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(54) Improvement in a washing machine with automatic determination of the weight of the wash load

(57) Clothes washing machine comprising a washing tub (1), a drum (2) rotatably arranged inside said washing tub and adapted to accomodate the washload (3), and an electric motor (4) adapted to rotatably drive said drum at differentiated rotational speeds, wherein at the beginning of the washing cycle the drum is driven so as to rotate at a progressively increasing speed until a first pre-set speed (V_s) is reached. Said first pre-set speed is then maintained during a first pre-set period of time (T_1), whereupon the power supply to said electric motor (4) is cut off, the drum is allowed to rotate by the force of inertia for a second pre-set period of time (T_2), means being provided which are adapted to calculate the weight of the washload out of said detected process parameters.

During said first period of time (T_1), in which the drum rotates under steady-state conditions, the pull-in torque of said motor is measured, whereas the instantaneous rotational speed of the drum (V_r) is detected at the end of said pre-set period of time in which the drum is allowed to rotate by the force of inertia.

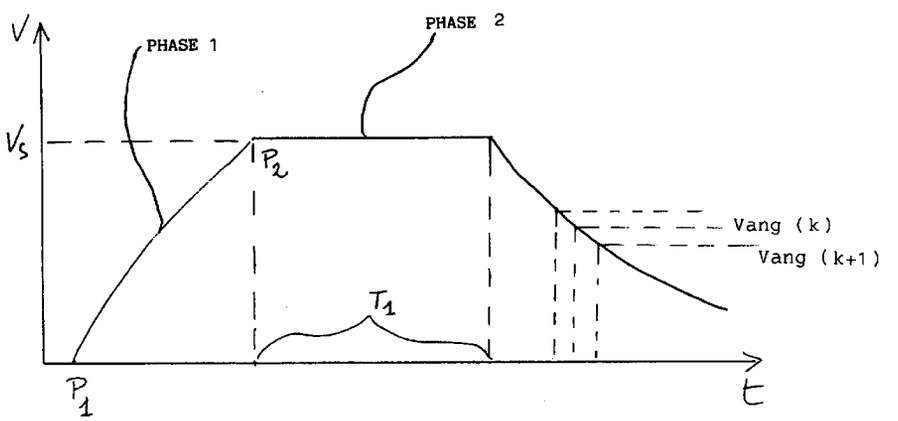

FIG. 2

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Description

The present invention refers to a clothes washing machine, particularly of the household type, provided with improved means for automatically determining the weight of the load of items to be washed.

Although the present invention refers specially to clothes washing machines of the front-loading type, and for the sake of convenient exemplification the following description is actually referred to such a front-loading type of clothes washing machine, it will be appreciated that it may advantageously apply to other types of clothes washing machines as well, particularly to top-loading machines or machines having their drum rotating about an oblique axis.

Clothes washing machines provided with means adapted to automatically identify the load of items to be washed are known in the art, wherein the term load, or washload, is used here and in the following description to solely mean the overall mass of the items to be washed, and not their nature or characteristics.

The ability of the washing machine to recognize in an automatic manner each washload that is introduced in its drum for processing is a pre-requisite in view of the self-programming ability of the same machine, which will then be able to automatically define all of the parameters to be used in the washing process, such as the amount of detergent, the amount of water to be filled in, the number and the type of washing and rinsing phases to be performed, etc., so as to each time optimize the operation of the machine, while sparing the user the trouble of having to select each time the most suitable programme and in this way avoiding his or her quite frequently introducing in the process programming errors that prevent the machine from operating in optimum conditions.

There are various patent specifications illustrating methods for the washing machine to be given an ability to automatically recognize the amount of items loaded into it for washing. Some of these methods operate in the presence of a washload that has already been soaked with water, and this fact brings in an initial inaccuracy that simply cannot be rectified any longer. According to other patent disclosures, the methods call for the washload to be measured when still dry, ie. before being soaked with water, as this is for instance illustrated in the US patent no. 5,161,393 filed to the name of General Electric Company.

