March 16, 1971 A. K. FERRARA 3,570,192

VIBRATORY FINISHING MACHINE HAVING GENERALLY CIRCULAR BOWL

Filed Feb. 24, 1969 3 Sheets-Sheet 1

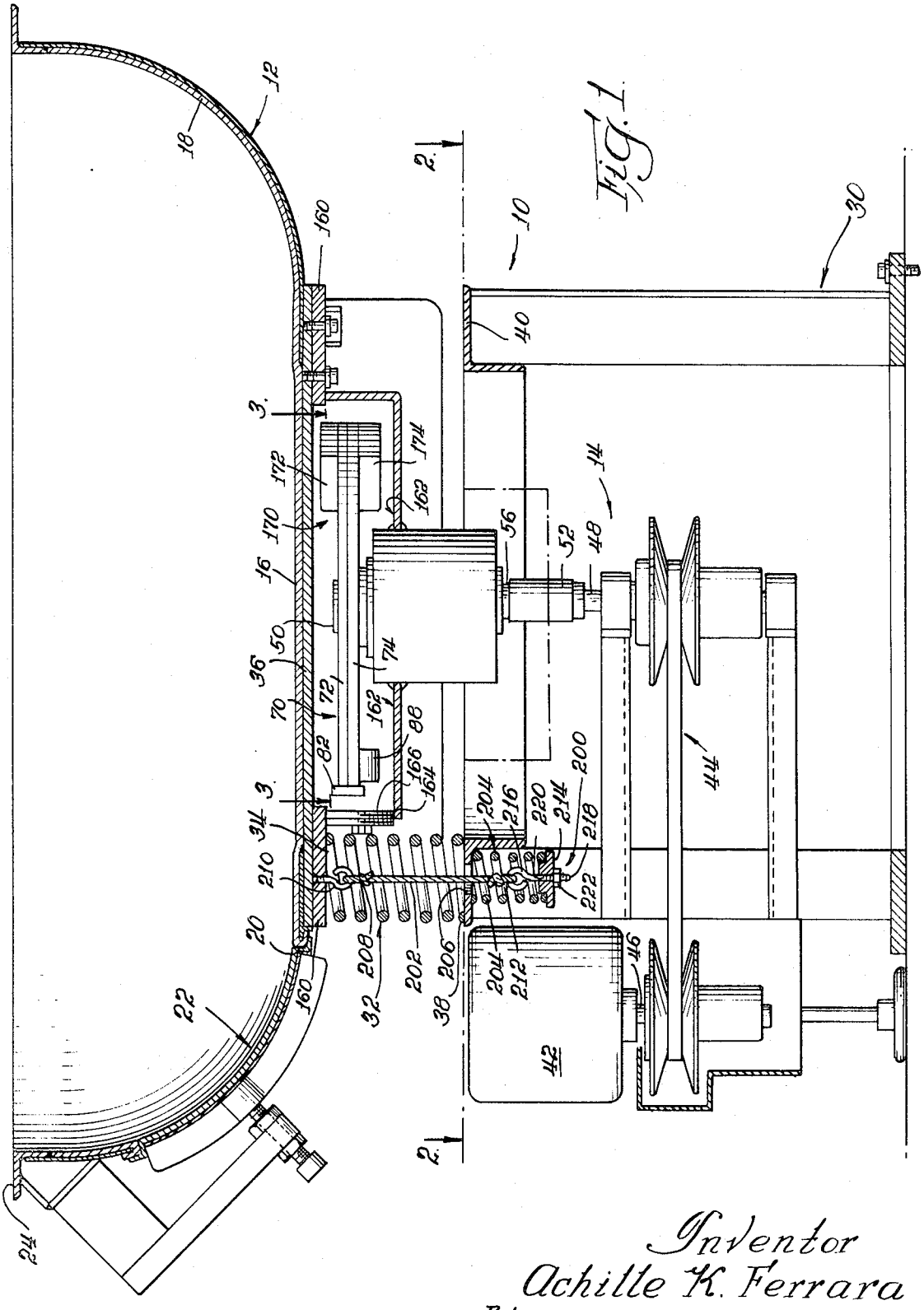

Fig. 1

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Fig. 2.

