Jan. 29, 1952 A. LODGE 2,583,579

MACHINE SUSPENSION

Filed Sept. 27, 1946 4 Sheets-Sheet 1

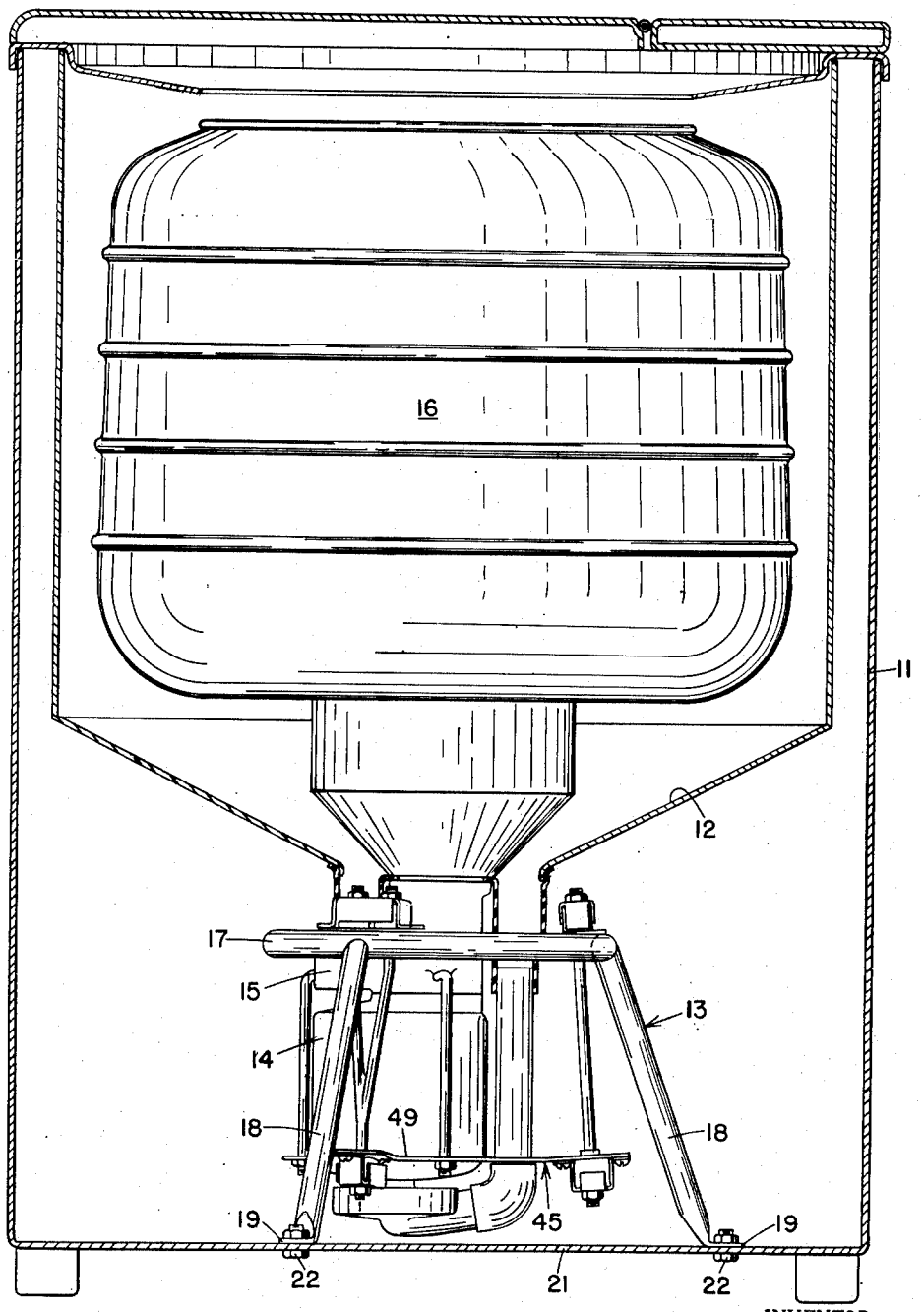

Fig. 1

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MACHINE SUSPENSION

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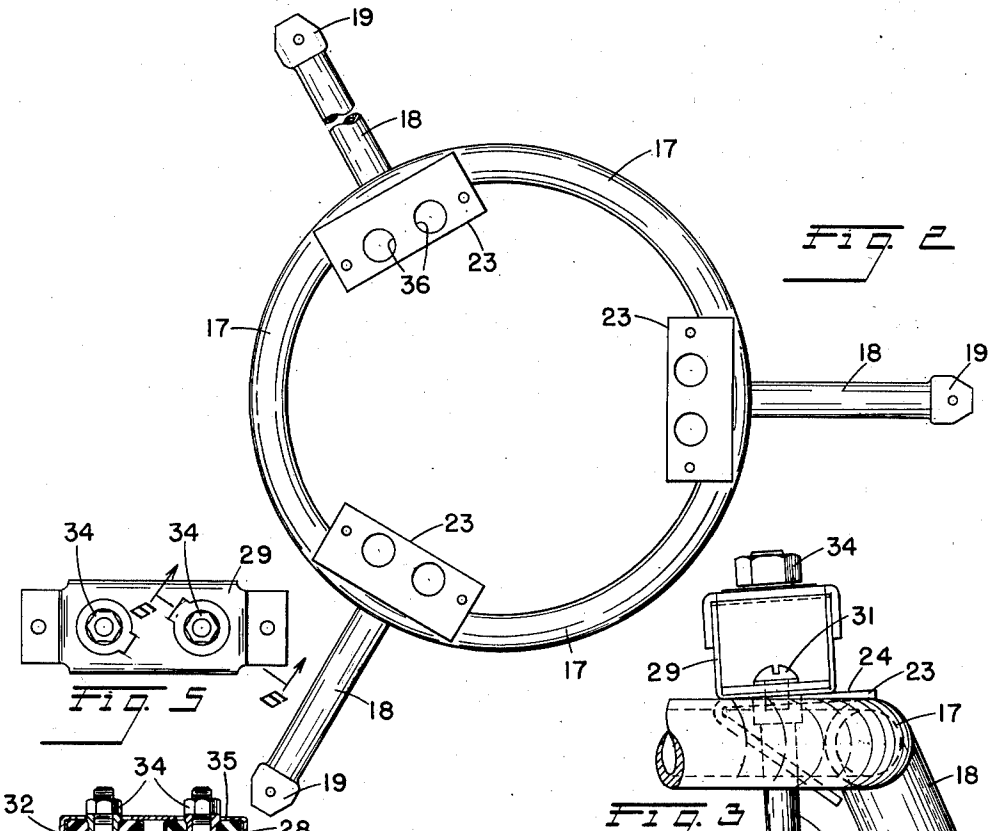

FIG. 2

FIG. 5

