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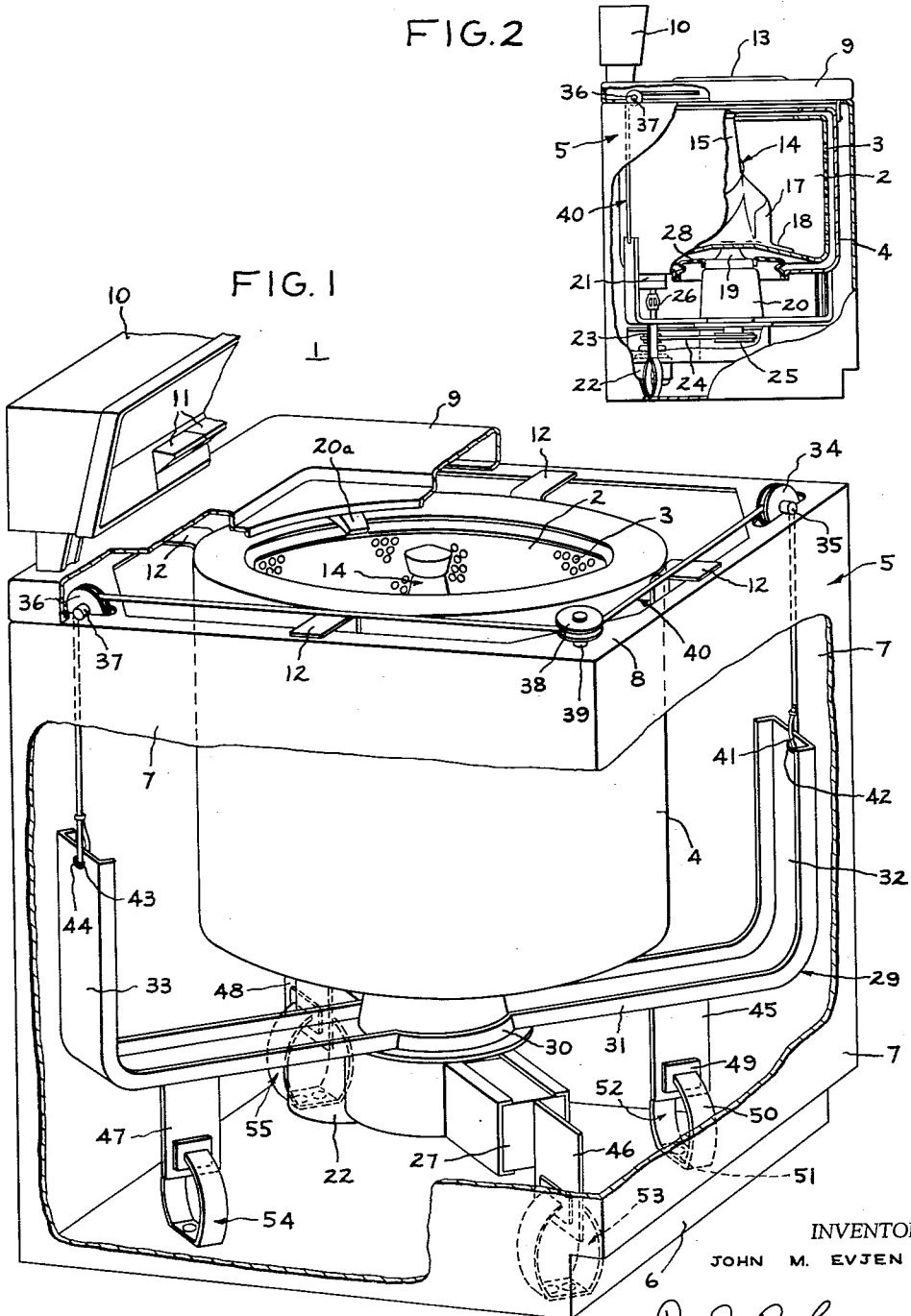
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2,987,189