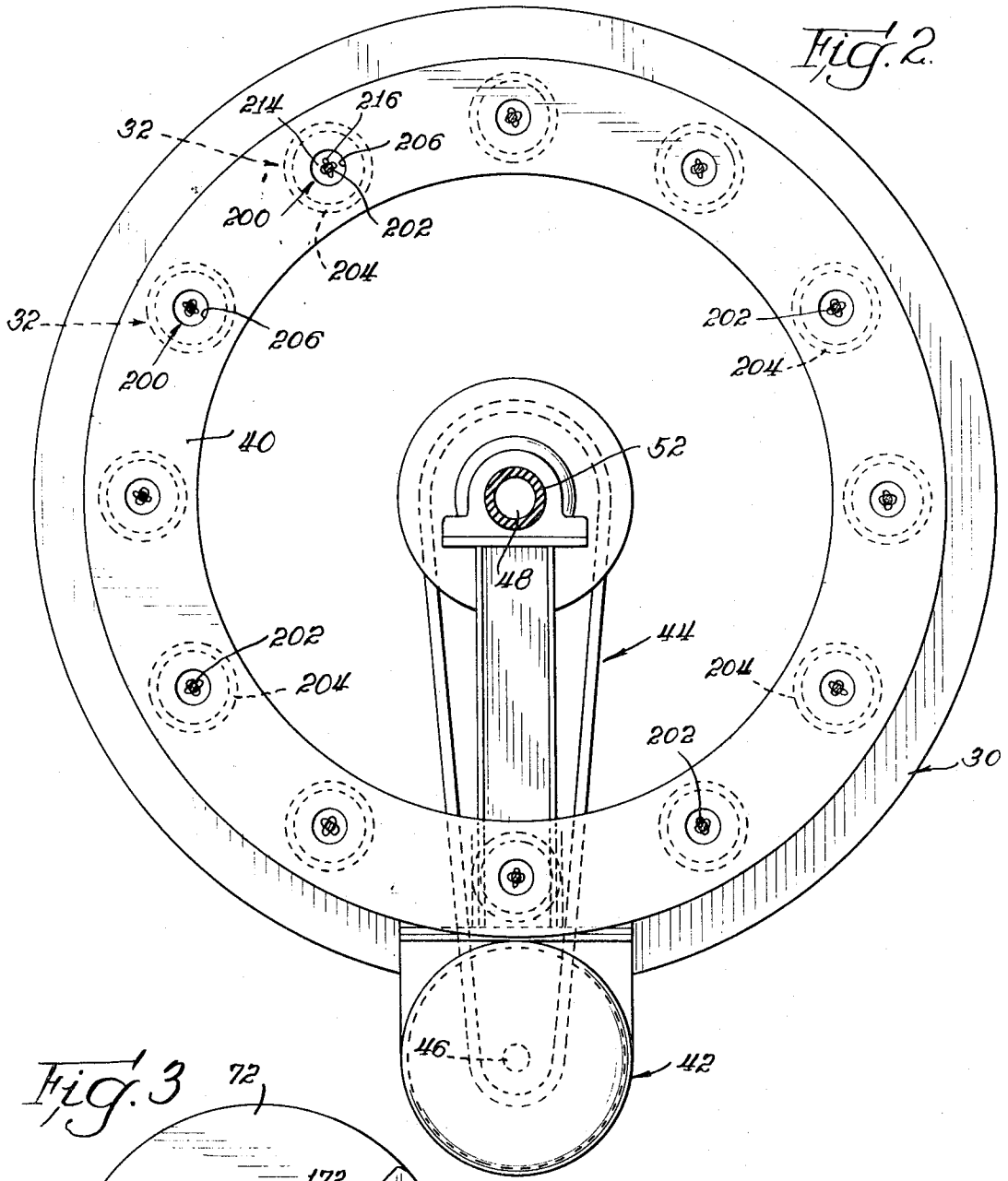

Fig. 3

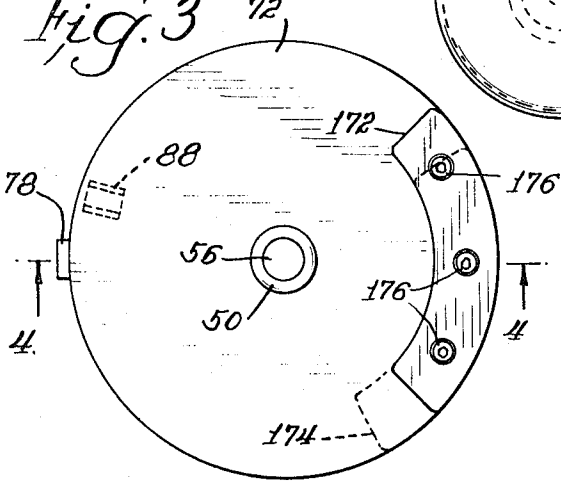

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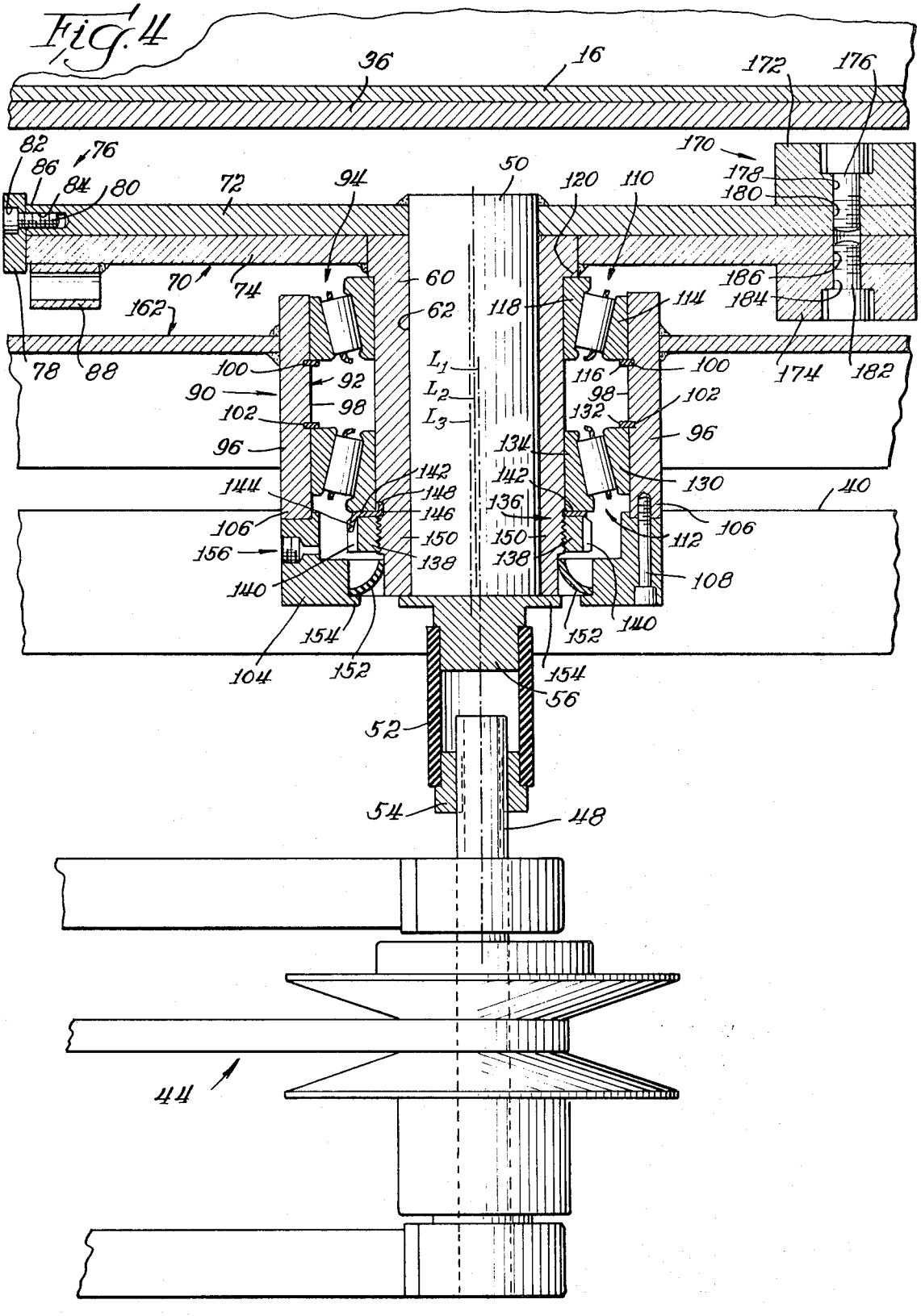
Fig. 4



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VIBRATORY FINISHING MACHINE HAVING GENERALLY CIRCULAR BOWL

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U.S. Cl. 51—163 14 Claims

ABSTRACT OF THE DISCLOSURE

Vibratory motion is imparted to a bowl through a cylindrical hub coupled to a drive shaft for conjoint rotation with the shaft in eccentric relation to the shaft and cylindrical cam means eccentric to the hub. Bearing means are utilized intermediate the cam means and inner surface portions of a housing connected to the bowl to permit rotation of the cam means with respect to the housing.

BACKGROUND OF THE INVENTION

This invention pertains generally to vibratory finishing machines for use in deburring, polishing, and other finishing, and more particularly to vibratory finishing machines of the type having a generally circular bowl and vibratory mechanism for vibrating the bowl.

Conventionally, the vibratory mechanism for vibrating the bowl comprises a vertically oriented shaft located beneath the bowl, bearing means intermediate the shaft and a housing connected to the bowl to permit rotation of the shaft relative to the housing, and unbalanced weights mounted to the housing for slinging rotation around the shaft to cause the shaft to vibrate eccentrically as the shaft is rotated, thereby to cause the housing to vibrate as the shaft is rotated. The housing is connected to the bowl such that vibratory motion of the housing is transmitted to the bowl. The bowl is supported in such a manner as to permit limited vertical and lateral vibration of the bowl, usually by means of a plurality of helical springs, and the principal mode of vibration of the bowl is orbital. The vibration of the bowl is transmitted to the contents of the bowl.

