June 18, 1963 R. M. CARRIER, JR., ET AL 3,093,941

VIBRATORY MILL DRIVE

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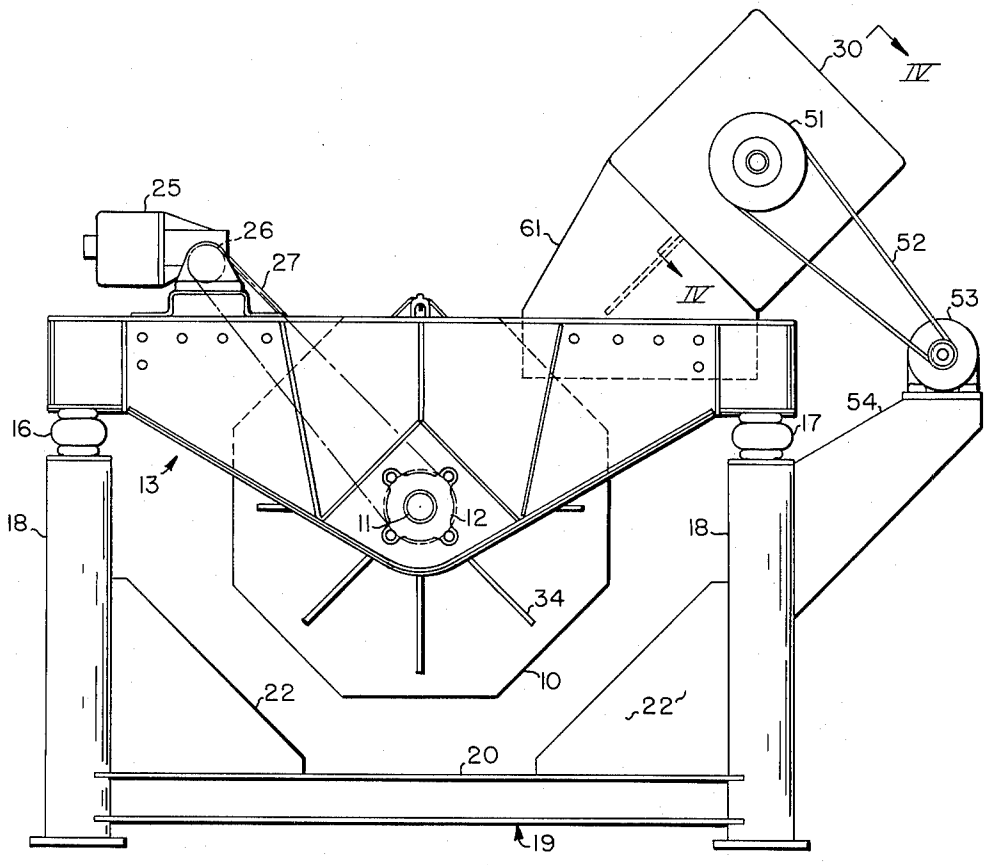


Fig. 1

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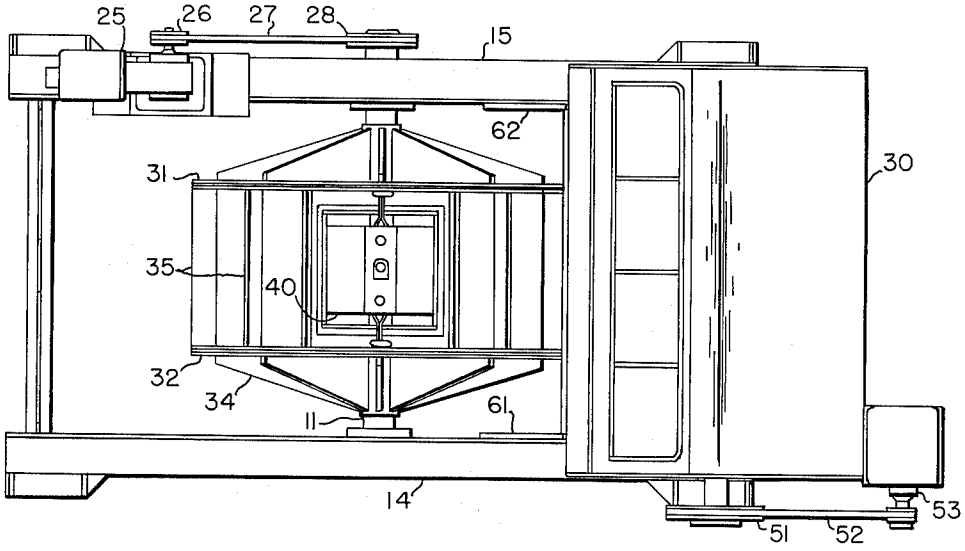