According to the method disclosed in the above cited patent, however, the measurement of the dry washload is performed by successively driving the drum holding the washload at two distinct, pre-determined speeds of rotation, while measuring both the time and the torque needed to reach the first one of said two speeds of rotation, as well as both the time and the torque needed to increase the speed of rotation of the drum from said first speed to a second pre-determined speed with a different motor torque. By subsequently processing all parameters detected in this way, along with the parameters that will have been stored previously in the system, it will then be possible to identify or recognize the washload regardless of the moment of inertia of the other rotating masses and the characteristics of the motor.

Such a method appears to be effective. However, it requires the washing machine to go through a preliminary operational sequence that is rather complex, as quite complicated turns out to be also the subsequent processing required to come to the actual identification of the washload.

It therefore would be desirable, and it is actually a main purpose of the present invention, to provide a clothes washing machine which is capable of automatically determining the weight of the dry washload with simpler and more reliable methods, through the addition of inexpensive component parts and the use of currently available technologies.

The invention will be more clearly understood from the description that is given below by way of non-limiting example with reference to the accompanying drawings, in which:

- Figure 1 is an exploded view reflecting the assembly sequence of a number of component parts which are of a fundamental importance to the purpose of the present invention, such as for instance the rotating drum, the driving motor and other auxiliary parts;

- Figure 2 is a diagram of the initial operation sequence of a washing machine according to the present invention.

In the course of the following description, the term "water" is used to equally mean washing liquor or rinsing water. Such a simplification should not, however, affect the clearness and intelligibility of what is set forth in said description, owing to the context in which such terms are used, as anyone skilled in the art will readily appreciate.

With reference to Figure 1, which illustrates a preferred embodiment of the present invention, a solution according to the present invention is explained along with the corresponding principle of operation.

The described clothes washing machine comprises a washing tub 1, a drum 2 rotatably arranged within said washing tub and adapted to accomodate the washload 3, an electric motor 4 associated with said drum and adapted to drive it at variable, pre-selectable speeds of rotation.

Although not shown in the Figure, also all other elements need to be considered which contribute to the overall inertia of the rotating mass. These, besides the drum itself and the rotor of the driving motor, include mainly, but without excluding any possible additional ones, the transmission belt and the related pulleys or any equivalent means used to such a purpose.

The washing machine is provided with a variable-speed motor and an arrangement adapted to deliver the information relating to the instantaneous speed of rotation of the drum (typically this is a tachometer, but any other device capable of delivering such an information would do for the job). Furthermore, appropriate devices capable of acquiring and delivering an information equivalent or corresponding to the output torque of the motor shall be provided accordingly. Such devices are generally known in the art and may be appropriately selected by those skilled in the art among the variety of existing solutions, such as for instance a peak-voltage detector and a phase-delay type motor control, or a circuit capable of integrating a current equivalent to the motor current, etc.

A processing element (not shown) is further provided, in which following data are stored:

- the stabilization speed,
- the length of the period of time in which said speed remains in its stabilized condition,
- the lowest and the highest speed limits defining the interval of observation of the speed during the natural slowing-down of the system,

and which is adapted to calculate and store the value of the torque supplied by the motor during the phase of stabilization of the speed, as well as the parameters describing the evolution of the rotational speed during the natural slowing-down of the system.

Referring now to Figure 2, the operation of the washing machine according to the present invention can be explained as follows:

- In the phase 1, the motor is energized to step up the speed of rotation of the drum, which has been previously loaded with the sole items to be washed, ie. without any water admission, from its zero value (at P_1) to a predetermined value V_s at P_2.

- Upon reaching said speed, the motor,in the subsequent phase 2, is automatically controlled during a certain time T_1 so as to maintain said speed, and during this phase the torque needed by the motor to maintain such a speed constant is measured.

  It will be readily appreciated that in steady-state conditions such a torque equals the resisting torque which, at constant speed, coincides with the sole torque due to the various frictions and resistances, the braking action due to the inertia of the rotating complex being null by its own definition.