FIG. 3

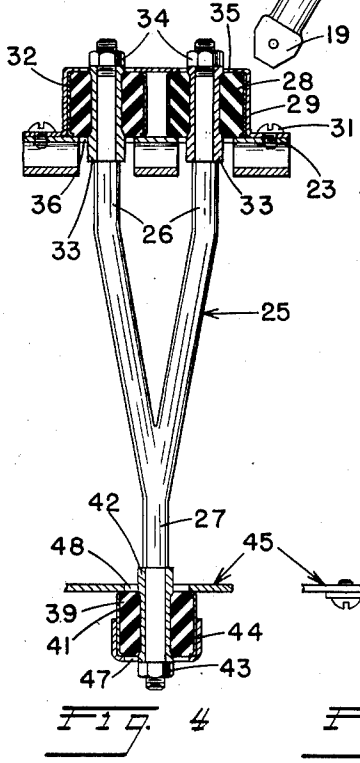

FIG. 4

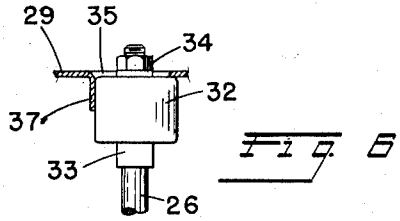

FIG. 6

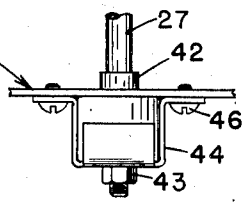

FIG. 7

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MACHINE SUSPENSION

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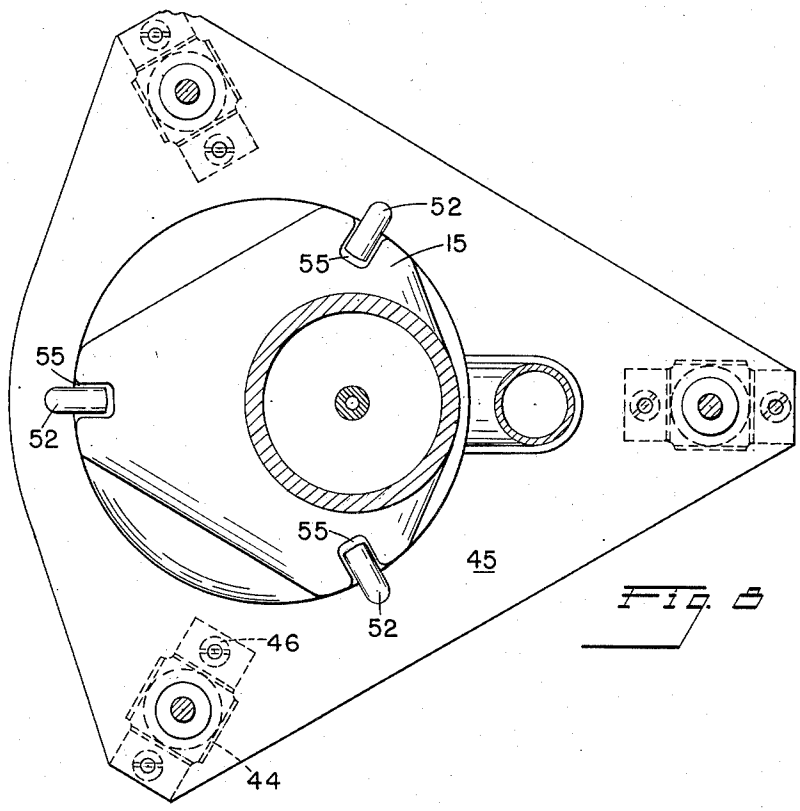