VIBRATION ISOLATING SYSTEM

Filed Sept. 21, 1959

2 Sheets-Sheet 1



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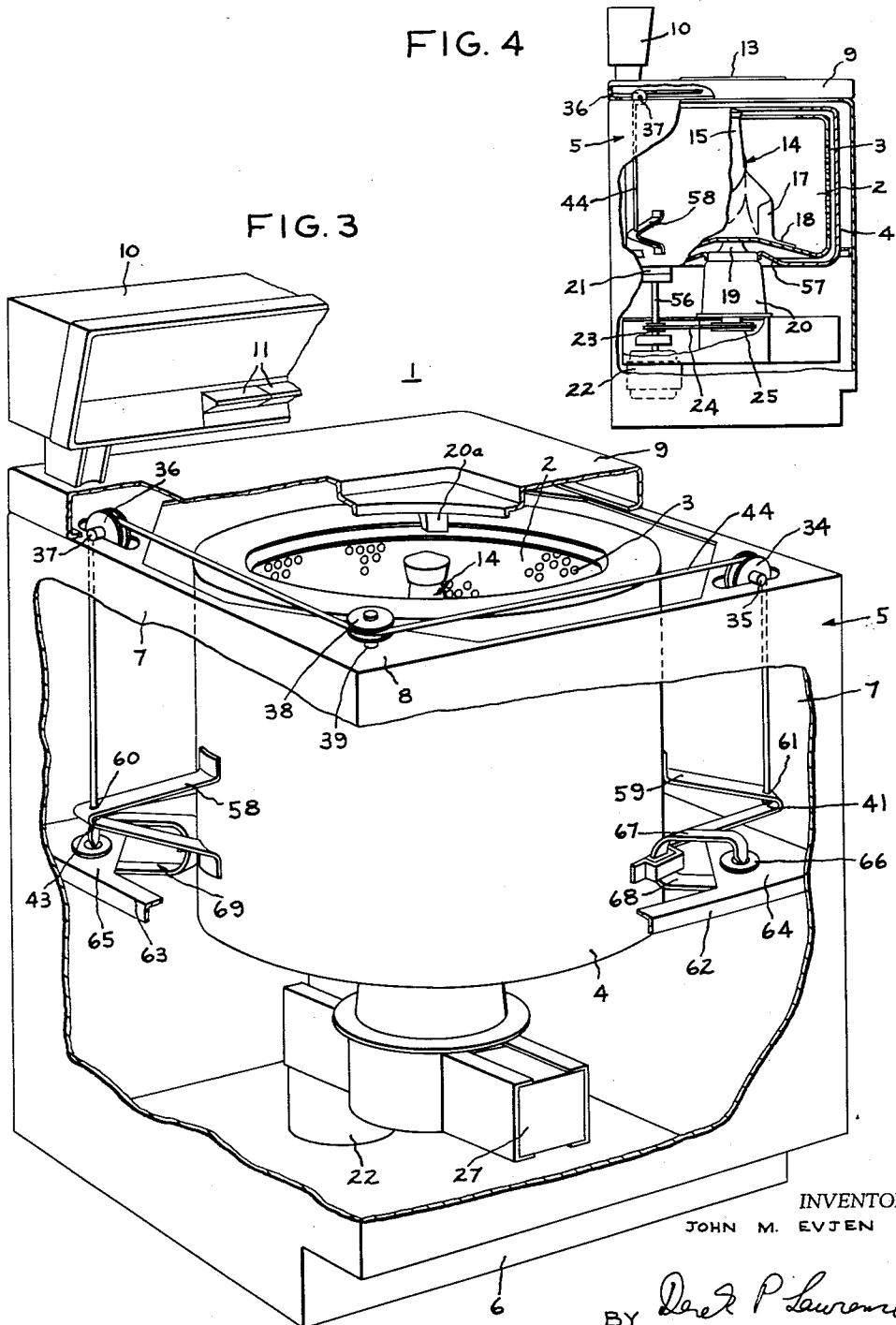
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VIBRATION ISOLATING SYSTEM

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7 Claims. (Cl. 210-364)

This invention relates to vibration isolating arrangements, and more particularly to suspension systems for isolating the vibrations of the moving system from the frame on which it is supported.

The problem of isolating vibrations of the moving parts of the machine from the stationary parts has long been recognized and many solutions have been proposed therefor. While many of the systems which have been evolved have been satisfactory, it has been found most difficult to provide an arrangement which, together with the elimination of undesirable vibrations in the supporting framework of the apparatus, is also economical while at the same time restricting the vibrational movement of the apparatus to a reasonable extent. In addition, it frequently occurs that the moving parts of such apparatus must often be allowed only a certain amplitude of movement and there is thus the problem of isolating the vibrations of the moving system from the frame while restraining the motion of the moving system within the predetermined limits.

