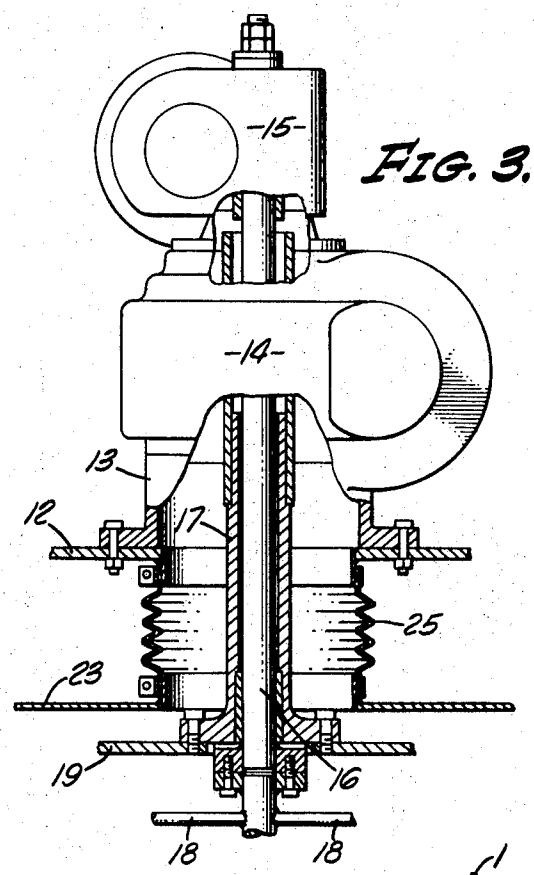


FIG. 3.

