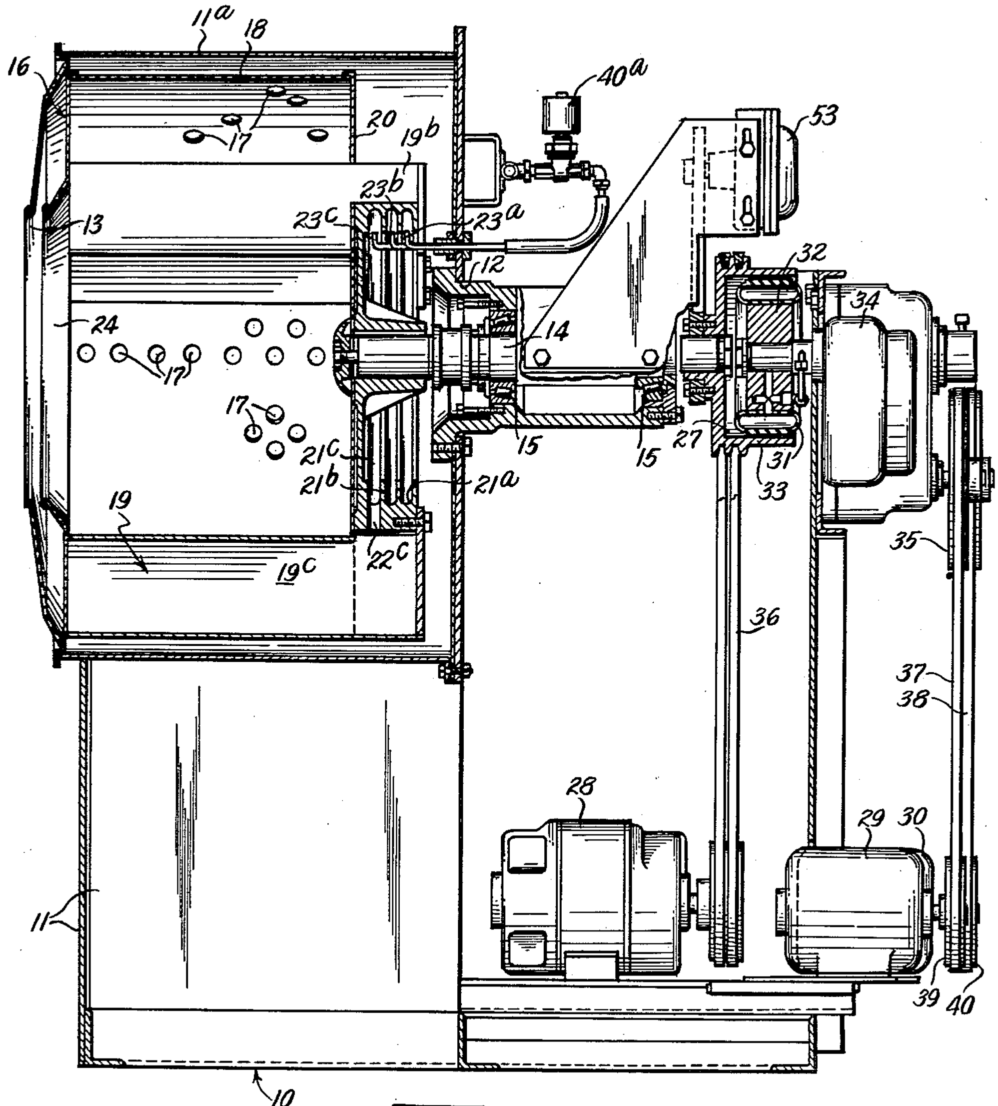

Fig. 1.

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Fig. 2

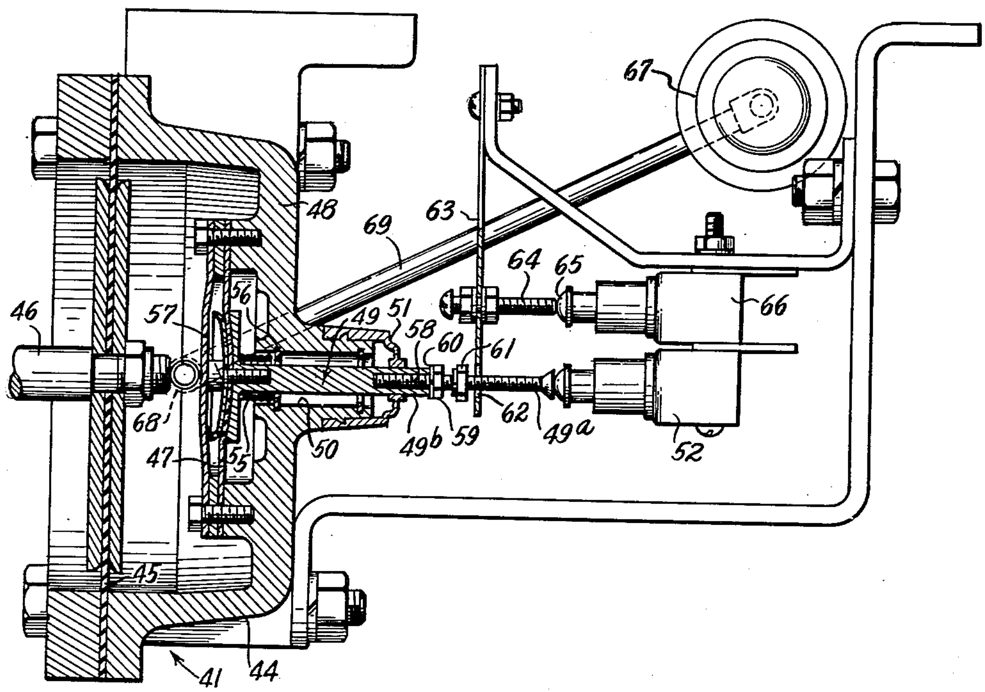

Fig. 3.