As an example of the problems encountered along this line, most automatic washing machines of the type presently commercially available for domestic use provide a clothes basket in which the clothes are washed and rinsed, and when it is desired to remove the liquid from the clothes the basket is then rotated at a high speed so as to centrifuge the liquid out of the clothes. Very often the system for effecting the washing and centrifuging operations does not have its weight symmetrically distributed about the axis of rotation so that there is inherently an unbalance in the system. In addition, the clothes which are being laundered most often will not distribute themselves perfectly about in the basket but will provide an additional degree of unbalance. There is the further consideration that vibration-caused motion of the moving system must be maintained within reasonable limits, usually on the basis that the supporting frame or cabinet of the machine must be small enough to be commercially attractive for home usage. Yet a further item for consideration is that vertical axis washing machines, that is, washing machines of the type which have a basket open at its top which is reached through a lid in the top of the machine, generally should have a highly limited amount of vertical freedom, both for proper functioning of the apparatus itself and again because of the restrictions on size inherent in an appliance which is to be used in the space normally available in most homes. A solution to this problem, in which use is made of a system of pulleys with an elongated flexible member passing over the pulleys and supporting the moving system on the frame, is disclosed and claimed in application Serial No. 843,611 (Bochan) filed concurrently herewith and assigned to the General Electric Company, owner of the present invention.

It is an object of this invention to provide an improved system, based on the invention of the aforesaid Bochan application, which will be even more simple in structure and economical to manufacture than the arrangement of the Bochan application yet which will also in the same manner effectively prevent the vibrations of the moving system for reaching the stationary part of the apparatus in which the moving system is included.

As a further object, directed toward apparatus having a particular type of moving system, it is an object of the invention to provide the improved vibration eliminating

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suspension system for apparatus including components designed to centrifuge.

As a further object directed toward an even more specific structure, I provide by my invention an improved vibration isolating suspension system for vertical axis washing machines.

A more specific object of the invention is to provide a vibration isolating suspension system in which a total of only three pulleys are fastened to the stationary frame of the apparatus and the cable is fastened to the moving system on opposite sides above the center of gravity of the moving system so as to run over the pulleys between its ends.

In one aspect of my invention, I provide apparatus which includes moving parts and a frame provided for the purpose of supporting the moving parts without receiving the vibrations therefrom. A suspension system for securing the moving system on the frame includes an elongated flexible member which has its ends secured respectively to the moving assembly above the center of gravity and on opposite sides thereof. The suspension system also includes first and second pulleys which are respectively secured on the frame of the apparatus on the two aforementioned opposite sides of the moving system above the cable ends. A single additional pulley is also secured on the frame with its axis of rotation so arranged that it rotates in a plane formed by the three pulleys. The cable is arranged to extend from one of its ends first over the first pulley means, then over the additional pulley, and finally over the second pulley back to its other end. By means of the additional pulley the entire system is integrated with only one additional pulley being used besides the two pulleys positioned on opposite sides of the moving system.

The features of the invention which I believe to be novel are set forth with particularity in the appended claims. The invention itself, however, both as to organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following detailed description taken in connection with the accompanying drawings.

In the drawings, FIGURE 1 is a view in perspective, partly broken away and partly in cross section in order to show details of the invention;

FIGURE 2 is a side elevational view of the machine of FIGURE 1, also partly broken away and partly in cross section to show details;

FIGURE 3 is a view in perspective, partly broken away and partly in cross section to show details, of my invention used in a different type of machine from that illustrated in FIGURES 1 and 2; and

FIGURE 4 is a side elevational view, partly broken away and partly in cross section, of the machine of FIGURE 3.

Referring now to FIGURES 1 and 2 of the drawings, I have shown therein an agitator type vertical axis washing machine 1 having a clothes basket 2 which is provided over its entire side wall with perforations 3 and which is disposed within an outer imperforate tub or casing 4. Tub 4 is mounted within a frame or outer appearance cabinet 5 which includes a base 6, vertically extending walls 7 and a top portion 8. In addition, the appearance cabinet may be completed by a separate section 9 seated on top of portion 8 which in turn supports the control panel 10 provided with appropriate controls such as 11. Tub 4 is secured to appearance cabinet 5 by any appropriate means such as, for instance, metal straps 12 each of which is secured at one end to portion 8 of the frame and at the other end to the side wall of tub 4. Thus, in effect, the tub forms part of the stationary portion of machine 1, being rigidly secured to the sta-

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tionary appearance cabinet 5. The upper member 9 is provided with a suitable lid 13 which may be opened so as to provide access to the basket 2 for insertion and withdrawal of clothes.