Fig. 8

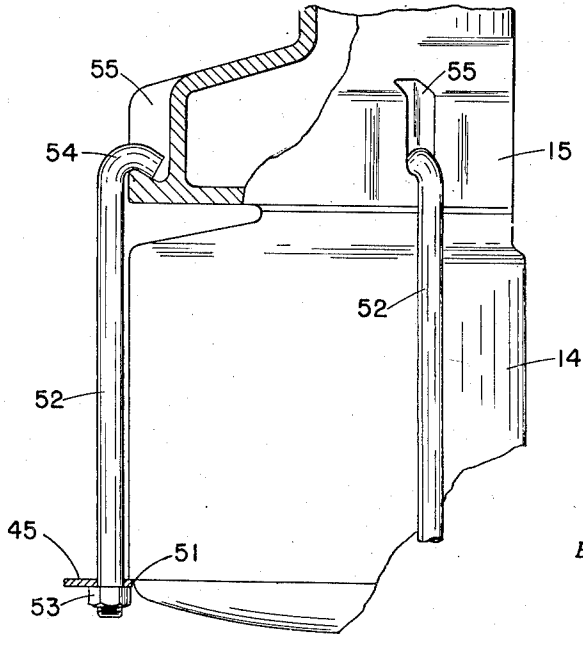

Fig. 9

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MACHINE SUSPENSION

Filed Sept. 27, 1946 4 Sheets-Sheet 4

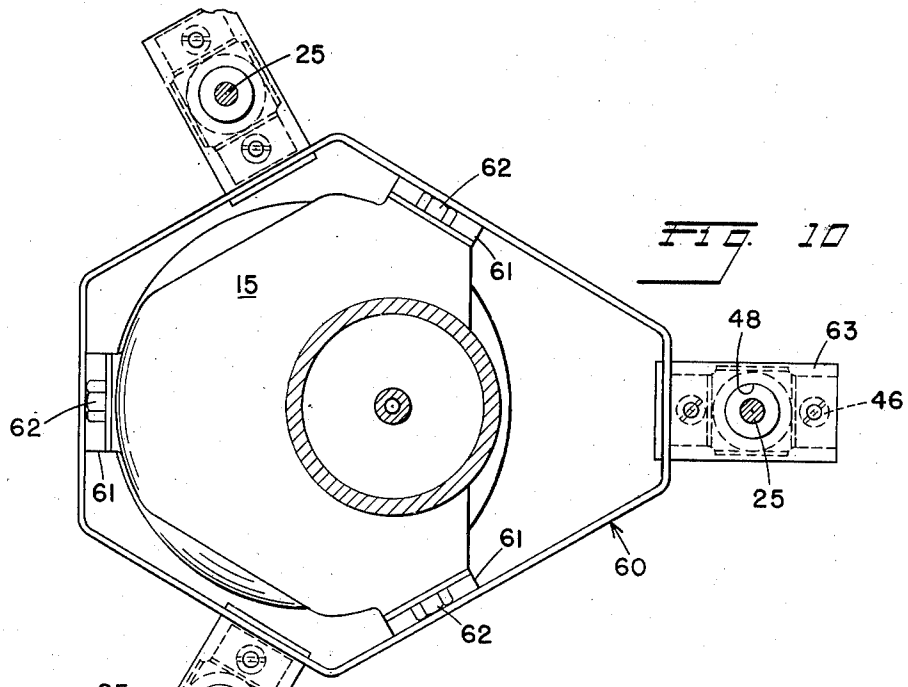

FIG. 10

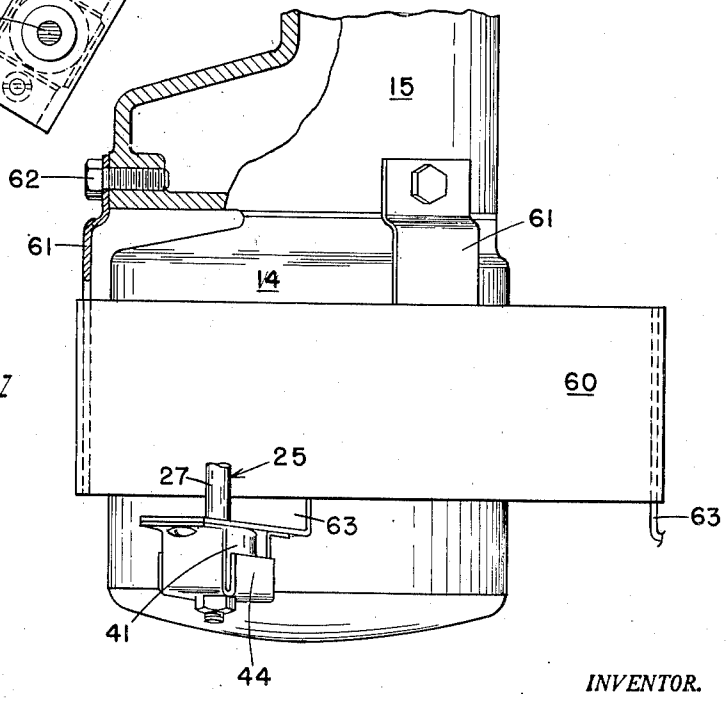

FIG. 11

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Patented Jan. 29, 1952

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UNITED STATES PATENT OFFICE

2,583,579

MACHINE SUSPENSION

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Application September 27, 1946, Serial No. 699,877

1 Claim. (Cl. 210—63)

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This invention relates to a machine for automatically washing and centrifuge drying textiles and similar materials and more particularly to a vibration controlling and dissipating suspension flexibly supporting the operating mechanism and tub in such a machine.

The control and absorption of energy of vibration presents a difficult problem in washing machines of the kind under consideration wherein a tub containing the clothes to be washed is mounted for rotational movement about a vertical axis. No matter how well balanced may be the mechanical parts of the tub and its drive assembly, unbalance due to off-center disposition and loading of the clothes in the tub is unescapable and both substantially unpredictable in degree and subject to variation due to uncontrollable shifting of the load. Further, in the washing machine under consideration, the tub is usually oscillated at about 60 R. P. M. and rotated at 500 to 1000 R. P. M. in successive phases of operation wherein unbalance of the load presents different aspects of the problem of vibrational control.

The purpose of vibration control and isolation is to prevent vibration from being transmitted to the washing machine support and thereby eliminate annoying vibrations and noises, and to dispense with massive machine foundations or supports bolted to the floor.

In the present invention the machine is not bolted to the floor but is movable about on a slidable carriage. As with any unbalanced body, the violence of vibration of the suspended tub and drive assembly mass with an unbalanced load in the tub is greatest when the tub reaches a critical speed of rotation that produces vibrations corresponding to the natural frequency of the supporting structure. It has therefore been found desirable to disassociate the operational speed or speeds of the tub from such critical speed or its harmonics, and to provide a suspension which will enable the rotating unbalanced tub to pass through such critical speeds with a minimum of transmitted vibration.