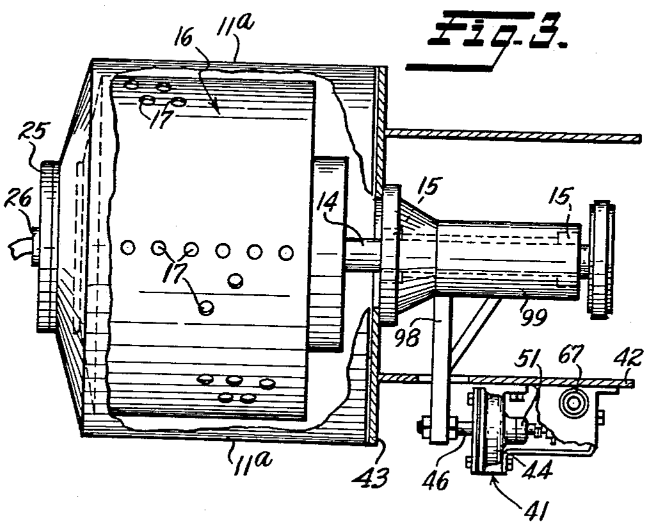

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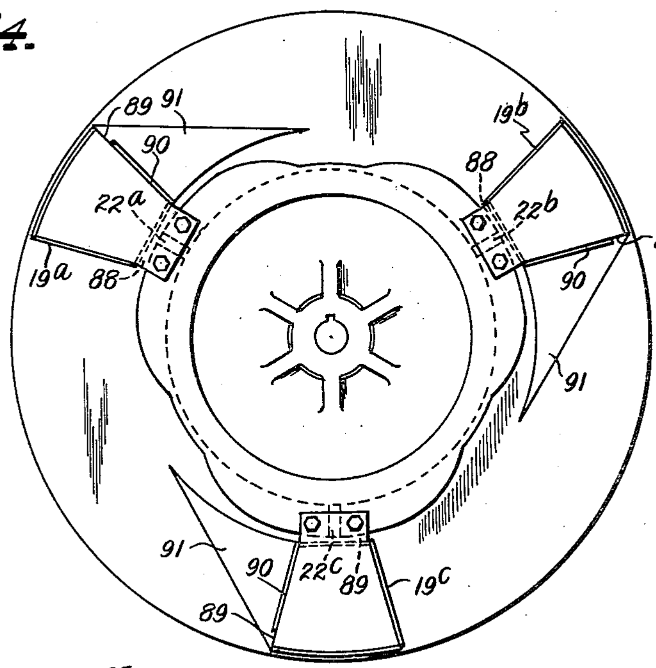
Fig. 4.



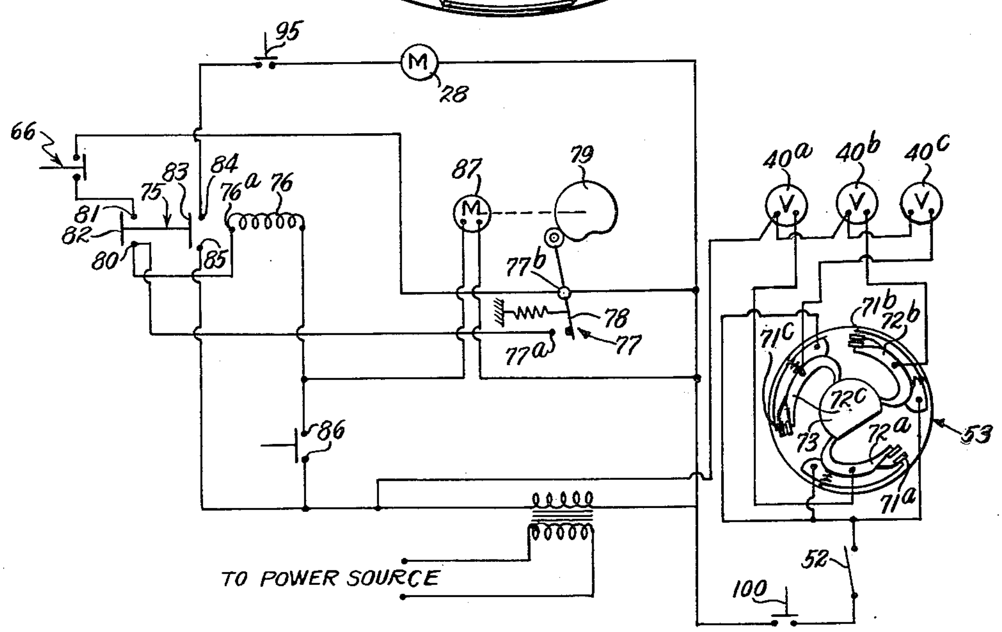


Fig. 5.

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AUTOMATIC IMBALANCE CONTROL SYSTEM FOR A CLOTHES WASHING MACHINE

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15 Claims. (Cl. 210—144)

Our invention relates to an improved automatic imbalance control system for a clothes washing machine of the type provided with a plurality of balancing compartments spaced about the periphery of a rotating drum and with means for selectively admitting water to these compartments in such a way as to compensate for any imbalance due to the manner in which the clothes within the drum are distributed about its axis.

Machines of this type have been proposed by various prior patentees, such as Verdier (U.S. Patent No. 2,224,-241), Kahn (U.S. Patents Nos. 2,534,267–8–9), and Keiper (U.S. Patent No. 2,647,386).

None have, however, heretofore proven commercially successful.

One reason for this lack of success resides in the fact that it is extremely difficult to provide a sensing device which is sufficiently delicate to respond to small displacements indicative of rotor imbalance, and which comprises means for automatically compensating for expansion and contraction of the cooperating parts of the machine due to wear, settling, and temperature changes, but is nevertheless sufficiently simple and rugged to stand up under heavy duty.

It is also necessary to provide means for preventing the operation of the machine for extended periods in which the magnitude of the vibrations is excessive, and since the sensing device is actuated for only a fraction of a second, the circuit which it controls must be exceptionally quick acting.

In our invention, such a sensing device and its associated circuits have been provided in connection with control means for automatically insuring the proper sequence and timing of operations in a machine which successively washes, drains, and extracts the water from the clothes.

