April 18, 1944. G. W. DUNHAM 2,346,669

WASHING MACHINE

Filed July 8, 1942 2 Sheets-Sheet 1

Fig. 1.

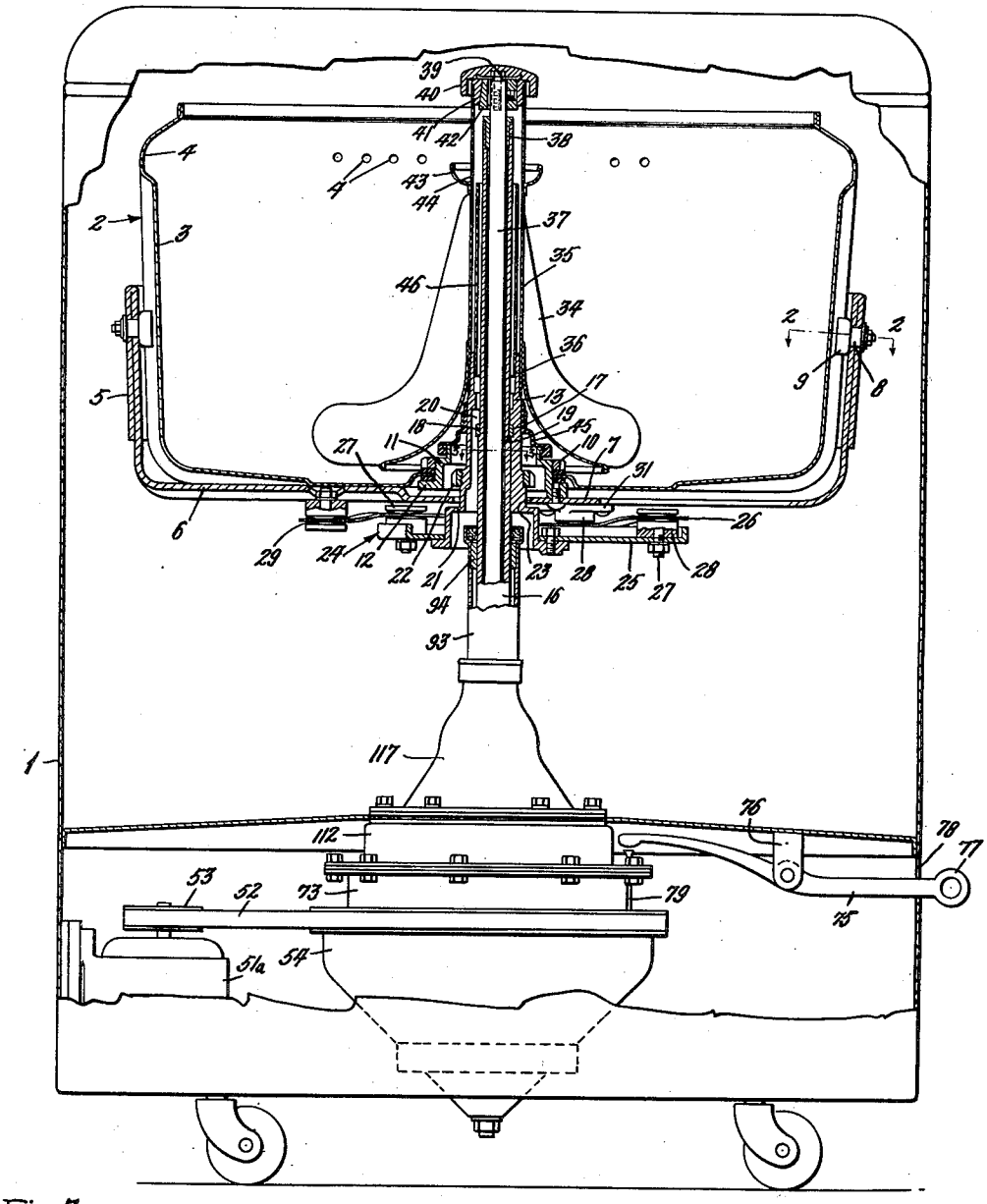


Fig. 3.