At the center of basket 2 there is provided a vertical axis agitator 14 which includes a center post 15 and a plurality of suitably formed vanes 17. The agitator is further provided with an outwardly and downwardly flared skirt 18 to which the vanes are joined at their lower ends. Both the clothes basket 2 and the agitator 14 are rotatably mounted. Thus, as schematically shown in FIGURE 2, the basket is secured to a rotatable member 19 extending up from within a transmission 20, and the agitator is mounted on a shaft (not shown) which extends upwardly from transmission 20 through member 19 and is joined to center post 15 of the agitator 14 by any suitable means (not shown). During a typical cycle of operation of machine 1 liquid is introduced through an inlet 20a; then the agitator is oscillated back and forth within basket 2 to wash the clothes. After a predetermined period of this washing action, basket 2 is rotated at high speed to extract centrifugally the washing liquid from the clothes, the liquid passing through perforations 3 into the outer tub 4 and thence being removed by a suitable pump 21 to a drain. Following this extraction operation, a supply of clean liquid is then introduced into the basket for rinsing the clothes as the agitator is then again oscillated. Finally, the basket is once more rotated at high speed to extract the rinse water and discharge it from the clothes so that it may be removed by pump 21.

Basket 2 and agitator 14 may be driven by any suitable means, as the drive means form no part of the present invention. However, by way of example I have shown them as driven from a reversible motor 22 which drives the basket and agitator through a drive including a clutch 23 mounted on the motor shaft. Clutch 23 allows the motor to start without load and then picks up the load as it comes up to speed. A suitable belt 24 transmits power to the transmission assembly 20 through pulley 25. Thus, depending upon the direction of motor rotation, pulley 25 of transmission 20 is driven in opposite directions. Transmission 20 is so arranged that it supports and drives both the agitator drive shaft and the basket mounting member 19. When motor 22 is rotated in one direction the transmission causes the agitator 14 to oscillate within the basket 2. Conversely, when the motor 22 is driven in the opposite direction, the transmission drives the wash basket 2 and the agitator 14 together at high speed for centrifugal extraction. While the drive means forms no part of the present invention, reference is made to Patent 2,844,225, issued on July 22, 1958 to James R. Hubbard et al. and owned by the General Electric Company, assignee of the present invention. That patent discloses in detail the structural characteristics of a transmission assembly suitable for use in the illustrated machine.

Additional structural features which may be noted for more complete understanding of the general driving arrangement provided in the washing machine of FIGURES 1 and 2 include a direct flexible drive 26 from motor 22 to pump 21 and a suitable counterweight 27 which, as shown in FIGURE 1, is positioned on the opposite side of the rotational axis of the basket 2 from the motor 22 so that, while there is necessarily some small static unbalance resulting from the unsymmetrical structure of the driving system, it is held to a minimum. A further structural feature to be noted is the provision of a flexible boot member 28 which is secured at its inner edge to the top of transmission 20 and at its outer edge to the tub 4. This arrangement provides a watertight connection between the transmission and the tub for retaining water in the tub and basket while at the same time permitting the relative motion between the tub and the basket which results from the fact that the basket is part of the suspended

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operating system of the machine (as will be more fully described herebelow) and the tub is secured to a stationary frame or appearance cabinet of the machine.

It will be understood that, while the description of the machine thus far excludes any substantial amount of detail relating to the drive, and does not show at all the valves and the particular controls normally provided on modern domestic washing machines, the elimination or simplification of these items is primarily for the purpose of permitting a clear explanation of the inventive concepts set forth below. In addition, it will readily be recognized that the omitted details are conventional items in all domestic washing machines, whose structure and positioning is well known to those skilled in the art.

As previously described, basket 2 is rotated at high speed to effect centrifugal extraction of the liquid from the clothes in the basket. As has also previously been mentioned, the structure of the machine itself and the arrangement of the clothes in the basket both tend to provide unbalancing forces which, during high speed rotation, cause vibration inducing forces. These forces result in gyrations of the moving system which includes the basket, transmission, motor, and counterweight. It is important that these vibrations be prevented from reaching the frame, that is, the appearance cabinet, in any substantial amount since otherwise the machine will have a tendency to move about on the floor on which it is located and in fact might well be damaged by such vibrations.