In order that the specific invention may be more readily understood, it should be noted that most commercial washing machines are operated through a number of successive sub-cycles which, when taken together, constitute a single complete cycle for washing a single batch of clothes. In the case of a machine adapted to handle say 25 pounds of clothing per cycle, the machine will first be loaded, while stationary, with the proper amount of clothing.

A washing sub-cycle will then be initiated by starting a tumbling speed motor which may rotate the drum at approximately 35 r.p.m., reversing 4 times per minute, to tumble the clothes. During the first part of this step water is introduced into the drum and the necessary treating supplies, as for instance, bleach, soap, detergent, etc., are added. This tumbling and washing step may be continued for five minutes or so.

The tumbling speed motor is then cut out and a drain speed motor cut in to drive the drum in a single direction at a higher rate of speed, say 61 r.p.m., for about 40 seconds, during which time the water is drained from the machine. During this stage the clothes are also distributed about the periphery of the drum. Speeds of the order specified have been found to be most effective in evenly distributing clothes and it is helpful to have water in the drum when rotation at this speed is begun since this also facilitates even distribution.

The drain speed motor is then cut out and a third or extraction speed motor cut in, which may accelerate the

drum to 1000 r.p.m. during the ensuing 30 seconds. The extraction speed motor is then cut out, the drum braked, the wash speed motor cut in, water and detergent added, and the washing sub-cycle of tumbling, draining and extracting may be repeated two or more times. The necessity for shifting from one motor to another poses certain problems and our invention consequently comprises novel means for connecting and disconnecting each of the three motors to drive the drum at the appropriate time.

The clothing may then be rinsed by running the machine through a plurality of rinsing sub-cycles comprising tumbling, draining, and extracting steps and identical to the washing cycles, except for the fact that no detergents or like supplies are added. Usually, however, the tumbling step is allotted only two minutes or so during a rinsing sub-cycle, instead of the five minutes consumed by this step during washing.

A bluing and/or souring sub-cycle may follow which is identical to the washing sub-cycle except that bluing and/or souring supplies are added instead of soap or detergent.

Finally, at the end of the last of the foregoing subcycles, the drum is held at the extraction speed of 1000 r.p.m. for approximately five minutes, braked, and unloaded.

It will be readily appreciated that it is desirable that the cycle represented by the aforesaid large succession of changes be performed automatically, and in the particular type of machine to which the applicants' invention relates, automatic means are provided for compensating for any imbalance which may occur.

In general, imbalance is not a problem at tumbling and draining speeds since relatively low speeds are employed for this purpose. Extraction, however, is carried out at a higher speed, as has already been indicated, and the clothes tend to become plastered against the outer wall of the rotating cylinder. If they are not evenly distributed about its circumference, substantial vibration with resultant excessive wear on the machine is likely to occur. As has already been indicated, such maldistribution may be minimized, but not completely eliminated, by operating the machine for a short period at the draining or distributing speed intermediate the tumbling and extraction speeds.

Unfortunately, if water is permitted to remain in the drum after it has exceeded the ordinary tumbling speed, water will also remain in the balancing compartments and it is exceedingly difficult to remove water therefrom at the higher speeds. The result is that if water is left at the drum after an increase in its r.p.m. to the normal draining speed of say 61 r.p.m., in order to reduce imbalance by facilitating the distribution of clothes at this higher or "distributing" speed, some water will remain in the balancing compartments when the drum first attains its extracting speed and will reduce the effective volume of said compartments available to receive balancing fluid and thus their capacity to counteract any imbalance which does occur.

Our invention, accordingly, comprises special means to facilitate the drainage of the balancing compartments at speeds greater than tumbling speed, thus permitting our machine to secure the full benefit of both the presence of water in the drum at draining or distributing speed, and the absence of water in the balancing compartments by the time a sufficiently high speed has been attained to make utilization of the balancing compartments important.

It is desirable that the machine be set to pass from draining to extracting speed as rapidly as possible so as to decrease the total time required for a complete cycle, but means must be provided for preventing too rapid an increase in speed if a particular batch of clothes did not become evenly distributed during the draining step, since under such circumstances excessive vibration is bound to result. We have accordingly provided a "coast" relay which acts to cut off the motor without, however, braking the cylinder, whenever the vibration becomes excessive.

The result is a balancing system which permits the machine to be automatically advanced from a tumbling to an intermediate distributing and draining speed and then to an extracting speed; which will automatically compensate for any ordinary imbalance; which will permit the balancing compartments to be drained at top draining speed, and which will stretch out the period intervening between draining and full extraction speeds by coasting whenever the degree of imbalance is such as to result in excessive vibration.

Other objects and advantages of our invention are in part obvious and will in part become apparent from the following description of a specific embodiment thereof, which is set forth purely by way of illustration, without limiting the scope of the invention to the specific details thereof.

In the accompanying drawings:

FIG. 1 is a vertical axial cross-section of our new machine;

FIG. 2 is an axial cross-section taken through the sensing device and the switches actuated thereby;

FIG. 3 is a detail view on a smaller scale showing the sensing device mounted on the machine;

FIG. 4 is an end view of the rotating drum showing the rib drain baffles; and

FIG. 5 is a simplified circuit diagram showing that portion of the wiring of the machine constituting our novel balancing and coast circuits. It will be appreciated that we have shown only those portions of the wiring diagram of a complete machine which fall directly within the scope of the invention and have omitted many switches and relays included in such circuits merely for the sake of convenience, or safety or to correlate them with other circuits in the machine. While a transformer and two lines have been shown for simplicity's sake as the source of all power, it will be understood that the machine is in fact supplied through one or more transformers from a power line and that the voltage across the various circuits is not necessarily the same.

Like reference numerals denote like parts throughout the several views.