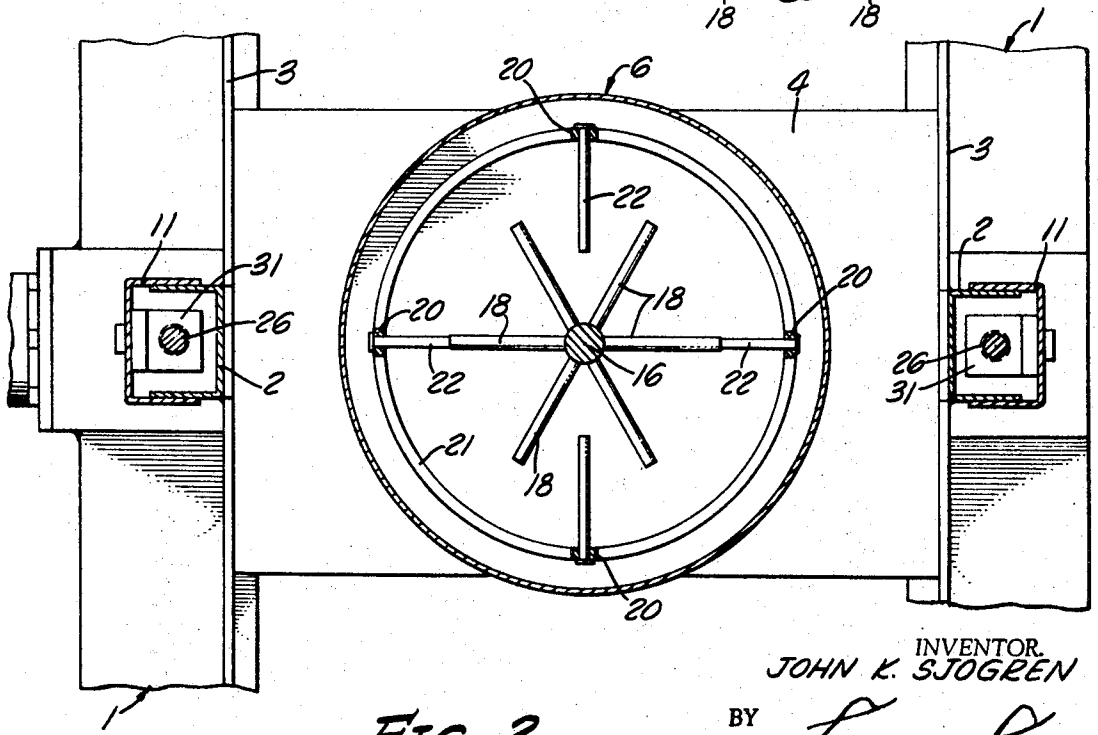
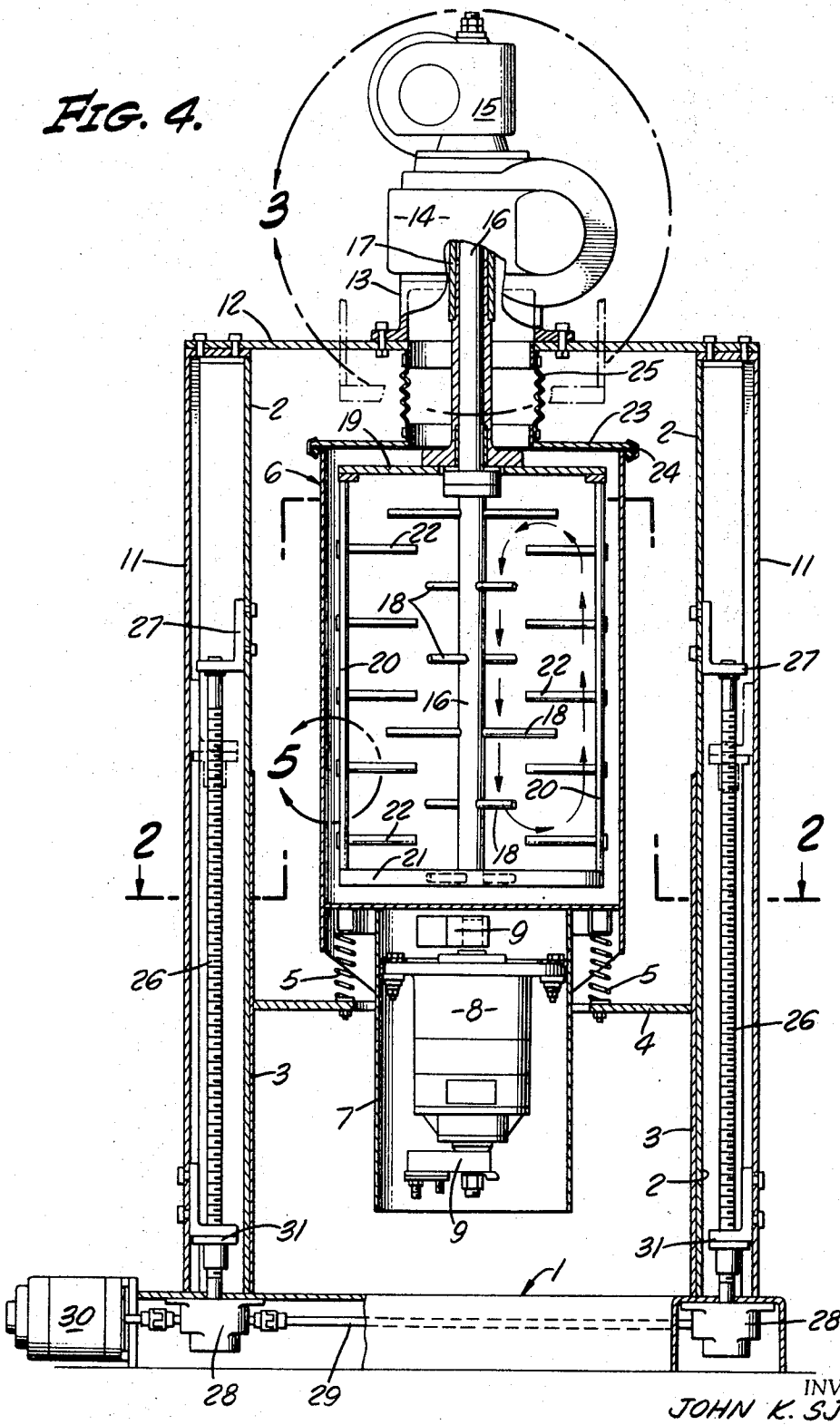


FIG. 2.

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FIG. 4.