In general, a rotating unbalanced load such as the loaded tub, at increasing speeds up to the critical speed, tends through centrifugal force to depart further from the desired vertical axis. After a maximum deflection at the critical speed, higher rotational speeds produce forces tending to force the unbalanced load opposite to the deflection until eventually the tub seeks to assume a new axis of rotation passing through its

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center of gravity. Since the tub is mounted in relatively rigid vertical axis journals in the suspension, this tendency results in vibrations whose violence depends on the eccentricity of the load.

I provide flexible mountings for the suspended mass comprising the tub and its drive mechanism, and it is particularly desirable to keep these mountings as soft as practically permissible. Soft mountings have low natural frequencies and thus tend to keep the critical speed low where it can do minimum damage, and soft mountings transmit a minimum of the vibration arising from the tendency of the rotating unbalanced tub to seek its new axis of rotation.

The vibrational forces to be controlled by the mountings at low tub speeds are generally laterally directed with respect to the vertical axis of tub rotation. Hence I have found it advantageous to so construct the suspension as to provide during low tub speeds for considerable but controlled substantially pendulous displacement of the suspended mass in response to such vibration with little provision for deflection in a vertical direction. Since it would result in an awkward and impractical structure in a washing machine to provide an overhead suspension for the mass, this suspension in the invention is constructed of the three link corner type which will fit within the casing of the machine in the space below the tub. Although the critical frequency of this type suspension is higher than could be obtained in an overhead suspension, due to the shorter links, I have found it within a practical range.

The chief disadvantage of this three link corner type suspension is that any dynamic unbalance in the suspended mass, such as that created by the rotating unbalanced tub at higher tub speeds, creates a force couple which when reacted between the links tends to cause vertical displacements of the links. At lower tub speeds, this dynamic unbalance is small and negligible, and readily absorbed by the flexible suspension. An important part of the invention is concerned with mounting the ends of the links in absorptive resilient material such as rubber bodies so that at least some of this vertical force component is isolated. These rubber bodies must also be strong enough to safely carry the entire weight of the suspended mass, so that they cannot be made indiscriminately soft.