Conventionally, the vibratory mechanism is enclosed within a protective housing. Often, the unbalanced weights are mounted directly to the shaft of an electric motor, and the housing of the electric motor is mounted directly to the bowl. In such instances, it is commonly found that inadequate ventilation and moisture accumulation contribute to the rapid failure of the electric motor. In other instances, an electric motor or other prime mover is used to drive a separate shaft having the unbalanced weights. In such instances, it is difficult to provide a satisfactory coupling between the prime mover and the shaft because the shaft vibrates eccentrically when rotated. In any such instance, the load on the bearing means intermediate the shaft carrying the unbalanced weights and the housing is constantly unbalanced. Consequently, bearing wear is excessive and average bearing life is short.

In the operation of vibratory finishing machines, it is desirable that the operator be able to selectively vary either the frequency or the amplitude of vibration of the bowl, or both, in order to meet the precise energy requirements for each finishing operation. Heretofore, expensive variable-speed electric motors have been used to permit selective variation of the frequency of vibration of the bowl, and it has been necessary to use interchangeable unbalanced weights to permit selective variation of the amplitude of vibration of the bowl.

In view of the foregoing, it is evident that there is a need for an improved vibratory mechanism for use in vibratory finishing machines of the aforementioned type. This invention is addressed to fulfilling such need.

SUMMARY OF THE INVENTION

Accordingly, it is one object of this invention to provide a vibratory finishing machine for use in deburring, polishing, and other finishing, and having a generally circular bowl and improved vibratory mechanism for vibrating the bowl.