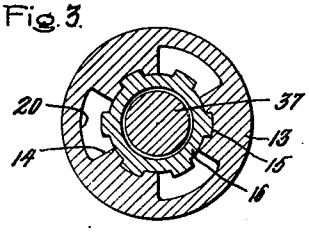
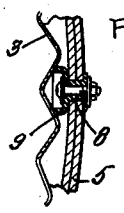


Fig. 2.



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Fig. 5.

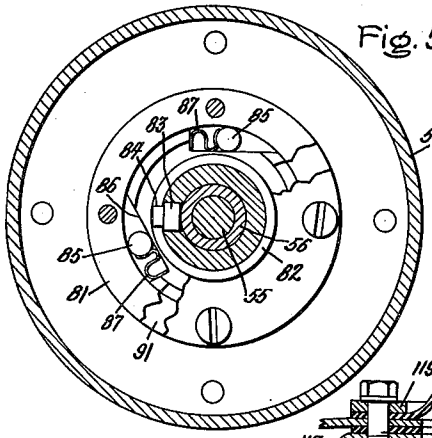
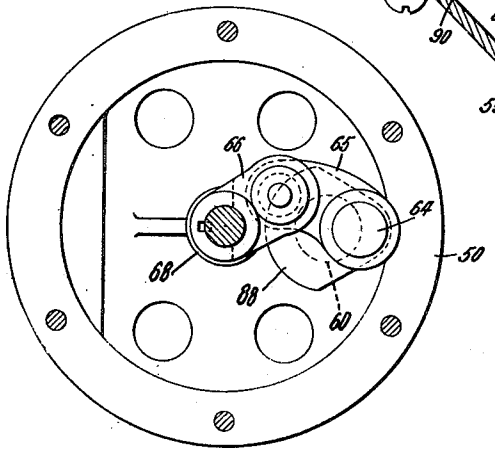


Fig. 4.

Fig. 6.



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UNITED STATES PATENT OFFICE

2,346,669

WASHING MACHINE

George W. Dunham, Westport, Conn., assignor to General Electric Company, a corporation of New York

Application July 8, 1942, Serial No. 450,119

4 Claims. (Cl. 68—23)

The present application is a continuation in part of my application Serial No. 425,165, filed December 31, 1941.

The present invention relates to washing machines of the type in which clothes are washed and centrifugally dried in a spinner basket.

In particular the invention is concerned with mechanism for oscillating the agitator and rotating the spinner basket and with the prevention of excessive vibration during centrifugal drying.

The object of my invention is to provide an improved construction and arrangement in machines of this type, and, for a consideration of what I believe novel and my invention, attention is directed to the following description and the claims appended thereto.

In the accompanying drawings, Fig. 1 is a sectional elevation of a washing machine embodying my invention; Figs. 2 and 3 are sectional views taken on lines 2—2 and 3—3 of Fig. 1; Fig. 4 is a sectional elevation of the driving mechanism; and Figs. 5 and 6 are sectional views taken on lines 5—5 and 6—6 of Fig. 4.

Referring to the drawings there is shown a washing machine having an outer casing 1 in the upper part of which is supported a spinner basket or clothes receptacle 2 having outwardly flaring fluted side walls 3 provided with centrifugal discharge openings 4 at the region of maximum diameter. The spinner basket is made of relatively thin sheet metal, which may be porcelain enameled steel, and is removably supported in a combined carrier and balance ring having relatively heavy side walls 5 surrounding the spinner basket and three spaced radial arms 6 extending beneath the bottom of the spinner basket and connecting the side walls 5 with a hub 7. The carrier side walls 5, as shown more clearly in Fig. 2, loosely surround the side walls of the spinner basket. Possible rattling due to this looseness is prevented by rubber stops 8 bolted to the carrier side walls and having flexible projections 9 which fit in the flutes in the side walls of the spinner basket. The spinner basket is secured to the carrier by means of a liquid tight connection having a nut 10 threaded on a sleeve 11 fixed to the carrier hub 7, the basket being clamped between the nut 10 and a shoulder 12 on the sleeve 11. The carrier hub 7 loosely surrounds a sleeve 13 which at its inner surface has spaced ribs 14 (Fig. 3) provided at the upper ends with axial grooves 15 by means of which the sleeve is splined on a tubular shaft 16. In the ribs 14 is a circumferential groove 17 receiving a snap ring 18 for engaging a shoulder 19 on the tubular shaft 16 so as to support the sleeve 13. The projections 14 are spaced apart (Fig. 3) so as to provide drain passages 20. At the lower end the sleeve 13 has a projecting flange 21 and a nut 22 both of greater diameter than the clearance opening 23 in the carrier hub 7. The flange and nut which are spaced on opposite sides of the carrier hub accordingly confine the carrier hub on the sleeve 13 and at the same time permit relative movement.