As best seen in FIG. 1, a machine embodying our invention comprises a base **10** comprising approximately vertical walls **11** which form a housing supporting a horizontal cylindrical portion **11***a* provided with axial openings **12** and **13** at each end. A drive shaft **14** turns in bearing means **15**, and projects into the cylindrical portion **11***a* of the housing, through the axial opening **12**. A rotatable clothes-carrying drum **16** is fixed to the inner end of the shaft **14** and provided with a plurality of small holes **17** in its cylindrical outer wall **18**. Three hollow ribs **19***a*, **19***b*, and **19***c* are equally spaced about this cylindrical outer wall, and project inwardly therefrom. The end of drum **16** which is connected to the drive shaft **14** is closed by a wall **20**, and an assembly of feed rings **21***a*, **21***b* and **21***c* is fixed to this wall and to the shaft **14**. As best seen in FIG. 1, these feed ranges are open all along their inner sides so as to receive any water projected axially thereinto and retain it while they are being rotated at a speed sufficient to cause centrifugal force to throw the water so projected against the outer peripheries of the rings. Each hollow rib **19** projects past the wall **20** to overlap the rings **21***a*, **21***b*, **21***c*, and each ring communicates with the projecting portion of one of said ribs through the channels **22***a*, **22***b*, **22***c*. Water is introduced into the feed rings through the injector pipes **23***a*, **23***b*, **23***c*.

The end of the drum **16** opposite the wall **20** is provided with an axial opening **24** which registers with a corresponding opening **13** in the cylindrical housing **11***a*, through which the clothes are introduced and which is closed during operation of the machine by a glass door **25**. This door is provided with inlet means **26** through which water may be introduced into the cylinder **16**.

The shaft **14** and drum **16** may be driven directly from extraction speed motor **28** or through a clutch **27** by either tumbling speed motor **29** or drain speed motor **30**, depending upon whether the machine is to be driven at a given instant at extracting, tumbling or draining speed.

The clutch is of the air actuated type, with an inflatable toroid **31** positioned between its driving member **32** and driven member **33**. The driving member **32** is driven through reduction gearing **34** by a pulley wheel **35** of the multiple type. The purpose of the reduction gearing is to avoid the necessity of transmitting substantial force through a low-speed belt drive.

When the toroid **31** is deflated the driven member **33**, shaft and drum may be driven through the belt **36** by extraction speed motor **28**. When the toroid **31** is inflated, they may be driven through the reduction gearing **34** and pulley wheel **35** either by tumbling speed motor **29** and belt **37** or by draining speed motor **30** and belt **38**. The motors **29** and **30** may actually turn at the same speed, but drive the shaft at different speeds by reason of different ratios between the sizes of the pulleys **39** and **40** attached thereto and pulley **35** attached to the reduction gearing unit.

The tumbling and drum speed motors **29** and **30** are permanently belted to the reduction gearing and the extraction speed motor **28** is permanently belted to the driven member **33**. Only one motor is energized at any one time. By reason of the permanent belting whenever the toroid **31** is inflated to engage the clutch, which ever of motors **29** and **30** is energized drives the other as a flywheel and also drives the motor **28** in like manner.

Balancing water is supplied to the injector pipes **23***a*, **23***b*, and **23***c* from a central source through control valves **40***a*, **40***b*, and **40***c*, respectively. These valves are electrically actuated by the sensing device **41** mounted on the vertical wall **42** which forms part of the base **10** and extends rearwardly from the end wall **43** of the cylindrical housing **11***a* parallel to the shaft **14**. A cooperating pick up arm **98** projects radially from the cylindrical housing **99** which carries the bearing means **15**. The sensing device is positioned on the wall **42** with its axis parallel to the shaft **14** and comprises a cup **44** closed by a flexible outer diaphragm **45**, which carries an axial pin **46** connected to the pick up arms **98**. An inner diaphragm **47**, slightly spaced from the base **48** of the cup, carries a rod **49** which projects through a channel **50** in the cup base, and through sealing means **51**. The rear end of this rod is positioned adjacent the switch **52** which is connected through a commutator switch **53** (FIG. 5) to the control valves **40***a*, **40***b*, **40***c* (FIG. 5) which control the admission of water to the injector pipes **23***a*, **23***b*, **23***c* respectively. The rod **49** is biased away from the base of the cup against a stop bar **57** by a spring **55** seated on a ring **56** set into the wall of the channel **50**. It consequently returns to a fixed reference point (abutting the stop bar **57**) after each displacement. The rod **49** is made in two parts **49***a* and **49***b*, one of which screws into the other. The overall length of the entire rod may be adjusted by varying the depth to which screw threaded part **49***a* is inserted into the threaded recess **58** in part **49***b*, locking the two parts together at the desired position by means of adjusting nut **59** and lock washer **60**. The rod **49** also carries a second nut **61** which is adjustable along the threaded rod parts **49***a*. This nut is slightly larger than the orifice **62** in the leaf spring **63** which is attached at one end through intermediate mounting means to the wall **42**. As best seen in FIG. 2, the orifice **62** in spring **63** encircles the rod **49** with sufficient clearance to permit the rod to pass freely therethrough. If, however, the rod moves sufficiently far for the nut 61 to engage the leaf spring 63, this spring is bent toward the switches and the plunger 64 presses the button 65 which operates the switch 66 of the "coast relay" which will be hereinafter described in greater detail.

The cup 44, between the two diaphragms, is filled with oil which is in constant communication with an oil reservoir 67 through an orifice 68 and tubing 69. The reservoir is vented to atmosphere. This arrangement possesses several important advantages:

(1) Since the net effective diameter of the outer diaphragm is greater than that of the inner diaphragm, (by a ratio of a little more than 2:1 in the embodiment disclosed) any axial movement of the plunger 46 results in a larger axial movement of the rod 49.

(2) Since the oil has a certain viscosity and the outlet through the orifice 68 is relatively small, rapid oscillations of the plunger are proportionately more effective in producing corresponding reciprocation of the rod 49 than low frequency oscillations, since in the latter case a substantial portion of the pressure can be dissipated through the orifice 68, but the viscosity of the oil prevents any such substantial dissipation through the narrow orifice when vibration is rapid. It will accordingly be appreciated that the sensing device may be designed to be sensitive primarily to vibrations above a desired threshold frequency by suitable selection of the proportion between the effective volume displaced by the expected movement of diaphragm 45 and the effective cross-section of the orifice, in view of the viscosity of the oil. In the particular embodiment disclosed the sensing device is designed to react primarily to vibrations at frequencies greater than 150–200 revolutions per minute. The device is, moreover, more sensitive to the higher frequency vibrations within the range to which it is designed to respond, and this is a useful characteristic, since a finer balance is required at the higher speeds.