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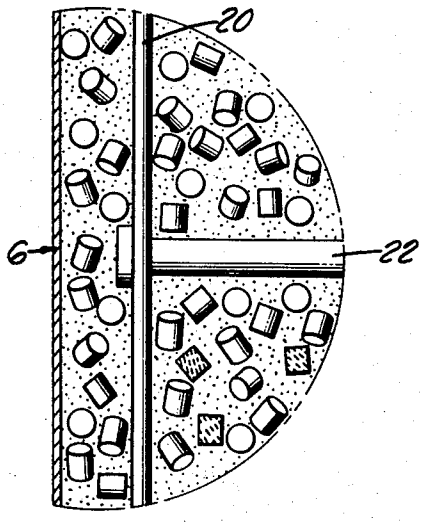


FIG. 5.

FIG. 9a

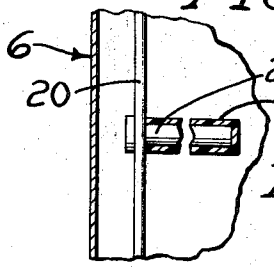
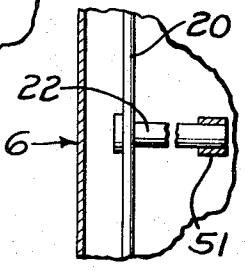


FIG. 9b



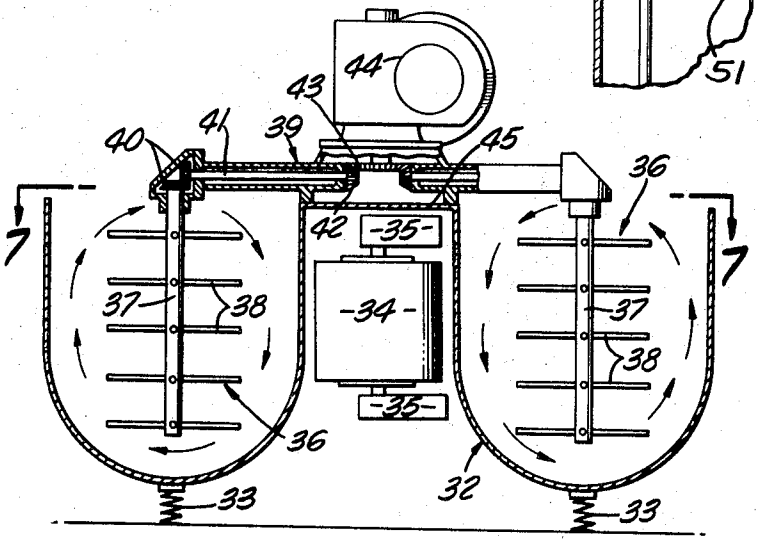


FIG. 6.

FIG. 7.

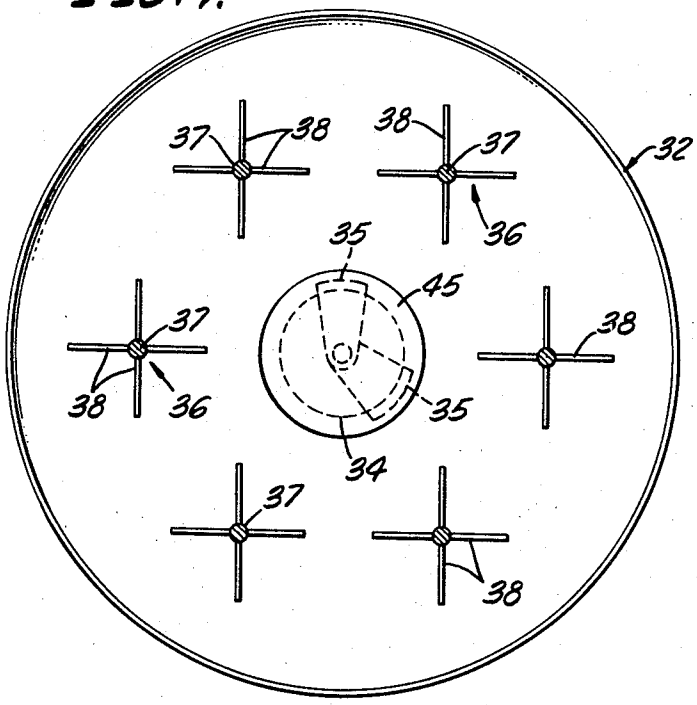
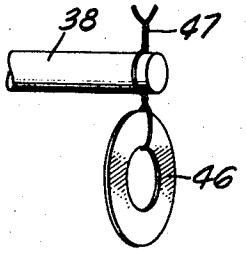


FIG. 8.