In order to support the moving system on the stationary frame or cabinet 5, I provide a U-shaped flange member 29 rigidly secured at its center 30 to transmission 20 so as to form part of the moving system previously described. Member 29 has a central portion 31 which extends substantially horizontally and merges at its ends respectively into substantially vertically extending portions 32 and 33. Portions 32 and 33 extend upwardly, as shown, on opposite sides of the moving system outside tub 4.

A pulley 34 is secured to rotate on a pin 35 fastened in the top portion 8 of frame 5, the pulley being positioned substantially in a vertical plane. A second pulley 36 is similarly mounted on a pin 37, also secured in the top portion 8 of frame 5. Pulley 36 is also positioned to rotate in a vertical plane. Pulleys 34 and 36 are respectively located on the same two opposite sides of the moving system as the upwardly extending portions 32 and 33 of member 29.

A pulley 38 is rotatably mounted on a pin 39 secured to portion 8 of frame 5, and is positioned in a third corner of the frame substantially equally distant from pulleys 36 and 34. Pulleys 34 and 36 are both positioned so that each one rotates in a plane, preferably vertical as shown, which is tangential to the outer operating surface of the pulley 38, i.e., pulley 38 is located substantially at the intersection of the planes of pulleys 34 and 36. Pulley 38 is mounted to rotate in the plane which it forms with the outer operating surfaces of the pulleys 36 and 34; in the illustrated embodiment the plane is a substantially horizontal one inasmuch as all three pulleys are mounted on portion 8 of frame 5, which portion is in a substantially horizontal plane. It will further be seen that the positioning of the third pulley 38 is such that straight lines drawn between it and each of the first and second pulleys 34 and 36 will be horizontally external to the moving system. This permits free unobstructed use of an elongated flexible member, such as cable 40, extending as shown between the three pulleys so that the cable may be used without interference resulting from vibrations of the moving system.

The cable member generally indicated at 40, has one end 41 secured within an opening 42 formed adjacent the upper end of portion 32 of member 29. From this point, the cable extends upwardly, passing over pulley 34, and then extends horizontally in the plane formed by the pulleys to pass around the outer surface of pulley 39.

From pulley 39, the cable then extends horizontally to pulley 36, passing over pulley 36 and then down to its other end 43 which is secured in the opening 44 provided adjacent the upper end of portion 33 of member 29. The points of engagement of the ends 41 and 43 of the cable with the moving system are, of course, represented by openings 42 and 44 in which the cable ends are secured. It is of importance to my invention that these points be located above the center of gravity of the moving system.

As described in the aforementioned Bochan application, the unbalance forces operating on the moving system when basket 2 is spinning at a relatively high speed cause basically two types of vibrational motion. First, there is a pendulous motion of the system in which it swings between the two pulleys 34 and 36 as though these were fixed points. Since the center of gravity is below the suspension plane where the cable is attached to portions 32 and 33 of member 29, the system is gravity centered and is stable. The second motion is a rocking motion, which occurs about a point, in which one side of the moving system will tend to rise and at the same time the other side of the system will be lowered because of the continuous nature of cable 44 and its attachment to the two opposite sides of the systems. Almost invariably, there is a combination of the two types of motion; however, their causes can to some extent be separated by stating that single plane unbalances (commonly called static unbalances) cause a predominantly pendulous motion, whereas a couple (equal unbalances removed 180° circumferentially from each other and axially separated), also known as a dynamic unbalance, causes a predominantly rocking motion. Thus, the only forces which can be transmitted to the frame 5 and to the floor are vertical forces which have very little harmful effect, and a very small amount of horizontal force due to the pendulous or swinging motion between the two pulleys 34 and 36. By far the greater part of the vibrational force of the moving system is absorbed by the cable suspension arrangement described and is therefore prevented from being transmitted to frame 5 and to the floor on which machine 1 rests. In addition, the fact that the cable and pulley arrangement causes one end of the system to rise when the other end lowers prevents to a substantial extent any vertical motion of the system which motion, as previously mentioned, is generally not desired.