Fig. III

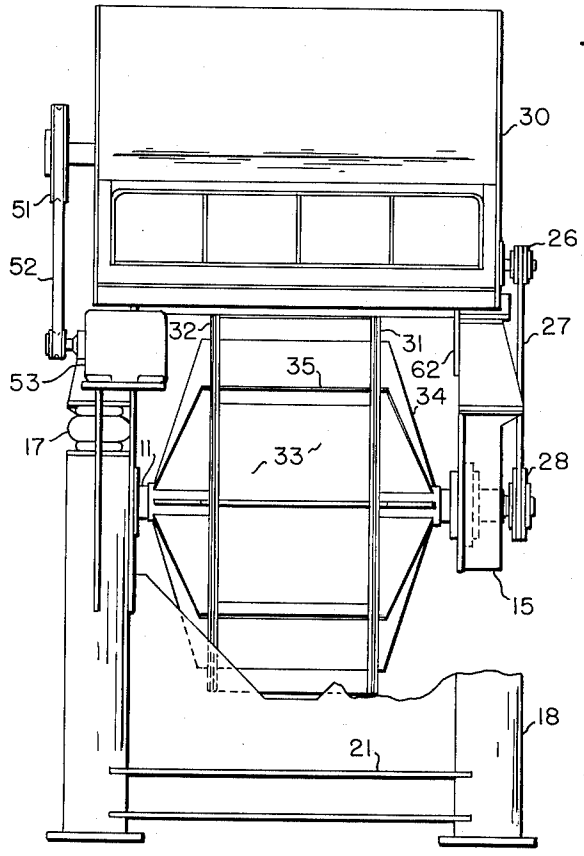


Fig. II

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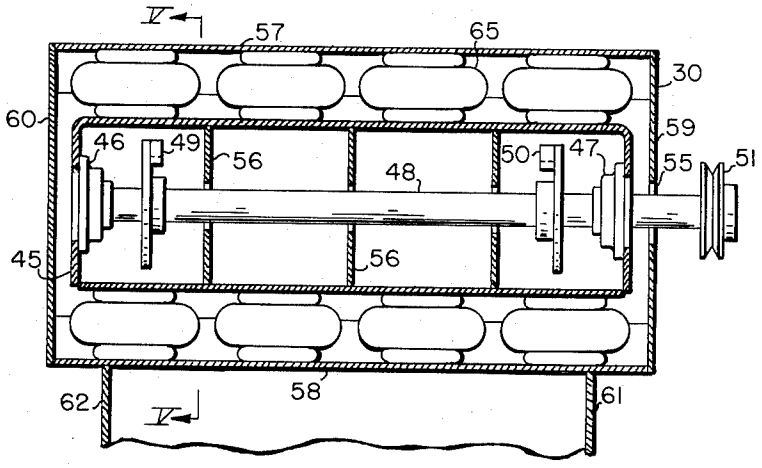