- In the subsequent phase 3, the drum driving motor is de-energized so that it slows gradually down due to the opposing action of inertia, which would tend to maintain the initial speed of rotation, and friction forces braking the whole of the rotating mass, thereby causing it to slow down.

During this phase a plurality of measurements of the rotational speed of the motor and, hence, of the drum are performed at different angular speeds taken at regular, short intervals Vang(0), Vang(k), Vang(k+1)...

The data acquired in this way during the last two phases are used to univocally determine the friction forces and the inertia offered to the driving shaft of the overall rotating system according to the equations:

1) TORQUE = A + B.(ang. speed)

2) Ang. speed (k+1) = P_1 ang. speed(k) + P_2

with $P_1 = e^{-B.T/J}$ and

$$P_2 = \frac{-A.(e^{-BT/J}-1)}{B}$$

where P_1 and P_2 are calculated on the basis of the historical series of speed values through the use of the least squares method, and whose mathematical justification is known to those skilled in the art, so that it shall not be explained here since it is unrelated with the subject covered by the present invention, while A, B and J describe the coefficients of both the constant friction and the friction which varies linearly with the speed, and the overall inertia experienced by the driving shaft, respectively.

The two above expressed equations represent a balance of the moments of the forces involved in the two operational conditions considered.

By further processing the given expressions, the following is obtained:

$$J = \frac{+T.C}{\left(\frac{P_2}{1-P_1} - W_1\right) \ln_e(P_1)}$$

where T is the period, espressed in seconds, with which the speed values are read during the phase 2) and W_1 is the holding speed during the phase 1).

It is assumed that the inertia of the rotating parts of the machine without washload $J_{(machine)}$ is known and, therefore, the inertia of the washload $J_{(washload)}$ can be derived from the difference with respect to the total inertia, ie.:

$$J_{(washload)} = J - J_{(machine)}$$

The dimensions and the geometry of the rotating drum being known along with the thickness of the ring formed by the washload at the speed W_1, a relation associating $J_{(washload)}$ with the weight of the washload M_{load} is derived. For instance:

$$J_{(washload)} = M_{load}(r_1^2 + r_2^2)$$

with $r_1 = r_2 - KM_{load}$ and $K = r_2/18$

The inertia of the washing machine without washload is determined automatically by the machine by performing the procedure under no load conditions, ie. without any washload introduced in the drum. A kind of self-calibration of each machine can in this way be performed so as to eliminate any manufacturing variable from the calculation of the weight of the washload.

The above described configuration is of course compatible with and can be applied to all technical variants and arrangements that are obvious to and within the abilities of anyone skilled in the art.

It will be appreciated that those skilled in the art are in a position to identify further technical solutions and optimizations out of the present teaching by making use of normal techniques and knowledges readily available in the art. As a consequence, although described by using a generally known terminology, the present invention shall not be considered as being limited by the examples given above.

Claims

1. Clothes washing machine, in particular of the household type, comprising a washing tub (1), a drum (2) rotatably arranged within said washing tub and adapted to accomodate the washload, and an electric motor (4) adapted to rotatably drive said drum at different, pre-selectable speeds, **characterized in that** it is provided with means adapted to calculate the weight of the washload on the basis of a plurality of parameters that are measured or computed or previously stored, said parameters including:

   - the coefficients of both the constant friction and the friction that varies linearly with the speed;
   - the overall moment of inertia of the rotating masses, inclusive of both the masses belonging to the machine and the mass of the washload;
   - the moment of inertia of the rotating masses belonging to the machine only.

2. Clothes washing machine according to claim 1, **characterized in that** said frictional resistance of the system of parts rotating at constant speed is determined by letting the drum rotate at a first pre-determined speed (V_s) and then letting it hold said speed of rotation for a pre-determined period of time (T_1), and that during said pre-determined period of time (T_1) the torque delivered by the motor (4) is either measured or computed.