It is a related object of this invention to provide improved vibratory mechanism for such a vibratory finishing machine.

It is another object of this invention to provide a vibratory finishing machine, as described, wherein the vibratory mechanism has a shaft which does not vibrate when rotated but is generally stable with respect to a fixed frame of reference found in the machine.

It is a related object of this invention to provide a vibratory finishing machine, as described, wherein the vibratory mechanism is balanced.

It is a related object of this invention to provide a vibratory finishing machine, as described, wherein the shaft of the vibratory mechanism does not carry unbalanced weights.

It is a related object of this invention to provide a vibratory finishing machine, as described, wherein the load on the bearings associated with the shaft is balanced at substantially all times during rotation of the shaft.

It is a related object of this invention to provide a vibratory finishing machine, as described, wherein an electric motor located apart from beneath the bowl and coupled to the shaft may be conveniently used to drive the vibratory mechanism.

It is another object of this invention to provide a vibratory finishing machine, as described, in which a variable-speed pulley mechanism or other variable-speed transmission means may be used to permit selective variation of the frequency of vibration of the bowl.

It is a related object of this invention to provide a vibratory finishing machine, as described, in which an inexpensive single-speed motor may be used in conjunction with a variable-speed pulley mechanism or other variable-speed transmission means.

It is another object of this invention to provide a vibratory finishing machine, as described, wherein the amplitude of vibration of the bowl may be selectively varied by simple mechanical adjustment.

It is a related object of this invention to provide a vibratory finishing machine, as described, wherein there is no need to interchange unbalanced weights to permit selective variation of the amplitude of vibration of the bowl.

The preceding objects may be attained in a vibratory finishing machine having a generally circular bowl suitably supported for vibration and vibratory mechanism for vibrating the bowl. In accordince with the principles of this invention, the vibratory mechanism comprises an upright shaft, an upright cylindrical hub coupled to the shaft for conjoint rotation with the shaft in eccentric relation to the shaft, cylindrical cam means formed with a longitudinal cylindrical eccentric opening through which the hub is fitted for rotation of the cam means upon the hub, holding means for releasably holding the cam means in a selected rotated position upon the hub for conjoint rotation of the cam means with the hub and the shaft, a housing connected to the bowl and formed with cylin-

drical inner surface means surrounding and being spaced from the cam means, bearing means intermediate the cam means and the inner surface means of the housing to permit rotation of the cam means with respect to the housing, and counterbalancing means for generally centrifugally counterbalancing the vibratory mechanism.

Preferably, the means for releasably holding the cam means in a selected rotated position with respect to the hub comprises a first flywheel fixed to the hub for conjoint rotation with hub and the shaft, a second flywheel fixed to the cam means for conjoint rotation with the cam means upon the hub, and means for releasably locking the first flywheel to the second flywheel in order to releasably hold the cam means in a selected rotated position upon the hub. Preferably, the counter-balancing means comprises a first counterbalancing weight mounted to the first flywheel in diametrically opposite relation to the greatest eccentricity of the hub and a second counterbalancing weight mounted to the second flywheel in diametrically opposite relation to the greatest eccentricity of the cam means.

These and other objects, features, and advantages of this invention will be evident from the following description, with the aid of the attached drawings, of a preferred embodiment of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a vertical sectional view of a vibratory finishing machine having a generally circular bowl suitably supported for vibration and vibratory mechanism for vibrating the bowl;

FIG. 2 is a sectional view taken substantially along line 2—2 of FIG. 1 in the direction of the arrows;

FIG. 3 is a fragmentary sectional view taken substantially along line 3—3 of FIG. 1 in the direction of the arrows;

FIG. 4 is a fragmentary sectional view taken substantially along line 4—4 of FIG. 3 in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawings, there is shown a vibratory finishing machine **10** embodying the principles of this invention and constituting a preferred embodiment of this invention. The vibratory finishing machine **10** has a generally circular bowl **12** suitably supported for vibration and vibratory mechanism **14** for vibrating the bowl **12**.

As shown, the bowl **12** is open at the top. The bowl **12** is characterized by a flat generally circular bottom wall **16** and a curved annular lateral wall **18**. A discharge opening **20** is provided in the lateral wall **18** of the bowl **12**. A suitably mounted plug door **22** is used to open and close the discharge opening **20**. The lateral wall **18** of the bowl **12** is formed with a horizontally extending lip **24** to which a cover (not shown) may be attached if desired. The bowl **12** may be lined with a suitable wear-resistant elastomer or other lining material (not shown) if desired. This structure of the bowl **12** is conventional and further details thereof may be supplied readily by those skilled in the art.

In use, the bowl **12** contains a mass of abrasive finishing media (not shown) of any type suitable for deburring, cleaning, polishing, or other finishing. Workpieces to be finished are introduced into the mass of abrasive finishing media through the top of the bowl **12**. After the workpieces have been finished, the plug door **22** is removed from the discharge opening **20** and the contents of the bowl **12** are discharged to a conventional screen separator or the like (not shown).

The vibratory finishing machine **10** further has a fixed frame **30** on which the bowl **12** is supported for vibration by means of a plurality of helical springs **32**. The upper ends **34** of the helical springs **32** are suitably connected

to the underside of a generally circular plate **36** which is welded or otherwise integrally mounted to the underside of the bottom wall **16** of the bowl **12**. The lower ends **38** of the springs **32** are suitably connected to a suitably elevated annular support **40**, which forms an integral part of the frame **30**. The frame **30** may be bolted to the floor, as shown. Thus, the bowl **12** is permitted limited vertical and lateral vibration. The manner in which the springs **32** are connected to the plate **36** and to the support **40** is conventional and further details thereof may be supplied readily by those skilled in the art.