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MATERIAL TREATMENT APPARATUS WITH ROTARY STIRRER IN VIBRATORY CONTAINER

This application is a continuation-in-part of U.S. Pat. application Ser. No. 440,138, filed Mar. 16, 1965, now abandoned.

This invention relates to apparatus for treating material and more particularly to means adapted to grind pulverizable material, or to finish material which is in the form of workpieces. Exemplary prior art devices of this nature are described, for example, in U.S. Pat. Nos. 2,983,454, 3,084,876 and 3,100,088.

It is an object of the present invention to provide an improved apparatus for treating material.

It is an additional object of this invention to provide an apparatus for treating material employing both vibratory motion and stirring motion.

Another object of this invention is to provide an apparatus wherein a charge of material to be treated, whether it is to be pulverized or to be given a surface treatment, is subjected to vigorous vibration so as to receive impacts at high frequency and low amplitude, while it is simultaneously stirred in such a manner as to receive impacts at low frequency and high amplitude.

A further object of this invention is to provide an apparatus adapted to both grinding and finishing operations which utilizes a vibratory chamber such as described in said aforementioned patents in combination with stirring elements immersed in the grinding or finishing media.

Another object is to provide an apparatus for grinding pulverizable material wherein the time required to grind the material to a selected particle size is materially reduced, and which is particularly effective in the grinding of materials which are normally difficult to grind or in the grinding of material which, as initially supplied, varies greatly in size, the larger particles being most effectively reduced by low frequency-high amplitude impact and the smaller particles being most effectively reduced by high frequency-low amplitude impact.

An additional object is to provide an apparatus for finishing material comprising workpieces wherein the time required to finish such material is substantially reduced, particularly, in the case of workpieces having surfaces requiring low frequency-high amplitude impact and other surfaces requiring high frequency-low amplitude impact.

Another object is to provide an apparatus wherein a shearing action between media and material takes place in addition to an impact action.

These and other objects and features of the present invention will be better understood through a consideration of the following description considered with the accompanying drawings in which:

FIG. 1 is a side view of an apparatus for treating material according to the present invention;

FIG. 2 is an enlarged transverse sectional view thereof taken along a line 2–2 of FIG. 4;

FIG. 3 is an enlarged elevational partially sectional view thereof taken within circle 3 of FIG. 4;

FIG. 4 is a longitudinal sectional view partially in elevation taken substantially along a line 4–4 of FIG. 1;

FIG. 5 is an enlarged fragmentary sectional view taken within circle 5 of FIG. 4;

FIG. 6 is a substantially diagrammatical transverse sectional view showing a modified form of the means for treating material;

FIG. 7 is a partial sectional plan view taken along a line 7–7 of FIG. 6;

FIG. 8 is a fragmentary perspective view showing a workpiece attached to a stirring rod; and

FIGS. 9*a* and 9*b* illustrate modifications of stirring rods.

Turning first to FIGS. 1 through 5, an exemplary apparatus for treating material includes a base frame 1 from which extends a pair of vertically disposed guide channel members 2 reinforced by gusset plates 3. Supported above the base frame 1 is a platform 4 on which is mounted a ring of springs 5. The springs support a cylindrical container 6. The platform 4 is

provided with a central opening, and a cylindrical housing 7 depends from the container 6. The housing contains a motor 8 and eccentric weights 9 on the shaft thereof located above and below the motor. The spring-supported container with its motor and eccentric weights constitute a vibratory grinding or finishing unit similar to that disclosed in the aforementioned patents.