In the embodiment illustrated the diameter of the larger diaphragm is 4⅛" and that of the smaller 1⅞", the oil viscosity is SAE 50, the orifice 68 has a diameter of ⅛", the return spring pressure is about four pounds, the micro-switch setting is .005 inch, and vibrations of an amplitude sufficient to close it may occur at any speed in excess of 150–200 r.p.m.

The micro-switch will not be actuated at lower speeds since at such speeds the vibration is insufficient to move the pin 46 and diaphragm 45 as far, and the movement thereof required to actuate the switch at such lower speeds is greater. On the other hand, once this threshold speed has been passed the greater the speed, the smaller the displacement of diaphragm 45 which is required to actuate switch 52. The device thus becomes increasingly sensitive at higher speeds.

It will be appreciated that the threshold speed may be regulated by varying any of the above-mentioned parameters, but it is most convenient to regulate the size of the orifice 68, any increase in the size of this orifice tending to increase the threshold speed and any decrease in its diameter tending to decrease the threshold speed.

The importance of the threshold speed resides in the fact that the majority of out-of-balance in a combination washer-extractor is caused by the disproportionate absorption of water by the clothes. Since the great bulk of the retained water is spun off in the first few seconds of extraction, most of the disproportionate out-of-balance caused by absorbed water will also be thrown off, thus reducing the total out-of-balance which must be compensated for. If balancing started too early, there would be an excess of counterbalance water added to the cylinder opposite the site of the clothing having the higher absorption rate, and then additional water would be required on the same side as the site of the higher absorption after the excess water had been spun off, which would result in a "hunting" condition, possibly coupled with complete filling of one or more of the ribs before full balancing has taken place.

With our "threshold" setting in effect, the machine is allowed to come partially up to speed and to throw out the bulk of the water retained in the clothes *before* beginning to counterbalance. This prevention of premature injection of balancing water permits a very fine final balance to be obtained.

(3) The interior of the cup is under a pressure slightly greater than atmospheric due to the head of oil in the reservoir, and the pin 46 is connected through arm 98 to bearing housing 99, the forward end of which is displaced by centrifugal force toward the position occupied by the overweighted portion of the cylinder at any instant, thus swinging the outer end of arm 98 toward or away from the sensing device 41, as the case may be. If, by reason of expansion and contraction of the machine, shifting of its foundation, or the like, the wall 42 moves slightly with respect to the bearing housing 99 and the arm 98, the pin 46 in the flexible diaphragm 45 follows along with it. The setting of the rod 49 with respect to the switches 52 and 66, however, remains unaffected. A little oil flows to or from the reservoir to keep the cup 44 filled and the slight change in the effective distance between the diaphragms has no effect on the operation of the machine. This "constant reference point" feature is highly important to the successful operation of the machine under practical commercial conditions, since if it were not for this feature the sensing and imbalance correcting arrangement would cease to function properly within a short period following its initial installation.

When the switch 52 is closed by the rod 49 it completes a circuit to the commutator arrangement 53 which comprises three pairs of contacts 71*a*, 71*b*, 71*c*, each of which closes a circuit to one of the valves 40*a*, 40*b*, 40*c* which control the admission of balancing water to the ribs 19. One of each pair of contacts is mounted at one end of a pivotally mounted arm, 72*a*, 72*b*, 72*c*, the other end of which is biased against a rotating cam 73, which turns in synchronism with the shaft 14. This cam is so contoured as to permit each pair of contacts to close during a 50°–70° portion of each revolution. If, during any one of these portions of the revolution, the switch 52 is closed, contact will be completed to one of the balancing valves and water will be admitted to the corresponding rib. The rotation of the cam is, of course, so synchronized with that of the drive shaft 14, that water is admitted to the rib opposite the locus of the overweight. It will be observed that there is a 50°–70° gap between the closing of one pair of contacts and the opening of the next. The reason for this is that the sensing device ordinarily closes its switch for nearly 180° of the revolution, since the shaft begins to bell the housing as soon as the overwight section passes through the vertical plane containing the central axis of the shaft. If the contacts 71*a*, 71*b*, 71*c* were closed for 120° each, it would be possible for an overweight located at a point diametrically opposite one of the ribs to successively actuate all three valves, one for 30° of the cycle, the next for 120° and the remaining valve for 30°. This is definitely undesirable.

Returning now to the sensing device, if the control rod 49 is forced back far enough for the nut 61 to engage the leaf spring 62, the normally closed "coast switch" 66 will then be opened. This switch is connected in the coast circuit which comprises a single throw double pole relay 75. One end 76*a* of the coil 76 of this relay is connected to one terminal 77*a* of timer switch 77, the other terminal 77*b* of which is connected to one side of the supply line. The timer switch 77 is provided with a pivoted arm 78 for closing its contacts and the arm is biased towards closed position. A cam 79 engages a roller on the arm 78 and normally holds it away from this closed position but is designed to permit it to close for a short portion of each revolution.

Coil terminal 76*a* is also connected to one of the pair of contacts 80, 81, closed by pole 82 of the double pole relay 75. The other contact 81 of this pair is connected through the coast switch 66 to the opposite side of the supply line.

The other pole 83 of the coast relay closes contacts 84 and 85. The former is connected through switch 95 to the extractor motor starter and the latter to the supply line.

It will be appreciated that in referring to a "single-throw, double-pole" relay, we intend merely a relay having two pairs of contacts simultaneously closed or opened as the result of a single operative step. It is not implied that the pairs of contacts are necessarily on separate bars.