In the invention I so construct and arrange the suspension links as to minimize the force cou-

ples arising from dynamic unbalance. This is done by grouping the links closely about the vertical axis of the tub so as to provide between the links and the axis a relatively small distance through which the vertical forces due to dynamic unbalance may act. This close grouping of the links also reduces their swinging movement due to the lateral forces of vibration, so that materially strong and relatively stiff bodies may be employed at the link ends with adequate resilience for isolating the vertical forces. The rubber bodies also permit and exert a cushioning action to the pendulous motion of the mass at the low tub speeds. Preferably the bodies are of synthetic rubber which has high energy absorbing characteristics due to its internal molecular composition.

The amplitude of pendulous motion of the suspended mass may be controlled by effective design of the links, variations in length, shape and inclination of the links being productive of predictable movement. According to the invention in its preferred embodiment, I form each link as an upright Y with its arms separately mounted in circumferentially spaced resilient bodies on the machine support and its lower end mounted in a resilient body on the suspended mass. This creates stability in the plane of each Y link, while not interfering substantially with the swinging of the mass as permitted by movement of the links radially with respect to the vertical axis. These Y links also contribute to oppose torsional forces between the mass and the machine support arising from drive mechanism reactions.

Control of the ability of the suspension to withstand horizontal vibrational and torsional forces may be realized by spreading or converging the arms of the Y of the link. This does not affect the ability of the suspension to carry the weight of the suspended mass.

I have found it advantageous to so arrange the links that they are all inclined at the same small angle downwardly and outwardly with respect to their attachment to the machine support, all of the links if extended intersecting each other and the vertical tub axis at a point well above the center of gravity of the suspended mass with the tub loaded with a normal consignment of water and clothes to be washed. Preferably the angle of the links is such that this point of intersection is well above the tub itself and, while the links themselves are short, usually about one foot long, they effectively suspend the mass from that point of intersection. This inclination of the links makes its possible to use a minimum size enclosing cabinet without unduly restraining lateral swinging of the suspended mass.

During operation, when the tub is oscillated at about 60 R. P. M. during the washing cycle, any vibrations due to unbalance of the load in the tube will be substantially absorbed by the resilient suspension. When the tub starts to rotate during the spin cycle, at relatively low rotational speeds of about 200 R. P. M., the unbalanced load causes departure of the mass from its vertical axis, and the suspension permits and causes the mass to assume a pendulous path with it lower end moving substantially circularly about a point on the vertical axis located above the center of gravity of the mass. The amplitude of this circular movement increases until a first critical speed is reached.

After this low critical speed is passed, the tub

rotates relatively smoothly although with some vibration due to its tendency to assume the new vertical axis of rotation passing through the center of gravity. As the speed of rotation increases, a second higher dynamic critical speed is attained during which the suspended mass moves in an hour glass pattern substantially about its center of gravity. At this higher critical speed, since the center of gravity of the suspended mass has been forced to lie on the vertical axis of the tub, as a result of passing through the lower critical speed, the amplitude of pendulous movement is not greater than at the lower critical speed and it is isolated and absorbed by the suspension by vertical movement of the links and attendant vertical displacement of their resilient mountings. The vibration during these speeds now contains a considerable vertical component due to the dynamic unbalance condition created by the force couple between the links, which component is isolated and absorbed by the soft mountings. When this higher speed is passed, the tub rotates smoothly and more quietly than between the two critical speeds.

My novel suspension arrangement and construction thus effectively separates the effect of unbalance of the rotating loaded tub into vibrational forces occurring at two different critical speeds during acceleration of the rotating tub. The suspension is such as to cause and permit the suspended mass to move in a predetermined path at each critical speed of the tub, and this control of the path of movement of the mass efficiently isolates the forces of vibration from the machine support. By properly balancing the resilient resistances to vertical and horizontal motion, the latter being controlled by varying the spread of the Y of the links, and by properly distancing the links from the vertical axis of the tub to control the force couple creating the vertical displacement of the links, the critical speed is kept so low that the suspension is enabled to easily isolate and absorb the vibrational forces.

It is therefore the major object of this invention to provide a novel flexible suspension to permit controlled floating relationship between the rotating tub and drive assembly and the supporting frame of a washing machine, which will isolate and absorb substantially all of the energy of the vibrations set up in normal operation.

A further object of the invention is to provide a novel flexible suspension and method to permit the maximum amount of controlled safe movement of the operating mechanism of such a machine, thus making it necessary for a minimum amount of vibrational energy absorption.