The vertical guide channel members 2 receive a pair of slidable channel members 11 which are joined at their upper ends to a cross plate 12 having a central opening. Located concentrically with respect to the opening in the cross plate is a tubular motor mounting 13 which supports a lower gear-motor unit 14 and an upper gear-motor unit 15. The upper gear-motor unit 15 drives a vertical shaft 16, and the lower gear-motor unit 14 drives a sleeve 17 surrounding the shaft 16. The shaft 16 extends downwardly into the container 6 and is provided with radially outwardly directed stirring rods 18. The sleeve 17 extends into the upper end of the container 6 and is joined to a circular plate 19 from which depends a cage of vertical bars 20 joined at their lower ends to a bottom ring 21. The vertical bars 20 are provided with radially inwardly directed stirring rods 22.

The container 6 is provided with a removable cover 23 secured by a clamping band 24 which may be readily removed. The cover 23 is connected by a bellows sleeve 25 to the cross plate 12.

The vertical guide channel members 2 and the slidable channel members 11 form vertical housings in which are mounted lifting screws 26 journaled at their upper ends by means of brackets 27 secured to the channel members 2. The lower ends of the lifting screws extend into gear housings 28 provided in the base frame 1. The two gear housings are joined by a connecting shaft 29 so as to operate in unison, and one of the gear housings also is joined to a motor drive 30. Each of the channel members 11 is provided with a traveler nut 31 which rides on the screw threads of the corresponding lifting screws 26.

Operation of the machine for treating material disclosed in FIGS. 1 through 5, when employed as a grinding machine, is as follows: Initially the stirring means, comprising the stirring rods 18 and 22 and their supporting members, occupies a raised position as indicated fragmentarily by broken lines in FIG. 4. The container 6 is filled with a charge comprising grinding media and pulverizable material. The grinding media may vary greatly depending upon the material to be ground. For example, alumina, steel, ceramic or natural pebble media may be used. For purposes of illustration, the media is shown in FIG. 5 as comprising ceramic cylinders. The apparatus is particularly suitable for use with a wet charge, but the charge may be dry.

When the motor 8 is operated, the container and its charge are vibrated at high frequency and low amplitude. A typical vibration frequency range is 900 to 1,800 c.p.m. Various size chambers may be used, and a suitable chamber may be 29 inches high and 2 feet in diameter. A chamber of this nature has a typical working capacity of 10 to 15 gallons of material plus the grinding or treating media. As a result of this vibration, the amplitude of the chamber varies from approximately .5 to 7 mm. measured at the exterior of the container. The horizontal component of the amplitude is high at the top and bottom of the chamber 6, there being essentially a null point or area substantially midway between the top and bottom of the chamber for the horizontal component. A suitable horsepower for the motor 8 is 5 horsepower.

The vibration causes the pieces of grinding media to impact against each other, and the pulverizable material therebetween, at correspondingly high frequency and low amplitude. This action, as brought out in the aforementioned patents, is particularly effective in grinding material of initially small dimension to smaller dimension.

In the course of vibration, the charge tends to progress upwardly adjacent the walls of the container and downwardly adjacent the center of the container as indicated by the arrows in

FIG. 4. Also, the charge tends to precess as a body in a circular path around the container. In spite of this movement, only minor relative migration of the media and material occurs; that is, a given group of particles tend to remain in the vicinity of a given group of media members.

After initiating vibration of the container, the stirring means is lowered into the container. Incidental to the grinding action, the vibration fluidizes the charge so that the stirring means is readily lowered and the stirring rods are readily rotated after the same are lowered into the container. The fluidizing effect on the charge enables more effective use of power for turning the rods. By reason of the counterrotation of the two sets of rods **18** and **22** no appreciable residual torque is applied to the container.

The stirring rods effectively mix the media and material; that is, relative travel between members of the media and the particles of material is greatly increased. This is particularly advantageous if the material comprises several ingredients which must be mixed as well as pulverized, or where a chemical action is desired in addition to the grinding action. The counterrotation of the rods creates a large amount of shear which is important from the standpoint of good wetting of pigments by solvents in which the pigments may be dispersed.