This circuit operates as follows. When the tumbling speed motor is cut out and the drain speed motor is cut in, the drain relay is deenergized and the contacts 86 on the drain relay are closed. The motor 87 which drives the cam 79 may operate constantly during operation of the machine or may, as shown, be started by closing of the contacts 86. Then, when the cam 79 next permits the timer switch 77 to close, a circuit is completed through the contacts 86 on the drain relay, the coast relay coil 76, and the timer switch 77, thus energizing the coast relay 75, one pole 83 of which closes contacts 84 and 85, connecting the power supply to one terminal of switch 95, which is then open, and has its other terminal connected to the extractor motor starter. The other pole 82 of the relay 75 connects the end 76*a* of the coil 76 to the supply line through contacts 80 and 81 and the normally closed coast switch 66. When the cam 79 turns further, and the timer switch 77 opens, the coil 76 remains energized through the coast switch 66 at one end and the drain relay contacts 86 at the other. Consequently, when the switch 95 is closed (thus cutting out the drain speed motor and deflating the clutch toroid 31 through means not shown) the extractor motor 28 is supplied through contacts 84 and 85 and switch 95. This motor continues to operate unless excessive vibration forces the control rod 49 far enough back for the nut 61 to engage the leaf spring 63 and open the normally closed coast switch 66. The coast relay coil 76 is then deenergized and pole 83 opens the contacts 84 and 85, breaking the supply line to the extractor motor, which proceeds to coast. The next time the cam 79 permits the timer switch 77 to close, the coast relay coil 76 is re-energized as before, first through the timer switch 77, and then by means of the pole 82 through the coast switch 66, which will by this time have closed, and the circuit between the power supply and extractor motor is reinstated. If the time allowed by the timer for coasting is insufficient for the excessive vibration to die down, the coast relay 66 will again open and the entire cycle will be repeated as often as necessary.

A switch 100 in the circuit through the balancing valves may be connected to be operated conjointly with the switch 95 so that the balancing valve circuit will be completed only when the machine is operating at extraction speed.

It will be noted that coasting is effected by *opening* of the coast relay rather than its closing. The reason for this is that contact between the nut 61 on the control rod 49 and the leaf spring 63 may be quite brief and relays are much more responsive to a short absence of energization than to a short energizing pulse. Consequently an opening of coast switch 66 for a time period which would be much too brief to pull the relay in, will permit it to drop out, and the present arrangement is therefore highly sensitive to the first signs of excessive vibration.

In order that the balancing arrangement may be fully effective it is essential that the balancing ribs be as nearly empty as possible when the machine is speeded

up so as to leave as much room as possible for the introduction of balancing liquid.

During the washing operation, each time the ribs dip into the water in the cylindrical housing 11*a*, water flows into the balancing ribs. The washing operation is performed at tumbling speed (circa 35 r.p.m.), which is low enough so that each time the drum rotates the ribs above the water level at least partially drain out through the spaces 88 between the inner walls of the ribs and the outer periphery of the feed rings. Unfortunately, the ribs which are immersed refill.

However, at the drain and distributing speed of about 61 r.p.m., which is used to distribute the clothes about the periphery of the container, the centrifugal force developed is sufficient to force any water picked up by the ribs to the outer portions thereof away from the spaces 88, so that the ribs do not drain. This has presented a serious problem since the volume of water retained by the ribs in this manner has been found to be so large as to reduce their balancing capacity by more than one third.

If, on the other hand, drain holes were provided at the outer edges of the ribs, any balancing fluid introduced thereto during extraction would immediately be thrown out due to the centrifugal force exerted at this higher speed.

This problem has been met by providing outlets 89 at the outer edges of the rib walls 90, and pocket-like baffles 91 which extend transversely inward from the circumferential periphery of said drum adjacent said outlets. When the machine is brought up to the draining and distributing speed, any water in the ribs will be forced to the outer peripheries thereof and will tend to flow out through the outlets 89 into the pockets formed by the baffles 91 and the centrifugal force at the draining and distributing speed in sufficient to prevent this water from flowing out of the pocket formed by baffle 91 and wall 20 of the drum 16 into the bottom of the stationary cylinder 11*a*, and thence to drain.

At the still higher extraction speed, however, centrifugal force will retain any fluid emerging from the outlets 89 in the bottoms of the pockets formed by the baffles 91, so that the net result is merely a slight increase in the effective volumes of the ribs.

The outlets may be formed in either the leading or trailing walls of the ribs, or both, but a position in the trailing wall is somewhat more effective than in the forward wall. The angular position of the baffle will depend somewhat on the speed at which balancing water is to be permitted to flow thereover, but for washers in which retention is desired at speeds materially greater than 61 r.p.m., the baffle should make an angle of between 30 and 60 degrees with the plane of the radius passing through the corresponding rib outlet.

Test results have shown that in a machine without baffles in which the effective balancing capacity was reduced 36.9% by reason of residual water, this loss was reduced to 18% when baffles were added.

Drainage may also be facilitated by positioning the axis of the machine at a slight angle with the feed rings at the lower end, or by providing a frusto-conical drum having a greated diameter at the feed ring end. In either case a wall is provided for the balancing ribs which slopes toward the feed ring end through which the water leaves as well as enters the ribs.

In order that the invention may be clearly understood, one representative washing sub-cycle will now be described with particular emphasis on the part played by the improved balancing system constituting our invention.

As previously indicated in the general description of this sub-cycle, the drum is first driven at a relatively low speed, as for instance 35 r.p.m., by the tumbling speed motor 29, belt 37, pulley wheel 35, reduction gearing 34 and clutch 27. This motor automatically reverses 4 times per minute, over a period of, say, two minutes.

gized, and the drain speed motor 30 is cut in, closing The tumbling speed motor is then automatically deener-drain relay contacts 86, and thus in due course connecting one terminal of switch 95 to the power source.

At the time the drain speed motor takes over there is water in the drum, in the cylindrical housing and, necessarily, in the balancing ribs as hereinbefore pointed out.

Rotation at draining speed distributes the clothes about the periphery of the drum as the water is drained from the machine. Due to the baffle arrangement already described the ribs drain through the outlets 89 over the baffles 91.

At the conclusion of the draining and distributing step the clothes are plastered against the walls of the drum by centrifugal force, the drum and balancing compartments have been drained, and the drum is rotating at 61 r.p.m. At this speed vibration due to imbalance is not a major problem since the imbalance does not generate sufficient force to deflect the arm 98 and there is thus no movement of the pin 46. In fact the machine may be so arranged that the circuit through the switch 52 is open until the extraction speed motor is started.