The driving connection between the shaft 16 and the spinner basket comprises a spider 24 fixed to the lower end of the sleeve 13 and having three radial arms 25 intermediate the carrier arms 6. The arms 25 are connected to a flexible steel ring 26 which at intermediate points is connected to the carrier arms 6. The connections to the arms 6 and 25 are made through bolts 27 having bushings 28 which clamp the ring against the heads of the bolts. The clamping surfaces are chamfered, as shown at 29, so as to prevent localized stresses in the ring.

The above described construction provides a support for the spinner basket which permits a universal tilting of the spinner basket relative to its driving shaft 16. This tilting tends to neutralize any unbalanced couple or dynamic unbalance which would otherwise transmit objectionable vibration to the driving shaft. The spinner basket is also resiliently supported for axial movement with respect to the shaft to cushion axial forces which, as hereinafter explained, arise while the spinner basket is rotating with precession and unbalanced distribution of the clothes.

An important feature of this universal connection is its relatively low friction which results from the use of a material of low internal friction for the ring 26 and from the design of the connections to the ring so as to minimize the friction. The low friction is important in preventing forward precession or shaft whip which is excited by friction in the rotating parts. Low friction means a low exciting force.

At the center of the spinner basket is a bladed agitator 34 having a hub 35 depending around the shaft 16 and journaled at its lower end on a bearing surface 36 integral with the upper end of the sleeve 13. The agitator is oscillated by means of a shaft 37 extending through the tubular shaft 16 and having its upper end journaled therein by means of a bearing 38. The agitator is connected to the upper end of the shaft 37 by means of a bolt 39 having its head

embedded in a cap 40 and its shank threaded into the shaft 37. Tightening the bolt 39 forces a socket 41 fixed in the upper end of the agitator hub into driving engagement with the tapered nut 42 fixed to the upper end of the agitator shaft. Slightly below the water level in the spinner basket during washing the agitator hub is provided with a trough 43 for collecting floating impurities which, due to the water currents set up by oscillation of the agitator, tend to collect around the hub. These impurities flow into the trough and through openings 44 in the hub into the space between the agitator hub and the tubular shaft 16. From this space the impurities flow through the passages 20 in the sleeve 13 into the bottom of the outer casing. The trough 43 is adjustable up or down on the agitator hub so it may be correctly positioned with reference to the water level and the openings 44.

The space between the spinner basket and the sleeve 13 is sealed by a flexible rubber seal 45 fixed to the sleeve 13 and to the upper end of the sleeve 11. At the upper end of the sleeve 13 is fixed a tube 46 intermediate the agitator hub 35 and the shaft 16. The upper end of the tube 46 is adjacent the lower edge of the openings 44. Due to the seal 45 and the tube 46 it is impossible for water to leak out of the spinner basket until the level reaches the upper edge of the trough 43. During washing the water overflowing from the spinner basket is preferably replaced so as to maintain the liquid level.