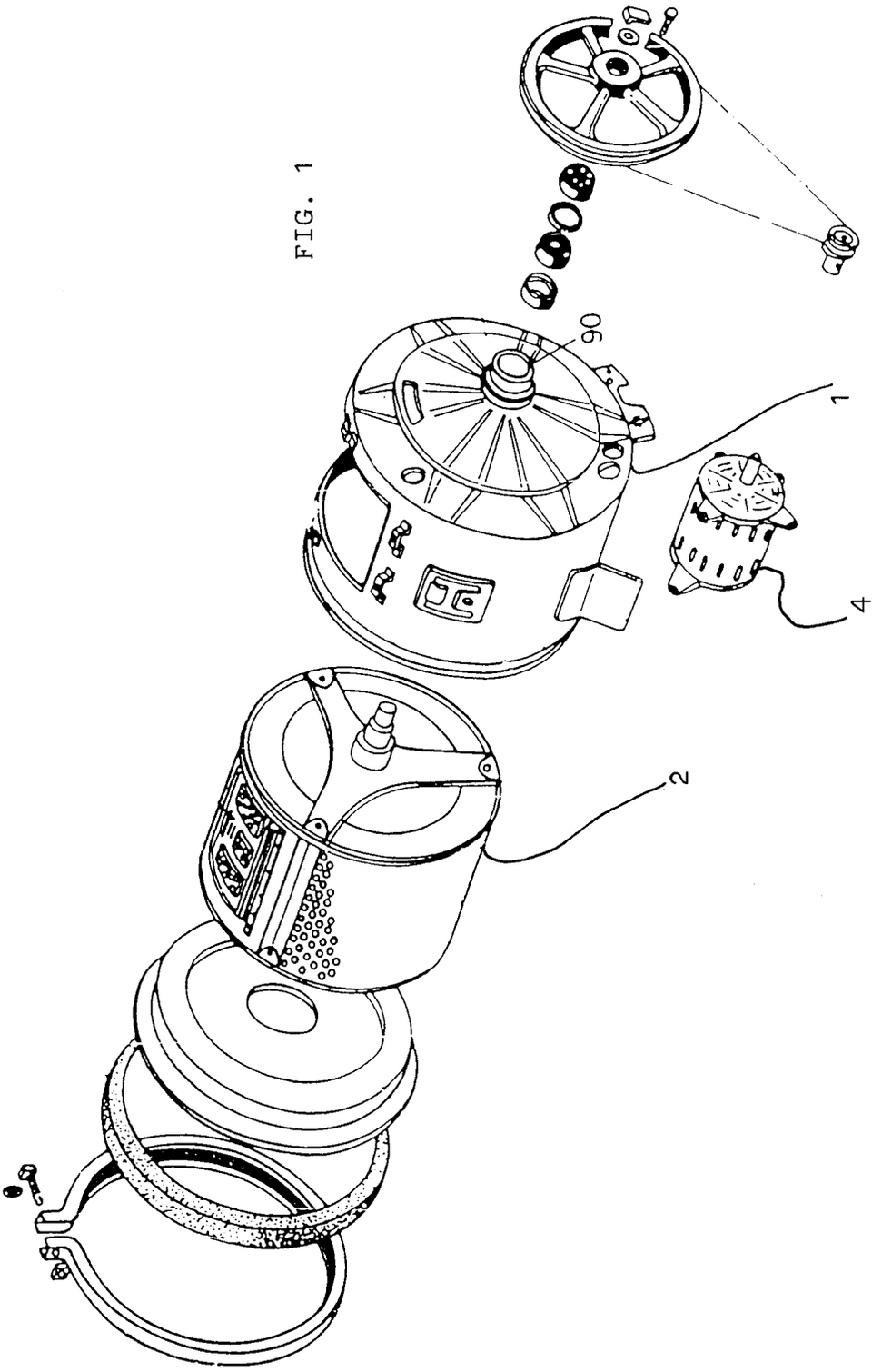
3. Clothes washing machine according to claim 2, **characterized in that** at the end of said pre-determined period of time said electric motor (4) is de-energized, the drum is allowed to further rotate inertially, and a plurality of rotational speeds of the drum (Vang(k)) corresponding to a plurality of previously stored successive instants are measured during said slowing-down period.