The vibratory mechanism **14** for vibrating the bowl **12** is driven from a conventional single-speed electrical motor **42**, which is suitably mounted to the frame **30**, by means of a conventional variable-speed pulley mechanism **44**. The input shaft **46** of the variable speed pulley mechanism **44** is driven directly from the motor **42**. The output shaft **48** of the variable-speed pulley mechanism **44** is upright, as shown, and also forms part of the vibratory mechanism **14** for vibrating the bowl. The longiutdinal central axis of the shaft **48**, about which the shaft **48** is rotated, is indicated at L_1 in FIG. 4.

The vibratory mechanism **14** comprises, in addition to the upright shaft **48**, an upright cylindrical hub **50** which is coupled to the shaft **48** for conjoint rotation with the shaft **48** in eccentric relation to the shaft **48**. The longitudinal central axis of the hub **50** is indicated at L_2 in FIG. 4. The hub **50** is coupled to the shaft **48** by means of a resilient sleeve coupling **52** intermediate an annular spacer **54** splined to the shaft **48** and a stub shaft **56** integrally mounted to the hub **50** in eccentric relation to the hub **50**. The annular spacer **54** is axially movable along a portion of the shaft **48** in order to accommodate settling of the bowl **12** under load and also permit limited vertical vibration of the bowl **12**. The resilient sleeve coupling **52** isolates the shaft **48** from lateral vibrations of the bowl **12**, such as might occur during start-up of the vibratory mechanism **14**, and from other shocks. The resilient sleeve serves to keep the stub shaft **56** generally in axially aligned relation to the shaft **48** yet permits slight misalignment or obliquity between the stub shaft **56** and the shaft **48**.

The vibratory mechanism **14** further comprises cylindrical cam means **60** formed with a longitudinal cylindrical opening **62**, through which the hub **50** is fitted for rotation of the cam means **60** upon the hub **50**. The longitudinal central axis of the cam means **60** is indicated at L_3 in FIG. 4. Rotation of the cam means **60** upon the hub **50** produces rotation of L_3 around L_2.

The eccentricity of the cam means **60** with respect to the shaft **48** may be selectively varied by rotation of the cam means **60** upon the hub **50**. Preferably, the greatest eccentricity of the cam means **60** with respect to the hub **50** is approximately equal to the greatest eccentricity of the hub **50** with respect to the shaft **48**, as shown, whereupon the greatest eccentricity of the cam means **60** with respect to the shaft **48** may be selectively varied, as mentioned, from nothing to twice the greatest eccentricity of the cam means **60** with respect to the hub **50**, or, equivalently, from nothing to twice the greatest eccentricity of the hub **50** with respect to the shaft **48**. When the greatest eccentricity of the cam means **60** with respect to the shaft **48** is nothing, the longitudinal central axis L_3 of the cam means **60** generally coincides with the longitudinal central axis L_1 of the shaft **48**, as will be understood.

The vibratory mechanism **14** further comprises holding means **70** for releasably holding the cam means **60** in a selected rotated position upon the hub **50** for conjoint rotation of the cam means **60** with the hub **50**. The holding means **70** comprises a first flywheel **72** fixed to the hub **50** for conjoint rotation of the cam means **60** with the hub **50**. The holding means **70** comprises a first flywheel **72** fixed to the hub **50** for conjoint rotation with the hub **50**, a second flywheel **74** fixed to the cam means **60** for conjoint rotation with the cam means **60** upon the hub **50**, and locking means **76** for releasably locking the first flywheel

72 to the second flywheel 74 in order to releasably hold the cam means 60 in a selected rotated position upon the hub 50. The flywheels 72 and 74 are disposed in closely spaced parallel relation, as shown. The locking means 76 comprises a flange 78 which is integrally attached to the rim portion 80 of the second flywheel 74, and a threaded stud 80, which engages a suitable shouldered opening 82 in the flange 78 and is threaded into a selected one of a plurality of suitably threaded sockets 84 (one shown) in the rim portion 84 of the first flywheel 72. The sockets 84 are sufficient in number, and are arcuately spaced around at least one half of the rim portion 86 of the first flywheel 72 in suitable positions, to offer the desired range of selectivity for the rotated position of the cam means 60 upon the hub 50. In practice, the second flywheel 74 may be held while the motor 42 is intermittently operated in such a manner as to rotate the hub 50 within the cam means 60. To facilitate such operation, the holding means 70 also comprises a radially oriented tubular member 88 integrally attached to the second flywheel 74 in a suitable position to receive a bar or the like (not shown) to be used to hold the second flywheel 74.

The vibratory mechanism 14 further comprises a housing 90, which is connected to the bowl 12 and is formed with cylindrical inner surface means 92 surrounding and being spaced from the cam means 60, and bearing means 94 intermediate the cam means 60 and the inner surface means 92 of the housing 90 to permit rotation of the cam means 60 with respect to the housing 90. As shown, the housing 90 comprises an annular wall member 96, which has a cylindrical inner surface 98 formed with axially spaced annular grooves 100 and 102, and a retaining ring 104, which is removably fastened to the lower margin 106 of the wall member 96 by means of a plurality of machine screws 108 (one shown).