The agitator shaft 37 is oscillated for washing and the spinner basket shaft 16 is rotated for centrifugal drying by driving mechanism contained within a horizontally split spherical housing 47. The housing comprises upper and lower semi-spherical parts 48 and 49 and a horizontal circular plate or frame 50 clamped therebetween. The frame 50 is held in alignment with the housing by concentric seats 50*a* machined in the clamping faces of the housing parts. The upper housing part 48 is fixed to the lower end of the spinner basket shaft 16 by means of set screw 51. The mechanism is driven by an electric motor 51*a* through a belt 52 and pulley 53 fixed on the motor shaft and a pulley 54 fixed on a drive shaft 55 journaled in the lower housing part 49 by means of a sleeve bearing 56 and a sleeve and thrust bearing 57. On the upper end of the drive shaft 55 is a pinion 58 meshing with a gear 59 keyed on a crank shaft 60 journaled at 61 in the lower housing part 49 and at 62 in a boss 63 integral with the plate 50. The distance between the crankshaft bearings 61 and 62 is kept at a minimum to provide a rigid support. On the upper side of the plate 50 the crankshaft is provided with a crank 64 connected by means of a link 65 to an arm 66 keyed to the lower end of the agitator shaft 37. The agitator shaft is journaled in a boss 67 integral with the plate 50 and is supported by means of a thrust washer 68 arranged between the boss 67 and the lower side of the arm 66. Since the connection between the crank arm and the agitator shaft is spaced very closely to the upper side of the plate 50, the twisting forces which tend to cause misalignment are kept to a minimum. The reaction forces present during the oscillation of the agitator shaft are taken by an annular brake shoe 69 having brake lining 70 cooperating with a concentric spherical surface on the lower housing part 49. The brake shoe is mounted on diametrically opposite pins 71 depending from an inwardly extending flange 72 at the lower end of a supporting ring 73 and is biased upward to the braking position by springs 74 on the pins 71. The brake shoe is moved away from the braking position by a lever 75 pivoted in a bracket 76 fixed to the bottom wall of the outer casing and having a handle 77 projecting out through a slot 78. When the handle is lifted a slide 79 is depressed engaging the brake shoe adjacent one of the pins 71 and moving it downward against the biasing force of the springs 74. Around the other pin 71 is a spacing washer 80 which serves as a pivot for the brake shoe.

So long as the brake is applied and the housing 47 is held stationary, the agitator shaft will be oscillated and the spinner basket, which is rigidly fastened to the housing through its shaft 16, will remain stationary. The spinner basket is rotated by connecting the pulley 54 to the housing by means of an overrunning clutch having a ring 81 fixed to the pulley, a sleeve 82 connected to the lower housing part 49 by means of a pin 83 fitting in a notch 84, and rollers 85 arranged in inclined notches 86 in the sleeve 82 and biased by springs 87 toward the small end of the notches so as to provide a driving connection between the sleeve 82 and the ring 81. When the pulley 54 rotates in a clockwise direction, as viewed in Fig. 5, the rollers 85 will be dragged toward the small end of the notches 86 and will be cramped into a position establishing a direct driving connection between the pulley and the gear housing 47. At this time the housing and all of the parts therein rotate as a unit. This means that the agitator shaft 37 and the spinner basket shaft 16 rotate in unison. A counterweight 88 on the crank shaft and a boss 89 on the lower housing part are arranged to balance the gear housing during the spinning. During reverse rotation of the pulley (while the agitator is oscillated) the rollers 85 are dragged toward the large end of the notches 86, and accordingly the overunning clutch is disengaged. The rollers 85 are held between a disk 90 on the under side of the ring 81 and a ring 91 fixed to the upper side of the ring 81. The ring 91 carries packing material 92.

The gear casing and spinner basket shaft are supported in a tube 93 projecting up from the bottom of the outer casing and having a sleeve bearing 94 at its upper end and a tapered roller bearing 95 at its lower end. The inner raceway 96 of the tapered roller bearing is clamped between the upper end of the housing part 48 and a shoulder 97 on the spinner basket shaft 16, there being a spacing washer 98 between shoulder 97 and the raceway 96. The outer raceway 99 of the tapered roller bearing is fixed in a sleeve 100 into which is threaded a sleeve 101 fixed to the lower end of the tube 93. At the lower end of the sleeve 100 is an outwardly projecting flange 102 to which is secured an annular supporting ring 103 having a spherical surface 104 resting on spherical surface brake shoes 105 fixed to a spherical surfaced supporting member 106 carried on the flange 72. The supporting member 106, the brake shoes 105, and the surface 104 are all concentric with the gear casing 47 so that during any tilting of the tube 93 the gear housing oscillates about its center and this movement is frictionally resisted by the brake shoes 105.