Another object of this invention is to provide a novel washing machine or like suspension wherein the maximum vibrations created by the static unbalance of the rotating tub and the maximum vibrations created by dynamic unbalance of the rotating tub occur at different tub speeds.

Yet another object of this invention is to provide a washing machine tub and drive suspension wherein the natural frequency of the vibration due to the static unbalance of the rotating mass, which vibrations are the strongest present, is very low in order that the corresponding critical speed will be low where it can do little harm.

A still further object of this invention is to provide an improved practical pendulum type

of suspension for supporting the operating mechanisms of a washing, rinsing and centrifuge drying machine with respect to its supporting frame.

Another object of this invention is to provide a pendulum type of suspension for such a machine, the effective pivot point of which is above the center of gravity of the operating mechanism, to thereby minimize horizontal movement of the largest diameter of the suspended operating mechanism, which is the tub, for enabling a casing of minimum size to be used.

Still another object of this invention is to provide a suspension which will permit the operating mechanism to undergo pendulous motion without undue restraint, while maintaining improved torsional stability of the suspended operating mechanism.

A still further object of this invention is to provide an improved suspension for a washing machine which utilizes the mass of the non-rotating suspended part to stabilize the unbalanced condition existing as a result of the uneven disposition of the load in the tub.

A further object of this invention is to provide a novel suspension for isolating the vertical vibration component caused by the operating mechanism of a centrifuging machine.

A still further object of this invention is to provide an improved suspension embodying relatively soft energy absorbing flexible members which isolate the motion of the vibrations and absorb energy caused by the vibrations.

Further objects of the invention will presently appear as the description proceeds in connection with the appended claim and the annexed drawings wherein:

Figure 1 is an elevation mainly in section of a washing machine having a suspension according to a preferred embodiment of this invention;

Figure 2 is a top plan view of the supporting framework for the suspension;

Figure 3 is a fragmentary elevation illustrating a structural detail of the support and the attached upper end of a link;

Figure 4 is an elevation illustrating a suspension and the flexible mounting members at each of its ends;

Figure 5 is a plan view showing the casing which houses the flexible mounting members at the top of each suspension link;

Figure 6 is a section along line 6—6 of Figure 5 illustrating a further detail of the link mounting;

Figure 7 is a side elevation view of the casing which houses the flexible mounting member at the bottom of each suspension link;

Figure 8 is a top plan view partly in section for illustrating the three cornered mounting plate through which the flexible mounting members for the lower ends of the suspension links are secured;

Figure 9 is a fragmentary side elevation partly in section illustrating the manner in which the suspension mounting plate is secured to the motor and transmission housing;

Figure 10 is a top plan view partly in section for illustrating a mounting frame for the flexible members at the lower ends of the links according to a further embodiment of the invention; and

Figure 11 is a side elevation view partly broken away and in section illustrating the manner in which the mounting frame of Figure 10 is secured to the motor and transmission housing.

The specification continues with reference to the drawings wherein like numerals designate the same parts throughout the several figures.

The washing machine in which the suspension of the invention is herein disclosed for purposes of illustration includes an exterior cabinet 11 having a stationary inner well 12, and mounted on cabinet 11 is a rigid suspension frame 13 from which is suspended the entire tube and drive assembly comprising an electric motor 14, a gear box and transmission assembly 15 and a rotatable tub 16.

Tub 16 is periodically oscillated and rotated about its vertical axis during operation. The construction and operation of the motor and drive connections to the tub, including change-over of the tub drive between low speed oscillating rotary and high speed continuous rotary, is disclosed in full in said Serial No. 587,474, now abandoned, to which attention is directed for further detail. However, the specific motor and tub drive connections are substantially independent of the present invention relating to the suspension.

Suspension frame 13 is preferably a tripod comprising a sturdy horizontal ring 17 to which is secured, as by welding, three downwardly and outwardly disposed rigid legs 18 that are equally spaced about the periphery of ring 17. Legs 18 at their lower extremities are formed with horizontal flanges 19. Frame 13 is rigidly anchored to the bottom panel 21 of cabinet 11 or to any suitable stationary part of the cabinet as by nut and bolt assemblies 22 extending through flanges 19.

Referring to Figures 2 and 3, three sheet metal brackets 23, which in cross section are generally V-shaped so as to be secured as by welding to upper and lower surfaces of ring 17, are rigid with ring 17, preferably at the upper ends of legs 18. Each bracket 23 has an upper flat surface 24 inclined at a small angle to the horizontal, this angle being equal to the desired inclination of the suspension links. Brackets 23 serve as the upper supports for the suspension links.

Three suspension links 25, which are of Y configuration in a plane and comprise upper arms 26 and a lower leg 27, extend downwardly and outwardly from brackets 23 at a small angle to the vertical. If extended upwardly, links 25 would all intersect at a point on the vertical axis of the tub well above the tub.