In addition, the movement of the stirring rods is much slower than the vibratory movement, and the rods separate the members of the media a much greater distance than the vibratory movement. As a consequence, the media and material are subjected to low frequency-high amplitude impact simultaneously with high frequency-low amplitude impact. This is particularly advantageous if the material, as initially introduced, varies greatly in size because the larger particles are best reduced by low frequency-high amplitude impact and the smaller particles are best reduced by high frequency-low amplitude impact. Substantial reduction in milling times for various materials are possible with the present apparatus when compared with milling times for standard wet grinding apparatus. The speed of the counterrotating rods may range between approximately 35 and 250 r.p.m., and the two may operate at different speeds if desired. Typical motor horsepower for these units are about 5 to 7½ horsepower. Another example of suitable apparatus employs an 18-inch diameter chamber, vibration of 1,200 c.p.m., outer impeller speed of 60 r.p.m. and inner impeller speed of 120 r.p.m.

Considering now the apparatus shown in FIGS. **6** and **7**, an annular container **32** is provided which, like the container **6**, is mounted on a ring of springs **33**. The central portion of the annular container forms a housing to receive a motor **34** and eccentric weights **35**. When this type of chamber is filled with a charge of grinding media and material, the charge tends to move upwardly along the radially outer walls of the container and downwardly along the radially inner walls of the container and simultaneously precess circumferentially. Without the presence of stirring means, the annular container functions in the manner described in the aforementioned patents, particularly U.S. Pat. No. 3,100,088.

In the construction shown in FIGS. **6** and **7**, a plurality of stirring units **36** are shown as including a central shaft **37** and radially outwardly directed rods **38**. Each of the stirring units is supported from a drive housing **39** and is connected by bevel gears **40**, a radiating shaft **41** and a bevel gear **42** to a central drive gear **43** connected to a motor **44**. The units may be driven together as shown, or driven individually. The drive housing **39** may be supported by a cover **45** positioned over the central portion of the annular container **32**. The drive housing may be fixed to the cover or be supported thereon by a bearing so that the set of stirring units **36** may precess about the annular container urged by the charge of media and material. The stirring units **36** are shown as permanently mounted in the container; however, it should be understood that the entire assembly may be supported by raising and lowering means such as shown in connection with the first described structure of FIGS. **1** through **5**. Operation of the construction shown in FIGS. **6** and **7** is essentially the same as in the first described structure.

The machines thus far described have been considered as grinding machines; however, they are also adapted to finishing operations. Similar to the situation regarding grinding operations, the media employed may vary substantially. The purpose, however, is not to grind the material, which in finishing operations, are workpieces, the surfaces of which are to be polished or the corners deburred, or in some instances, a coating is to be applied. If the workpieces are relatively small, the charge of media and material in the form of workpieces is introduced into the container and the container vibrated while the stirring members are simultaneously moved through the charge in the same manner as in the case of grinding media and pulverizable material.

If the workpieces are relatively large, the workpieces, as represented by a washer **46** shown in FIG. **8**, may be secured to the stirring rods by fastening means as represented by the tie wire **47** in FIG. **8**. In actual practice, the stirring rods also function as workpiece holders and may take various shapes in order to accommodate workpieces of various sizes and shapes.

When the apparatus shown in FIGS. **1** through **5** or in FIGS. **6** and **7** is used for finishing, the material, whether in the form of large workpieces or small workpieces, is subjected simultaneously to high frequency-low amplitude impact and low frequency-high amplitude impact. As a consequence, workpieces which may have different types of surfaces requiring different types of impact are efficiently finished by operation of the apparatus.

It should be noted that the circular motion of the charge of media and material as shown in FIG. **4** and in FIG. **6** is due to the fact that the amplitude of the high frequency or gyratory motion increases with increasing distance from the vibrating means and from the center of the container.

The method of effecting mechanical treatment of material consists essentially of subjecting the media and material simultaneously to high frequency-low amplitude impact and low frequency-high amplitude impact. Still further, the method envisions effective dispersion or distribution of both the media and material throughout the charge.

It should be noted when the apparatus is employed for grinding operations, the movement of the stirring rods through the media produces a shearing action; that is, the pieces of media are caused to rub across each other shearing the material therebetween. Similarly, when the apparatus is employed for finishing operations, the workpieces are rubbed by the media.