4. Clothes washing machine according to claim 3, **characterized in that** it is provided with means adapted to store, before the actual operation cycle starts,

   - the moment of inertia of said drum, said motor and all other moving parts rotating together with said motor and said drum;
   - said speed (V_s) of rotation under steady-state operating conditions.

5. Clothes washing machine according to any of the preceding claims, **characterized in that** it is capable of automatically determining at the beginning of the cycle, and before the introduction of the washload, the moment of inertia of the inherent rotating masses of the machine, and then storing said moment of inertia.

FIG. 1



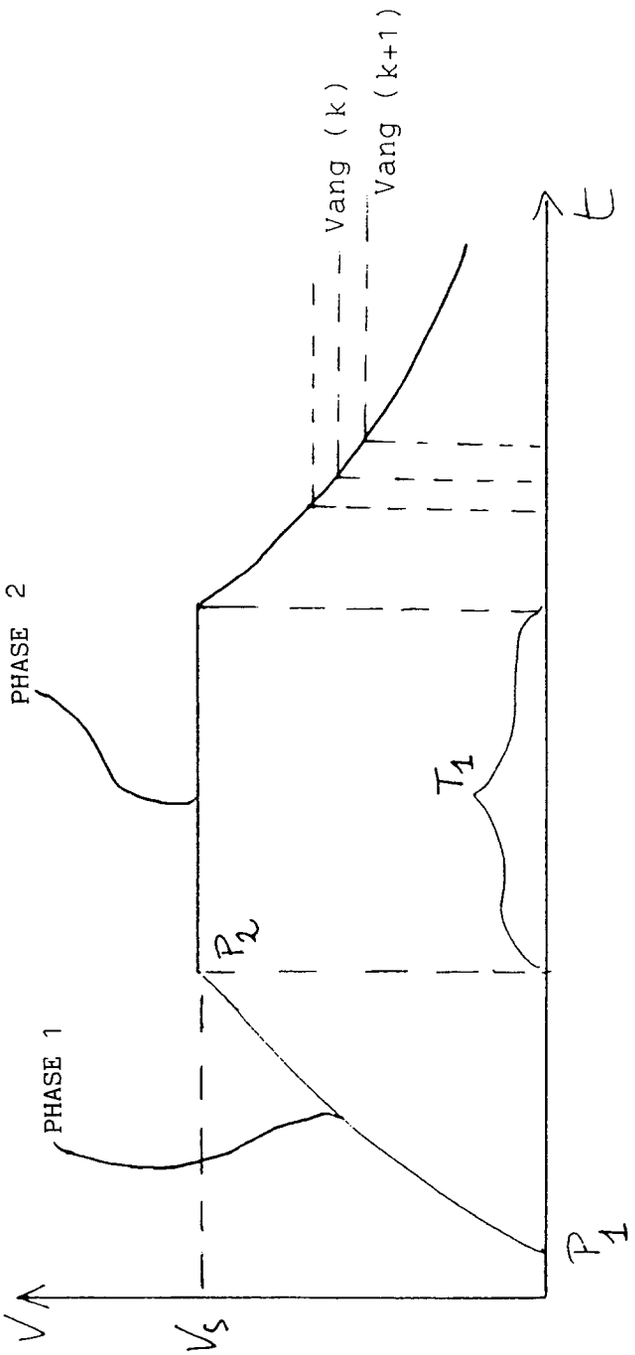


FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 95 11 2646

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 143 685 (ESSWEIN S.A.) * the whole document * ---	1,2,4	D06F39/00
X	EP-A-0 410 827 (CIAPEM) * the whole document * ---	1,2,4	
A	EP-A-0 415 743 (FISHER & PAYKEL LIMITED) * column 4, line 30 - column 7, line 7; figure 6 * ---	1-3	
A	EP-A-0 536 542 (ZANUSSI ELETTRODOMESTICI S.P.A.) * abstract; figure * -----	1,3	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 January 1996	Courrier, G

CATEGORY OF CITED DOCUMENTS

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