As shown, the bearing means 94 comprises an upper tapered-roller bearing 110 and a lower tapered-roller bearing 112. The outer race member 114 of the upper tapered-roller bearing 110 slidably fits within the annular wall member 96 and is restrained against axial movement in an inward, or downward, direction by means of a split ring 116 seated in the annular groove 100 in the inner surface 98 of the annular wall member 96. The inner race member 118 of the upper tapered-roller bearing 110 slidably fits around the cam means 60 and is restrained against axial movement in an outward, or upward, direction by means of an annular rest 120 integrally formed on the cam means 60. It is to be understood that the upper tapered-roller bearing 110 is axially oriented in such a manner as to be capable of being axially loaded between the ring 116 and the annular rest 120, the opposite axial orientation being unsuitable, as is evident from the manner in which the outer and inner race members 114 and 118 are restrained. The outer race member 130 of the lower tapered-roller bearing 112 also slidably fits within the annular wall member 96 and is restrained against axial movement in an inward, or upward, direction by means of a split ring 132 seated in the annular groove 102 formed in the inner surface 98 of the annular wall member 96. The inner race member 134 of the lower tapered-roller bearing 112 also slidably fits around the cam means 60 but is restrained against axial movement in an outward, or downward direction by means of conventional lock-nut means 136. It is to be understood that the lower tapered-roller bearing 112 is to be axially oriented in such a manner as to be capable of being axially loaded between the ring 132 and the lock-nut means 136, the opposite axial orientation being unsuitable, as is evident from the manner in which the outer and inner race members 130 and 134 are restrained.

The lock-nut means 136 comprises an internally threaded generally annular lock nut 138, which has a plurality of axially spaced transverse grooves 140, and a generally annular lock washer 142, which has a plurality of circumferentially spaced outer tabs 144 (one shown),

and which has a generally axially inwardly extending inner tab or key 146. The cam means 60 is formed with a keyway 148, which receives the key 146 when the lock washer 142 is positioned around the cam means 60 against the inner race member 134 of the lower tapered-roller bearing 112. The keyway 148 is slightly longer than the key 146 to permit limited axial movement of the lock washer 142 along the cam means 16. The lock washer 142, which thus is keyed to the cam means 60, is held against the inner race member 134 of the lower tapered-roller bearing 112 by the lock nut 138, which threadably engages a suitably threaded portion 150 of the cam means 60. It is characteristic of tapered-roller bearings that the radial tolerances thereof are determined by the axial tolerances thereof. Adjustment of the axial tolerances of the upper and lower tapered-roller bearings 110 and 112 may be accomplished by turning the lock nut 138 upon the lock nut 138 upon the threaded portion 150 of the cam means 60 to adjust the axial spacing of the lock nut 138 and the annular rest 120, the axial spacing of the rings 116 and 132 being fixed. The minimum axial spacing of the respective outer race members 114 and 130 is determined by the fixed axial spacing of the rings 116 and 132, and the maximum axial spacing of the respective inner race members 118 and 134 is determined by the adjusted axial spacing between the annular rest 120 and the lock washer 142 engaging the lock nut 138. The lock-nut means 136 should be locked to the threaded portion 150 of the cam means 60 by bending one of the outer tabs 144 of the lock washer 142 into one of the peripheral grooves 140 of the lock nut 138, as shown. As normal non-destructive bearing wear is incurred, further advancement of the lock nut 138 may be made to restore the proper axial tolerances to the upper and lower tapered-roller bearings 110 and 112, as will be understood.

As shown, a conventional seal 152 is held against the cam means 60, beneath the lock-nut means 136, by means of a radially inwardly extending flange 154 integrally formed on the retaining ring 104. Suitable means, exemplified by a port 156 formed in the retaining ring 104, may be provided to facilitate lubrication of the bearing means 94.

The housing 90 is connected to the bowl 12 by means of an annular plate 160, which is rigidly connected to the aforementioned generally circular plate 37 at the underside of the bottom wall 16 of the bowl 12, and reinforced structure 162, which extends radially outwardly and upwardly from the housing 90, as shown, and is welded or otherwise rigidly connected to the annular wall member 96 and to the annular plate 160. As shown, the housing 90 is rigidly connected to the bowl 12. In other instances, a non-rigid connection may be useful.

Access to the aforementioned locking means 76 for releasably locking the first flywheel 72 to the second flywheel 74, and to the aforementioned tubular member 84 on the second flywheel 74, may be had through a circular opening 164 in the reinforced structure 162. The opening 164 is threaded in order that a threaded plug 166 may be used to open and close the opening 164.

In operation of the vibratory finishing machine 10, the hub 50 and the cam means 60 are conjointly rotated about the longitudinal axis L_1 of the shaft 48, and, as a result vibration is imparted to the bowl 12 and its contents through the bearing means 94. The principal mode of resultant vibration is orbital. The frequency of the principal mode of resultant vibration of the bowl 12 is essentially equal to the frequency of rotation of the shaft 48. The amplitude of the principal mode of resultant vibration of the bowl 12 is essentially equal to the greatest eccentricity of the cam means 60 with respect to the shaft 48.