The spinner basket is resiliently centered in an upright position by a rubber ring 107 arranged between an outwardly extending flange 108 at the

lower end of the supporting ring 103 and a ring 109 clamped between a flange 110 at the upper edge of the supporting ring 73 and a flange 111 at the lower end of a supporting ring 112. The rubber ring 107 is confined between the supporting ring 73, the supporting member 103, and a flange 113 at the inner end of the ring 109. Rotation of the rubber ring 107 relative to the support 104 and the ring 109 is prevented by tabs 114 struck out of parts 108 and 109 and fitting in notches in the rubber ring. The rubber ring 107 is initially compressed to a point at which its modulus of elasticity increases. This means that upon tilting of the spinner basket from a central position the restoring force due to the rubber ring increases at a continually increasing rate. Since the pressure on the brake shoes 105 is due to the weight of the spinner basket and gear casing and the compressive forces in the rubber ring, the pressure on the brake shoes (and accordingly the frictional drag of the brake shoes) increases as the spinner basket tilts away from its central position. This means that the friction damping effect of the brake shoes 105 increases as the spinner basket moves from its central position.

The spinner basket and its driving mechanism are all supported from the bottom wall of the outer casing by a flange 115 on the ring 112 which is clamped between a ring 113 and the bottom wall of the outer casing. The upper end of the driving mechanism projects through a clearance opening 116 in the bottom wall of the outer casing which is sealed by a rubber sleeve 117 having its upper end fixed to the tube 93 by a clamp 118 and having its lower end clamped between a ring 119 and the upper side of the bottom wall of the outer casing.

During washing, when the gear housing is held stationary by the brake 69, the crank shaft 60 is rotated by the gears 58 and 59, causing oscillation of the agitator shaft 37 at a rate of 350 strokes a minute and through a stroke of 62 degrees. This is radically different from the customary practice in which the agitator shaft is oscillated at a rate of the order of 60 strokes a minute and through a stroke of the order of 180 degrees. The higher speed and shorter stroke of oscillation produce an improved washing action in which the clothes are subjected to a high speed scrubbing action which, as compared to the prior art, is more in the nature of a vibration. One apparent difference between the present high speed, short stroke oscillation and the prior art low speed, long stroke oscillation is the absence of oscillating movement of the entire body of water around the tub. The high speed and short stroke apparently set up water currents which are substantially wholly radial. This results in a freedom from tangling and a more rapid turnover (continuous redistribution) of the clothes.

During centrifugal drying, when the brake 69 is released and the motor 51a is reversed, the motor is directly coupled to the gear housing by the overrunning clutch illustrated in Fig. 5. In the present machine the ratio of the pulleys 53 and 54 is such that the spinner basket is rotated at a speed of about 1200 R. P. M.

During centrifugal extracting, the unbalanced distribution of the clothes is a source of vibration which, in the absence of any corrective, would prevent smooth operation. The unbalance is of two types, static unbalance (equivalent to a single weight at one side of the basket which displaces the center of gravity transversely from the geometric center) and dynamic unbalance or unbalanced couple (equivalent to a couple tending to tilt the basket about an axis perpendicular to the axis of rotation).

The static unbalance is neutralized by the gyratory support provided by the rubber ring 107 which permits tilting of the spinner shaft 16 about the center of the gear casing to bring the center of gravity of the spinner basket directly above the center of the gear casing. In this position, the spinner basket rotates about its center of gravity. From one aspect the rubber ring 107 can be considered as resiliently supporting the shaft (gear casing and basket) for gyratory movement. While the spinner basket is rotating about its center of gravity, the upper end of the agitator hub, which is at the geometric center of the basket, describes a circle about the center of gravity having a radius equal to the displacement of the center of gravity due to static unbalance. The motion of the spinner basket can be divided into two components, rotation on its geometric axis and gyration about an axis passing through the center of gravity of the spinner basket and through the center of the gear casing (the spinner shaft 16 and the gear casing also rotate and gyrate about these axes).