It has been found that the stirring rods, particularly the tips thereof, may wear rapidly. In order to ensure long life of the various stirring rods, the same may be fitted with polyurethane sleeves **50** as shown in FIG. **9***a* having capped ends for higher wear resistance. This enables a reduction of wear over carbon steel or stainless steel, and reduces the possibility of discoloration and contamination from metallic components. For example, steel rods tend to gray a white water base paint. Similarly, the container may be lined with polyurethane. Stainless steel is preferred for the parts which may contact the material to be treated where the latter includes a solvent-type system which is not compatible with polyurethane. Additionally, tungsten carbide tips or collars **51** as shown in FIG. **9***b* may be secured to the ends of the stirring rods to serve as wear surfaces. Furthermore, the arrangement shown in FIGS. **6** and **7** is particularly useful for large capacity operations which require a large diameter-treating chamber inasmuch as a single stirring unit would require relatively long rods resulting in a very high tip speed and high wear for a typical speed of rotation of the stirring unit.

While particular embodiments of this invention have been shown and described, it is not intended to limit the same to the details of the construction set forth, but instead, the invention embraces such changes, modifications and equivalents of the various parts and their relationships as come within the purview of the appended claims.

I claim:

1. A machine for causing media to treat material by mechanical interaction between the media and material, said machine comprising:

a container dimensioned to receive a charge including treating media and material to be treated;

high frequency means for vibrating said container at a frequency below approximately 2,000 c.p.m. to effect high frequency impact between media and material; and

relatively low velocity stirring means movable through said media and material to superimpose low frequency impact between said media and material, said stirring means including a drive member extending substantially the height of said container and including a plurality of vertically spaced element means coupled with and radiating from said drive member for contacting the charge in said container throughout a substantial portion of the height of said container.

2. A machine for causing media to treat material by mechanical interaction between the media and material, said machine comprising:

a container dimensioned to receive a charge including treating media and material to be treated;

high frequency means coupled with said container for vibrating said container to effect high frequency impact between media and material; and

relatively low velocity stirring means movable through said media and material to superimpose low frequency impact between said media and material, said stirring means including first and second coaxially mounted drive members disposed for counterrotation and extending substantially the height of said container, each of said drive members including a plurality of vertically spaced element means coupled with and radiating from the respective drive member for contacting the charge in said container throughout a substantial portion of the height of said container.

3. A machine for causing media to treat material by mechanical interaction between the media and material, said machine comprising:

an annular container dimensioned to receive a charge including treating media and material to be treated;

high frequency means coupled with said container for vibrating said container to effect high frequency impact between media and material; and

relatively low velocity stirring means movable through said media and material to superimpose low frequency impact between said media and material, said stirring means including a plurality of support means defining a ring within said annular container, each support means having a plurality of stirring rods thereon.

4. A machine for treating material by mechanical interaction between treating media and material comprising:

a container for receiving a charge including treating media and material to be treated;

vibratory means coupled with said container for vibrating said container to fluidize said charge; and

counterrotating stirring means movable through said media and material, said counterrotating stirring means including a plurality of counterrotating stirring rods, said stirring rods being mounted substantially horizontally and being vertically spaced from one another substantially throughout the height of said container for contacting the charge in said container throughout a substantial portion of the height thereof.

5. A machine for treating material by mechanical interaction between treating media and the material comprising:

a container for receiving a charge including treating media and material to be treated;

vibratory means coupled with said container for vibrating said container, said vibratory means including a rotary power source having a substantially vertically disposed output shaft having eccentric weights on said shaft; and

stirring means movable through said media and material, said stirring means including a drive member extending substantially the height of said container and including a plurality of vertically spaced element means coupled with and radiating from said drive member for contacting the charge in said container throughout a substantial portion of the height thereof.

6. A machine as in claim 5 wherein said stirring means includes a second drive member extending substantially the height of said container and being mounted substantially coaxially with respect to said first drive member for counterrotation with respect thereto, said second drive member having a plurality of vertically spaced element means coupled with and radiating from said second drive member.