Fig. IV

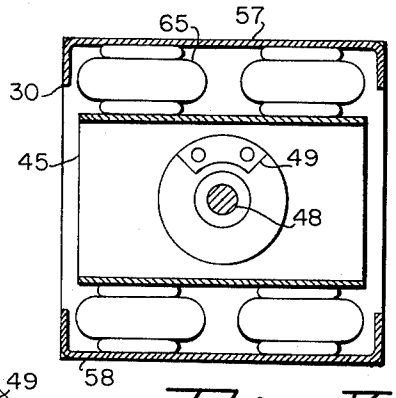


Fig. V

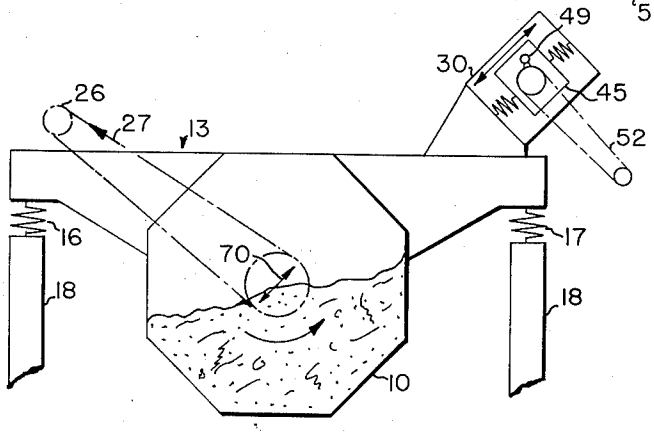


Fig. VI

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VIBRATORY MILL DRIVE

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3 Claims. (Cl. 51—164)

This invention relates generally to vibratory tumbling mills and in particular to an improved drive arrangement that provides enhanced operating performance.

Tumbling mills have long been used in certain types of manufacturing processes where it is desired to clean up the rough edges of stamped or otherwise formed parts or to polish the surfaces of irregular pieces. The process ordinarily involves placing the articles to be processed together with an abrasive mixture into a container and slowly rotating the container so that the contents are continually mixed with each other and continuously agitated. It previously has been proposed to impose orbital vibrations on the container of a tumbling mill in an effort to secure additional agitation and relative movement between the abrasive materials and the work pieces and thus accelerate the process. Such orbital vibrations which may be produced by rotating weights carried on high-speed rotating shafts that are coaxial with or parallel to the axle or axis of the container do not always provide the best vibratory action. In many cases a linear vibration of the tumbling mill container is preferable to the orbital vibratory motion.

The principal object of the invention is to provide a vibratory drive for a vibratory mill in which the drive produces a linear vibration of the container of the mill in a direction transverse to its axis of rotation.

Another object of the invention is to provide means in a vibratory mill for simultaneously rotating the mill to provide mixing and agitating of the contents and vibrating the mill along a linear path that is perpendicular to the length of the axis of rotation of the mill.

These and more specific objects and advantages are apparent from the following description of a preferred form of the invention.

According to the invention the improved vibratory mill comprises a resiliently supported frame in which is journaled a rotatable container for the material to be tumbled. A tuned exciter drive is applied to the frame to linearly vibrate the frame at a substantial amplitude to cause further agitation of the material in the container while other means slowly rotate the container and thus enhance the mixing and vibratory action of the material in the container.

A preferred form of the invention is illustrated in the accompanying drawings.

In the drawings:

FIG. I is a front elevation of the improved vibratory mill showing the means for driving the container and the means for linearly vibrating the container.

FIG. II is an end elevation, with parts broken away, of the equipment as seen from the right side of FIG. I.

FIG. III is a plan view of the improved apparatus.

FIG. IV is an oblique view of the vibration exciter as seen from the line IV—IV of FIG. I.

FIG. V is a cross section of the exciter as seen from the line V—V of FIG. IV.

FIG. VI is a schematic diagram illustrating the cooperation of the various elements to secure the enhanced performance of the equipment.

These specific figures and the accompanying description are intended merely to illustrate the invention and not to impose limitations on its scope.

In the improved tumbling mill, as illustrated in the accompanying drawings, a polygonal drum **10** is carried on stub shafts **11** which in turn are journaled in bearings **12** rigidly mounted in a frame **13**. The frame **13** comprises a pair of deep-center girders **14** and **15** the ends of which are supported on flexible air bags **16** and **17** which in turn rest on columns **18** located at the four corners of a base **19**. The lower portion of base **19** comprises I-beams **20** and **21** connecting the columns **18** and gusset plates **22** bracing the columns against lateral deflection.

The air bags **16** and **17** are similar to air springs employed as automotive suspension systems and in this arrangement constitute resilient means for supporting the frame **13**.

The drum **10** is slowly turned in a counterclockwise direction, as seen in FIG. I, by means of a geared motor **25** that includes a pulley **26** that is connected through a belt **27** to a pulley **28** (FIG. II) mounted on one of the stub shafts **11**.