Dynamic unbalance is neutralized by the tiltable support of the spinner basket provided by the ring 26. The basket tilts relative to the shaft 16 to a position in which there is no unbalanced couple.

Of course, the static and dynamic unbalances are not perfectly neutralized since the stiffness of the rings 107 and 26 limits the degree of neutralization.

Dynamic and static unbalance cause vibrations of shaft frequency which are of greatest magnitude at the critical speeds, the speeds at which the shaft speed is resonant with one of the natural frequencies of vibration of the rotating system (the basket, shaft, gear casing, etc.). In the present machine there are two critical speeds to be considered, the first critical speed in which the basket and other parts supported by the rubber ring 107 vibrate as a unit on the ring and the second critical speed in which the basket would tend to tilt or vibrate relative to the upper end of the shaft 16. The first critical speed is due to the rubber ring 107 and can be called a "mounting" critical speed. The second critical speed, in which there is a flexure between the shaft and the basket, can be called a "shaft" critical speed.

It has been observed, and these observations have been checked by theoretical computations, that the second critical speed exists only when the moment of inertia of the basket about the axis of rotation is less than the moment of inertia of the basket about an axis at right angles to the axis of rotation and through its center of gravity. The second critical speed, being higher than the first critical speed, is objectionable due to the higher centrifugal forces which make it more difficult to bring the spinner basket up through the second critical speed. This second critical speed has been eliminated in the present construction by making the moment of inertia of the basket about its axis of rotation greater than the moment of inertia of the basket about an axis at right angles to its axis of rotation and through its center of gravity.

The rubber ring 107 is preferably proportioned so that the first critical speed is substantially below the normal extracting speed. In the present machine the critical speed due to the rubber ring 107 (the natural frequency of vibration of

the basket, shafts, gear casing, etc., on the rubber ring) is of the order of 100 R. P. M., while the extracting speed is 1200 R. P. M. It is of considerable advantage to have the natural frequency due to the rubber ring 107 (the first critical speed) low so that the centrifugal forces due to the unbalance, which vary as the square of the speed, will be small. If the critical speed is high the centrifugal forces which vary as the square of the speed will be correspondingly higher and the friction forces on the bearings may be sufficient to keep the basket from coming up to speed.

Another feature in the present construction which assists in bringing the basket up through the critical speed is the friction damping provided by the brake shoes 105 which frictionally resist tilting of the axis of rotation and accordingly limit the amplitude of the vibration at the critical speed. This limitation on the amplitude at the critical speed keeps the spinner basket in a more nearly central position in which it can be more easily accelerated.

At speeds above the first critical speed there are gyroscopic vibrations known as precession. These vibrations consist of either a forward or a backward rotation of the basket about its axis of rotation and are known respectively as forward and backward precession. During precession the basket gyrates around the position of perfect balance with the resultant vibration. Precession, which is usually important at speeds near the centrifugal extracting speed, is decreased or prevented by the friction damping effect of the brake shoes 105 which act through the sleeve 93 in which the spinner basket is journaled and frictionally resist tilting of the axis of rotation of the basket. Forward precession, which is due to friction in the rotating system, is kept to a minimum by making the ring 26 of a materal having low internal friction, such as spring steel, and by designing the connections to the ring so as to minimize friction. It has been demonstrated by adding friction in the supporting ring 26 that forward precession may be excited to a value difficult to control by the brake shoes 105.

The resilient support for tilting of the basket relative to the shaft is designed for a minimum of friction while the resilient support for gyration of the shaft is designed to have friction damping provided in the present construction by the brake shoes 105. The friction in the resilient support for the basket is low compared to the friction in the resilient support for the shaft. This relation between the friction in the respective supports is an important factor in the design.