In operation, the moving system of machine 1 is so constructed to have relatively low critical or resonant speeds for both static and dynamic unbalances. At the dynamic unbalance resonant speed, the transmitted frame-vibrating forces are at a peak. Since vibrational forces at the critical speed increase approximately with the square of that speed, it is highly desirable, in order to keep these forces relatively small, that low critical speeds be provided by proper design of the machine. The design of machines to provide a low static unbalance resonant speed is well known. However, substantial difficulty has been encountered in the design of a system which will also have the desired low dynamic unbalance resonant speed. The cable suspension system described has been found very helpful in this respect in readily permitting a low critical speed design to be attained for both types of unbalance. Once the moving system is operating above critical speed, the vibratory motion is a combination of a pendulous motion and a rocking motion which are isolated as described above.

It will, of course, be recognized that the extent of motion of the moving system as it passes through the critical speed may be such as to require damping means, particularly in cases where the system proceeds relatively slowly through the critical speed and the vibrational forces have a consequently longer time to operate. While this is not true where a high torque power source is available to push the system through critical speed quickly, it is not normally economically or practically feasible to provide such a source for domestic washing machines and,

as briefly described above, a more conventional procedure is to provide a relatively small motor with clutch means for preventing sudden large torque requirements. As a result it is desirable in the machine described to provide suitable damping means; while these may take any of various forms, in the present case one preferred construction provides for four downwardly extending strip members 45, 46, 47 and 48. Strips 45 and 47 may be attached, as shown, to the under side of portion 31 of member 29, strip 46 is attached to the end of the counterweight 27, and strip 48 is attached to the moving system on the motor side. Strips 45, 46, 47 and 48 are thus secured on the moving system. Arranged in co-operative relationship with strip 45 is a frictional damper pad 49 biased against the surface of strip 45 by means of a spring 50 secured at its base 51 to the base 6 of the machine. A similar damping pad (not shown) engages the other surface of strip 45 and is biased thereagainst by a similar spring 52. It will readily be seen that as the moving system goes through its vibrational unbalance caused motion, the pad 49 will rub over the surface of strip 45 to provide a damping effect. In the same manner, damping assembly 53 cooperates with strip 46, damping assembly 54 with strip 47 and damping assembly 55 with strip 48. The damping assemblies associated with the strips 45 and 47 provides damping in one vertical plane and strips 46 and 48 provide damping in a perpendicular vertical plane, so that essentially uniform damping is provided for all motions allowed by the system.

It will be seen from the foregoing that a highly effective yet economical and simple suspension system is provided by my invention whereby a major part of the undesirable vibrations existing as a result of the operation of the moving system is prevented from reaching the frame of the machine and consequently the base on which the machine stands. In addition, it will be observed that a total of three pulleys and a cable are required to effect the suspension and vibration isolating functions, with only a single pulley being required in addition to the two basically essential pulleys which must be provided on opposite sides of the moving system.

As mentioned in the aforesaid Bochan application, while the construction described has only two oppositely positioned pulleys 34 and 36, it will readily be understood that additional pairs of oppositely positioned pulleys may be provided as desired and the system will still be effective.

Referring now to the use of the same suspension system in a modified type of washing machine as illustrated in FIGURES 3 and 4, the structure will be described using like numerals to illustrate like parts. The main difference between the structure already described and the structure of FIGURES 3 and 4 is that, in the latter, tub 4 is rigidly secured at the base to the top of transmission 20 and is not secured to frame 5. Thus, the tub is part of the moving system rather than part of the stationary frame. As a result, since the tub has the same movement as motor 22, it is stationary with respect thereto and an ordinary shaft 56 may be used to connect motor 22 to drain pump 21. In addition, the fact that the tub moves with the transmission 20 and basket 2 means that the lower portion 57 of the tub may be rigidly secured to the transmission rather than requiring, as in FIGURES 1 and 2, a flexible boot member. Also, because tub 4 is part of the moving system, it is not necessary to provide as in FIGURES 1 and 2 a member 29; instead, outrigger arms 58 and 59 are provided on the opposite sides of the moving system secured to and extending from tub 4. At the ends of the outrigger arms 58 and 59 there are provided openings 60 and 61 to which the two ends 41 and 43 of cable 44 are, as before, secured to the moving system at a point substantially above the center of gravity on opposite sides of the system.