Simultaneously with the slow rotation, the drum **10** is vibrated linearly along an inclined path by means of a vibration exciter **30** the frame of which extends from one of the girders **14** across to the other girder **15** in the space above and to one side of the drum **10**. The vibration exciter **30**, shown in greater detail in FIGS. IV and V, produces linear vibration along an inclined path normal to the axis of the shafts **11** so as to provide a linear vibration of the drum tending to cause material therein to be conveyed counterclockwise within the drum. Thus the conveying motion of the vibration adds to the conveying motion produced by the slow rotation of the drum so that the two effects are additive in mixing the material and the vibration is particularly effective in producing sliding relative movement between the abrasive material and the articles being processed.

The drum or rotating container **10** is preferably constructed of three major sections which are bolted together to form the drum. By unbolting the sections the drum may be disassembled for cleaning or repair. These three sections include, as indicated in FIG. II, a pair of endplates **31** and **32** and a central prismatic section **33**. Each of the endplate assemblies **31** or **32** comprises an octagonal plate, having an outline as seen in FIG. I, that carries the plurality of reinforcing ribs **34** extending radially from the stub shaft **11**. The stub shaft **11**, and the radiating ribs **34** provide a stiff rigid structure as is required to transmit vibratory forces from the shafts **11** into the container itself.

The middle section of the drum, the part **33**, comprises an octagonal open-ended shell the marginal areas which are turned radially outwardly to abut the marginal portions of the end sections **31** and **32** to which they are bolted. A plurality of transverse webs **35** serve to stiffen the individual sides of this middle section of the container.

The interior surfaces of the drum or container are preferably lined with neoprene or other resilient material that is inert to the materials used in the polishing or abrasion processes in the mill. An access opening with a cover **40** is provided in one of the sides of the center section **33** of the drum for loading and unloading the drum. The cover **40** is arranged with latching mechanisms so that it can form a water-tight seal to the container.

As was mentioned previously the drum **10** is slowly turned on the stub shafts **11** by a gear reduction motor **25**, the shafts **11** turning in bearings **12** mounted on the deep-center portions of the side girders **14** and **15**. The lateral vibration to enhance the polishing or abrading action of the tumbling materials is provided by the linear vibration of an exciter mass **45** that is resiliently mounted within the exciter housing **30**. The exciter mass **45** includes a

generally box-like frame that carries bearings **46** and **47** in which an exciter shaft **48** is journaled. The exciter shaft **48**, which carries eccentric weights **49** and **50**, is driven through pulley **51** and belt **52** from a constant speed drive motor **53** which is preferably mounted on a bracket **54** extending from one of the columns **18**. Clearance holes **55** in the end of the housing **30** admit the shaft **48** and allow it to vibrate relative to the housing. The box-like exciter frame **45** has interior partitions **56** that serve as stiffeners and as means for increasing the weight of the exciter mass.

The exciter housing **30**, in which the exciter mass **45** is mounted, is preferably constructed of a pair of channels **57** and **58** having their flanges facing each other and spaced apart by end plates **59** and **60** to form a generally open-sided box. This housing **30** is then attached by means of side plates **61** and **62** to the girders **14** and **15** making up the frame for the mill.

The exciter mass **45** is resiliently connected to the housing **30** by means of a plurality of air bags **65** which may be similar to the air bags **16** and **17** serving as resilient supports for the girders and which preferably are of the same general construction as the air springs used in many heavy motor vehicles. As indicated in FIGS. IV and V sixteen of these air bags or air springs are employed eight on each side of the box-like exciter mass **45** to connect it to the adjacent portions of the housing **30**. The elasticity or spring rate of the air bags **65** may be varied by varying the pressure to which they are inflated. Thus the higher the pressure the higher the spring rate.

For economical efficient operation it is desirable that the mass of the exciter **45** be approximately ¼ of a combined mass of the frame **13** comprising the side girders **14** and **15** and the drum **10** with the parts rigidly mounted thereon. Satisfactory operation may be obtained with this mass ratio ranging between 1 to 1.5 as one extreme to about 1 to 6 for the other extreme. If the mass ratio becomes much nearer unity than 1 to 1.5 the stroke of the exciter member **45** becomes generally equal to the vibratory motion of the drum and the resonant frequency of the system varies beyond tolerable limits with changes in load in the drum. At the other extreme if the exciter member is too light it must move through too long a stroke to exert the proper force on the frame **13** and this leads to difficulty with the springs **65**.