7. A machine for treating material by mechanical interaction between media and the material comprising:

a container dimensioned to receive a charge including said media and said material;

high frequency means for vibrating said container within a frequency range of approximately 900 to 1,800 c.p.m. to effect high frequency impact between media and material; and

relatively low velocity stirring means movable through said media and material to superimpose low frequency impact between said media and material, said stirring means including a drive member extending substantially the height of said container and including a plurality of vertically spaced element means coupled with and radiating from said drive member for contacting the charge in said container throughout a substantial portion of the height of said container.

8. A machine as in claim 7 wherein the velocity of said stirring means is in the range of approximately 35 to 250 r.p.m.

9. A machine according to claim 7 wherein said container is adapted to receive grinding media and pulverizable material.

10. A machine according to claim 7 wherein said container is adapted to receive finishing media and material in the form of workpieces.

11. A machine according to claim 7 wherein:

said container is cylindrical; and

said stirring means includes a second drive member extending substantially the height of said container and being mounted in concentric relation for counterrotation with respect to said first drive member, and including a plurality of vertically spaced element means coupled with and radiating from said second drive member.

13. A machine for causing a media to effect mechanical treatment of a material comprising:

a circular container for receiving a charge of media and material;

means coupled with said container for producing a gyratory motion having increasing amplitude at increasing distance from the axis of said container whereby the charge is caused to move upwardly at the radially outward portions of the container and downwardly in its central region; and to precess circumferentially; and

stirring means extending within said container and rotatable therein through said media and material, said vibrating means and said stirring means causing mechanical interaction between said media and material at high frequency and low amplitude and at low frequency and high amplitude respectively, said stirring means including a drive member extending substantially the height of said container and including a plurality of vertically spaced element means coupled with and radiating from said drive member for contacting the charge in said container throughout a substantial portion of the height of said container.

14. An apparatus for treating material by mechanical interaction between media and said material, said apparatus comprising:

a container means for receiving a charge including treating media and material to be treated;

vibratory means coupled with said container means for vibrating said container means to fluidize said charge; and

stirring means in said container means and movable through said media and material, said stirring means including a drive member and a plurality of substantially horizontal

vertically spaced stirring rods depending from said drive member, said drive member extending substantially the height of said container for allowing said stirring rods to contact the charge in said container throughout a substantial portion of the height thereof.

15. An apparatus as in claim **14** wherein said stirring means includes a second drive member and a second plurality of stirring rods depending therefrom, individual rods of said second plurality of stirring rods extending between adjacent rods of the first-named plurality of rods, said first and second plurality of stirring rods being adapted to be counterrotated.

16. An apparatus as in claim **14** including means coupled with said stirring means for moving said plurality of stirring rods into said container means and for withdrawing said stirring rods from said container means.

17. An apparatus as in claim **14** wherein said stirring rods include tip means thereon covering the ends of said rods for decreasing wear thereof.

18. A machine for causing media to treat material by mechanical interaction between the media and material comprising:

a support assembly;

a container resiliently mounted on said support assembly for receiving a charge including treating media and material to be treated;

vibratory means coupled with said container for vibrating said container to fluidize said charge, said vibratory means including a rotary power source mounted substantially centrally below said container and having a substantially vertically disposed shaft having at least a weight mounted thereon; and

stirring means extending within said container and rotatable therein through said charge, said stirring means including a drive member extending substantially the height of said container and including a plurality of vertically spaced element means coupled with and radiating from said drive member for contacting the charge in said container throughout a substantial portion of the height thereof.

19. A machine as in claim **18** wherein said stirring means includes a second drive member extending substantially the height of said container and being mounted substantially coaxially with respect to said first drive member for counterrotation with respect thereto, said second drive member having a plurality of vertically spaced element means coupled with and radiating from said second drive member.

20. A machine as in claim **18** wherein said vibratory means is operative to vibrate said container at a frequency below approximately 2,000 c.p.m., and the velocity of said stirring means is in the range of approximately 35 to 250 r.p.m.

21. A machine as in claim **19** wherein said vibratory means is operative to vibrate said container at a frequency below approximately 2,000 c.p.m., and the velocity of said stirring means is in the range of approximately 35 to 250 r.p.m.