The upper ends of arms 26 are mounted in synthetic rubber or like resilient bodies 28 which, as illustrated in Figure 4, are enclosed in sheet metal clips 29 secured to surface 24 of brackets 23 as by screws 31. Each resilient body 28 is laterally encased by a sheet metal jacket 32 vulcanized to it and is centrally formed with a vertical bore for receiving a short hollow metal sleeve 33 also vulcanized to body 28. The upper ends of arms 26 are shouldered and reduced to fit within sleeves 33 and are threaded to receive nuts 34 which clamp arms 26 to sleeves 33. The upper wall of each clip 29 is apertured at 35, and the upper wall of each bracket 23 is apertured at 36 for permitting free flexure of the link arms. As illustrated in Figure 6, integral tabs 37 bent down from the top wall of each clip 29 are welded to jackets 32 to anchor the resilient bodies to the clips.

Each pair of arms 26 lies in a plane parallel to a tangent to ring 17, and the links 25 are equidistantly spaced circumferentially of ring

17. Arms 26 project downwardly through suitable apertures 38 in brackets 23 as illustrated in Figure 4.

At their lower ends, the legs of links 25 are mounted in resilient bodies 39 which are vulcanized within encasing sheet metal jackets 41 and carry hollow metal sleeves 42 also vulcanized to them. Each leg 28 is reduced and shouldered at its lower end to fit within sleeve 42 and is threaded to receive a clamping nut 43.

As illustrated in Figures 4 and 7, each body 39 is encased in a clip 44 secured to a plate 45 as by screws 46 and apertured at 47, plate 45 being likewise apertured at 48 to permit free flexure of the link. Jacket 41 is welded to clip 44.

Plate 45 is provided with a horizontal center portion 49 formed with a central seating aperture 51 in which rests the lower end of the housing of motor 14 as illustrated in Figure 9. The upper end of the motor housing interfits with the lower end of transmission and drive gear casing 15 and is secured thereto by three equally spaced clamp rods 52. Each rod has a threaded lower end extending through a suitable aperture in plate 45 and, below the plate, carries a nut 53. The upper end of each rod 52 is hooked over at 54 to fit with integral recesses 55 formed on the lower periphery of casing 15, so that when nut 53 is tightened rods 52 pull casing 15 tight with housing 14.

The entire weight of the motor and drive assembly, as well as the rotatable tub, is therefore carried by plate 45 which in turn is connected to tripod 13 by the above-described flexible suspension. The outer end regions of plate 45, where links 25 are secured, are preferably bent to be parallel to surfaces 24 of brackets 23, so that links 25 are perpendicular to these surfaces at both ends. This aids in assembly and in the pendulum action of the suspension.

A further embodiment of the suspension of the invention is illustrated in Figures 10 and 11. A polygonal mounting bracket 60 having flat vertical sides is disposed horizontally about motor 14. A plurality of mounting arms 61 secured at their upper ends to casing 15, as by bolts 62, and secured as by welding at their lower ends to flat sides of bracket 60, rigidly support bracket 60 as an extension of the motor and drive assembly.

The same type of three link suspension as described above is used to interconnect bracket 60 to the tripod 13, the upper ends of suspension links 25 in this embodiment of the invention being connected to the tripod as in Figures 1–8.

In this second embodiment of the invention, the lower ends or legs 27 of links 25 and their associated resilient bodies mounted in clips 44 are attached to the outwardly extending ends of spaced depending arms 63 which are welded or similarly secured to bracket 60. Arms 63 are of course apertured, as at 48 in plate 45, where the links 25 extend therethrough. Thus in this form of the invention the entire motor, drive and tub assembly is carried by the same suspension as in Figures 1–8. Motor 14 is secured, as by bolts, rigidly to casing 15. This type of suspension is useful where space in the extreme bottom of the cabinet may be occupied by other apparatus.

This invention therefore has provided a suspension which flexibly mounts the motor drive and tub assembly and allows the suspended assembly to assume at a low tub speed a pendulous motion in which the lateral movement of tub 14 is minimized due to the fact that the large diameter tub is the nearest part of the assembly to the focal point of the downwardly and outwardly disposed suspension links 25. Due to the pendulous motion permitted by the suspension, lateral movement of the assembly is much less restricted than is its vertical movement. Therefore it is readily apparent that the natural frequency of lateral vibrations of the tub is lower than the natural frequency of vertical vibrations of the tub.

Inasmuch as the tub has the largest diameter of the suspension mass, its amount of permissible horizontal movement is the controlling factor in determining the minimum size of the tripod and cabinet. In this suspension, all vibrations that tend to horizontally displace the mass cause it to vibrate about its normal axis of rotation like a pendulum from the focal point of the links, and the inertia of the entire suspended mass acts to stabilize this motion. The tub, being nearer to the link focal point, has its horizontal movement minimized while the transmission and motor mechanism, being a greater distance from the link focal point have, greater permissible horizontal movement. This latter, however, is immaterial because, due to the smaller diameter of the transfer gearing and motor mechanism, in horizontal movement these parts will never swing beyond the diameter of the tub.