The vibratory mechanism 14 further comprises counterbalancing means 170 for centrifugally counterbalancing the vibratory mechanism 14 with respect to the shaft 48. The counterbalancing means 170 comprises a first counterbalancing weight 172 mounted to the first flywheel 72

in diametrically opposite relation to the greatest eccentricity of the hub 50 and a second counterbalancing weight 174 mounted to the second flywheel 74 in diametrically opposite relation to the greatest eccentricity of the cam means 60. The first counterbalancing weight 172 is mounted to the first flywheel 72 by means of a plurality of bolts 176 engaging respective recessed openings 178 in the weight 172 and threadably engaging respective suitably threaded sockets 180 in the flywheel 72. The second counterbalancing weight 174 is mounted to the second flywheel 74, in similar manner, by means of a plurality of bolt 182 engaging respective recessed openings 184 in the weight 174 and threadably engaging respective suitably threaded sockets 186 in the flywheel 74.

As is known with regard to vibratory finishing machines of the type to which this invention pertains, in operation of the vibratory finishing machine 10, the contents of the bowl 12 tend to become displaced radially outwardly from the center of the bottom wall 16 of the bowl 12 toward the lateral wall 18 of the bowl 12 until normal running conditions are achieved, and, under normal running conditions, the contents of the bowl 12 are concentrated at the outermost portions of the bowl 12 and tend to move through the bowl 12 in a generally toroidal path. Until normal running conditions have been achieved, the first and second counterbalancing weights 172 and 174 may overcompensate for the centrifugal unbalance of the vibratory mechanism 14 and cause the vibratory mechanism 14 and the bowl 12 to wobble with respect to the shaft 12. Such wobbling is permitted by the springs 32 supporting the bowl 12 and by the resilient sleeve coupling 52 driving the hub 50 from the shaft 48.

Once normal running conditions have been achieved, the centrifugal force of the combined first and second counterbalancing weights 172 and 174 opposes and tends to overcome the centrifugal unbalance imposed on the vibratory mechanism 14 by the orbiting bowl 12 and its contents.

Because the greatest eccentricity of the cam means 60 with respect to the hub 50 is approximately equal to the greatest eccentricity of the hub 50 with respect to the shaft 48, it is possible and furthermore is preferred to have the first and second counterbalancing weights 172 and 174 approximately equal in mass and to locate the respective weights 172 and 174 at approximately equal radial distances from the longitudinal central axis L_2 of the hub 50. As the cam means 60 is rotated upon the hub 50, the second counterbalancing weight 174 is moved correspondingly with respect to the first counterbalancing means over an arcuate path around the longitudinal central axis L_2 of the hub 50. By way of example, in FIG. 3, the second counterbalacing weight 174 is shown as having been moved a few degrees of arc with respect to the first counterbalancing weight 172. When the greatest eccentricity of the cam means 60 with respect to the shaft 48 is equal to twice the greatest eccentricity of the cam means 60 with respect to the hub 50, or, equivalently, twice the greatest eccentricity of the hub 50 with respect to the shaft 48, the lever arm of the second counterbalancing weight 174 generally coincides with the lever arm of the first counterbalancing weight 172, as shown in FIGS. 2 and 4, and the effective lever arm of the combined first and second counterbalancing weights 172 and 174 is maximal. When the greatest eccentricity of the cam means 60 with respect to the shaft 48 is nothing, that is, when the longitudinal central axis L_3 of the cam means 60 generally coincides with the longitudinal central axis L_1 of the shaft 48, the lever arm of the second counterbalancing weight 174 is generally diametrically opposed to the lever arm of the first counterbalancing weight 172, and the effective lever arm of the combined first and second counterbalancing weights 172 and 174 is nothing. The effective lever arm of the combined first and second counterbalancing weights 172 and 174 remains proportionate to the greatest eccentricity of the cam means 60 with respect to the shaft 48 as the cam means 60 is rotated upon the hub 50 to intermediate positions with respect to the hub 50. Consequently, for normal running conditions, by proper selection of the masses of the first and second counterbalancing weights 172 and 174, the vibratory mechanism 14 may be generally centrifugally balanced, at any amplitude of vibration, for a predetermined charge of abrasive finishing media and workpieces to be finished.

As mentioned, the principal mode of vibration of the bowl is orbital. The full response of the bowl 12 is determined by the characteristics of the mass-spring system defined by the bowl 12 and its contents together with the helical springs 32 supporting the bowl 12. The response of the bowl 12 may be varied by variably pre-loading selected ones of the helical springs 32. To this end, the vibratory finishing machine 10 further comprises snubbing means 200 for snubbing selected ones of the helical springs 32.

One of the snubbing means 200 is shown in detail in FIG. 1. As shown, each of the snubbing means 200 comprises a wire cable 202 attached to the underside of the bowl 12 and a secondary helical spring 204 arranged to bias the wire cable 202 downwardly. Preferably, the wire cable 202 extends through the helical spring 32 to be snubbed, as shown. Alternatively, the wire cable 202 may extend between two of the helical springs 32 to snub both helical springs 32. The wire cable 202, which passes freely through an opening 206 in the aforementioned framework 40, is fastened, at its upper end 208, to the aforementioned annular plate 160 by means of an eyelet 210 which is threadably secured to the annular plate 160 and, at its lower end 212, to a generally disc-shaped member 214 by means of an eyelet 216 which is adjustably secured to the generally disc-shaped member 214. The secondary helical spring 204 is disposed around the wire cable 202 between the generally disc-shaped member 214 and the lower margin of the opening 206 in the framework 40. A lower end portion 218 of the eyelet 216 passes through an opening 220 in the generally disc-shaped member 214 and is threaded to receive a nut 222. Adjustment of the position of the nut 222 along the lower end portion 218 of the eyelet 216 effects corresponding adjustment of the pre-compression of the secondary helical spring 204 and thereby correspondingly pre-loads the helical spring 32 supporting the bowl 12.