In order to show the possibility of various damping ar-

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rangements suitable for use with the general type of washing machine shown, I have illustrated in FIGURE 3 a damping system wherein members 62 and 63 are provided with upper horizontal surfaces 64 and 65 respectively. In addition, each of the members 62 and 63 has a lower horizontal surface (not shown). In cooperation with surface 64 of member 62 there is provided a frictional damping pad 66 which is secured to tub 4 and biased against surface 64 by a spring member 67. A similar damping pad (not shown) is biased against the lower surface of member 62 by a spring member 68. A similar damper pad assembly 69 is provided in cooperation with member 63. It will readily be observed that during the various rocking and pendulous motions of the moving system the damper pad arrangements will move over the horizontal surfaces of members 62 and 63 to provide a damping effect on the vibrational movement of the moving system. This type of damping system, being closer to the planes in which unbalances occur, may require less damping force than the type of damping system described in FIGURES 1 and 2.

In all other respects the structure of the machine of FIGURES 3 and 4 is the same as in the machine of FIGURES 1 and 2; both the machines of FIGURE 1 and of FIGURE 3 use the same suspension system which operates in precisely the same manner: the cable and pulley arrangement provides for pendulous motion of the moving system between the two tub pulleys, for rocking motion of the moving system with one outrigger arm going up as the other one goes down, and for the normally occurring combinations of the two types of movement. In both cases a single additional pulley besides the two oppositely positioned pulleys is all that is necessary in order to provide a continuous cable connection from one side of the moving system to the other. The two structures using my invention are provided to show the ready adaptation of the system to the most commonly encountered types of vertical axis washing machines, namely, the type wherein the tub is rigidly fastened to the frame and does not form a part of the moving system and the type where the tub is part of the moving system and is separated from the frame.

While in accordance with the patent statutes I have described what at present is considered to be the preferred embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. A machine comprising a moving system including driving means and driven means operated at a relatively high speed by said driving means; a rigid frame for said moving system including a base adapted to seat on a supporting surface; and means supporting said moving system on said rigid frame so as to prevent any substantial part of any vibrations of said moving system from reaching said frame comprising an elongated flexible member having its ends secured respectively to said moving system on two opposite sides thereof above the center of gravity of said moving system, first and sec-

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ond pulleys secured respectively on said two opposite sides of said moving system above the ends of said flexible member, and a third pulley secured on said frame intermediate said first and second pulleys, said third pulley being positioned so that straight lines drawn between it and each of said first and second pulleys are horizontally external to said moving system said third pulley being secured to said frame to rotate in the plane which it forms with said first and second pulleys, said flexible member extending from one of its ends first up over said first pulley, then in said plane around said third pulley, and then in said plane over said second pulley and down to its other end.

2. The apparatus defined in claim 1 wherein said moving system comprises centrifuging means.

3. The apparatus defined in claim 1 wherein said machine is a laundry machine and said moving system comprises means for laundering clothes including a clothes receiving basket and drive means for rotating said basket on a vertical axis at a centrifuging speed.

4. The apparatus defined in claim 1 wherein first damping means is secured on said frame and second damping means is secured to said moving system, said first and second damping means engaging each other and forming together a damping system for said machine to limit vibrational movement of said moving system as it passes through its critical speed.

5. The apparatus defined in claim 3 wherein said laundering means further includes an imperforate tub member surrounding said basket in water-retaining relation thereto.

6. The apparatus defined in claim 3 wherein said rigid frame includes an imperforate tub member rigidly secured thereto surrounding said basket in water-retaining relation thereto.

7. A laundry machine comprising means for laundering clothes including a clothes receiving basket and means for rotating said basket at centrifuging speed; a rigid frame formed as an enclosing cabinet for said laundering means; and means supporting said laundering means on said frame so as to prevent a substantial part of any vibrations of said laundering means from reaching said cabinet comprising a cable having its ends secured respectively to said laundering means on two opposite sides thereof above the center of gravity of said laundering means, first and second pulleys secured respectively on said frame on said two opposite sides of said laundering means above the ends of said cable, said first and second pulleys being secured to said frame to rotate in substantially vertical planes perpendicular to each other, and a third pulley secured on said frame in a common horizontal plane with said first and second pulleys at the intersection of said vertical planes, said cable extending from one of its ends first over said first pulley then in said horizontal plane over said third pulley, then in said horizontal plane to said second pulley, and back down to its other end.

References Cited in the file of this patent

UNITED STATES PATENTS

413,780	Griswold	Oct. 29, 1889
2,454,112	Woodson	Nov. 16, 1948
2,707,088	Shelton et al.	Apr. 26, 1955