Particular attention is again called to the fact that soft energy absorbing flexible mounting members are used for the links ends in this construction. These are advantageous for the reason that the soft mountings transmit a minimum of vibrational force to the frame when the journalled axis of the rotating tub is forced to revolve about an axis other than its own due to the eccentric center of gravity of the load. Further, the soft mountings reduce the natural frequency of vibration of the suspended mass to where the least damage will result.

Another advantage of this suspension is that the motor and transfer gearing assembly both of which are below the center of gravity of the rotating tub serve to stabilize vibrational tendencies caused by eccentricity of the load in the tub during high tub speeds because of their location on the opposite side of the vertical axis from the tub during such unbalanced rotation.

The force couple created by the dynamic unbalance of the rotating tub which becomes important as higher tub speeds cause the suspended mass to vibrate in an hour glass pattern about its center of gravity which remains substantially unmoved from its position on the normal axis of rotation of the tub while the top of the tub is radially displaced in one direction and the bottom of the mass is radially displaced in the opposite direction. This hour glass vibration causes not only a swinging motion of the links, but also a vertical motion. As each link swings away from the center of the rotating tub it has an upward motion and as it swings toward the center it has a downward motion, and these motions are substantially isolated from the tripod by the flexible members at the ends of the links.

The Y configuration of the links compensates for the reaction set up by the low-speed oscillating washing cycle and aids in stiffening resistance to lateral movement of the mass during the spinning cycle. By equally peripherally spacing the three links and keeping both arms of the Y's substantially on the periphery, a high degree of torsional stability is obtained between the tripod

and the oscillating mass without unduly restraining the hour glass motion of the mass occurring in the high-speed rotating cycle. By decreasing the center distances between the links it is possible to design a compact suspension which is extremely strong and rigid yet flexible enough to isolate the vertical forces caused by the dynamic unbalance of the rotating tub. The flexible members at the ends of the links also permit a restrained pendulous motion which gives a certain amount of cushioning. This is true particularly when the flexible members are soft.

By changing any one of several variables, such as the downward and outward angle of the links, the angle between the Y's of the links, the distance between the centers of the links, the length of the links and the hardness and thickness of the flexible members, a high degree of control may be maintained both over the patterns of the suspended mass and its degree of vibration.

By the proper balancing of all the variable factors, the natural frequency of the pendulous vibrations produced by the static unbalance of the rotating tub is readily and distinctly made lower than the natural frequency of the hour glass vibrations produced by the dynamic unbalance of the rotating tub, and I have found it most advantageous to so separate these conditions. The rotating tub therefore has two critical speeds, pendulous vibrations being predominant in one and the hour glass vibrations being predominant in the other. The pendulous vibrations, which are of greater lateral amplitude than the hour-glass vibrations, have their critical value at the lower speed where it is least objectionable.

During and at speeds approaching the first critical, the entire suspended mass assumes a pendulous vibrational motion about the vertical axis of rotation of the tub, becoming most violent when the speed of the rotation equals the natural frequency of the pendulous vibrations. Any apparent hour-glass vibrations during the first critical of the rotating tub are slight as their natural frequency is greater than the relatively slow speed of the rotating tub. After the first critical speed of the rotating tub is passed, the pendulous vibrations are considerably lessened. The suspended mass then vibrates smoothly close to the normal axis of rotation of the tub until a tub speed is reached which approaches the natural frequency of the hour-glass vibrations. These two critical speeds are attained only during the continuous rotary, or centrifuge, stage and are not attained during the oscillating washing stage of the cycle. The suspended mass now vibrates in an hour-glass pattern about its center of gravity which remains substantially on the normal axis of rotation while the top of the mass is radially displaced in one direction and the bottom

of the mass is displaced in the opposite direction, and the links swing inwardly and move downwardly and then swing outwardly and move upwardly. The vibratory effect of these motions is isolated by the flexible mountings, and the energy of the vibration is absorbed by the hysteresis of the synthetic rubber bodies in the flexible mountings.

After the second critical speed of the rotating tub is passed, the suspended mass again rotates smoothly close to the normal axis of rotation of the tub.

This invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claim rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claim are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

In a washing machine, a relatively stationary support, a suspended mass comprising container drive mechanism and a container rotatable about a vertical axis and adapted to contain an unbalanced load, and a flexible vibration isolating suspension between said support and said mass comprising a plurality of circumferentially spaced links extending in the general direction of the container axis, each of said links having one of its ends bifurcated, and resilient means for connecting the ends of each link to said support and mass respectively, said resilient means comprising resilient bodies secured to the ends of the bifurcations of each link, a resilient body secured to the opposite ends of each link, and means for attaching said resilient bodies to said support and mass respectively.

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