The operating speed at which the shaft **48** is driven may be fixed by employing a constant speed motor and is selected according to the frequency of vibration desired in the tumbling mill. Once this frequency is selected the inflation pressure of the air bags **65** is then varied until the natural frequency of the vibratory system comprising the exciter mass **45** as one element, the mass of the frame **13** and parts carried thereby as the other element, and the air bags as the spring is slightly above a desired operating frequency. When operated in this condition the inertia force of the exciter mass **45** plus the force applied by the eccentric weights **49** and **50** is equal to the interia force of the frame **13** and these forces are each equal to the forces transmitted through the air bags **65**. In this condition of operation the relative strokes or motions of the masses are generally inversely proportional to the magnitude of the masses so that the exciter member **45** thus vibrates through a stroke from 3 to 4 times the stroke of the frame **13**.

The directions of the vibrations are indicated in FIG. VI. In this figure, as shown, the drum **10** rotates counterclockwise as driven by the motor pulley **26** and belt **27** at the same time that it is vibrated along an inclined path **70** by forces produced by vibration of the exciter frame or exciter mass **45** moving along the same inclined path **70**. As was mentioned previously the magnitudes of the strokes are inversely proportional to the masses with the magnitude of the motion of the drum **10** in linear vibration being approximately ⅓ the movement of the exciter mass **45**. The tuning of the system and the relatively low rate of the air bags in shear prevent the buildup of any appreciable vibration at right angles to the desired vibration. The elasticity of the supporting air bags or springs **16** and **17** is low enough that only minor vibratory forces are transmitted from the frame **13** through the supporting columns **18**.

This drive arrangement makes it possible to impose a vigorous linear vibration on the material contained within the drum **10** as such material is being mixed and tumbled by the slow rotation of the drum so that the abrasive material is effective on all parts of the article being polished including interior surfaces of such articles. This operation is thus superior to the orbital vibration ordinarily employed with such types of apparatus.

Various modifications may be made in the details of construction without departing from the scope of the invention.

Having described the invention, we claim:

1. A vibrating tumbling barrel assembly comprising, in combination, a resiliently mounted frame, a symmetrically shaped drum journaled on the frame for rotation about an axis, means for rotating the drum, an exciter mass, resilient means mounting said exciter mass on the frame for the transmission of vibratory force along a line directed transversely through the axis of rotation of the drum, and means for vibrating said exciter mass along a path having a major axis along said line to produce a predominantly straight line vibration of said frame and drum.

2. A vibrating tumbling barrel assembly comprising, in combination, a resiliently mounted frame, a drum journaled on the frame for rotation about an axis, means for rotating the drum, an exciter mass, resilient means connecting the exciter mass to the frame for transmitting vibratory force along a substantially straight inclined path generally perpendicular to the axis of rotation of the drum, a shaft carrying eccentric weights journaled in the exciter mass and extending parallel to said axis, said exciter mass and said frame cooperating with the resilient means to form a vibratory system having a natural frequency, and means from driving said shaft at a speed generally equal to said natural frequency.

3. A vibrating tumbling barrel assembly comprising, in combination, a resiliently mounted frame, a multisided drum journaled on the frame for rotation about a generally horizontal axis, means for rotating the drum, an exciter mass that is movable along an inclined path generally perpendicular to said axis, a plurality of pneumatic springs coupling the exciter mass to the frame and resiliently opposing movement of the exciter mass along such path, a shaft carrying eccentric weights journaled in the exciter mass, and means for rotating the shaft at a generally constant speed equal to a desired operating speed, said pneumatic springs being inflated to a pressure such that said springs cooperate with the exciter mass, the frame and the drum to form a vibratory system that vibrates along said path with a natural frequency near said operating speed.

References Cited in the file of this patent

UNITED STATES PATENTS

2,200,724	Robins	May 14, 1940
2,469,484	Thiman	May 10, 1949
2,702,633	Dekanski	Feb. 22, 1955

FOREIGN PATENTS

811,439	Great Britain	Apr. 8, 1959