Forward precession is also decreased by designing the friction damper so that its friction damping increases as the basket tilts from the vertical. In the present construction this friction damping characteristic is obtained by initially compressing the rubber ring 107 to a point at which its modulus of elasticity increases. This means that the pressure on the brake shoes 105 (and accordingly the frictional resistance or damping) is a minimum when the basket is in the vertical position. By tests in which the friction damper was replaced by a damper in which the friction damping was a minimum when the axis of rotation of the basket was tilted from the vertical, it has been found that the basket tended to assume the position of minimum damping and that objectionable forward precession built up. For a minimum of forward precession it is important that the friction damping does not increase toward the center.

When there is both precession and unbalance, there is an axial force of shaft frequency tending to move the basket up and down along the axis of rotation. This axial force arises when the shaft frequency gyration of the spinner basket about its axis of rotation is superimposed upon the low frequency rotation or precession of the axis of rotation. This results in a variable displacement of shaft frequency of the spinner basket from the position of perfect balance. From another aspect the angularity of the shaft varies at shaft frequency. Since either the shaft length, or the axial position of the basket, must vary with each angular position of the shaft, there is a resultant up and down or axial force which, unless cushioned, would result in objectionable vibration. This force is cushioned by the axial flexibility of the ring 26. In the present machine the natural frequency of the basket on the ring 26 is of the order of 200 oscillations per minute, which is sufficiently below the normal extracting speed of 1200 R. P. M. to effectively cushion this axial force and prevent transmission to the floor.

The above described construction produces a compact arrangement of the driving mechanism, the resilient support, and the friction damper. The driving mechanism is contained within a spherical housing concentric with the friction damper and with the brake for controlling the driving mechanism. Since the driving mechanism occupies a minimum of space, it can be made relatively light and accordingly will have a minimum of inertia reaction on the bearings 94 and 95 during the extracting operation when it is forced to gyrate with the basket. The reaction due to the force gyration of the gear casing is further decreased by the fact that the casing is spherical and rotates at the same speed as the basket. A perfect sphere while rotating can be tilted about any axis without producing any reaction. In the present gear casing the inertia reaction due to its forced gyration is due to the deviation of the gear casing from a theoretically perfectly balanced sphere. This deviation can be kept to a minimum by counterweights such as the boss 89 and the counterweight 88.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a washing machine of the type having a spinner basket and an agitator in said basket, driving mechanism for selectively oscillating the agitator or rotating the basket comprising, a horizontally split housing having upper and lower parts and a frame member fixed therebetween, a driving shaft journaled in said lower part, an agitator shaft journaled in said member and extending through said upper part, a crank shaft journaled in said member, oscillating mechanism between said crank and agitator shafts, meshing gears on said driving and crank shafts, means for selectively holding the housing stationary whereby the agitator shaft is oscillated and for preventing relative rotation between the drive shaft and the housing whereby the housing is rotated, and a driving connection between the housing and the spinner basket.

2. In a washing machine driving mechanism, a rotatable housing having upper and lower parts and a frame member fixed therebetween, a tubular shaft fixed to said upper part, a driving shaft journaled in said lower part, an agitator

shaft journaled in said member and extending through said tubular shaft, a crank shaft journaled in said member, oscillating mechanism between said crank and agitator shafts, meshing gears on said driving and crank shafts, and means for selectively holding the housing stationary whereby the agitator shaft is oscillated and for preventing relative rotation between the drive shaft and the housing whereby the tubular shaft is rotated.

3. In a washing machine agitator driving mechanism, a split housing having a frame member extending between and having a part spaced from the housing parts, a power shaft and an agitator shaft on opposite sides of said member, and a crank shaft journaled in said part of said member and having its ends projecting on opposite sides of said member and connected respectively to said power and agitator shafts.

4. In a washing machine agitator driving mechanism, a split housing having a frame member extending between and having a part spaced from the housing parts, a power shaft and an agitator shaft on opposite sides of said member, said agitator shaft being journaled in said part of said member, an arm fixed to the agitator shaft having a thrust surface supporting the agitator shaft on said member, and a crank shaft journaled in said part of said member and having its ends projecting on opposite sides of said member, one end of said crank shaft having a crank connected to said arm and the other end of said crank shaft having a gear connected to said power shaft.

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