After the draining step has been completed, the switch 95 is closed, simultaneously cutting out the drain speed motor and disengaging the clutch (through conventional means not shown) and starting the extraction speed motor 28.

The extraction speed motor begins driving the shaft 14 through the belt 36 and the driven member of the clutch 27 and speeds up rapidly to 1000 r.p.m. or so.

As this speed-up occurs, the threshold of the sensing device 41 is exceeded at about 150 to 200 r.p.m. and any substantial vibrations are communicated through the sensing device 41 to the sensing switch 52, which actuates the proper control valves *40a*, *40b*, or *40c*, through the commutator switch 53 to introduce balancing fluid into the appropriate rib to counteract the imbalance.

If this fails to adequately control the vibration, the nut 61 will contact the leaf spring 63, opening the normally closed coast switch 66, deenergizing coil 76, thereby permitting relay 75 to open, thus cutting off the current supply to extractor motor 28, which coasts until the cam 79 again closes timer switch 77, and thus completes the alternative circuit energizing the coil 76, closing the relay 75 and its contacts 84 and 85, again supplying the extractor motor. This may be repeated as often as necessary.

It will accordingly be seen that we have provided a washing machine equipped with an inbalance control system based on the proper distribution of a balancing fluid to peripherally disposed balancing compartments which permits the drainage of said compartments at an intermediate distributing speed, which is provided with a motion multiplying, self-adjusting, sensing device which is most sensitive to vibrations of those frequencies it is most desirable to counteract, and which comprises quick-acting means for slowing the machine if vibration exceeds a permissible maximum. It will of course be appreciated that the scope of our invention is not limited to the specific details of the particular embodiment disclosed herein, since other embodiments may readily be devised by men skilled in the art which differ in detail without departing from the substance of our invention as defined in the following claims.

What we claim is:

1. An automatic washing machine for washing and subsequently extracting the washing fluid from clothing, said machine comprising a rotatable drum for holding said clothing, a plurality of hollow balancing compartments spaced about the periphery of said drum, means for selectively delivering a balancing fluid to any one of said compartments, an electrical actuating circuit for each compartment, the completion of which circuit actuates said delivery means to deliver balancing fluid to the corresponding compartment, a sensing device responsive to vibrations caused by the passage of an over-weighted portion of said drum past a predetermined point, switch means actuated by said sensing device, and means synchronized with the rotation of said drum for completing, when said switch means is closed, the circuit which will actuate said delivery means to admit balancing fluid to the compartment most remote from said over-weighted portion, said sensing device comprising a fluid filled container closed on one side by a movable member positioned to be displaced by said vibrations and on another side by a second movable member the displacement of which actuates said switch means, said movable members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said movable members toward the other with equal freedom, and a fluid reservoir which communicates through a restricted orifice with the space in said container between said movable members.

2. An automatic washing machine for washing and subsequently extracting the washing fluid from clothing, said machine comprising a rotatable drum for holding said clothing, a plurality of hollow balancing compartments spaced about the periphery of said drum, means for selectively delivering a balancing fluid to any one of said compartments, an electrical actuating circuit for each compartment, the completion of which circuit actuates said delivery means to deliver balancing fluid to the corresponding compartment, a sensing device responsive to vibrations caused by the passage of an over-weighted portion of said drum past a predetermined point, switch means actuated by said sensing device, and means synchronized with the rotation of said drum for completing, when said switch means is closed, the circuit which will actuate said delivery means to admit balancing fluid to the compartment most remote from said over-weighted portion, said sensing device comprising a fluid filled container closed on one side by a flexible member positioned to be displaced by said vibrations and on another side by a second flexible member the displacement of which actuates said switch means, said flexible members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said flexible members toward the other with equal freedom, and a fluid reservoir which communicates through a restricted orifice with the space in said container between said flexible members.

3. An automatic washing machine for washing and subsequently extracting the washing fluid from clothing, said machine comprising a rotatable drum for holding said clothing, a plurality of balancing compartments regularly spaced about the periphery of said drum, means for selectively delivering a balancing fluid to any one of said compartments, an electrical actuating circuit for each compartment, the completion of which circuit actuates said delivery means to deliver balancing fluid to the corresponding compartment, a sensing device responsive to vibrations of a given part of said machine caused by the passage of an over-weighted portion of said drum past a predetermined point, switch means actuated by said sensing device, and means synchronized with the rotation of said drum for completing, when said switch means is closed, the circuit which will actuate said delivery means to admit balancing fluid to the compartment most remote from said over-weighted portion, said sensing device comprising a fluid filled container closed on one side by a flexible member fixed to said given port and on another side by a second flexible member, a control arm actuated by said second flexible member, the displacement of which actuates said switch means, said flexible members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said flexible members toward the other with equal freedom, and a fluid reservoir which communicates through a restricted orifice with the space in said container between said flexible members.

4. A machine as claimed in claim 3 comprising means for rotating said drum a certain number of times per minute for washing and a higher number of times per minute for extraction, in which said orifice is so proportioned to said sensing device container and its flexible members and the viscosity of the fluid within said sensing device is so chosen that fluid displaced by vibrations of said first flexible member at the frequency used for washing passes through said orifice without deforming said second flexible member sufficiently to close said switch, but said second flexible member is deformed sufficiently to close said switch when said first flexible member is deformed at higher frequencies whenever the product of the displacement of said first flexible member and said higher frequency exceeds a predetermined minimum.

5. A machine having rotating parts and means for automatically balancing said rotating parts upon receipt of actuating impulses indicative of the magnitude and frequency of the vibrations of a given part of said machine resulting from said rotation, in which said impulses are transmitted to said balancing means by a vibration sensing device comprising a fluid filled container closed on one side by a movable member positioned to be displaced by vibrations of said given part and on another side by a second movable member, said movable members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said movable members toward the other with equal freedom, means actuated by displacement of said second movable member for actuating said balancing means when said displacement exceeds a predetermined minimum, and a fluid reservoir which communicates through a restricted orifice with the space in said container between said movable members, said second movable member being smaller than said first movable member.