When the snubbing means 200 are used to pre-load diametrically opposed pairs of the helical springs 32 supporting the bowl 12, the principal mode of vibration of the bowl 12 remains orbital. When the snubbing means 200 are used to pre-load only one of the helical springs 32, or adjacent groups thereof, the principal mode of vibration of the bowl 12 becomes spiral. In the latter instance, the resultant obliquity is permitted by the springs 32 supporting the bowl 12 and by the resilient sleeve coupling 52 driving the hub 50 from the shaft 48. It should be understood that the use of the snubbing means 200 is flexible.

Modifications and improvements within the scope of this invention may be suggested by the present disclosure to those skilled in the art. Accordingly, the scope of this invention should be determined from the following claims.

What I claim is:

1. A vibratory finishing machine having a generally circular bowl suitably supported for vibration and vibratory mechanism for vibrating said bowl, said vibratory mechanism comprising an upright shaft, an upright cylindrical hub coupled to said shaft for conjoint rotation with said shaft in eccentric relation to said shaft, cylindrical cam means having a longitudinal cylindrical eccentric opening through which said hub is fitted for rotation of said cam means upon said hub, holding means for releasably holding said cam means in a selected rotated position upon said hub for conjoint rotation of said cam means and said hub, a housing connected to said bowl and formed with cylindrical inner surface means surrounding and being spaced from said cam means, bear-

ing means intermediate said cam means and said inner surface means of said housing to permit rotation of said cam means with respect to said housing, and counterbalancing means for generally centrifugally counterbalancing said vibratory mechanism with respect to said shaft.

2. The vibratory finishing machine of claim 1 wherein said counterbalancing means comprises a first counterbalancing weight connected to said hub in diametrically opposite relation to the greatest eccentricity of said hub with respect to said shaft and a second counterbalancing weight connected to said cam means in diametrically opposite relation to the greatest eccentricity of said cam means with respect to said hub.

3. The vibratory finishing machine of claim 1 wherein the greatest eccentricity of said cam means with respect to said hub is approximately equal to the greatest eccentricity of said hub with respect to said shaft.

4. The vibratory finishing machine of claim 3 wherein said counterbalancing means comprises a first counterbalancing weight connected to said hub in diametrically opposite relation to the greatest eccentricity of said hub with respect to said shaft and a second counterbalancing weight connected to said cam means in diametrically opposite relation to the greatest eccentricity of said cam means with respect to said hub.

5. The vibratory finishing machine of claim 4 wherein said first and second counterbalancing weights are approximately equal in mass and are located at approximately equal radial distances from the longitudinal central axis of said hub.

6. The vibratory finishing machine of claim 1 wherein said holding means comprises a first flywheel fixed to said hub for conjoint rotation with said hub, a second flywheel fixed to said cam means for conjoint rotation with said cam means upon said hub, and locking means releasably locking said first flywheel to said second flywheel in order to releasably hold said cam means in a selected rotated position upon said hub.

7. The vibratory finishing machine of claim 6 wherein said counterbalancing means comprises a first counterbalancing weight mounted to said first flywheel in diametrically opposite relation to the greatest eccentricity of said hub with respect to said shaft and a second counterbalancing weight mounted to said second flywheel in diametrically opposite relation to the greatest eccentricity of said cam means with respect to said hub.

8. The vibratory finishing machine of claim 6 wherein the greatest eccentricity of said cam means with respect to said hub is approximately equal to the greatest eccentricity of said hub with respect to said shaft.

9. The vibratory finishing machine of claim 8 wherein said counterbalancing means comprises a first counterbalancing weight mounted to said first flywheel in diametrically opposite relation to the greatest eccentricity of said hub with respect to said shaft and a second counterbalancing weight mounted to said second flywheel in diametrically opposite relation to the greatest eccentricity of said cam means with respect to said hub.

10. The vibratory finishing machine of claim 1 further comprising a prime mover and variable-speed transmission means for transmitting power from said prime mover to said shaft.

11. The vibratory finishing machine of claim 1 further comprising means for resiliently coupling said hub to said shaft.

12. The vibratory finishing machine of claim 11 further comprising a prime mover and variable-speed transmission means for transmitting power from said prime mover to said shaft.

13. The vibratory finishing machine of claim 1 further comprising a plurality of helical springs supporting said bowl in such a manner as to permit limited vertical and lateral vibration of said bowl.

14. The vibratory finishing machine of claim 13 further comprising means for snubbing at least one of said helical springs to a predetermined variable extent.

References Cited

UNITED STATES PATENTS

3,464,674	9/1969	Pick	51—163X
3,435,564	4/1969	Balz	51—163
2,650,033	8/1953	Ahlmann	241—175X

HAROLD D. WHITEHEAD, Primary Examiner

U.S. Cl. X.R.

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