6. A machine having rotating parts and means for automatically balancing said rotating parts upon receipt of actuating impulses indicative of the magnitude and frequency of the vibrations of a given part of said machine resulting from said rotation in which said impulses are transmitted to said balancing means by a vibration sensing device comprising a fluid filled container closed on one side by a flexible member positioned to be displaced by vibrations of said given part and on another side by a second flexible member, said flexible members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said flexible members toward the other with equal freedom, means actuated by displacement of said second movable member for actuating said balancing means when said displacement exceeds a predetermined minimum, and a fluid reservoir which communicates through a restricted orifice with the space in said container between said flexible members, said second flexible member being smaller than said first flexible member.

7. A machine having rotating parts and means for automatically balancing said rotating parts upon receipt of actuating impulses indicative of the magnitude and frequency of the vibrations of a given part of said machine resulting from said rotation, in which said impulses are transmitted to said balancing means by a vibration sensing device comprising a fluid filled container closed on one side by a flexible member fixed to said given part and on another side by a second flexible member provided with a control arm, means actuated by displacement of said control arm to actuate said balancing means, said flexible members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said flexible members toward the other with equal freedom, and a fluid reservoir which communicates through a restricted orifice with the space in said container between said flexible members, said second flexible member being smaller than said first flexible member.

8. A machine as claimed in claim 7 comprising means for rotating said rotating parts a certain number of times per minute for one purpose and a higher number of times per minute for another purpose, in which said orifice is so proportioned to said sensing device container and its flexible members and the viscosity of the fluid within said sensing device is so chosen that fluid displaced by vibrations of said first flexible member at the frequency used for washing passes through said orifice without deforming said second flexible member sufficiently to actuate said balancing means, but said second flexible member is deformed sufficiently to actuate said balancing means when said first flexible member is deformed at higher frequencies whenever the product of the displacement of said first flexible member and said higher frequency exceeds a predetermined minimum.

9. An automatic machine for washing and subsequently extract the fluid from clothing, said machine comprising a rotatable drum for holding said clothing, a motor for driving said drum, a supply circuit for said motor, means for automatically balancing said rotating drum upon receipt of actuating impulses indicative of the magnitude and frequency of vibrations resulting from said rotation, in which said impulses are transmitted to said balancing means by a vibration sensing device comprising a fluid filled container closed on one side by a flexible member provided with an outwardly extending projection positioned to be displaced by said vibrations and on another side by a second flexible member which actuates a control arm, said flexible members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said flexible members toward the other with equal freedom, first switch means actuated by a predetermined displacement of said control arm and positioned to open and close an electrical circuit, thereby supplying said actuating impulses to said automatic balancing means, and a coast switch opened by further displacement of said control arm, said coast switch being connected in the energizing circuit of an electromagnetic coil which, when energized, urges to closed position a circuit completing element in the supply circuit of said motor, said circuit-completing element being biased toward open position so that de-energization of said coil cuts off the supply to said motor.

10. A machine having rotating parts, means for automatically balancing said rotating parts and a vibration sensing device comprising a liquid filled container closed on one side by a first movable member and on another side by a second movable member, said movable members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said movable members toward the other with equal freedom, a liquid reservoir which communicates through a restricted orifice with the space in said container between said movable members, a control arm mounted to move with said second movable member, means actuated by a predetermined movement of said control arm to actuate said automatic balancing means, and means for reciprocating said first movable member in response to vibrations of a given part of said machine caused by the rotation of said rotating parts.

11. A machine comprising a rotating receptacle and means for automatically balancing said receptacle in response to impulses indicating imbalance thereof, in which said impulses are transmitted to said balancing means by a vibration sensing device comprising a liquid filled container closed on one side by a movable member positioned to be displaced by vibrations indicative of said imbalance, and on another side by a smaller movable member, said movable members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said movable members toward the other with equal freedom, means actuated by displacement of said second movable member for actuating said balancing means when said displacement exceeds a predetermined minimum and a fluid reservoir which communicates

through a restricted orifice with the space in said container between said movable members.

12. A machine as claimed in claim 11 in which said orifice is dimensioned to permit relief therethrough of the volume of liquid displaced by vibrations of said first movable member having less than a predetermined amplitude within a predetermined time, thereby avoiding actuation of said balancing means by movement of said smaller movable member in response to small, infrequent vibrations, but said orifice is too small to permit relief therethrough of larger volumes of liquid in a shorter time, so that an increased amplitude and frequency of vibration by the first movable member results in a movement of said smaller movable member to actuate said balancing means.

13. A machine as claimed in claim 12 in which said smaller member is resiliently biased toward a normal position, thereby inhibiting motion thereof in response to small pressures and is set to move a predetermined distance from its rest position before actuating said balancing means.

14. A machine of the type comprising a rotating drum, means for balancing said drum, and a sensing device connected to actuate said balancing means, said sensing device being responsive to vibrations caused by the passage of an over weighted portion of said drum past a predetermined point, said machine being characterized by the fact that said sensing device comprises a liquid filled container closed on one side by a movable member positioned to be displaced by said vibrations, and on another side by a smaller movable member, said movable members being connected by walls defining therewith a chamber permitting the movement of fluid from each of said movable members toward the other with equal freedom, means actuated by displacement of said second movable member for actuating said balancing means when said displacement exceeds a predetermined minimum, said movable members being resiliently maintained in normal positions in which said balancing means is not actuated, and a liquid reservoir which communicates through a restricted orifice with the space in said container between said movable members, said orifice being dimensioned to permit relief therethrough of the volume of liquid displaced by vibrations of said first movable member having less than a predetermined amplitude within a predetermined time, thereby avoiding actuation of said balancing means by movement of said smaller movable member in response to small, infrequent vibrations, but said orifice being too small to permit relief therethrough of larger volumes of liquid in a shorter time, so that an increased amplitude and frequency of vibration by the first movable member results in a movement of said smaller movable member to actuate said balancing means.

15. A machine as claimed in claim 14 in which said smaller member is resiliently pressed against a fixed stop defining its normal position.

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